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Vol. I

TRANSCRIPT OF RECORD

Supreme Court of the United States

OCTOBER TERM, 1942

No. 369

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA, PETITIONER,

vs.

THE UNITED STATES

No. 373

THE UNITED STATES, PETITIONER

vs.

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA

ON WRITS OF CERTIORARI TO THE COURT OF CLAIMS

PETITIONS FOR CERTIORARI FILED {**SEPTEMBER 2, 1942.**
SEPTEMBER 3, 1942.

CERTIORARI GRANTED DECEMBER 14, 1942.

SUPREME COURT OF THE UNITED STATES

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ON PETITIONS FOR WRITS OF CERTIORARI TO THE COURT OF CLAIMS

VOL. I

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IN THE COURT OF CLAIMS OF THE UNITED STATES

No. 33642

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA

vs.

THE UNITED STATES

I. HISTORY OF PROCEEDINGS

The original petition was filed July 29, 1916, by Richard A. Ford, Esq., as Attorney of Record.

On May 21, 1919, supplemental petition was filed.

On June 15, 1922, the amended supplemental petition was filed, which is as follows:

II. AMENDED AND SUPPLEMENTAL PETITION—Filed June 15, 1922

To the Honorable Chief Justice and Associate Justices of the Court of Claims of the United States:

Now comes the Marconi Wireless Telegraph Company of America, a corporation duly incorporated under the laws of the State of New Jersey, and files this its amended and supplemental petition against the United States pursuant to the provisions of the Act of Congress of June 25, 1910, entitled "An Act to Provide Additional Protection for Owners of Patents of the United States, and for other purposes," and also pursuant to the said Act of June 25, 1910, as amended by the Act of Congress approved July 1, 1918, Making Appropriations for the Naval Service; and respectfully shows to the court as follows:

First: That on the twenty-fifth day of June, 1910, and for a long time prior thereto, your petitioner was the [fol. 4] owner by duly recorded assignments of the entire title to each of the following described Letters Patent of the United States, namely:

> Re-Issue No. 11913 (Original No. 586193, July 13, 1897), granted to G. Marconi on June 4, 1901, for transmitting electrical impulses and signals and apparatus therefor;

No. 609154, granted to O. J. Lodge on August 16, 1898, for inventions in electric telegraphy;
No. 763772, granted to G. Marconi on June 28, 1904, for apparatus for wireless telegraphy;
No. 803864, granted to J. A. Fleming on November 7, 1905, for instrument for converting alternating electrical currents into continuous currents;

by each of which said Letters Patent of the United States there was granted and secured to the assignor of your petitioner, named therein, his heirs and assigns, for the term of seventeen (17) years from the date thereof, respectively, the full, sole and exclusive right and liberty of making, using and selling the invention set forth in and by said Letters Patent throughout the United States and the territories thereof to the full end of the term thereof, which said Letters Patent, or duly certified copies thereof, and duly certified copies of the assignment of each of said Letters Patent to it, your petitioner now here produces and shows to the court, and the same are prayed to be read as part hereof.

Second: Your petitioner alleges that it was, from the date of the assignments thereof to it as aforesaid and during all the period from the twenty-fifth day of June, 1910, to, to-wit, the twenty-first day of November, 1919, the sole and exclusive owner of the inventions set forth in said Letters Patent, and the sole and exclusive owner of said Letters Patent of the United States numbered Re-Issue 11913 (Original No. 586193), 609154, 763772 and [fol. 5] 803864; that it is the sole and exclusive owner of the claim herein made and set forth, and that no action on the claim herein made and set forth has been had either by the Congress of the United States or by any of the Departments of the Government.

Your petitioner further shows that it is an American corporation, controlled by loyal American citizens, and that in the conduct of its business it at all times bore true allegiance to the Government of the United States, and has not in any way aided, abetted or given encouragement to any of the enemies of the Government.

Third: That your petitioner is advised by its counsel and believes and therefore avers that said Letters Patent of the United States, numbered Re-Issue 11913 (Original

No. 586193), 609154, 762772 and 803864, as hereinabove set forth, are valid and effectual in law to secure to your petitioner the exclusive rights and privileges thereby granted, and that your petitioner was, during all the period covered by the claim herein made, entitled to the sole and exclusive use and enjoyment of the said inventions and the said Letters Patent, and to the exclusive rights and privileges thereby granted and to receive the profits of the same, except in so far as your petitioner may have granted to others the right to use the same.

That the infringement by the United States of the said Letters Patent, as herein complained of, has been in violation of the exclusive rights and privileges granted by said Letters Patent and has seriously interfered with the enjoyment thereof by your petitioner, as it was by law entitled to do, and has prevented it from receiving the profits to which it was entitled as the sole owner of said inventions and said Letters Patent.

Fourth: That none of the inventions covered and claimed in the said Letters Patent were discovered or invented by the patentees thereof while such patentee was an employee [fol. 6] of the Government of the United States, nor was any of such patentees in the employment or service of the Government of the United States at the time said Letters Patent were assigned to your petitioner.

Fifth: That your petitioner is informed and believes, and therefore avers, that the United States, through its officers and agents, and especially through the officers or officials of its Department of the Navy, its Department of War, its Department of Commerce, and various of the bureaus of its said Departments, and through other officers and agents the names of whom are to your petitioner unknown but information of which is in the possession of the Government, which is requested to produce the same, and otherwise, well knowing the premises and the exclusive rights and privileges granted by said Letters Patent as aforesaid, and that such exclusive rights and privileges had become vested by duly recorded assignments in your petitioner, and further well knowing that the validity of said Letters Patent had been adjudicated in favor of your petitioner by several of the courts of the United States, has, since the twenty-fifth day of June, 1910, and prior to the twenty-first day of November, 1919, without license of

your petitioner, and without lawful right, made, constructed or manufactured, or caused or procured to be made, constructed or manufactured, and used, or caused or procured to be used, a very large amount of apparatus containing and embodying in use the inventions covered and claimed in and by said Letters Patent of the United States, numbered Re-Issue 11913 (Original No. 586193), 609154, 763772 and 803864, in violation and infringement of said Letters Patent and of the rights of your petitioner thereunder. That in violation and infringement of said Letters Patent and of the exclusive rights and privileges of your petitioner thereunder, the United States, through its said officers and agents, has, since the said twenty-fifth [fol. 7] day of June, 1910, entered into agreements and placed orders with divers persons and corporations, among such persons and corporations being Emil J. Simon, Fritz Lowenstein, Telefunken Wireless Telegraph Company, Atlantic Communication Company, Kilbourne and Clark Company, Wireless Specialty Apparatus Company, International Radio Signalling Company, Western Electric Company, Westinghouse Electric Manufacturing Company, General Electric Company, Liberty Electric Company, American Radio and Research Corporation, General Radio Company, DeForest Radio Telegraph and Telephone Company, Wireless Improvement Company, United Wireless Telegraph Company, Cutting and Washington, Electric Ind. Manufacturing Company, Clapp Eastham Company, John Firth, Radio Telegraph and Telephone Company, Marine Engineering Company, Ira M. Henry, Bellini Tosi Company, Patent Exploitation Company, Federal Telegraph Company, Dubilier Condenser Company, Morehead Laboratory, National Electrical Supply Company, Lowenstein Radio Company, Garwood Manufacturing Company, Sperry Gyroscope Company, International Radio Telegraph Company, Adams Morgan Company, Liberty Electric Corporation, Manhattan Electric Supply Company, Conn. Telephone and Telegraph Company, L. S. Brach Supply Company, American Pulley Company, Holtzer Cabot Electric Company, Crocker Wheeler Company, American Propeller Company, The Robins & Myers Company, DeLaurier's Aircraft Company, Automatic Telegraph Manufacturing Company, Roy O. Fitch, Dyro Motor Company, American Gas Accum. Company, Electric Importing Company, Richard Pfund, Radio

Controller Corporation, Foote-Pierson Company, Doran Bros. Elec. Company, Roy E. Hall, Louis Cohen, Muirhead and Company, H. Krautz Manufacturing Company, Dore- [fol. 8] mus Machine Company, Electric Dental Company, Central Scientific Company, and other persons and corporations whose names are to your petitioner unknown but information of which is in the possession of the Government, which is requested to produce the same, for wireless apparatus which constituted an infringement of said Letters Patent and the inventions set forth thereby, and has used, or caused or procured to be used, the apparatus so obtained. That such unlawful and unauthorized making, construction, manufacture and use of your petitioner's said patented inventions, and such violation and infringement of your petitioner's said Letters Patent, has resulted in great injury, damage and loss to your petitioner, to-wit, as your petitioner is informed and believes, and therefore avers, in the aggregate sum of six million dollars ($6,000,000), which sum is justly due to your petitioner, no part thereof having been paid, and which sum, or such other reasonable compensation as this honorable court may find to be due to your petitioner, your petitioner avers it is justly entitled to recover, after allowing all just credits and offsets.

Sixth: Your petitioner further shows the court that it has at all times been ready, able and willing to furnish and supply to the United States any of the inventions set forth in said Letters Patent, together with apparatus embodying said inventions and to charge the United States only reasonable prices therefor.

Seventh: Your petitioner further shows the court that upon learning of the violation and infringement by the United States of the said Letters Patent and the inventions set forth and claimed therein of which inventions and Letters Patent your petitioner was, as before alleged, the sole and exclusive owner, your petitioner notified and warned the United States to desist therefrom, well believing that it would cease the same; but that, notwithstanding such [fol. 9] notice and warning, the United States neglected and refused so to do and continued to make, construct, manufacture and use, or cause or procure to be made, constructed, manufactured and used, the inventions set forth

and claimed in said Letters Patent, in violation and infringement of your petitioner's rights in the premises.

Eighth: Your petitioner's said claim for compensation for the use of said patented inventions is not based in any part on the use by the United States of any article or apparatus owned, leased or used by or in the possession of the United States prior to June 25, 1910.

Wherefore your petitioner prays judgment in its favor against the United States for the sum of six million dollars ($6,000,000), and for such other and further relief as to the court may seem just.

Marconi Wireless Telegraph Company of America,
By E. J. Nally, Vice-President. (Seal.)

Attest: L. MacConnach. Asst. Secretary.
Richard A. Ford, Attorney for Petitioner.

[fol. 10] *Duly sworn to by Edward J. Nally. Jurat omitted in printing.*

[fol. 11] III. General Traverse—Filed August 23, 1938
(out of time by leave of court)

And now comes the Attorney General, on behalf of the United States, and answering the amended and supplemental petition of claimant herein, denies each and every allegation therein contained; and asks judgment that the amended and supplemental petition be dismissed.

Paul Campbell, Acting Assistant Attorney General.
JFM.

IV. Argument and Submission of Case

On March 5, 1935, the case was argued and submitted on merits by Mr. Thomas G. Haight and Mr. Edward W. Vaill for plaintiff, and by Mr. Clifton V. Edwards and Mr. John F. Mothershead for defendant.

[fol. 12] V. **Special Findings of Fact, Conclusion of Law and Opinion of the Court by Green, J.**— Filed November 4, 1935

Messrs. Thomas G. Haight and *Edward W. Vail* for plaintiff. *Messrs. James R. Sheffield, James J. Cosgrove, Abel E. Blackmar, Jr., Richard A. Ford,* and *Sheffield & Betts* were on the briefs.

Messrs. Clifton V. Edwards and *J. F. Mothershead,* with whom was *Mr. Assistant Attorney General George C. Sweeney,* for defendant. *Mr. Paul P. Stoutenburgh* was on the briefs.

This case having been heard by the Court of Claims, the court, upon the evidence adduced, makes the following

Special Findings of Fact

I. Plaintiff was a corporation of New Jersey for more than six years preceding the filing of the original petition herein on July 29, 1916, and until November 20, 1919, when an agreement was entered into with the Radio Corporation of America and beyond which time no claim for infringement is apparently made on any of the patents in suit.

II. Guglielmo Marconi, an Italian subject, on December 7, 1896, applied for letters patent of the United States for improvements in transmitting electrical signals and patent #586193 dated July 13, 1897, was granted to him. On April 1, 1901, he applied for a reissue of said patent and the same was granted bearing reissue #11913 dated June 4, 1901, for transmitting electrical impulses and signals and apparatus therefor to Marconi's Wireless Telegraph Company, Limited, of England. On March 6, 1905, this patent, together with all claims for past infringement thereof, was assigned to plaintiff.

Exhibit 19, a copy of Reissue patent #11913, and exhibit 24, a stipulated copy of the assignment of the patent to plaintiff, are by reference made a part of this finding.

III. Oliver Joseph Lodge, a British subject, applied February 1, 1898, for letters patent of the United States for improvements in electric telegraphy and patent #609154 dated August 16, 1898, was granted him. He owned this

patent until he assigned it, together with the right to sue for past infringements, to the plaintiff on March 19, 1912. [fol. 13] Exhibit 20, a copy of the Lodge patent #609154, and exhibit 25, a stipulated copy of the assignment of said patent to plaintiff, are by reference made a part of this finding.

IV. The aforementioned Marconi also applied November 10, 1900, for letters patent of the United States #763772 dated June 28, 1904, which was granted to Marconi's Wireless Telegraph Company, Limited, of London, England. Said patent was assigned with the Reissue patent #11913 to plaintiff, together with all claims for past infringement thereof, on March 6, 1905.

Exhibit 21, a copy of the Marconi patent #763772, and exhibits 23 and 24, stipulated copies of assignments of said patent, are by reference made a part of this finding.

John Ambrose Fleming, a British subject, on April 19, 1905, applied for letters patent of the United States for improvements in "Instrument for converting alternating electric currents into continuous currents." The invention and application were assigned September 13, 1905, to plaintiff and the patent thereon, #803684 dated November 7, 1905, was issued to plaintiff.

Exhibit 22, a copy of the Fleming patent #803684, and exhibit 26, a stipulated copy of the assignment of said patent to plaintiff, are by reference made a part of this finding.

V. On November 26, 1919, plaintiff sold to the defendant for $1,450,000 forty-five coastal wireless stations and a large number of ship stations. The contract of sale contained, among other things, the following provision:

"The Marconi Company hereby stipulates and agrees that the compensation above named is intended to be and is accepted by it as compensation in full for and on account of any and everything transferred by it under this agreement, and that it will not make claim and that the Government is not bound to pay any other or further sum than the above-named consideration as payment, royalty, or other compensation *on account of its patent rights involved in any of the apparatus hereby transferred.*" (Italics ours.)

It is admitted that the apparatus so sold included the combinations of the Marconi reissue patent, the Lodge patent, and the Marconi patent #763772.

VI. On October 16, 1929, a stipulation was entered into between the parties, in which paragraphs 2 and 7 are as follows:

"2. That on November 20, 1919, the claimant entered into an agreement with the Radio Corporation of America, a copy of which is marked herein as defendant's exhibit C-7, and that said agreement has not been terminated or canceled, nor has it been modified except as stated below in carrying out some of the provisions thereof.

"7. That on August 2, 1920, the claimant caused to be filed in the office of the Secretary of State of New Jersey a certificate of dissolution of which a certified copy is offered in evidence by claimant and marked 'Claimant's Exhibit No. 359.'"

This stipulation and the copy of the certificate of dissolution, plaintiff's exhibit 359, are by reference made a part of this finding. The circular of the Radio Corporation of America and the Marconi Wireless Telegraph Company of America dated December 20, 1919, and the form of stockholders' agreement, both referred to in the quotation in paragraph 4 of the stipulation of October 16, 1929, are also [fol. 14] by reference made a part of this finding, being embodied in the stipulation of June 1, 1933.

VII. An agreement was entered into November 20, 1919, between Radio Corporation of America and plaintiff, which contained the following statements:

"Article I.

"1. It is desired that the Radio Corporation acquire all the assets of the Marconi Company, present and future, including its goodwill and business, rights of action, patent rights, and all other rights and property to which it is now or may hereafter become entitled, except the 'reserved assets' hereinafter described * * *. All claims and rights of action which the Marconi Company possesses being transferred by this present agreement to the Radio Corporation, it is understood and agreed that from such transfer there are reserved each and all of the claims or rights of action as follows, and that in any proceeding with respect thereto the Marconi Company may sue in its own name, joining the Radio Corporation as complainant if

necessary. The claims or rights of action enumerated below are the 'reserved assets' above referred to.

"(*a*) A claim against the United States Government arising from unlicensed use by and for the Government of the apparatus covered by the patents of the Marconi Company.

* * * * * * *

"Article II.

"6. The Marconi Company warrants and agrees to keep its organization alive until the Radio Corporation shall in writing agree that it may be dissolved and the Marconi Company may at any time require the Radio Corporation to pay the expenses incurred thereafter in carrying out the foregoing agreement to keep its organization alive provided that at the same time the stockholders of the Marconi Company assign to the Radio Corporation a majority of the voting shares of the Marconi Company. * * *

"7. The Marconi Company agrees to prosecute at its own expense all the claims which are the 'reserved assets' above described, and the Marconi Company agrees that all amounts received in cash by it at any time but after paying expenses for maintaining its corporate organization and the prosecution of such claims shall forthwith be paid to the Radio Corporation, and it is agreed that the Radio Corporation shall from time to time on such payments issue therefor preferred stock of a par amount equal to the amount of cash so paid subject to the provisions of sections 3, 4, and 8 of this article, provided that when and if such par amount of preferred stock so delivered shall amount to five million dollars ($5,000,000), if the Aldene factory is transferred under section 4 of this article, or four million five hundred thousand dollars ($4,500,000), if it is not transferred, *and in any case on December 31, 1930, regardless of the amount then issued, the Marconi Company shall forthwith assign to the Radio Corporation the reserved assets and all of them and all other assets which it then has without further compensation or consideration.* (Italics ours.)

"8. The Radio Corporation will advance such sums to the Marconi Company as may from time to time be reasonably necessary in the opinion of the counsel hereinafter [fol. 15] mentioned to prosecute the claims or rights of action mentioned above as well as for the defense of any patent suits now pending against the Marconi Company or

hereafter brought with reference to operations of the Marconi Company prior to the coming into effect hereof. * * * All amounts advanced, and all recoveries against the Marconi Company with respect to operations which it performed prior to the date hereof, shall be charged against and deducted from such reserved assets. * * *"

Said agreement, defendant's exhibit C-7, is by reference made a part of this finding.

On December 29, 1930, the Radio Corporation of America and the trustees in dissolution of the plaintiff entered into an agreement postponing the transfer of the reserved assets referred to in section 7 of article II of the agreement of November 20, 1919 (herein referred to in findings VI and VII), until there shall have been a final determination of the claims against the United States in the courts of last resort having jurisdiction over said claims, and until the said claims shall have been allowed, the amounts thereof ascertained and warrants issued for their payment.

A stipulation dated June 14, 1933, having attached thereto said agreement of December 29, 1930, is by reference made a part of this finding.

VIII. An undated assignment from plaintiff to Radio Corporation of America, stipulated to have been executed and delivered November 20, 1919, and recorded in the Patent Office December 30, 1919, in Liber R 109, page 78, conveyed—

"all inventions, licenses, and patent rights of any character whatsoever, owned by it * * * together with all claims for profits and damages by reason of past infringement * * * with the exception of the following claims or rights of action which are excepted from this assignment and are reserved to said Marconi Wireless Telegraph Company of America;

"(*a*) A claim against the United States Government arising from unlicensed use by and for the Government of the apparatus covered by the patents of the Marconi Company * * *."

This assignment expressly mentioned the two patents in suit then unexpired, namely, Marconi #763722 and Fleming #803684. It did not specifically mention the Marconi reissue #11913 and Lodge #609154.

Another assignment from plaintiff to Radio Corporation of America dated December 8, 1919, and recorded in the Patent Office December 30, 1919, in Liber R 109, page 86, confirmed the undated assignment recorded the same date.

A further assignment from plantiff to Radio Corporation of America dated December 8, 1919, and recorded in the Patent Office December 30, 1919, in Liber R 109, page 93, expressly mentioned the two expired patents in suit, Marconi reissue #11913 and Lodge #609154, and assigned these patents, together with all claims for profits and damages by reason of past infringement, except for the same reservation previously mentioned.

These three assignments, being exhibit 362, are by reference made a part of this finding.

[fol. 16] Marconi Reissue #11913

IX. The reissue patent #11913 relates to a—

"complete system or mechanism capable of artificially producing Hertz oscillations and forming the same into and propagating them as definite signals and capable of receiving and reproducing, telegraphically, such definite signals; * * *."

The embodiment shown by figs. 10 and 11 of the patent, reproduced below, is the basis of the alleged infringement.

Fig. 10.

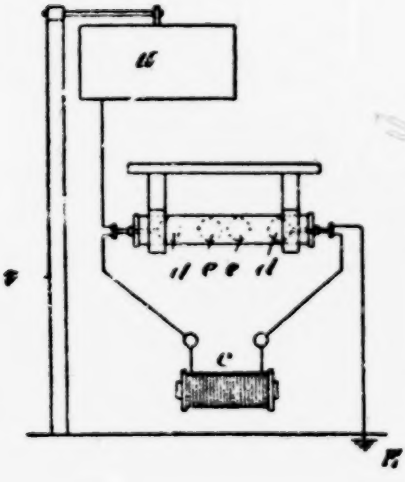
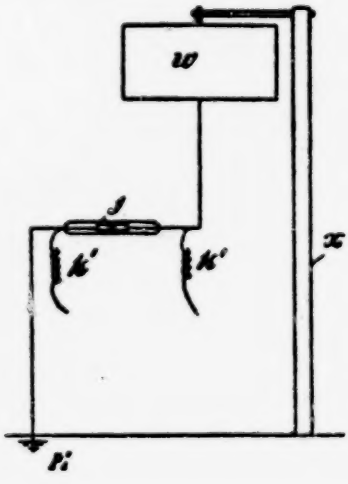


Fig. 11.



To one skilled in the art a transmitting station is shown at fig. 10, having a Morse key and battery in the primary circuit, not shown, of an induction or Ruhmkorff coil *c* or other source of high tension, high frequency current. A spark gap *d, e, e, d,* in the secondary circuit has one side grounded at *E* and the other side connected to an elevated wire and plate *u* insulated from the earth on the pole *v*.

The receiving station in fig. 11 has a coherer or imperfect electrical contact type detector *j* connected on one side to an elevated conductor *w* insulated from the earth, while the other side of the detector is grounded at *E*. Choke coils k^1k^1 are provided to keep high frequency waves out of the local battery circuit, not shown in fig. 11 but shown in fig. 4 of the patent. A relay in this local battery circuit operates a stronger battery circuit containing a sounder and a trembler for tapping the coherer so that its circuit will be broken after the incoming waves have ceased. Metal plates are provided of a size to cause the receiving system to resonate with the wave length transmitted.

X. The only claim in suit of the reissue patent reads as follows:

"3. The combination, in an apparatus for communicating electrical signals, of a spark producer at the transmitting station, an earth connection to one end of the spark producer, an insulated conductor connected to the other end, an imperfect electrical contact at the receiving sta- [fol. 17] tion, an earth connection to one end of the contact, an insulated conductor connected to the other end, and a circuit through the contact, substantially as and for the purpose described."

The spark producer at the transmitting station, shown in fig. 10, includes coil *c* and its connected spark gap. The earth connection is shown in fig. 10 as being made on the right side of spark producer. The insulated conductor connected to the other end of the spark producer includes the elevated plate *u*. At the receiving station in fig. 11 the imperfect electrical contact *j* has the earth connection on the left side, an insulated conductor plate *w* on the right side, and a circuit through the contact as described. The insulated conductor at both the transmitting and receiving station is elevated to increase the range of signalling.

XI. More than two years after the date of the original patent, Marconi applied for his reissue, alleging his original

patent was believed defective because some of the claims were thought to cover apparatus employed by Prof. Popoff.

The original patent #586193 stated—

"The tube *j* may be replaced by other forms of imperfect electrical contacts, but this is not desirable."

In the reissue patent the meaning of this quotation was changed by omitting the words, "but this is not desirable." No satisfactory explanation of the reasons for this change in the scope of the description of the invention has been given.

The closest claim in the original patent to the claim now in suit was no. 43, which was the same as present claim 3 of the reissue patent except that it lacked the words "in an apparatus for communicating electrical signals," and also the phrase at the end of the claim, "substantially as and for the purpose described."

Certified copies of the file wrapper of the original and reissue patents, exhibits Z-5 and A-6, are by reference made a part of this finding.

XII. Plaintiff's apparatus was marked with name plates and some of these name plates lacked any marking as to the reissue patent in suit, although another and previously used name plate for the same type apparatus, i. e., switchboards and transmitting transformers, did contain a reference to the number or date of this reissue patent.

The United States was orally notified of its use of the Marconi inventions with particular reference to the four patents in suit in the winter or spring of 1912 by Mr. Griggs, president of plaintiff, and by Mr. Sheffield, counsel for and a director of plaintiff, at a White House conference at which the President and the Secretary of War, Secretary of the Navy, the Attorney General, and the Secretary of Commerce were among those present. The proofs do not satisfactorily show that any copy of any of the patents was shown at the conference, or that any particular apparatus was alleged to infringe or that any allegation was made that the United States would be held liable for any alleged infringement. Title to the Lodge patent in suit was not acquired by plaintiff until March 19, 1912. Written notice of the two Marconi patents and of the Lodge patent in suit and of their alleged infringement was given by registered mail to the Navy Department and to the War Department on March 7, 1913, and on March 8, 1913, respectively.

[fol. 18] Previous to the winter or spring of 1912 the Navy Departm[illegible] had been notified of an adjudication of the two Marcon. patents in suit but not of their alleged infringement.

XIII. A British Marconi patent # 12039 was filed June 2, 1896, and corresponds to the reissue patent # 11913 in suit. Claims 15 and 16 of this British patent read as follows:

"15. A receiver consisting of a sensitive tube or other imperfect contact inserted in a circuit, one end of the sensitive tube or other imperfect contact being put to earth whilst the other end is connected to an insulated conductor.

"16. The combination of a transmitter having one end of its sparking appliance or poles connected to earth, and the other to an insulated conductor, with a receiver as is mentioned in claim 15."

The earliest date to which plaintiff is entitled for constructive reduction to practice of the invention of the reissue patent is December 7, 1896, the filing date in this country. The provisions of the International Convention had not then become law.

The term of this British patent was for fourteen years from the filing of the provisional specification of June 2, 1896.

The British patent # 12309 of 1896 had its complete specification accepted July 2, 1897, before the issue of the original patent # 586193 in this country July 13, 1897. This British patent was published July 31, 1897, and sealed September 21, 1897.

Section 15 of the British patents act of 1883 was in force until January 1, 1908, and states:

"After the acceptance of a complete specification and until the date of sealing a patent in respect thereof, or the expiration of the time for sealing, applicant shall have the like privileges and rights as if a patent for the invention had been sealed on the date of the acceptance of the complete specification: Provided that an applicant shall not be entitled to institute any proceeding for infringement, unless and until the patent for the invention has been granted to him."

A copy of this British patent, exhibit 339, is by reference made a part of this finding.

XIV. The subject matter of the reissue patent went into wide use until displaced by later improvements. This reissue patent has been called the plain antenna patent.

XV. The alleged infringement of the Marconi reissue patent is for unlicensed use by the United States of transmitting and receiving sets between July 29, 1910, and July 13, 1914.

The receiving sets, the use of which has been satisfactorily proven in connection with this alleged infringement, are all of the type using a crystal detector. As a detector the crystal functions in a different manner from the coherer or imperfect electrical contact of the patent in suit, in that the crystal acts substantially as a rectifier or one-way valve allowing much larger portions of the waves to flow in one direction than in the other and thereby enabling speech or music to be heard. The use of the crystal as a detector was not discovered until after this Marconi patent.

XVI. Tests were made with the aid of improvements developed after the invention in suit for the purpose of demonstrating that with critical adjustments the coherer [fol. 19] might be made to transmit speech and music. These tests did not demonstrate the presence of any new properties or functions inherent in the coherer when used in the manner intended by the patent. The patent contemplated such a degree of imperfection in the contact of the particles in the coherer that the local battery circuit would be broken on tapping, but plaintiff in conducting these tests tried to keep the circuit through these particles from being broken and to this extent operated a coherer in a different manner from that contemplated by the patent. Later improvements used for this test included a transformer and tuning means connected in shunt with the detector to provide more sensitive reception than was possible with the plain antenna connections of the patent.

XVII. The words "imperfect electrical contact", as found in claim 15 of the Marconi patent, are used in their ordinary meaning and would be well understood by those skilled in the art if not also by those having little technical knowledge. Lodge described six classes of detectors for Hertzian waves more than two years before the filing date of the original patent of Marconi in a journal called the "London Electrician", June 15 and 22, 1894, pp. 187-190, and 204-205, and also discussed the utility of imperfect contact devices as detectors. One skilled in the art would understand that the

imperfect contact devices disclosed by Lodge did not include the other types or classes of then known detectors not making use of an imperfect electrical contact in reacting to Hertzian waves. In the same way those skilled in the art would understand the reference in the Marconi patent to "an imperfect electrical contact" to restrict the claim to apparatus making use of some form of an imperfect contact inserted in a circuit.

Exhibit E-4, the Lodge article in "London Electrician" of 1894, is by reference made a part of this finding.

XVIII. The crystal detector does not utilize an imperfect electrical contact in the detection of Hertzian waves but requires a good small contact of such degree of perfection that it is frequently necessary, when the contact becomes imperfect, to abandon the imperfect and unsuitable contact area and find a new sensitive spot or good contact. Occasionally the crystal is cleaned with alcohol.

The possession of substantial electrical resistance by a detector does not necessarily denote a bad contact device. Variation in resistance is not synonymous with an imperfect electrical contact.

The use of an imperfect electrical contact detector by the United States has not been satisfactorily proven. No use of the crystal detector in a manner contemplated for the imperfect electrical contact of the Marconi reissue patent, has been satisfactorily proven. Imperfect electrical contact detectors were largely superseded by more sensitive detectors before July 29, 1910.

XIX. The ticker detector construction has not been satisfactorily proven in sufficient detail to permit any finding as to whether or not such is an imperfect electrical contact type detector. No date of use prior to July 13, 1914, has been satisfactorily proven for the ticker detector.

XX. The transmitting circuits and receiving circuits of the wireless telegraph sets used by defendant and alleged [fol. 20] to infringe claim 3 of the Marconi reissue patent, all include a transformer connection between the antenna circuit and a closed circuit which latter circuit in the transmitter includes the spark producer or gap and in the receiver includes the crystal detector.

The transformers are of two types: (a) separate primary and secondary windings; (b) an auto-transformer type of winding.

In all instances in which a transformer having separate primary and secondary windings is utilized, no electrical connection is existent between the ground and the antenna and the spark producer or gap in the transmitter, or between the ground and the antenna and the detector in the receiver.

With this type of transformer no physical metallic connection exists; the coupling is purely inductive in character.

Such arrangement of transmitting and receiving circuits is shown in a diagram of the apparatus of the Wireless Specialty Apparatus Company, illustrated in Finding XXII.

XXI. In the transmitting and receiving circuits utilizing the autotransformer type of coupling, a single inductance coil is utilized and certain turns of this inductance are in common with both the antenna circuit and the associated closed circuit in which is included either the spark producer or the detector.

The fact that the use of the autotransformer establishes a direct electrical communication between the primary and secondary windings in the coupling of the closed circuit to the open circuit, is merely incidental to the construction of the autotransformer, the true function of which is to electromagnetically couple the open and closed circuits together, and such electrical connection is not for the purpose of connecting the receiving antenna and the ground directly to the detector so as to pass all of the high-frequency currents generated in the antenna through the detector, as was the case in the Marconi patent.

On the contrary, with respect to the transmitting circuit, such connection is merely incidental and not for the purpose of connecting the antenna and the earth directly to the spark producer or gap.

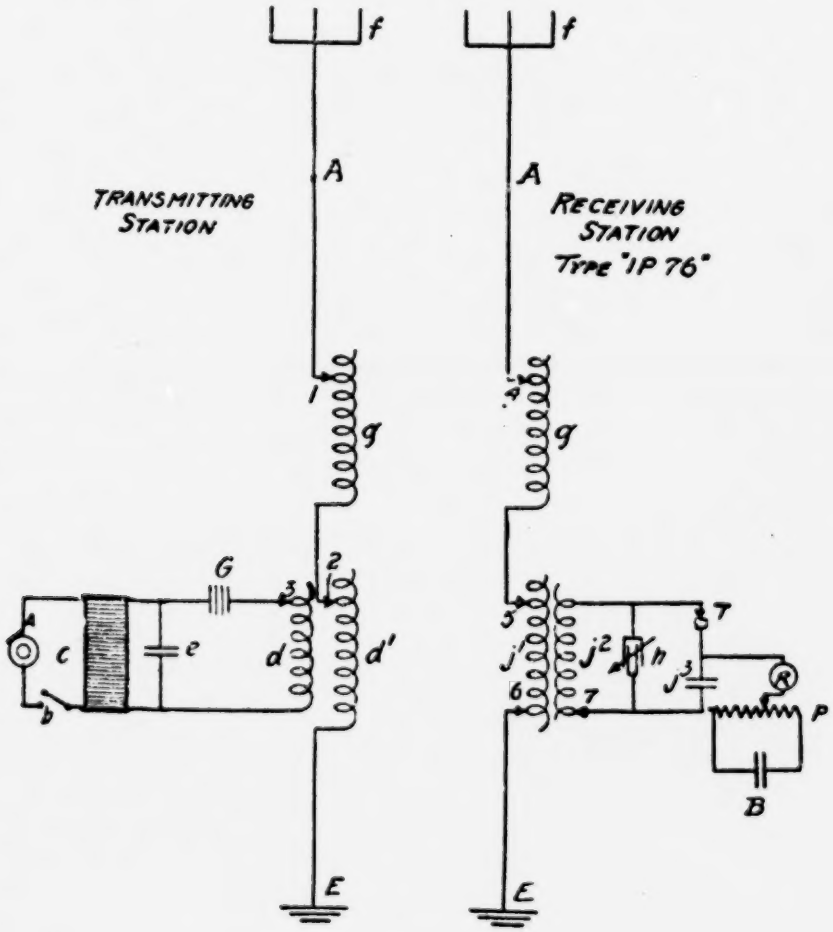
In the Marconi reissue patent the spark gap and detector, which were relatively high resistant devices, were located between the elevated conductor and the ground connection in the antenna circuit, and the location of these devices in a separate closed circuit coupled electromagnetically with the antenna circuit lessened the resistance in the antenna circuit and permitted much sharper tuning and selectivity. In the defendant's device the spark gap and detector are not in the antenna at all, they are in closed circuits only associated inductively and through oscillation transformers with the grounded antenna in the manner indicated in Finding XX.

The Telefunken sets, plaintiff's exhibit 79, utilized an autotransformer coupling in the transmitting system and a transformer having separate primary and secondary windings in the receiving system.

The National Electric Supply Company's field pack set, plaintiff's exhibit 80, utilized transformers having separate primary and secondary windings in both the transmitting and receiving systems.

[Vol. 21] The Foote-Pierson pack set, plaintiff's exhibit 102, utilized autotransformer coupling in both the transmitting and receiving systems.

XXII. The diagram below illustrates the apparatus constructed by the Wireless Specialty Apparatus Company.



XXIII. The prior art relied on by defendant to show lack of novelty and invention and to limit the scope of the claim of the patent includes the following United States patents:

Smith, # 247127, September 13, 1881;
Phelps, # 312506, February 17, 1885;
Dolbear, # 350299, October 5, 1886;
Edison, # 465971, December 29, 1891;

and the following publications:

An article by Lodge in "London Electrician" June 8, 1894, pp. 153-155; June 15, 1894, pp. 186-190; June 22, 1894, pp. 204-205; July 6, 1894, pp. 271-274; July 13, 1894, p. 299; July 20, 1894, pp. 332-335.

[fol. 22] Article by DeTunzelmann in "London Electrician", September 14, 1888, pp. 587-589; September 21, 1888, pp. 625-627; September 28, 1888, pp. 663-665; October 5, 1888, pp. 697, 698; October 12, 1888, pp. 725-726; October 19, 1888, pp. 757-758; October 26, 1888, pp. 788-789; November 9, 1888, pp. 16-18; November 16, 1888, pp. 41-44.

"Inventions, Researches and Writings of Nikola Tesla", by Martin, pp. 165, 169, 174, 188-193, 202, 203, 207, 208, 210-213, 225, 226, 231, 234, 303-313, 317, 332, 333, 337, 340-349, 384, 488, 489.

Article by Crookes in "Fortnightly Review", February 1892, pp. 173-181.

Article by Popoff in the Journal of the Russian Physico Chemical Society, St. Petersburg, 1896.

"The Alternate Current Transformer", by Fleming, London, 1893, p. 419.

"Electric Waves", by Hertz, London, 1893, pp. 183-184.

Journal of the Society of Arts, February 23, 1894, pp. 274-280—"Electric Signaling without Wires", by Preece.

The foregoing patents and publications, exhibits L-4, M-4, N-4, O-4, E-4, F-2, B-4, A-4, F-4, K-4, J-4, and S-6, are by reference made a part of this finding.

XXIV. The Smith patent #247127 relates to the inductive transmission of telephone signals between the metal roof of a moving car and a stationary wire strung along

the tracks as close to the car roof as possible. No spark-producer is contemplated or used, and the transmission without wires was through a small space as close as possible to the top of the cars. The medium for signaling was not intended to be by Hertzian waves.

The Phelps patent #312506 is for another inductive telegraphic transmission system for cars. There is no spark-producer for the generation of Hertzian oscillations. The apparatus on the car, shown at X in fig. 4, is not grounded.

Dolbear's patent #350299 is for the telephonic communication by what was said to be currents flowing through the earth when the grounded wires at the transmitting station A and receiving station B were said to be at different potentials. There was no spark-producer at the transmitting station. Dolbear had no idea of using Hertzian waves or oscillations.

Edison's patent #465971, December 29, 1891, discloses a system for telegraphing without wires by induction. A Morse key short-circuited a rapid make and break device in the primary circuit of an induction coil. The secondary circuit of such coil was grounded on one side and connected at the other to an elevated conducting surface through "an electro-motograph telephone receiver." There was no spark-producer for the generation of Hertz oscillations.

XXV. The Lodge article in the "London Electrician" of June and July 1894, reviewed the knowledge of the art of Hertzian oscillations but did not disclose the combination of apparatus called for by reissue claim 3. A number of different types of detectors of Hertzian oscillations, including coherers, were discussed and some of Hertz's experiments were repeated.

The DeTunzelmann article in the "London Electrician" of 1888, was an earlier discussion of the Hertz experiments. [fol. 23] Wave lengths or frequencies are discussed, but no disclosure is made of any combination of apparatus as set forth in claim 3 of the reissue patent.

The Martin book on Tesla's work relates to transmission by induction, to resonance, to peculiar lighting effects, and to the production of arcs in various ways. There is no disclosure of an imperfect electrical contact receiver nor

any definite idea for the transmission and reception of signals by Hertzian waves. This article states:

"I think that beyond doubt it is possible to operate electrical devices in a city through the ground or pipe system by resonance from an electrical oscillator located at a central point. But the practical solution of this problem would be of incomparably smaller benefit to man than the realization of the scheme of transmitting intelligence, or perhaps power, to any distance through the earth or environing medium. If this is at all possible, distance does not mean anything. Proper apparatus must first be produced by means of which the problem can be attacked, and I have devoted much thought to this subject. I am firmly convinced that it can be done, and hope that we shall live to see it done."

The article further shows that Tesla used a powerful alternating current.

The Crookes article in the "Fortnightly Review" of 1892, referred to the work of Hertz and Lodge with ether waves and prophesied the transmission of Morse code signals by having the sending and receiving apparatus tuned to a special wave length, but described no apparatus capable of carrying such a prophecy into effect, much less did this publication reveal the particular apparatus of the claim in suit.

The Popoff article did disclose a coherer grounded on one side and connected on the other side to an elevated insulated conductor for indicating thunderstorms. It failed to disclose a transmitting apparatus connected as called for by the claim in suit. This article stated—

"In conclusion I can express the hope that my apparatus, with further improvements of the same, may be adapted to the transmission of signals at a distance by the aid of quick electric vibrations, as soon as the source of such vibrations, possessing sufficient energy, will be found."

The other publications likewise do not disclose the apparatus of the claim in suit.

XXVI. No prior patent or publication discloses the combination of the claim in suit.

The invention of the Marconi reissue patent made possible new results by permitting the use of the Morse code

for signalling with Hertz waves, and permitted signalling with Hertz waves to greater distances than was previously possible.

Lodge Patent #609154

XXVII. With alternating currents of given frequency a circuit will carry its strongest current under a given pressure or voltage when there is a condition of resonance, or, in other words, when the natural period of the circuit corresponds with the frequency of the current. In the alternating current circuit its natural period depends on the value of its capacity and inductance, also called self-inductance. A helical coil of wire has principally inductance and an [fol. 24] electric condenser has essentially capacity. Variation in the value of either the inductance or capacity changes the period of the circuit.

The Lodge patent relates to the provision of a self-inductance coil between a pair of capacity areas in an oscillating circuit of either or both a sending or receiving set for Hertzian wave telegraphy. Such a coil may be adjustable to vary the value of its self-inductance. The purpose of such coil is to attain a condition of resonance or syntony in the oscillating circuit whereby the oscillations will be prolonged and a feeble impulse is gradually strengthened by cumulative action until it causes a perceptible effect on the principle of sympathetic resonance.

In the figures of the patent drawings on pages 14 and 15, fig. 1 was said to show the art prior to Lodge without the use of any inductance coil in either the transmitting or receiving circuits. Fig. 2 is one illustration of an oscillating circuit embodying the invention and having the inductance coil h^4 in series with the spark gap h^2h^3 and the condenser plates or capacity areas h and h^1. Wires h^5 lead to the source of high-frequency oscillations. One of the capacity areas may be the earth.

Fig. 3 is similar to fig. 2 except that the gap h^2h^3 is optionally short-circuited by the bridge h^9 and the wires h^5 from the high-frequency source are connected through gaps h^6 and h^7 instead of directly connected so that the circuit through the capacity area and coil h^4 may oscillate independently of the supply circuit h^5. The detector circuit x includes a coherer e, battery f, and sounder g, all connected across the coil h^4. The bridge h^9 must short-circuit the gap

h^2h^3 for the reception of messages when the transmitter is not in operation.

Fig. 4 is an arrangement like unto fig. 3 except that coil h^4 is in two parts, one on each side of the gap h^2h^3. Leyden jar capacitors j are placed in the supply circuit and an inductance k acts as a bypass but does not prevent the formation of sparks at the gaps.

Figs. 5, 6, 7, and 8 illustrate different shapes for one or both the capacity areas.

The coil is adapted for adjustment in value of its inductance by cutting in or out some or many of the turns in figs. 9 and 10.

The receiver of fig. 12 is similar to that of fig. 2 with the addition of a resistance or capacity w placed in shunt with the sounder g. In fig. 13 the detector circuit is connected with the oscillating circuit through a transformer u in order to leave the oscillating circuit free to vibrate without disturbance from the attached wires.

Lodge contemplated varying either the inductance or capacity to attain syntony or resonance.

XXVIII. The claims in suit are numbers 1, 2, and 5 of the Lodge patent, which read as follows:

"1. In a system of Hertzian-wave telegraphy, the combination, with a pair of capacity areas, of a self-inductance coil inserted between them electrically for the purpose of prolonging any electrical oscillations excited in the system and constituting such a system a radiator of definite frequency or pitch.

"2. In a system of Hertzian-wave telegraphy, the combination, with a pair of capacity areas, of a self-inductance coil inserted between them electrically for the purpose [fol. 25] of prolonging any electrical oscillations excited in the system, thus constituting the system a resonator or absorber of definite frequency or pitch, and a distant radiator of corresponding period capable of acting cumulatively.

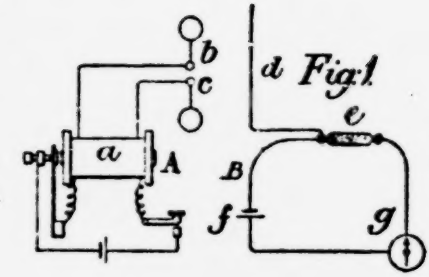


Fig. 1.

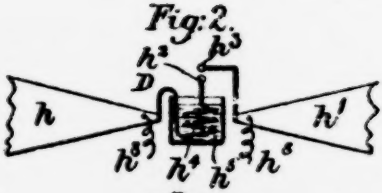


Fig. 2.

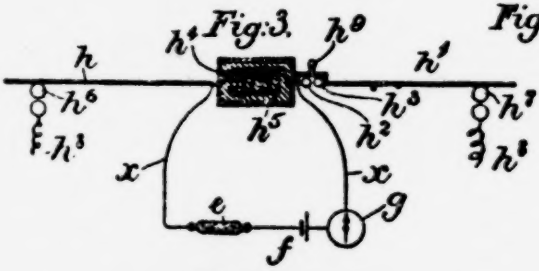


Fig. 3.

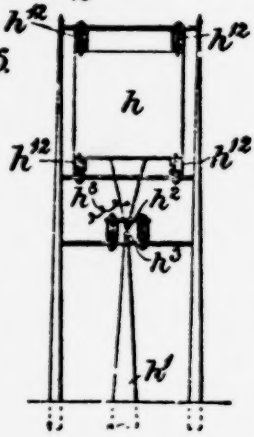


Fig. 6.

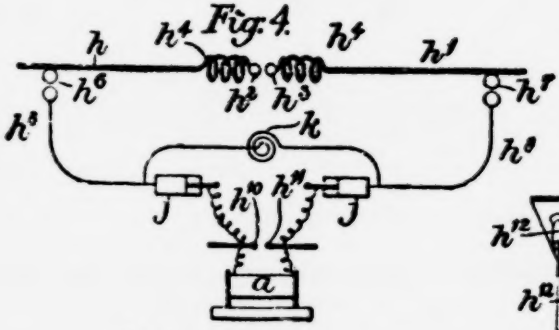


Fig. 4.

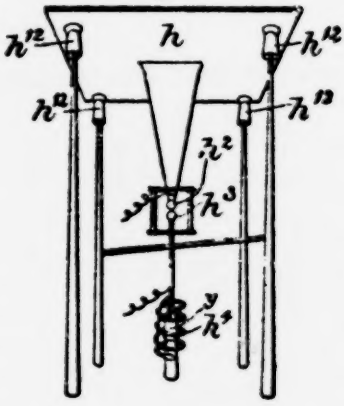


Fig. 7.

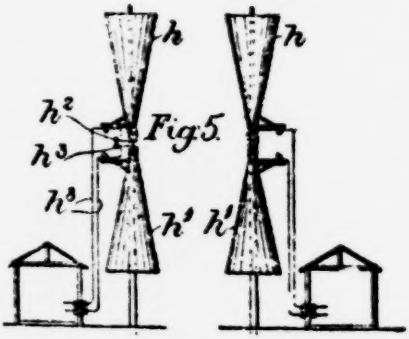
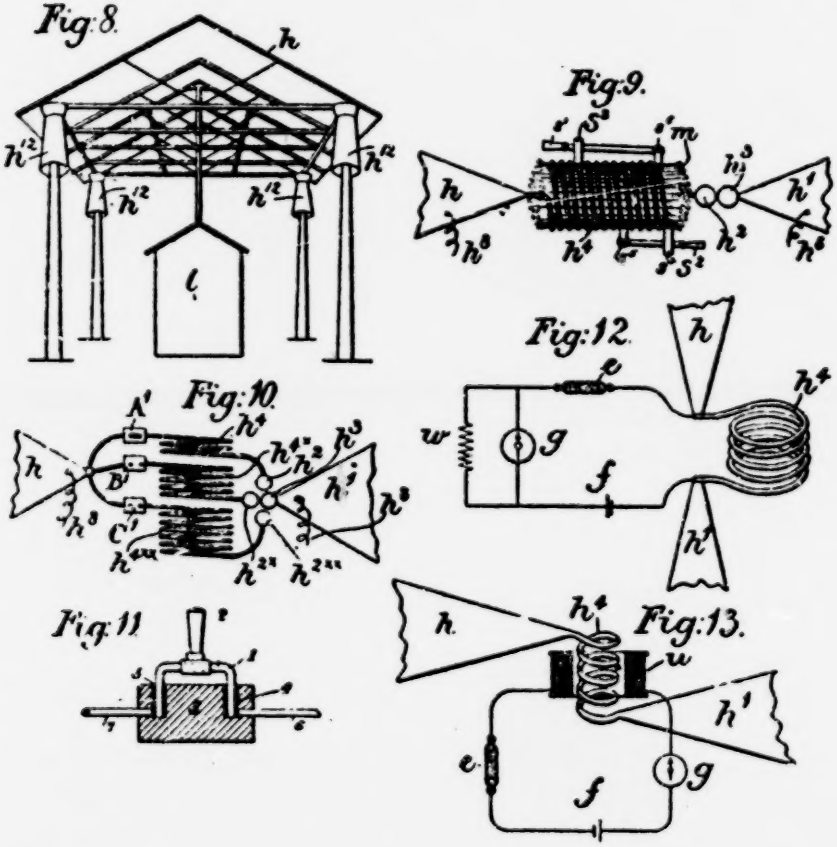


Fig. 5.

"5. In a system of Hertzian-wave telegraphy, the combination, with a pair of capacity areas, of a variably acting self-inductance coil, serving to syntonize such a radiator or resonator to any other such resonator or radiator, whereby signalling may be effected between any two or

[fol. 26] more correspondingly attuned stations without disturbing other differently attuned stations."

XXIX. The pair of capacity areas in fig. 2 includes metal plates h and h^1, and one of these capacity areas may be the earth. The self-inductance coil h^4 is inserted between the capacity areas for the purpose of prolonging any electrical oscillations excited in the system and constituting such a system a radiator of definite frequency or pitch. In other words, the value of the inductance coil between the capacity areas gives the circuit a definite effective period or pitch. Claim 1 is specific to a transmitter or apparatus in which the oscillating circuit constitutes a radiator.



The combination in claim 2 is similar to that in claim 1, except that the system constitutes an absorber or receiving

station of definite frequency and also calls for a distant radiator or sending station of corresponding period.

The combination in claim 5 is more specific by the inclusion of a variably acting self-inductance coil or, in other words, a coil that is adjustable to vary its self-inductance, in a transmitter or receiver in order that the transmitter may be tuned with another station without disturbing operation of substantially differently tuned stations.

[fol. 27] XXX. The earliest date for constructive reduction to practice available to Lodge is February 1, 1898, the filing date in this country. The provisions of the International Convention were not law when this patent was filed and granted.

XXXI. During prosecution in the Patent Office the examiner cited against claim 1 of the Lodge application—

"Marconi # 586193 taken in connection with the well-known state of the art of syntonizing electrical circuits as disclosed, for example, in each of the following references:

"Hutin, et al. # 522564 July 3, 1894.

"Wiedmann's 'Annalen', published in Leipsic, 1891, vol. 44, page 74, • • •.

"The Marconi patent shows it to be old to syntonize a radiator by suitably varying its capacity. The other references show that it is old to syntonize circuits employing either Hertzian waves or other forms of electrical waves by suitably proportioning self-induction to the capacity of the circuits. It does not amount to invention, therefore, to substitute for the means used by Marconi for syntonizing his circuits, another old and well-known method of accomplishing this result as shown by each of the other references. This claim is further rejected upon the disclosure contained in the above-cited article by Bjerknes in Wiedmann's 'Annalen' when taken alone. This reference shows it to be old to transmit Her[t]zian waves by a suitable radiator consisting of capacity areas and a self-induction coil inserted therebetween."

Claims 2 and 5 were also rejected upon references, and reasons cited against claim 1. It reply, Lodge said:

"Marconi does not effectively syntonize at all. He may think he does, but capacity alone will not syntonize. • • • I add self-induction to capacity • • • to prolong the

oscillations * * * and for the first time to render effective syntony possible * * *. Hutin's specification * * * will not work. * * * I know the Bjerknes paper in Wiedmann's 'Annalen', vol. 44. It does not disclose a method of syntonizing electric vibrators."

Subsequently these claims were allowed.

A copy of the file wrapper of the Lodge patent, exhibit 32, is by reference made a part of this finding.

XXXII. The Lodge invention went into wide and almost universal use. It increased the range for signaling with Hertz waves, and increased selectivity.

XXXIII. It was not the universal practice of plaintiff to mark all name plates, and especially its earlier ones, with notice of the Lodge patent because title to this patent was not acquired until 1912.

Actual notice of the Lodge patent and its infringement by the United States was given as stated in finding XII.

XXXIV. The Wireless Specialty Apparatus Company diagram on page 10 has in the transmitting station for Hertzian-wave telegraphy a pair of capacity areas comprising the capacity area of the antenna f and another capacity area constituted by the ground E. A self-inductance coil, which is adjustable to vary its inductance, is located between these areas and such coil in the transmitter is made up of the variable parts g and d^1, the latter of which is the secondary of the transformer $d\,d^1$. This coil enables the oscillating circuit $f\,A\,g\,d^1\,E$ to be a radiator of definite frequency or pitch in [fol. 28] which the oscillations excited in the system are prolonged over what they would be if such inductances were absent. The receiving station has a two-part variable inductance coil $g\,j^1$ in the oscillating circuit $f\,A\,g\,j^1\,E$ constituting the system an absorber of definite frequency or pitch adapted to cooperate with the distant sending station or radiator of corresponding period capable of acting cumulatively. Both the transmitter and receiver have their inductances adjustable whereby signalling may be effected between any two or more correspondingly attuned stations without disturbing other differently attuned stations. This Wireless Specialty Apparatus Company layout embodies the invention of claims 1, 2, and 5 of the Lodge patent in suit

and was used by the United States before the expiration of the patent on August 16, 1915. Other apparatus used by the United States and embodying the invention of these claims includes at least that made by the Foote-Pierson Company, National Electric Supply Company, Telefunken Wireless Tel. Company, Kilbourne & Clark Mfg. Company, and United States Navy type.

XXXV. The prior art publications relied on to show anticipation and lack of invention include:

Transactions of the American Therapeutic Association, November 1894;

An article entitled "D'Arsonval's Modification of Currents of Great Frequency";

Lightning Conductors and Lightning Guards, London, 1892, by Lodge, pp. 351-355;

Popoff article in the Electrician, London, December 10, 897, p. 253;

London Electrician, October 22, 1897, p. 869;

DeTunzelmann article in London Electrician, September 14 to November 16, 1888;

An article by Crookes in Fortnightly Review, 1892, pp. 173-181;

Article by Lodge in London Electrician, June 8 to July 20, 1894;

Pages from the Martin book on Tesla;

London Electrician, pages from June 8 to July 20, 1894.

Copies of these publications, exhibits F-2, G-2, H-2, I-2, A-4, B-4, C-4, E-4, and I-4, are by reference made a part of this finding.

XXXVI. The Popoff article shows an inductance in shunt with the coherer connected on one side to the ground and on the other side to a lightning rod which necessarily possessed capacity to the earth, but such inductance was functionally no more like this invention than was the inductance of the relay in the local battery circuit of Marconi's original patent #586193, and neither was adapted to tune the oscillating circuit as intended by Lodge.

Marconi in his patent #586193 (the original Marconi patent which was reissued as the first patent in suit) contemplated making the plates *k* of such length that the

receiver would be "electrically tuned with the electric oscillations transmitted", but as pointed out by Lodge in his file wrapper argument before the Patent Office, such tuning means would not satisfactorily accomplish its purpose. Marconi in his patent #586193 apparently did not appreciate the desirability of tuning the primary oscillating circuit by the use of an inductance coil, and did not contemplate varying the effective tuning of the receiver to one of several transmitters.

[fol. 29] The American Therapeutic Association publication told how to determine and vary the period of an oscillating circuit by modifying the inductance and capacity.

The patents to Pupin #640516 dated January 2, 1900, filed May 28, 1895; Hutin et al., #838545 dated December 18, 1906, filed May 9, 1894; and Stone #577214, February 16, 1897, filed September 10, 1896, show that the laws of closed resonant circuits in general were known prior to the Lodge invention, but such patents do not show knowledge of the desirability of tuning an open oscillating circuit for Hertzian-wave signalling.

No one prior to Lodge appreciated the desirability of tuning the oscillating circuits of both the transmitter and receiver for the purpose intended and in the manner performed by him.

The laws regarding the relationship of capacity and inductance to achieve the tuning of an alternating current circuit were known prior to Lodge's invention. There has been no satisfactory evidence submitted to show that the elevated wire of a Hertzian-wave transmitter or receiver and the ground connection were known to constitute an electric condenser in the open oscillating circuit prior to the Lodge invention. Lodge appears to have been the first to recognize that the elevated wire and ground connection constituted a condenser and was apparently the first to realize the desirability of applying the known laws of resonance for closed circuits to a Marconi open oscillating circuit.

Exhibits U-2, S-2, and T-3 are by reference made a part of this finding.

XXXVII. The British patent to Oliver Joseph Lodge #11575 was filed May 10, 1897, over seven months before the United States application for the same invention, the patent in suit #609154, was filed. This British applica-

tion was referred to in the oath of and corresponds to the United States application for the patent #609154. This British patent was sealed October 25, 1898, and its complete specification accepted August 10, 1898, and was obtained by the inventor of the United States patent in suit.

A copy of this British patent to Lodge #11575 of May 10, 1897, is embodied in the stipulation of June 1, 1933, and such stipulation is by reference made a part of this finding.

Marconi #763772

XXXVIII. This invention relates to means for providing a stronger transmitted signal in wireless telegraphy and to means for rendering the receiver more selective than had theretofore been the practice. Specifically, the invention comprises a variably tuned antenna circuit inductively coupled through an oscillation transformer to a tuned closed oscillating circuit containing a spark gap. This is best illustrated by figs. 1 and 2 of the patent reproduced on page 19.

In fig. 1 *a* is a battery or other source of current for the primary winding of an induction coil *c*, the circuit closing key *b* being for the purpose of making the dots and dashes of the Morse code. The secondary of the induction coil *c* includes a spark gap as a generator of high frequency oscillations located in a closed circuit containing the winding *d* of an oscillation transformer and a variable condenser *e*. The secondary d^1 of the transformer is in the [fol. 30] antenna circuit and is grounded on one side at *E* and connected on the other side to a variable inductance coil *g* and an elevated plate *f* through the vertical wire *A*.

In fig. 2 a receiving station is illustrated and comprises a tuned antenna circuit $f^1 A g^1 j^1 E$, g^1 being a variable inductance and j^1 the primary of a transformer connected to the earth at *E*. In shunt with the primary winding j^1 is a variable condenser *h*. The secondary j^2 of the transformer is in two parts, each of which is connected to a variable inductance coil g^2 and to the condenser j^3. A detector *T* is connected between the variable inductance coils g^2, and a condenser h^1 is sometimes connected in shunt with the detector. A battery *B* and relay *R* controlling a telegraph instrumer are placed in shunt with the condenser j^3. Choke coils $c^1 c^2$ prevent the high frequency oscillations getting into the battery and relay.

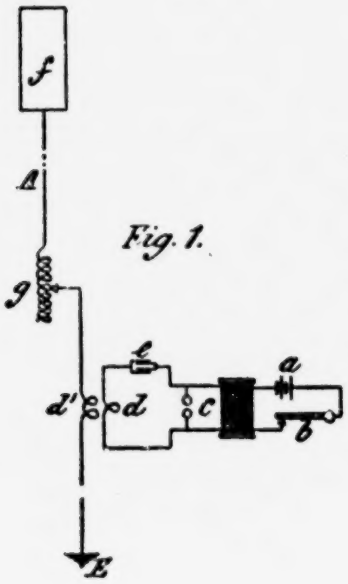


Fig. 1.

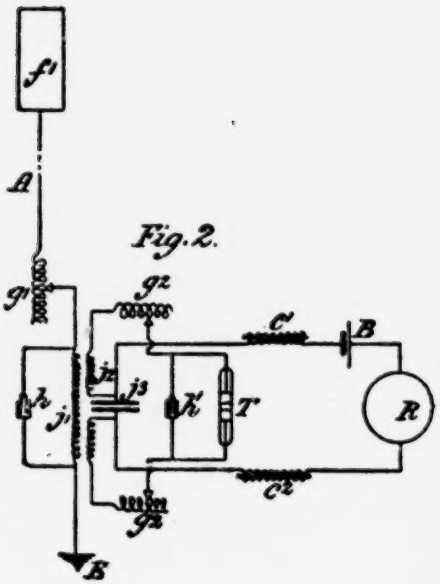


Fig. 2.

Marconi intended each of the transformer circuits at the transmitting and receiving stations to be tuned to the same frequency or time periods or octaves of each other. This was in order to get the most persistent or strongest signals radiated and the most sensitive reception at the receiver. By adjusting the receiving circuits to a detuned condition, the receiver becomes nonresponsive to the transmitted signals.

XXXIX. Marconi specifically describes the construction of the primary and secondary of his oscillation transformers. The best results and sharpest tuning with his apparatus would be present when there was loose coupling between the transformer windings. Tightening the coupling makes the tuning broader and less sharp and does not make either the transmitter or receiver as effective as it would be with loose coupling. This is because with tight coupling neither transformer winding has the same resonant condition that it does when loose or alone.

[fol. 31] XL. The claims in suit may be divided in three classes, the transmitter claims 1, 3, 6, 8, 11, and 12, and receiver claims 2, 13, 14, 16, 17, 18, and 19, and the combined transmitter and receiver claims 10 and 20. These claims read as follows:

"1. At a station employed in a wireless-telegraph system, a signaling instrument comprising an induction coil, the secondary circuit of which includes a condenser discharging through a means which automatically causes oscillations of the desired frequency; an open circuit electrically connected with the oscillation producer aforesaid and a variable inductance included in the open circuit, substantially as and for the purpose described.

"2. At a station employed in a wireless-telegraph system, an oscillation-receiving conductor, a variable inductance connected with said conductor; a wave-responsive device electrically connected with said conductor and in circuit with a condenser, substantially as and for the purpose described.

"3. At a station employed in a wireless-telegraph system, a signaling instrument comprising an induction coil, the secondary circuit of which includes a condenser discharging through a means which automatically causes oscillations of the desired frequency, and the primary circuit of which includes a generator; means for varying the primary circuit; an open circuit electrically connected with the oscillation producer aforesaid, and a variable inductance included in the open circuit, substantially as and for the purpose described.

"6. At a transmitting station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating conductor at one end and capacity at the other end, and whose primary is connected to a condenser circuit discharging through a means which automatically causes oscillations of the desired frequency, and means for adjusting the oscillation period of each of the two circuits connected with the transformer to bring them into accord with each other, substantially as described.

"8. At a transmitting station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating conductor at one end and capacity at the other end, a variable inductance being included in said circuit, and whose primary is connected to a condenser circuit dis-

charging through a means which automatically causes oscillations of the desired frequency, substantially as described.

"10. A system of wireless telegraphy, in which the transmitting station and the receiving station each contains an oscillation transformer, one circuit of which is an open circuit and the other a closed circuit, the two circuits at each station being in electrical resonance with each other and in electrical resonance with the circuits at the other station, substantially as described.

"11. In apparatus for communicating electrical signals, the combination, with an oscillation transformer, at a transmitting station, of an induction coil; an electric circuit containing the secondary of said coil, a condenser and the primary coil of the oscillation transformer; a producer of electric waves of high frequency electrically connected with the secondary of the induction coil; a signaling instrument in circuit with the primary of the induction coil; the secondary coil of the oscillation transformer; electrically connected, [fol. 32] at one end to capacity and, at the other end, to an inductance, and an aerial conductor connected to the inductance, substantially as and for the purpose described.

"12. In apparatus for communicating electrical signals, the combination, with an oscillation transformer, at a transmitting station, of an induction coil; an electric circuit containing the secondary of the said coil, a condenser and the primary coil of the oscillation transformer; a producer of electric waves of high frequency connected with the secondary of the induction coil; a signaling instrument in circuit with the primary of the induction coil; the secondary coil of the oscillation transformer electrically connected, at one end, to capacity and, at the other end, to a variable inductance, and an aerial conductor connected to the variable inductance, substantially as and for the purpose described.

"13. At a receiving station employed in a wireless-telegraph system, the combination of an oscillation transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a variable inductance being included in said circuit, a wave-responsive device electrically connected with the other winding of the oscillation

transformer, and a condenser in circuit with the wave-responsive device, substantially as described.

"14. At a receiving station employed in a wireless-telegraph system, the combination of an oscillation transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a wave-responsive device electrically connected with the other winding of the oscillation transformer, and means for adjusting the two transformer circuits in electrical resonance with each other, substantially as described.

"16. At a receiving station employed in a wireless-telegraph system, the combination of an oscillation transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, an adjustable condenser in a shunt connected with the open circuit and around said transformer coil, a wave-responsive device electrically connected with the other coil of the oscillation transformer, and means for adjusting the two transformer circuits in electrical resonance with each other, substantially as described.

"17. At a receiving station employed in a wireless-telegraph system, the combination of an oscillation transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a wave-responsive device electrically connected with the other winding of the oscillation transformer, and means included in each of said transformer circuits, for adjusting said circuits in electrical resonance with each other, substantially as described.

"18. At a receiving station employed in a wireless-telegraph system, the combination of an oscillation transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end, and capacity at the other end, a variable inductance being included in said open circuit, a wave-responsive device electrically connected with the other winding of the oscillation transformer, and a variable inductance included in cir-

cuit with the wave-responsive device, substantially as described.

[fol. 33] "19. In a system of wireless telegraphy, the combination at a receiving station, of an oscillation transformer; an open circuit comprising, in part, an aerial conductor connected with one end of the primary coil of the oscillation transformer; a connection from the other end of said coil to capacity; a variable inductance in said open circuit; and electrical connections from the secondary coil of the oscillation transformer to a receiving instrument, battery, condenser, wave-responsive device and a variable inductance, substantially as and for the purpose described.

"20. In a system of wireless telegraphy, a transmitting station containing an oscillation transformer, the primary of which is connected to a condenser circuit discharging through a spark gap which automatically causes electric waves of the desired frequency, the secondary of said transformer connected to an open circuit including a radiating conductor, and with a capacity and a coil for charging the condenser aforesaid; a receiving station containing an oscillation transformer, the primary of which is connected with an oscillation-receiving conductor and with a capacity, a wave-responsive device connected with the secondary of said transformer, and a receiving instrument connected with the wave-responsive device, all in combination with means for bringing the four transformer circuits, two at each station, into electrical resonance with each other, substantially as described."

Referring to claim 1, in fig. 1 there is shown a station employed in a wireless-telegraph system and a signaling instrument *abc* which comprises an induction coil *c*, the secondary of which includes a condenser formed by the spark gap. This gap discharges through a variable condenser means *e* which with the inductance *d* automatically causes oscillations of the desired frequency. The open antenna circuit *fAgd'E* is electrically connected with the spark-gap oscillation producer and contains a variable inductance *g* in this open circuit substantially as and for the purpose described. Claim 6 calls for a capacity connected at one end of the open radiating circuit and thus refers to the earth connection as a capacity, which might more properly be designated as a capacity area, as was done in

the Lodge patent in suit, since the earth constitutes one plate of a condenser instead of a capacity or condenser itself. Thus the same remarks concerning a capacity connected at one end of the open radiating circuit apply to claims 8 and 11 to 20, inclusive. Claim 6 includes the variable inductance *g* and the variable capacity *e*, each of which constitutes means for adjusting the oscillation period of its circuit to bring the two circuits into accord with each other. Claims 8 and 12 are limited to a variable inductance in the antenna circuit, while claim 11 calls for an inductance in addition to the transformer winding in the antenna circuit.

Referring to claim 2, fig. 2, the wave-responsive device or detector *T* is electrically connected with the antenna through the transformer $j'j^2$ and the detector *T* is in circuit with a condenser j^3. There is a variable inductance g' in the open circuit.

XLI. The earliest date proven for this invention is November 10, 1900, the filing date in this country for constructive reduction to practice. The provisions of the International Convention were not in force when the Marconi patent #763772 was filed.

XLII. During prosecution in the Patent Office the examiner cited the following art against the Marconi application:

[fol. 34] British patent to Lodge #29505, of 1897;
Marconi #586193;
Pupin #640515;
A work of Hertz, by Lodge, pp. 7-8, The Electrician Co., London, 1894;
British patent to Marconi #7777, of 1900, corresponding to this application;
British patent to Thompson #22020, of 1899;
British patent to Braun #5104, of 1899;
British patent to Braun #1862, of 1899;
British patent to Braun #1863, of 1899;
British patent to Brown #14449, of 1899;
British patent to Wilson, et al. #10153, of 1899;
Lodge #609154;
Marconi #627650;
Marconi #647007;
Marconi #647008;

Marconi #647009;
Marconi #668315;
Tesla #649621;
Tesla #645576;
Ascoli in L'Elettricista, Rome, August 1897;
Slaby in Electrician, London, April 25 and May 2, 1902;
Fessenden, Proceedings of American Institute of Electrical Engineers, December 1899;
Fessenden #706735;
Fessenden #706736;
Stone #714756;
Stone #714831;
L'Industrie Electrique, Paris, June 25, 1898, p. 363;
L'Electrician, Paris, October 8, 1898, pp. 235-237;
Books by Ducretat, October 1898;
Book by Graffigny;
Book by Breton.

Exhibits 34, 119, X-2, Z-2, P-3, Q-3, B-6, C-6, D-6, E-6, F-6, and L-6 are by reference made a part of this finding.

XLIII. During the prosecution in the Patent Office of the Marconi application which materialized into the patent in suit, #763772, the examiner of the Patent Office, on June 3, 1902, rejected all claims but fifteen on Tesla, #649621, stating as follows with respect to this rejection:

"All the other claims are rejected on Tesla, 649621, May 15, 1900, division of 645576, Mch. 20, 1900, filed Sep. 2, 1897. On page 3, lines 113 to 125, the details of device G are given. This is an electrical oscillator comprising an alternating current generator charging a condenser and an interrupter, which is a spark gap, for discharging the same. The primary of a transformer is fed by this oscillation producing circuit. The secondary is connected to the ground at one end and to an elevated conductor at the other. The periods of the primary and secondary circuits are in accord with each other.

"Claims 4, 13, 14, and 16, which specify a variable inductance and means for adjusting the inductance, are not patentable over Tesla because Lodge, of record, has shown that it is old to adjust the period of a circuit by a variable [fol. 35] inductance; and claims 3 and 5, which specify an adjustable condenser, are not patentable over Tesla because applicant has shown in his prior patent No. 627650 that

this adjustment may be produced by a variable condenser. Since it is impossible to exactly calculate the values of the electromagnetic constants of two circuits for the purpose of making their time periods agree, it is fair to assume that the electrical oscillator of Tesla must necessarily be made with an adjustable inductance or condenser, or both."

Nearly two years later the case was resubmitted to a new examiner who on March 31, 1904, stated:

"The claims are all allowed except claims 4, 5, 6, and 7, which are rejected on the patent to Stone, #714756, December 2, 1902, application filed February 8, 1900.

"Stone shows in fig. 5 a transformer M whose secondary I_2 is connected to an open circuit including a radiating conductor V at one end and a capacity E at the other and whose primary I_1 is connected to a condenser circuit discharging through a spark gap, viz, the circuit CsI_1L. These circuits are in 'electrical resonance with each other', see lines 16-20, page 2. It is not stated how the elevated conductor is given a natural period equal to that of the oscillations impressed upon it but it is well known by all skilled in this art that this may be accomplished by adjusting the length of the elevated conductor, thereby adjusting the distributed capacity and the distributed inductance of the same until the natural period of such conductor is equal to the natural period of the condenser circuit CsI_1L. When this is done 'the frequency impressed upon the elevated conductor' is 'the same as the natural period or fundamental of such conductor', to quote from the Stone patent.

"Applicant discloses another means whereby the same result may be effected, viz, by including a 'variable inductance' in the elevated conductor. All claims which include this element are considered allowable over the Stone patent.

"In regard to claim 7 it may be said that Stone states that the operator at each station may at will adjust his apparatus in such a way as to place himself in communication with any other station (page 4, lines 28-36) and that he also states that this result may be effected by making the coil L of the condenser circuit adjustable (page 6, lines 76-81). Inasmuch as the period of an oscillating circuit depends upon the capacity of the condenser in the same way that it depends upon the inductance of the coil, it is held that it is not patentable to make the condenser e of applicant's oscillat-

ing circuit adjustable for the same purpose as Stone makes the coil *L* of his oscillating circuit adjustable.

"Claims 4, 5, 6, and 7 will be allowed if amended by inserting the words *a variable inductance and* after the word 'including' in line 3 of each claim."

The fig. 5 which is referred to in the statement of the examiner set out above is shown in the diagram illustrating the Stone patent which appears in finding LIII.

In response to this action by the examiner, Marconi canceled claims 4, 5, and 7 then in his application and substituted others in place thereof and amended claim 6 to specify that the "means for adjusting the oscillation period of the two circuits connected with the transformer" was for each of these two circuits. In the remarks in the last amendment of June 1, 1904, Marconi said:

[fol. 36] "The claims now presented all include an elevated conductor, or a circuit which is a good radiator of electric waves or oscillations, and means for adjusting the tune of such elevated conductor or radiating circuit. It is believed that the examiner recognizes the fact that the Stone patent does not show such an arrangement, and an early allowance is requested."

Exhibit X-5, a certified copy of the file wrapper of Marconi patent #763772, is by reference made a part of this finding.

XLIV. The invention of patent #763772 went into wide use in the United States and elsewhere. Apparatus embodying the invention of #763772 was employed in the first transatlantic radio signalling.

XLV. Some but not all name plates carried by apparatus manufactured by plaintiff were marked with notice of the Marconi patent #763772. The name plate of exhibit 14 was not so marked.

Defendant was notified of the alleged infringement of patent #763772, as stated in finding XII.

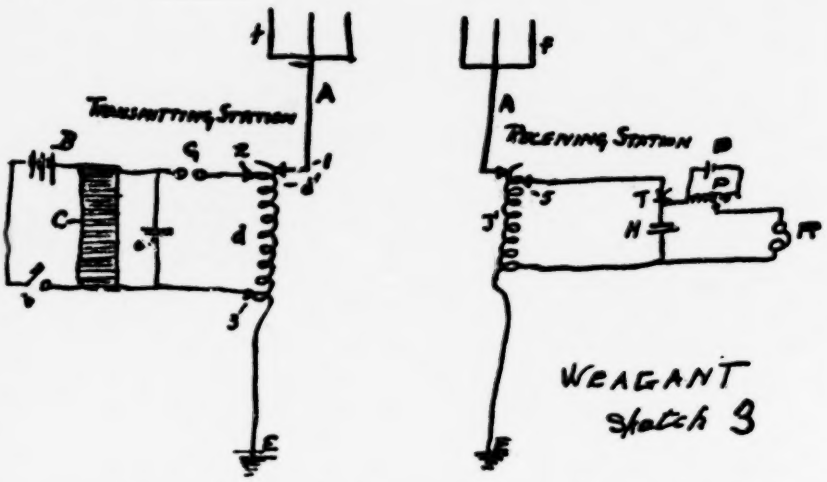
XLVI. The alleged infringing transmitting apparatus may be divided into three groups:

(*a*) The plain open gap apparatus;

(*b*) That having a rotary gap; and

(*c*) The larger group using a quenched gap.

A plain open gap apparatus used by the United States between 1910 and 1919 was made by the Foote-Pierson Company and is shown by exhibit 251, reproduced here:



An autotransformer having only one winding is electromagnetically the equivalent of a transformer having two separate windings. This apparatus has an induction coil C, the secondary circuit of which includes a condenser G discharging through a capacity e^1, and an inductance d which automatically cause oscillations of the desired frequency. An open circuit Ad^1E is electrically connected with the oscillation producer G. The secondary of the transformer constitutes a variable inductance d^1 included in the open circuit. This variable inductance is not in addition to the transformer winding or other electrical connection between the oscillation producer and the open circuit. The primary oscillating circuit Gde^1 may be varied or tuned at least to some extent by adjustment of the inductance d by [fol. 37] varying the position of the taps 2 and 3. In a similar manner the open circuit may be tuned, at least to some extent, by adjustment of its transformer tap. Coupled circuits are tuned at least to some extent when the currents flowing herein are greater than they would be with less tuning. There is no means in addition to the transformer for adjusting the oscillation period of each of the two circuits. The secondary circuit of the transmitter is connected to an open circuit including a radiating conductor fA at one end and a capacity area E at the other end.

The receiver of this Foote-Pierson pack, subject of exhibit 251, comprises an oscillation-receiving conductor fA

and a variable inductance constituted by the primary of the autotransformer connected with said conductor and with a capacity area *E*. There is a wave-responsive device *T* electrically connected with said conductor and in circuit with a condenser *H*. Here again the variable inductance of both transformer primary and secondary circuits is a part of, and not in addition to, the transformer. There is no condenser in the open circuit other than that formed by the antenna and the earth. At least some tuning of both the open and closed oscillating circuits to each other and to the period of the transmitter is possible.

All of the alleged infringing transmitters of the open-gap type possess an oscillation transformer, one circuit of which is a closed circuit containing a condenser and a spark producer in the form of a plain open gap. The other circuit of the oscillation transformer was connected to an open antenna radiating circuit; both of said circuits have inductance and capacity and are electromagnetically coupled and are capable of adjustment so that the two circuits, i. e., the open and the closed circuit, are in tune or electrical resonance with each other.

XLVII. The Marconi specification states, on page 2, as follows:

"My experiments have demonstrated that the best results are obtained at the transmitting station when I use a persistent oscillator, an electrical circuit of such a character that, if electromotive force is suddenly applied to it and the current then cut off, electrical oscillations are set up in the circuit which persist or are maintained for a long time, in the primary circuit, and use a good radiator, i. e., an electrical circuit which very quickly imparts the energy of electrical oscillations to the surrounding ether in the form of waves, in the secondary circuit."

The specification does not make it definite whether the "electrical circuit of such a character" as described above, relates to the functioning of the closed circuit when contemplated by itself or in combination with an open circuit. The persistence of the oscillations in a closed circuit is largely dependent upon the type of spark gap utilized therein.

The Marconi patent, on page 1, lines 82 to 88, indicates that the inventor does not limit himself to any specific type of spark producer or oscillation producer.

The claims in suit of Marconi patent #763772 in no way limit the patent monopoly expressed in them to any specific spark producer or to a closed circuit possessing elements which would cause it to function as a persistent oscillator when coupled to the open circuit.

XLVIII. The quenched spark gap is a spark producer made up of a series of metal disks separated by insulated washers. It functions to permit all of the energy of the closed oscillating circuit to be transferred to the open cir- [fol. 38] cuit in a comparatively few oscillations after which the spark is quenched and activity in the closed circuit having ceased, the open circuit continues to oscillate at its own frequency.

Defendant instructed its personnel in manuals distributed both by the United States Navy and the Signal Corps of the United States Army, that the closed transmitting circuit should be tuned in resonance with the open circuit in transmitting apparatus using the quenched gap. A Signal Corps pamphlet of 1916, plaintiff's exhibit 92, page 110, states that, "Tuning of the closed and open circuits to resonance and the determination of the correct coupling between them are the two most important adjustments in a quenched spark transmitter."

The oscillation transformers and their associated open and closed circuits utilized in connection with the quenched spark gap, are substantially similar in form and function to those utilized in connection with the plain open gap apparatus with the exception that a closer coupling can be achieved between the open and closed circuits.

Because the quenched gap was more efficient than the plain open gap, it began widely displacing the plain open gap about 1910, although some plain open-gap apparatus was retained and some was ordered and used during the war.

An example of a quenched-gap transmitter used by the United States between 1910 and 1919 is illustrated in exhibit 87, reproduced on page 10. The transmitter of exhibit 87 comprises an induction coil *c*, the secondary of which includes a condenser *G* discharging through a means comprising a condenser *e* and inductance *d* which automatically cause oscillations of the desired frequency. There is also an open circuit $fAgd^1E$ electrically connected with the oscillation producer and a variable inductance gd^1 included in the open circuit. The inductance in the open and closed

oscillating circuits constitutes a means for adjusting the oscillation period of each of the two circuits to bring them into at least substantial accord with each other. There are other makes of quenched-gap transmitters to which these remarks apply and which were used by the United States between 1910 and 1919.

The quenched-gap transmitters purchased by the United States and equipped with wave changers and wave-selecting switches are of the same general type, so far as this Marconi patent is concerned, as the apparatus of exhibit 87.

The wave-changing switches constituted a quick and convenient means for varying tuning conditions of the oscillating circuits. Such switches were used with both the quenched-gap and rotary-gap apparatus.

The receiver of exhibit 87 shown on page 10 was adapted to be used with a transmitter of any type. The receiver illustrated in exhibit 87 comprised an oscillation-receiving conductor *f A* and a variable inductance gj^1 connected with said conductor. There was a wave-responsive device *T* electrically connected with said conductor and in circuit with a condenser j^2h. In this apparatus the variable inductance *g* is in addition to the transformer in both the transmitter and receiver. There is no condenser across the primary j^1 of the receiving transformer. Other similar makes of receiving apparatus were used by the United States between 1910 and 1919.

Some of the receiving sets used by the United States between 1910 and 1919 did have such a condenser in shunt with [fol. 39] the primary of the transformer as is shown, for example, by the Kilbourne & Clark receiver of exhibit 95 and by the Telefunken receiver of exhibit 79.

Exhibits 79 and 95 are by reference made a part of this finding.

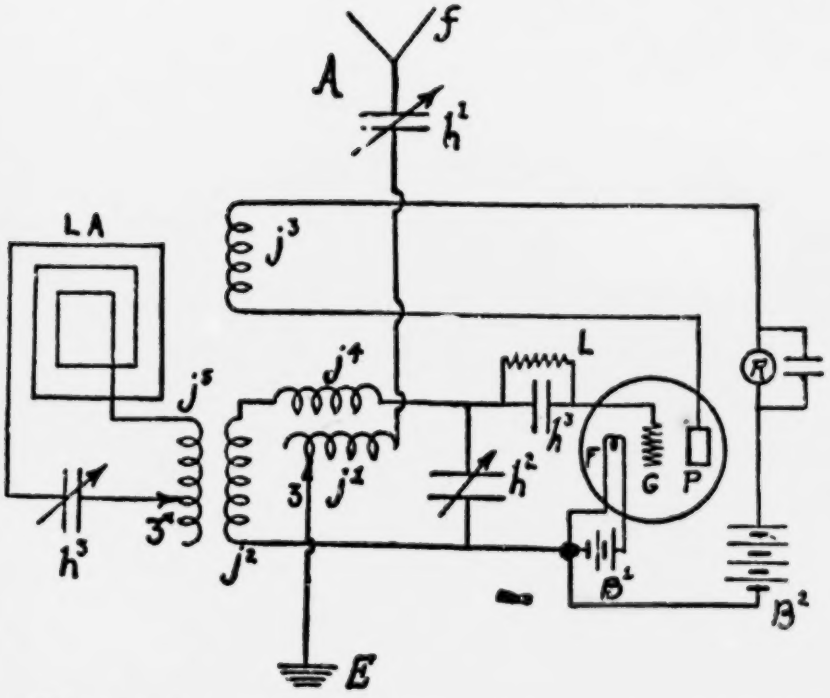
XLIX. A rotary spark gap of either the synchronous or non-synchronous type differ from the fixed or plain spark gap in that a plurality of spark electrodes are located on the periphery of a disk in such manner that when the disk is rotated they alternately approach and recede from a fixed spark electrode. Such functioning of the spark gap possesses the dual effect of cooling the spark electrode and effecting a lengthening of the spark and its quenching as the moving electrodes recede from the fixed electrode.

Such operation causes the primary circuit oscillations to tend to cease and the operation, therefore, approximates that of the quenched gap. The circuits and apparatus util-

ized by the rotary gap apparatus in the Government installation, with the exception of the spark producer or gap, are identical with those used with the plain gap, and the same condition of resonance between the open and closed circuits exists.

L. A direction finder used by the United States between 1910 and 1919 is shown by exhibit 115, here reproduced:

Direction Finder



This exhibit comprises an open oscillating circuit $fAh'j'E$ containing a variable inductance j^1 constituted by the transformer primary winding, but such is not in addition to such [fol. 40] transformer winding. The open circuit was electrically connected with a wave-responsive device (a 3-electrode tube) in circuit with a condenser. There was no condenser across the primary of the oscillation transformer.

LI. The art relied on to show anticipation and lack of invention includes:

Marconi #586193 (original to reissue patent in suit);
Lodge #609154 (patent in suit);

Marconi #627650, dated June 27, 1899, filed January 5, 1899;

Marconi #647007, April 10, 1900, filed June 13, 1899;

Marconi #647008, April 10, 1900, filed June 13, 1899;

Marconi #647009, April 10, 1900, filed June 13, 1899;

British patent to Braun, #1862, of 1899;

British patent to Braun, #12420, of 1899;

Stone #577214, February 16, 1897;

Stone #638152;

Stone #714756, December 2, 1902, filed February 8, 1900;

Stone #714831, December 2, 1902, filed February 8, 1900;

The letters from Stone to Baker of June 30, 1899, and July 18, 1899;

Tesla #645576, March 20, 1900, filed September 2, 1897;

Pupin #519347, May 8, 1894;

Pupin #640516, January 2, 1900;

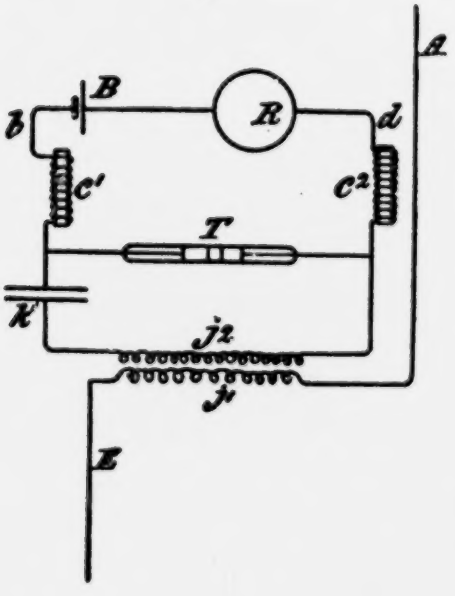
Tesla #649621, May 15, 1900, filed February 19, 1900;

British patent to Tesla #20981, of 1896.

Exhibits T-2, U-2, X-2, Y-2, Z-2, A-3, E-3, F-3, G-3, P-3, Q-3, T-3, U-3, B-6, C-6, D-6, E-6, L-6 are by reference made a part of this finding.

LII. Marconi #627650, fig. 1 of which is here reproduced, shows a receiver comprising an open circuit Aj^1E inductively coupled through an induction coil or transformer to the closed oscillating circuit $j^2k^1\ T$ in which is located the

Fig. 1.



[fol. 41] condenser k^1 and the coherer or wave-responsive device T. This patent states in lines 31-34 of page 1:

"It is desirable that the induction coil should be in tune or syntony with the electrical oscillation transmitted."

It was not known to Marconi at the time this patent was filed that it was desirable to have the closed oscillating circuit in tune with the open oscillating circuit. The statement quoted meant, to one skilled in the art at the time this patent was filed, that the primary or open circuit should be in tune with the transmitter according to the teaching of Lodge in his patent in suit. No means was shown for tuning the open circuit of this Marconi patent and it was not necessary to show any such means since the art after the Lodge patent in suit knew how to adjust a variable inductance coil in the open circuit to obtain the tuning desired, as well as by older and more tedious tuning operation of adjusting the length of the vertical wire. Such a variable inductance in the primary or open circuit would be implied by one skilled in the art at that time. After the disclosure of this patent #627650 it required no invention to have an oscillation-receiving conductor A connected to a variable inductance with a wave-responsive device T electrically connected with said conductor through the transformer $j^1 j^2$, and with a condenser k^1 in circuit with the detector.

Claim 2 of Marconi #763772 not being limited to the primary and secondary circuits being in tune, is directed to an arrangement contemplated by Marconi's earlier patent #627650.

Lines 38–42 of page 1 of patent #627650 state:

"The capacity of the condenser on the connection between the imperfect contact and the secondary of the coil should be varied (in order to obtain the best effects) if the length of the wave is varied." Do to the rather high resistance of the coherer T no sharp tuning would be possible on adjusting the capacity k^1. However, no satisfactory evidence has been submitted to show how else the "best effects" referred to could be obtained other than as the result of some tuning.

These quotations are not sufficiently clear to one skilled in the art at that time to point out the desirability of tuning both circuits to the same period.

LIII. The Stone patent #714756 was filed February 8, 1900, about two and a half months before the British patent to Marconi, #7777, of 1900, was filed.

Fig. 5.

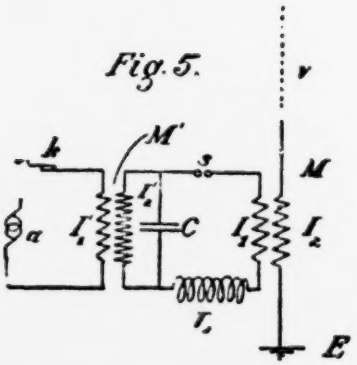


Fig. 6.

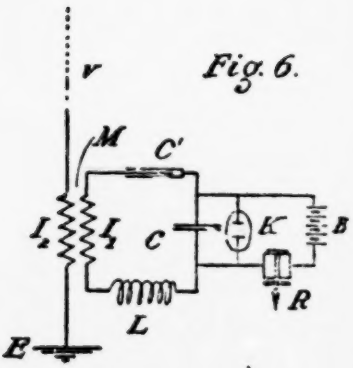


Fig. 7.

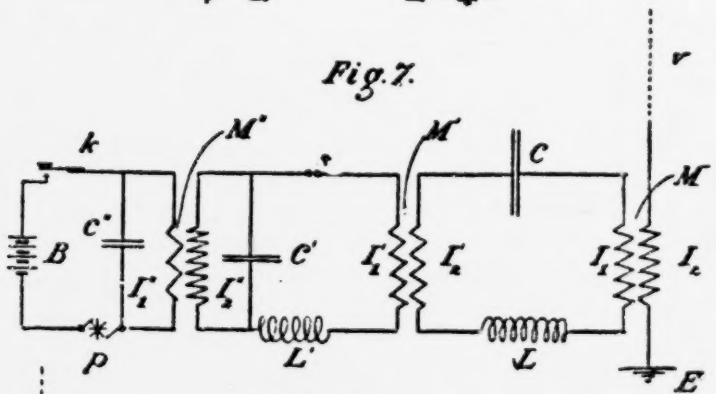
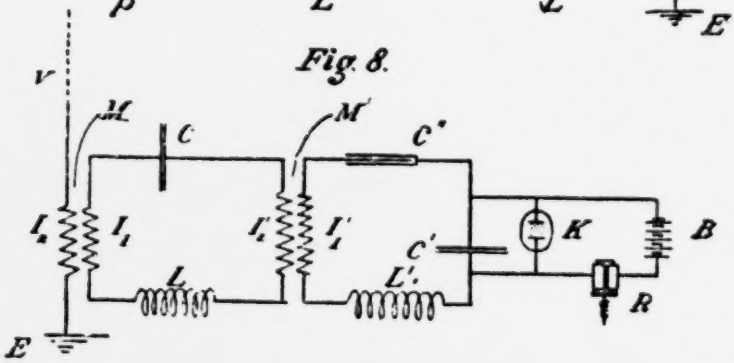


Fig. 8.



In fig. 5, reproduced on page 31 of this finding, is shown a transmitter having a telegraph key *k* in the primary of an induction coil M^1. In the secondary of this induction coil is a spark gap *s* which generates high-frequency oscillations through the closed circuit $sCLI_1$. This circuit is electrically connected through an oscillation transformer *M* with an open or antenna oscillating circuit v I_2E. The receiver is shown by fig. 6 to comprise an open oscillating circuit v I_2E inductively coupled through the transformer *M* with a closed oscillating circuit I_1C^1CL. A coherer or wave-responsive device *K* is connected across the condenser *C*. Figs. 7 and 8 are similar to figs 5 and 6 except that another closed oscillating circuit is placed between the open circuit

and the closed oscillating circuits of figs. 5 and 6 for the purpose of screening out other than the desired frequencies [fol. 42] to get sharper tuning. In figs. 13–15, reproduced on page 32 of this finding, are shown other embodiments of Stone's invention using more than one closed circuit coupled to one open circuit.

Stone was "a man possessed of unusual theoretical knowledge relative to the behavior of circuits, understanding fully the means necessary to tune an electrical circuit." Lines 16-29 of page 2 of the Stone patent state:

"Thus the frequency impressed upon the elevated conductor may or may not be the same as the natural period or fundamental of said conductor."

To one skilled in the art this meant the period or frequency of the closed circuit oscillations may or may not be the same as the natural period of the open circuit. When it is the same both circuits are in tune.

[fol. 43] Another pertinent portion of the Stone patent specification is found in lines 62-66 of page 6 which read as follows:

"The vertical wire may with advantage be so constructed as to be highly resonant to a particular frequency, and the harmonic vibrations impressed thereon may with advantage be of that frequency."

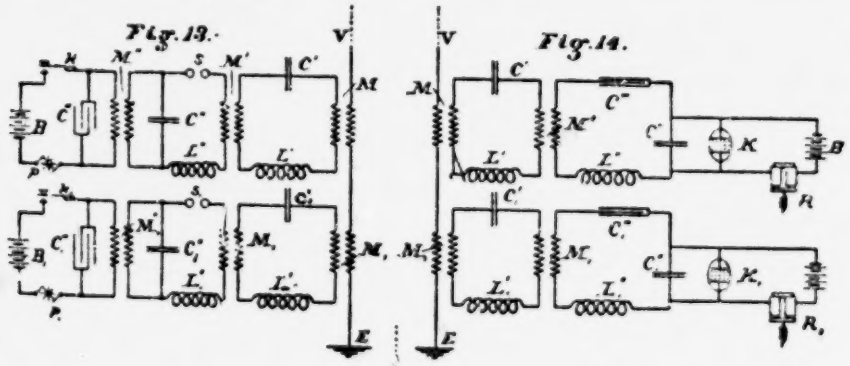
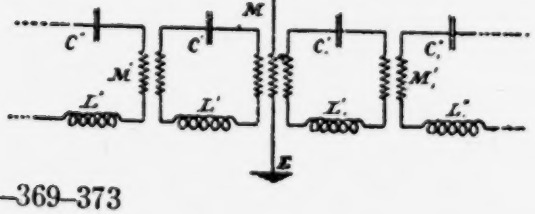


Fig. 15.



To one skilled in the art this meant that certain advantages were known to exist in having the open circuit of figs. 5 and 6 of the patent, for example, highly resonant or exactly in tune with the oscillations impressed upon it. On page 4 of the Stone patent specification lines 17-36 and 47-56 read as follows:

"When the apparatus at a particular station is attuned to the same periodicity as that of the electromagnetic waves emanating from a particular transmitting station, then this receiving station will respond to and be capable of selectively receiving messages from that particular transmitting station to the exclusion of messages simultaneously or otherwise sent from other transmitting stations in the neighborhood which generate electromagnetic waves of different periodicities. Moreover, by my invention the operator at the transmitting or receiving station may, at will, adjust the apparatus at his command in such a way as to place himself in communication with any one of a number of stations in the neighborhood by bringing his apparatus into resonance with the periodicity employed by the station with which intercommunication is desired.

• • • • • • •

"In order that the electric translating apparatus at the receiving station shall be operated only by electric waves of a single frequency and by no others, I interpose between the vertical conductor at the receiving station and the translating devices a resonant circuit or circuits attuned to the particular frequency of the electro-magnetic waves which [fol. 44] it is desired to have operate the translating devices."

Stone used circuit connections at his receiver to correspond with those at the transmitter, and his receiver and transmitter each had an open circuit inductively coupled to a closed circuit which was tuned to the frequency of the transmitted signal. From the suggestion to tune the open transmitter circuit it was obvious to one skilled in the art that the receiver open circuit should also be tuned. The closed oscillating circuits of both figs. 5 and 6 of the Stone patent are stated to be in tune with each other. To one skilled in the art, Stone's patent contemplated having all four oscillating circuits in tune or accord with each other.

The Stone patent drawing shows none of the condensers or inductances in any of these oscillating circuits to be adjustable, yet one skilled in the art at the time knew how to adjust any or all of them to obtain the desired resonance in the open and closed circuits. The Stone drawing did not show the open circuits provided with a tuning coil because it sometimes represented an embodiment in which the open circuit was adapted to receive simultaneously several frequencies and it could not be tuned to each.

LIV. The quotations from lines 16-20 of page 2 and lines 62-66 of page 6 of the Stone specification were inserted by the amendment of April 8, 1902, after the application was filed in the Patent Office.

As filed in the Patent Office, the invention of the Stone application was directed to obtaining a simple wave instead of a complex one in the transmitted signal. It was Stone's belief that the early apparatus for Hertzian-wave signalling gave complex waves where the oscillations were generated in the open circuit. To avoid this difficulty Stone generated his oscillations in a tuned closed circuit inductively coupled to the open circuit. Other precautions taken by Stone included the avoidance of substantial hysteresis losses and the use of an inductance in a circuit which was large compared to the mutual inductance between coupled circuits, for the purpose of obtaining simpler waves and lessening the mutual inductive effect upon tuning. Marconi's specification is silent upon the mutual inductive effects of the coupled circuits upon tuning, and it is not apparent that Marconi appreciated the necessity for loose coupling to get the best operation. Stone did appreciate the disadvantage of mutual inductive effects of the coupled circuits upon their tuning and suggested the large additional inductance to reduce this effect. Many of the apparatuses used by the United States contained this additional inductance in the open circuit. Both Stone and Marconi obtained free oscillations at the transmitter in a tuned closed circuit. By free oscillations is meant that their frequency was determined by the constants of the circuit in which they were generated. The Stone application as filed impressed these oscillations upon the open circuit, and therefore used "forced" oscillations in the open circuit of the transmitter, that is, the frequency of the oscillations in the open circuit was deter-

mined by the frequency of the oscillations in the closed circuit.

The effect of forcing vibrations upon a tuned and untuned circuit may be likened unto the effect of a tuning fork upon a stretched cord in a viscous medium. When the cord is vibrated by the tuning fork it has the same period as does the fork regardless of whether such period be that of [fol. 45] the natural period of the cord, but when the fork vibrations are in tune with the natural period or fundamental of the cord, then the amplitude of vibrations in the cord is a maximum. Marconi wanted his open and closed circuits to be tuned to the period of the impressed or forced oscillations, whereas Stone's application as filed was primarily concerned with having the closed circuits in tune at both stations. The advantage in having open and closed transformer circuits in tune at both transmitting and receiving stations not used for radio signalling was known to those skilled in the art before Stone filed as is shown by Tesla #645576 and such advantage for radio signalling was known to Stone as is shown by his letters to Baker referred to in finding LV.

The British patent of Marconi #7777, of 1900, corresponding to the patent in suit had the provisional specification filed April 26, 1900, the complete specification filed February 25, 1901, the complete specification accepted April 13, 1901, the complete specification and drawing printed and placed on sale May 4, 1901, and the patent granted June 25, 1901. No satisfactory evidence of knowledge or conception of the Marconi invention in Europe prior to the filing of the British patent #7777 of 1900, has been shown.

Exhibit R-3, a certified copy of the file wrapper of the Stone patent #714756, and exhibit 34, the British patent #7777 of 1900, are by reference made a part of this finding.

LV. Stone conceived the idea of having all four oscillating circuits of his figs. 5 and 6 tuned to the same frequency, at least as early as June 30, 1899. The letter from Stone to Baker, dated June 30, 1899, disclosed the wiring diagrams, reproduced on page 35, the top two figures of which are substantially the same as figs. 5 and 6 of the patent.

This letter stated:

"Instead of utilizing the vertical wire itself at the transmitting station as the oscillator, I propose to impress upon this vertical wire oscillations from an oscillator, which oscil-

lations shall be of a *frequency corresponding to the fundamental of the wire*. Similarly at the receiving station I shall draw from the vertical wire only that component of the complex wave which is of the lowest frequency.

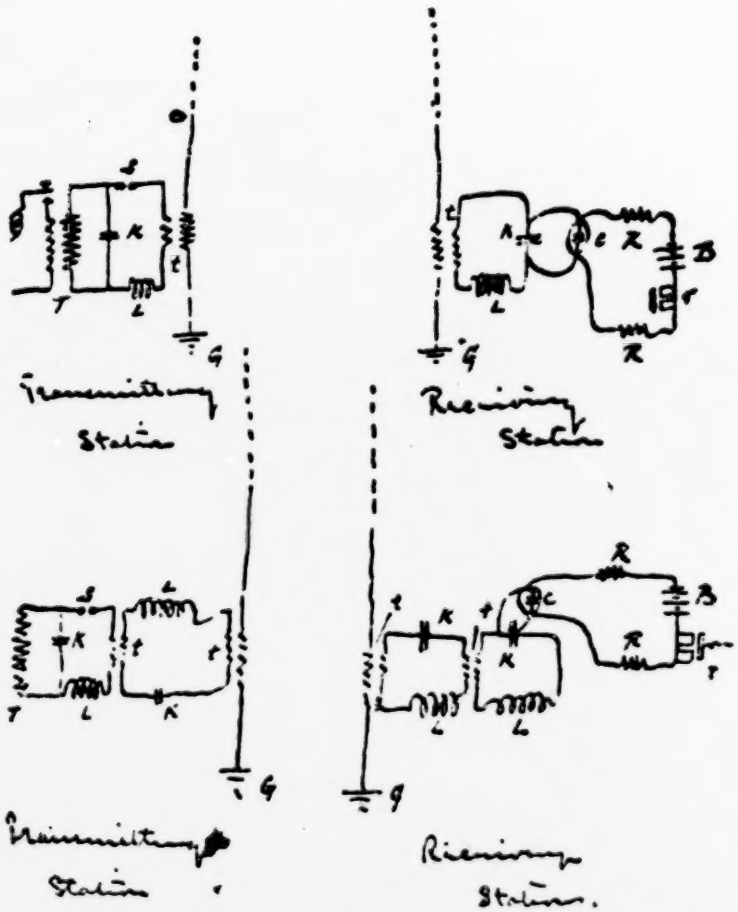
"*If now the fundamental of the wire at the receiving station be the same as that of the wire at the transmitting station*, then the receiving station may receive signals from the transmitting station, but if it be different from that of the transmitting station it may not receive these signals. * * * *The tuning of these circuits one to another and all to the same frequency* will probably be best accomplished empirically, though the best general proportions may be determined mathematically." (Italics ours.)

The Stone letter to Baker of July 18, 1899, in reference to his invention mentioned in the letter dated June 30, 1899, states:

"The current in the vertical wire in my system may therefore be represented by a simple harmonic * * * and if the *period of this impressed force be the same as that of the fundamental of the vertical wire*, then it may be represented by * * *.

"I place the coherer at the receiving station in a resonant circuit tuned to the periodicity p. Under these circumstances the coherer will be operated by the signals sent from [fol. 46] the sending station described, but if a second sending station develops radiations of periodicity p_1, materially different from p, then the receiving apparatus will not be affected by these radiations, since the circuit in which the coherer is located is practically opaque to these radiations or more properly speaking, to the current which these radiations are capable of exciting.

"The first transmitting circuit shown in my letter to you of June 30 is practically the same as that employed by Tesla for the production of high-frequency currents except that I place an inductance coil L in the circuit to give additional means of tuning and to swamp by its greater inductance the reactions from the induction coil t which would tend to make the oscillations multiperiodic instead of simple harmonic. The inductance of this coil should be made large compared to the inductance of the primary of t. *The use of an auxiliary inductance coil for the purpose of rendering the oscillations simple harmonic in the case of circuits con-*



nected with other circuits as described above, was first made by me and I have elsewhere given a mathematical demonstration of the fact that it accomplishes that purpose * * *. At the receiving station the coil L and the condenser k form a resonant circuit which is attuned to the frequency of the [fol. 47] current developed at the transmitting station. Again the inductance of the coil L should be made large compared to the inductance of the secondary of the induction coil t at the receiving station in order to obtain well defined resonance to a single frequency * * *.

"In the second set of transmitting and receiving stations shown in my letter to you of June 30 ultimo, everything is the same as that shown in the first two diagrams except that an additional resonant circuit attuned to the same frequency as the others is interposed between the vertical wire and the transmitting and receiving apparatus for the

purpose of additionally sifting out the undesired harmonics." (Italics ours.)

The Stone Tel. & Tel. Company was organized in December 1901 or January 1902 and it manufactured radio apparatus under this Stone invention.

LVI. Marconi, in order to obtain his patent, canceled some of his former claims when they were rejected on the Stone patent #714756. Marconi's former claims 4, 5, and 7, which were canceled after being rejected on this Stone patent, read as follows:

"4. At a transmitting station employed in a wireless telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating conductor at one end and capacity at the other end, and whose primary is connected to a condenser circuit discharging through a means which automatically causes oscillations of the desired frequency, such condenser circuit and the open circuit being in electrical resonance with each other, substantially as described.

"5. At a transmitting station employed in a wireless telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating conductor at one end and capacity at the other end, and whose primary is connected to a condenser circuit discharging through a means which automatically causes oscillations of the desired frequency, such condenser circuit and the open circuit being in electrical resonance with one another; an induction coil, the secondary of which includes the condenser aforesaid, a source of energy included in the primary winding of said coil, a means for varying the circuit of said primary winding, substantially as described.

"7. At a transmitting station, employed in a wireless telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating conductor at one end and capacity at the other end, and whose primary is connected in a series with an adjustable condenser, and with a means which automatically causes oscillations of the desired frequency, substantially as described."

No effort by appeal or argument was made by Marconi to traverse the ruling of the examiner as to the propriety and pertinency of this Stone patent.

LVII. It was within the skill of those versed in the art to tune an open oscillating circuit such as that disclosed by the Stone patent #714756 or the Tesla patent #645576 by means of an adjustable inductance according to the teaching of the Lodge patent #609154, as well as by varying the length of the elevated conductor to control the distributed inductance and capacity. Stone did not intend to tune by [fol. 48] adjustment of the distributed inductance or capacity, as stated in lines 32-36 of page 9, where the patent states:

"and I wish it understood that I here disclaim any system employing distributed inductance and capacity as a means for tuning the resonant circuits described in this specification."

It was within the ability of those skilled in the art to tune the open circuits of the Stone patent transmitter and receiver by the use of a variable inductance, either an inductance constituted by the transformer winding or by a variable inductance in addition to the transformer winding. Stone was the first to teach the advantage in having a separate tuning inductance in addition to the transformer winding in order to make the inductance of the coupled tuned circuits large compared to their mutual inductance for use in Hertzian-wave signalling, as stated in lines 84-98 of page 5 of the patent and embodied in the Stone application when filed:

"The principle may for the present purpose be stated thus—that when two simple oscillators, each such as that shown in fig. 1, are inductively associated with each other, as in fig. 3, the system is a system of two degrees of freedom, and the natural period of oscillation of each simple circuit is modified by the presence of the other; but if the proportions of the circuits be such that the product of the inductances of the two circuits is large compared to the mutual inductance between the circuits the natural period of oscillation of each of the circuits becomes practically the same as if the circuits were isolated."

The Stone patent #714756 having pointed out the desirability for tuning the open transmitter circuit to the period of the closed transmitter circuit, it was obvious to one skilled in the art that open and closed receiver circuits should also be tuned to accord with each other and with the transmitter tuned circuits. It was also apparent that both the receiver circuits should be tuned in the same way, i. e., by the use of tuning inductances in addition to the transformer. The feature of a separate tuning inductance in any circuit inductively coupled to another was not novel with Marconi, but was, to one skilled in the art, disclosed in the Stone patent and was embodied in the Stone application when filed.

LVIII. The phraseology of claims 1, 2, 3, 6, 8, 10, 11, 12, 13, 14, 17, 18, 19, and 20, of Marconi #763772 relates to the same subject matter as is disclosed by the Stone patent #714756 as granted.

LIX. The phraseology of claims 2, 13, 18, and 19, of Marconi #763772 not being limited to the open and closed receiving circuits being in tune or resonance with each other, is directed to an arrangement of apparatus that was within the ability of one skilled in the art after Marconi's prior patent #627650.

LX. The terminology of claim 16 of the Marconi patent #763772 is directed to a combination of elements which is new and useful.

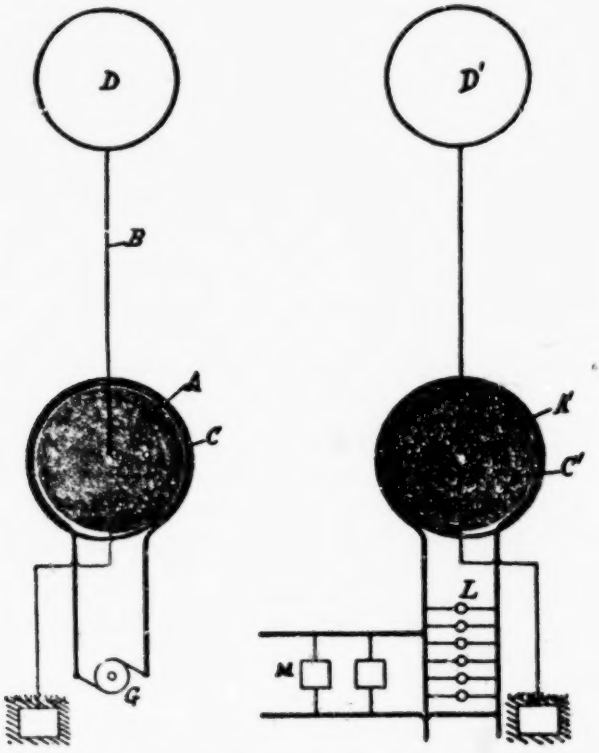
The tables on page 4 of the specification thereof indicate that the purpose of the condenser connected in shunt with the primary winding of the transformer of the receiver, is to enable the electrical periodicity or tuning of the open circuit of the receiver to be altered.

LXI. The phraseology of claims 1 and 3 not including an oscillating transformer nor the open and closed circuits being tuned, is directed to an apparatus such as that shown [fol. 49] by fig. 4 of the Lodge patent in suit. Claim 2 relates to fig. 12 of the Lodge patent in suit when a condenser *w* is used in circuit with the coherer. Claim 2, not being limited to the open and closed circuits being in tune nor to the variable inductance being in addition to the transformer primary winding, is directed to the apparatus shown by fig. 13 of Lodge. All of the loading

coils or inductances in the open circuits were intended to be adjustable by Lodge in order to syntonize or tune such open circuit.

LXII. Neither the British patent to Braun #1862, of 1899, nor the British patent to Braun #12420, of 1899, describes an apparatus having open and closed oscillating circuits in the transmitter and receiver which are to be tuned to accord with each other.

The United States patent to Tesla, #645576, patented March 20, 1900, on an application filed September 2, 1897, relates to a system of transmission of electrical energy through space.



As shown in the single figure of the drawings, reproduced above, the transmitter of this system comprises an elevated conductor or wire *B* with a capacity element D mounted at its upper end. This elevated conductor is connected with one end of the secondary *A* of an oscillation transformer; the other end of which is grounded. The primary

C of this transformer is connected with a source of high frequency oscillations *G*.

The receiving system also comprises an elevater conductor having a capacity element at its upper end *D'* con- [fol. 50] nected with one end of the primary winding *A'* of an oscillation transformer, the other end of said winding being grounded. The secondary of this receiving oscillation transformer is shown as connected to current using instrumentalities *L* and *M* defined on page 3, lines 24, 25, and 26 of the Tesla specification as "lamps *L*, motors *N*, or *other devices for utilizing current.*" While the specific disclosure of the drawings is illustrative of a continuous radiation and reception of energy through space, the Tesla specifications on page 5, lines 30 to 31, state that the method of energy transmission "will obviously have many other valuable uses", as *"for instance when it is desired to transmit intelligible messages to great distances."*

In view of such statement it would be within the knowledge of those skilled in the art to interrupt the continuous generation of high frequency energy in the transmitting system by means of a telegraph key, and to substitute for the current receiving instrumentalities disclosed in connection with the receiving system, a radio signal detector device.

The Tesla patent on page 4, lines 26 to 28, refers to the fact that the primary and secondary circuits in the transmitting apparatus are "carefully synchronized" and further on the same page (lines 40 to 45) states that "the results were particularly satisfactory when the primary coil or system *A'* with its secondary *C"* was carefully adjusted so as to vibrate in synchronization with a transmitting coil or system *A C.*" Such phraseology instructs those skilled in the art that the open and closed circuits of the transmitting system and the open and closed circuits of the receiving system, of the Tesla patent, should be in resonance with each other, or, in other words, that all four circuits should be in resonance.

Such teaching is further implied in Tesla patent #649621, based on a divisional application of the above-named Tesla patent in which it is stated, beginning with line 97, page 1, that "it will be readily understood that when the above-prescribed relations exist the best conditions for resonance between the transmitting and receiving circuits are attained,

and, owing to the fact that the points of highest potential in the coils or conductors *A A'* are coincident with the elevated terminals the maximum flow of current will take place in the two coils, and this, further, necessarily implies that the capacity and inductance in each of the circuits have such values as to secure the most perfect condition of synchronism with the impressed oscillations."

LXIII. The receiving apparatus of the Kilbourne & Clark Company, shown in exhibit 95, and the receiver made by the Telefunken Company, illustrated in exhibit 79, each has apparatus coming within the terminology of claim 16.

Fleming Patent #803684

LXIV. The invention of the Fleming patent #803684 relates to a substantially inertialess rectifier that is suitable for use as a part of a detector with very high frequencies encountered in radio signaling, to permit the use of a direct current galvanometer to indicate the presence of the signals. The drawing of the Fleming patent is reproduced on page 40. [fol. 52] In fig. 1 of the foregoing drawing, *n* is the aerial wire of the receiving station connected to the ground *o* through the primary winding *m* of the transformer whose secondary winding *k* is located in a closed circuit containing a two-electrode vacuum tube and a galvanometer or other indicator *l* of the received signal. The tube comprises a glass bulb *a* provided with a carbon filament *b* like that of an incandescent lamp operable at six or eight volts to consume two to four amperes. An aluminum cylinder *c* is suspended by platinum wires *d* from the glass bulb. The battery *h* heats the filament *b* through the leads *f*, *e*, to a temperature near 1,700° C. in a good or very high vacuum, with the result the current will flow only in one direction between the filament and the cold electrode *c*. The radio-frequency impulses received in the antenna are induced in the closed circuit of the transformer secondary winding and are rectified by the vacuum tube with the result that half of the radio-frequency waves in fig. 1 are lost and half pass through the vacuum tube and are effective to actuate the direction-current galvanometer *l*. In fig. 2 the closed circuit contains two tubes oppositely connected so that the differential galvanometer *q* receives both halves of the rectified waves and no large amount of energy is lost as is the case in fig. 1. In fig. 3 the use of a number of these

Fig. 1.

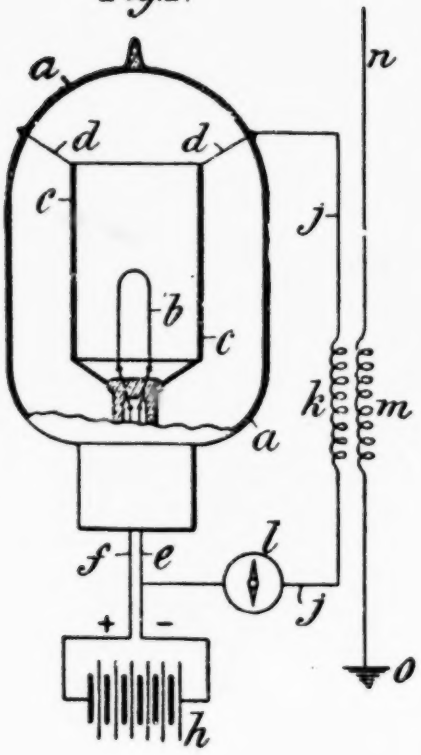


Fig. 2.

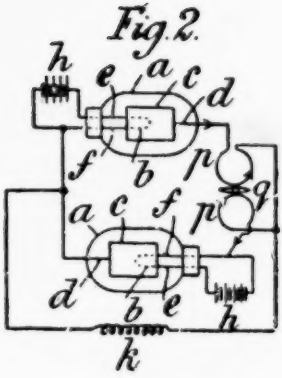
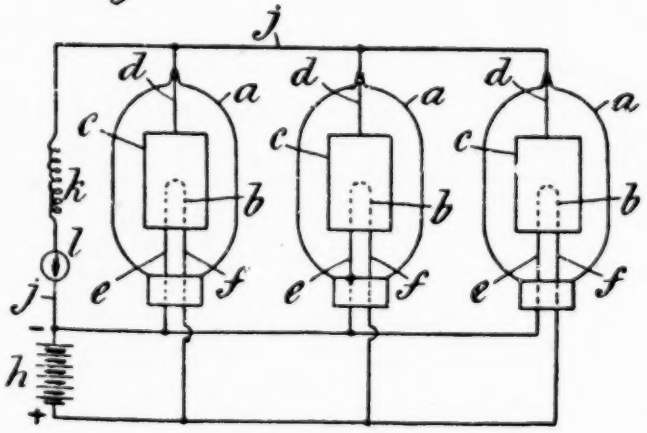


Fig. 3



one-way valves is shown in parallel to increase the possible current flow. Negative electrons are given off by the hot electrode to constitute the current flow in only one direction.

LXV. The claims in suit are numbered 1 and 37:

"1. The combination of a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for heating one of the conductors, and a circuit outside the vessel connecting the two conductors.

"37. At a receiving station in a system of wireless telegraphy employing electrical oscillations of high frequency a detector comprising a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for heating one of the conductors, a circuit outside of the vessel connecting the two conductors, means for detecting a continuous current in the circuit, and means for impressing upon the circuit the received oscillations."

On November 17, 1915, the assignee, Marconi Wireless Telegraph Company of America, disclaimed the combinations of elements in certain claims, including claim 1, "except as the same are used in connection with high-frequency alternating electric currents or electric oscillations of the order employed in Hertzian wave transmission." The disclaimer also eliminated the words "whether of low frequency or" in page 2, lines 32 and 33, and "either", in line 98 of page 2, and also the words "or low-frequency alternating currents of", in lines 98 and 99 of page 2 of the patent.

In claim 1 the vacuous vessel is the exhausted glass tube *a*, the two conductors are the filament *b* and the cold cylindrical electrode *d*. The means for heating one of the conductors is the connected battery *h*, and the circuit outside the vessel is that through the galvanometer and transformer secondary winding *k*, *j*, *d*, *c*, *b*, *e*, *l*.

In claim 37 the receiving station is shown by fig. 1 to include the vacuum tube as a detecting rectifier and a galvanometer for detecting or indicating the presence of a continuous or unidirectional pulsating current. The antenna circuit and the transformer connections are the means [fol. 53] for impressing upon the circuit the received oscillations. By the term "detector" Fleming's specification

meant to one skilled in the art a device adapted to make feeble high-frequency impulses measurable with an ordinary direct-current mirror-galvanometer, or in other words, the term "detector" includes both the rectifier tube and the direct-current indicator of the rectified current. The term as used in the Fleming patent did not include all apparatus associated with the detector tube and did not include any amplifying tube or tubes.

LXVI. The earliest date available to Fleming for this invention is November 16, 1904, the filing date under the International Convention for the corresponding British patent #24850 of 1904.

The file wrapper of this Fleming patent has not been offered in evidence.

Exhibit 77, the British patent corresponding to the United States patent in suit, is by reference made a part of this finding.

LXVII. The Fleming two-electrode valve went into use in a limited way; less than seven hundred Fleming valves having been shipped to various ship and store stations by plaintiff between 1910 and 1915. These Fleming valves were more sensitive than some types of crystal detectors and less sensitive than other types.

In 1914, the plaintiff company began to have manufactured for it and sent to the stations to which the valves had been sent originally, crystal detectors with adaptors so the same could be used in the sockets of the receiving sets in lieu of the Fleming valves.

There is no satisfactory evidence of any infringing use of the two electrode tubes by the United States.

LXVIII. It was not the custom of the plaintiff to mark all of its name plates with notice of this Fleming patent. Name plates of exhibits 14 and 31, used on receivers, contained no notice of this patent. Except as mentioned in finding XII, no notice to the United States of the Fleming patent and its infringement has been satisfactorily proven to have been given by the plaintiff to the United States before the commencement of this action.

In January 1914 a release was proposed by the United States from all patents granted to the plaintiff prior to

1907 and such proposed release was declined. The Fleming patent and the other patents in suit were not specifically mentioned in the proposal.

LXIX. The prior art relied upon to show anticipation and lack of invention includes:

United States patent to Edison #307031 October 21, 1884;

French patent to de Valbreuze #328687 May 7, 1903;

The Electrician, London, February 21, 1890, pp. 393-395;

Proceedings of the Royal Society, London, 1890, vol. 47, pp. 118-126;

Philosophical Magazine, London, 1899, vol. 48, pp. 547-560;

Proceedings of the American Institute Electrical Engineers, November 1897, vol. 14, pp. 31-35;

Philosophical Magazine, London, 1898, vol. 46, p. 528;

Proceedings of Cambridge Philosophical Society, London, March 1901, vol. 11, p. 286;.

Philosophical Transactions of the Royal Society, London, March 1903, vol. 11, p. 497;

[fol. 54] Proceedings of Cambridge Philosophical Society, London, 1897, vol. 9, p. 244;

Proceedings of Cambridge Philosophical Society, London, 1897, vol. 9, p. 333;

Proceedings of Cambridge Philosophical Society, London, April 1903, vol. 5, p. 429;

Philosophical Magazine, London, March 1903, vol. 5, p. 345;

Annalen der Physik, Berlin, April 20, 1904, pp. 425, 467;

Physikalische Zeitschrift, Berlin, October 20, 1904, pp. 680, 681;

United States patent to Hewitt #781001, January 31, 1905, filed May 16, 1902;

United States patent to Hewitt #781002, January 31, 1905, filed May 16, 1902.

Exhibits J, O, P, I-1, K-1, M-1, O-1, P-1, Q-1, R-1, S-1, T-1, U-1, V-1, W-1, X-1, Y-1, Z-1, A-2, and B-2 are by reference made a part of this finding.

LXX. The Edison patent #307031 showed a two-electrode vacuum tube in which one of the conductors is a heated filament adjacent to but not touching the other conductor, and provided with a circuit outside the vacuous vessel connecting the two conductors. Edison believed the

current flow through his tube to be proportioned to the degree of incandescence or candle power of the filament and connected his tube in circuit with a galvanometer or relay for indicating or controlling conditions in the filament circuit. Fig. 4 of the Edison patent set out below illustrates the lamp with a heated filament and within the loop of the filament the plate, marked *b*. The heated filament is one of the conductors mentioned and the plate is the other. The wire leading downward from the plate in the illustration is continued in a circuit shown in another figure of the patent which connects the two conductors. Current passed from the heated filament to the cold plate and for this reason Edison's tube is referred to as the two-electrode tube.

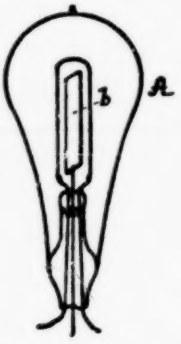
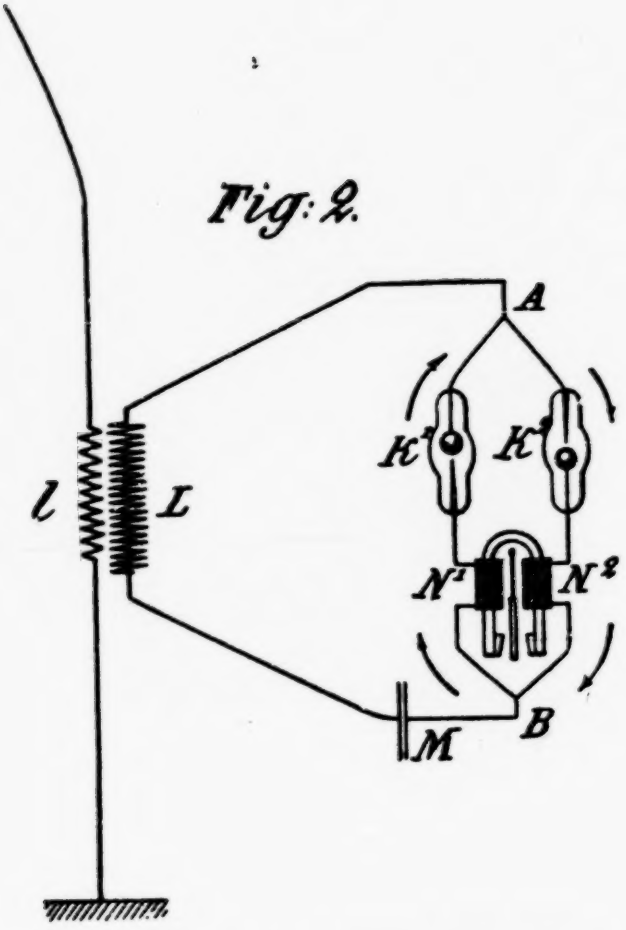


Fig 4.

Long before the application for the Marconi patent was made the Edison two-electrode tube was investigated and experimented with in great detail.

The French patent to de Valbreuze #328687 did not have a vacuum tube with heated filament but did propose a vacuum tube with two cold electrodes for use with radio frequencies as a rectifier. This patent, by fig. 2 herein reproduced, shows an open oscillating circuit through the primary *l* of the transformer. The secondary *L* is con-[fol. 55] nected oppositely through two vacuum tubes K^1 and K^2. The current then flows through the coils N^1 and N^2 of a sensitive polarized relay, somewhat after the manner of fig. 2 of Fleming and thence through a condenser *M*. This patent has date of May 7, 1903, and was published July 18, 1903, over a year before the filing date of Fleming's British patent.



LXXI. The proceedings of the Royal Society, London, 1890, volume 47, pp. 118-126, contained an article by Professor Fleming in which he described the unilateral conductivity between the hot and cold electrodes in a vacuum tube of the general type of the Edison patent mentioned above and showed that the current flowed only in one direction when an alternating current was used in connection with a lamp of an Edison apparatus. He also discussed the flow of current from the hot negative terminal of the lamp to the cold electrode of the plate, with the result that negative electricity flowed from the plate into an additional circuit connected with the lamp.

[fol. 56] A- a meeting of the American Institute of Elec-

trical Engineers at New York in 1897, Clark Howell described, in a paper read, the Edison effect and again pointed out that an alternating current passing through the lamp of an Edison apparatus produced in a branch circuit a unidirectional current, and this fact was commented upon at the same meeting by Dr. Kennelly.

These papers by Fleming and Howell and the early Edison patent #307031 anticipate claim 1 of the patent in suit before the disclaimer was filed. This publication was made by Professor Fleming about fifteen years before he filed his application for the patent in suit and about twenty-five years before the disclaimer as to claim 1 was filed. Professor Fleming knew that a combination of apparatus such as is called for by claim 1 of the patent as issued, to be old, and he did not file or cause to be filed the said disclaimer until about ten years after the patent issued.

In the Philosophical Magazine of December 1899, volume 48, pp. 547-566, Professor J. J. Thompson showed that the mass of the negatively charged particles emitted from the heated filament in the vacuum tube was only a small fraction of the size of the hydrogen ion, and these were the smallest then known particles.

LXXII. The inventive monopoly expressed in the Fleming patent in suit after the disclaimer had been filed therein, does not include, as features of novelty, the unilateral conductivity of Edison's two-electrode tube; the fact that the negative electrons emitted by the heated filament were of very small mass; the fact that the electron stream could be controlled by the potential of the cold electrode; or that the valve was an appropriate rectifier for alternating current, all of which facts were known to those skilled in the art more than two years prior to November 16, 1904, the earliest date available to Fleming for his invention.

The Fleming patent, as modified by the disclaimer, does not include all uses for the electron emissions from the heated electrode, nor all uses for such emissions in connection with radio frequencies, but relates only to a rectifying use for such emissions in connection with currents of radio frequencies.

What the invention did include, to one skilled in the art, was an appreciation of the desirability of using the Edison two-electrode vacuum tube as a rectifier for radio frequencies, where other types of rectifiers were not appropriate for such high-frequency oscillations. Professor Fleming found a new application for Edison's two-electrode vacuum tube.

LXXIII. The Fleming patent as modified by the disclaimer filed therein, is directed to a new and useful use of an old structure, i. e., the two-electrode tube, but in a short time it was practically superseded by apparatus using the three-electrode tube.

LXXIV. A two-electrode tube of the Edison or Fleming type may be made to produce oscillations, provided an independent source of electric energy is inserted in the exterior circuit connecting the cold electrode to the filament; this source of energy has a certain selected potential, the value of which varies with the characteristics of the tube used, and a sufficient residual amount of gas is present in the tube to permit an ionization effect. Such oscillations [fol. 57] as are thus obtained are critical and unstable, and no satisfactory evidence has been introduced to show that the Fleming, or two-electrode tube, was ever commercially operated in this manner.

A two-electrode tube may also be made to oscillate or amplify by inserting an independent source of energy in the exterior circuit connecting the cold electrode to the filament, and by locating the tube adjacent an electrostatic or electromagnetic field in such manner that the field exerts a control action on the electron flow taking place within the tube. This was discovered subsequently to the use of a three-electrode tube as an amplifier.

The Fleming patent in suit does not disclose or teach those skilled in the art that the vacuous space in the tube should have a definite residual gas content; that an exterior source of electric energy should be located in the circuit between the cold electrode and the filament, or that the potential of this source should be varied in accordance with the individual characteristics of the tubes. Nor does the patent in suit instruct those skilled in the art how to control or vary the electron flow within the tube in accordance

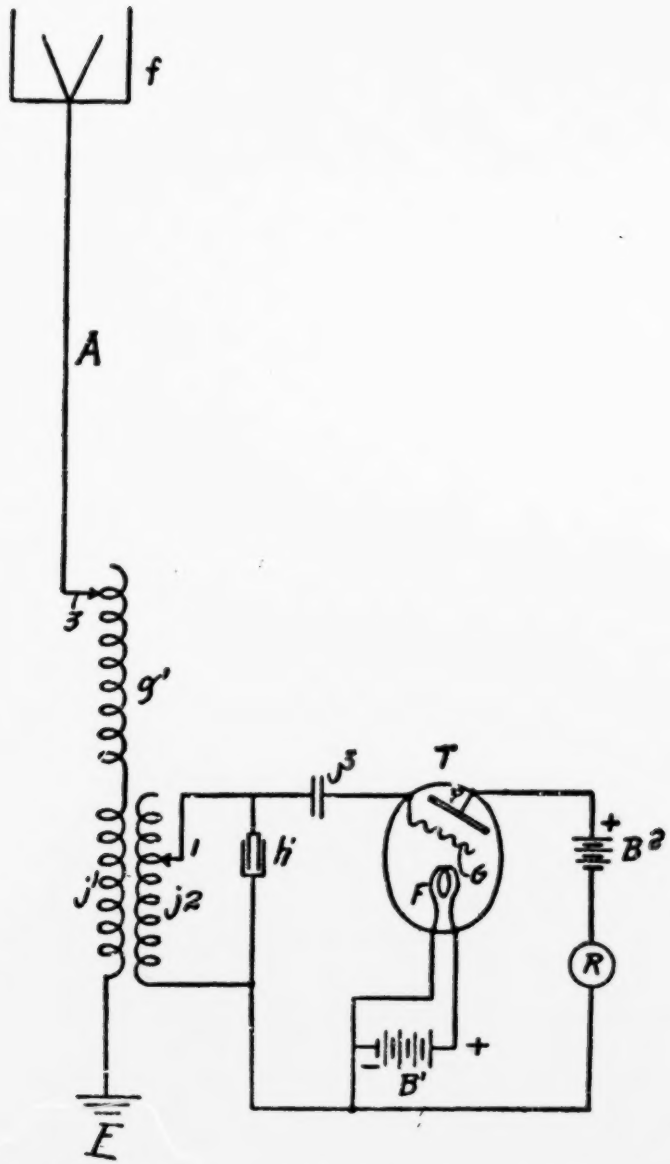
with an incoming radio signal in such manner as to produce an amplified reproduction of such signal in the exterior circuit connecting the plate and filament.

The Fleming tube does not possess any inherent ability to generate radio oscillations or to amplify them and can be made to do so only by circuit connections never appreciated by the inventor of the patent in suit. The United States operated no two-electrode tubes as either amplifiers or oscillators by either of the two above-mentioned methods.

LXXV. All alleged infringements comprise use of the three-electrode tube and sales of such tubes and apparatus for using them.

One such alleged infringement is the audion detector connected as shown in exhibit 83, reproduced on page 47.

The open antenna circuit fAg^1j^1E is inductively coupled to the tuned closed oscillating circuit j^2h^1. The grid G and filament F of the three-electrode tube T are connected across the condenser h^1 and in series with the condenser j^3. Small variations in potential on the grid control the electron flow to the plate and cause a larger variation in potential at the plate, which corresponds with the grid potential variations. As soon as the grid and its connected plate of condenser j^3 become negatively charged, rectification of the full high radio-frequency waves ceases. The only rectification taking place after that is of a small portion of the radio-frequency wave necessary to replace the loss in negative charge on the grid condenser through leakage. Due to the grid condenser and leakage through residual gas, the potential of the grid G varies according to the audio frequencies and not fully with radio frequencies as intended by Fleming for his cold electrode. In later detector tubes with less residual gas it was customary to have a very high resistance arranged in shunt with the grid condenser, so proportioned that the grid potential varied accurately with audio frequencies yet very little with radio frequencies. Such a grid leak is shown, for example, in exhibit 114. Looked at in another way, the grid condenser and properly [fol. 58] desiged leakage path do not allow the radio oscillations to be fully impressed on the tube and only allow the audio-frequency waves to pass and become impressed upon the plate circuit.



DeForest Audion, Used by Navy (Exhibit 83)

The variation in plate potential is due to the control of the electron discharge from the filament effected by the grid. This type of electron control by a third filament within the field of electron discharge was not appreciated by Professor Fleming and causes the three-electrode tube when used as a detector to operate in a different manner from the use of the two-electrode tube discovered by him.

[fol. 59] The audio variations in potential impressed upon the grid appear upon the plate in magnified or amplified form, and thus the tube in exhibit 83 amplifies as well as detects. Where the Fleming patent contemplated detection by rectification of the full radio or high-frequency oscillations impressed upon an indicator adapted to register the strength of the rectified unidirectional pulsating current, the three-electrode tube in exhibit 83 detects by substantially suppressing the high-frequency oscillations and amplifying principally the low or audio-frequency oscillations.

The apparatus shown by exhibit 83 is for use at a receiving station in a system of wireless telegraphy employing electrical oscillations of high frequency, and has a detector comprising a vacuous vessel with three conductors adjacent to but not touching each other in the vessel, and means for heating one of the conductors. The only circuit outside of the vessel connecting any two conductors and containing a means for detecting currents in this circuit, is the plate circuit containing the telephone receiver *R*.

This telephone receiver is not so much a means for detecting or indicating a continuous current in its circuit as it is a means for detecting the presence of audio-frequency changes in such direct current. The telephone receiver would not indicate the presence of unidirectional current of constant strength pulsating at radio-frequencies as would the galvanometer in the Fleming patent. Having in mind that the plate circuit is the only one which might be regarded as the output circuit because it contains an audible indicator, it may be further seen from exhibit 83 that there is no means for impressing upon this outside circuit the full received oscillations of radio frequency. The grid circuit constitutes a means for impressing upon the plate circuit mainly only audio oscillations received and not the radio or high-frequency oscillations contemplated by claim 37, because the grid condenser substantially suppresses these received high-frequency oscillations and impresses no large part of them upon the plate circuit. While a small portion of the received high-frequency oscillations may be so impressed upon the plate circuit and require a condenser across the telephone receiver, any such small part of the radio-frequency oscillations not suppressed hardly constitute the full received radio-frequency oscillations contem-

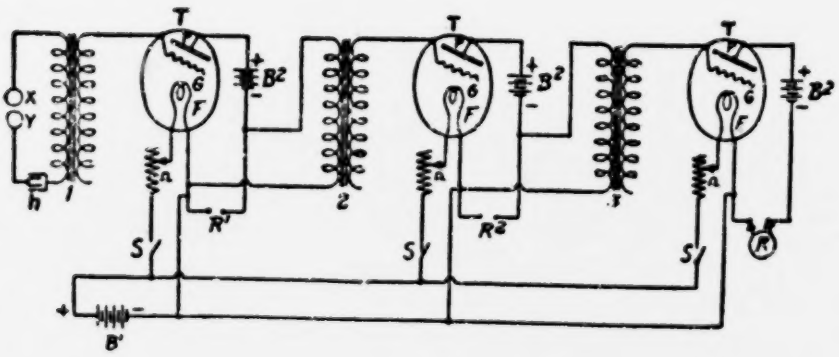
plated by the patent as being impressed upon the tube and its outside circuit.

To summarize, the three-electrode tube of exhibit 83 functions differently from the tube in the Fleming patent because (*a*) it has a third electrode located within the tube to effect a control of the electron stream, which electrode is connected to an input circuit separate from the output circuit, which latter circuit contains a local source of energy, and a radio signal impressed upon the input circuit is reproduced in amplified form in the output circuit; and (*b*) the tube in exhibit 83 is used to supply the plate or output circuit principally with low or audio-frequencies since the grid condenser suppresses the major part of the received high frequency radio oscillations, and prevents them from being impressed upon either the grid or the plate circuit containing the audible indicator.

Exhibit 114 is by reference made a part of this finding.

[fol. 60] LXXVI. Another alleged infringement includes the use of three electrode tubes connected for amplifying purposes as shown by exhibit 85, here reproduced:

DE FOREST AUDION AMPLIFIER
USED BY NAVY



Each tube has no detecting function but magnifies in the filament plate output circuit the oscillations applied to the input or filament grid circuit. There is no detecting action within the meaning of the Fleming patent even if the amplifier be used in connection with a detector and used with either radio or audio frequencies. The device illustrated being intended for use with audio frequencies, as is evidenced by the presence of the iron transformer cores, is

not for use in connection with high frequency oscillations as contemplated by the disclaimer to claim 1, and in this exhibit there is no detector nor any means for detecting the continuous or unidirectional current in a circuit connected to a tube having high frequency oscillations impressed thereon, as called for by claim 37. When the three-electrode tube is used for purposes of amplification it functions in a radically different manner from any use contemplated by Fleming.

LXXVII. The properties of the three-electrode tube are such that when it is utilized as a detector tube in a circuit arrangement involving no feedback or regeneration, it gives a signal response approximately 50% better than a good crystal detector.

Where a three-electrode tube is utilized in a receiving circuit of a type in which a feedback or regenerative action takes place, the signals are twenty to thirty times stronger than can be obtained in the nonregenerative circuit due to the fact that the inherent amplifying properties of the three-electrode tubes are more completely utilized.

When a plurality of three-electrode tubes are utilized in a radio receiving apparatus in which both radio frequency and audio frequency amplification are utilized, the resultant amplification is of such high magnitude, that radio signals from Europe can be received in this country by the use of indoor antenna.

The three-electrode tube was a valuable contribution to the radio art in the manner stated above and represented a vast improvement over the Fleming two-electrode tube.

[fol. 61] LXXVIII. The oscillators of exhibit 116 also function in a different manner from that possessed by the use of the two-electrode tube discovered by Fleming. Neither the two-electrode tube nor its use discovered by Fleming possesses any inherent ability to oscillate in a manner susceptible of commercial use. The oscillators have no detecting function of claim 37.

Exhibit 116 is by reference made a part of this finding.

LXXIX. The regenerative receiver of exhibit 114 (referred to in finding LXXV) functions like the receiver of exhibit 83 except that it has an added amplifying function by means of the coil j^3 in the plate circuit impressing further audio potential changes upon the grid circuit.

The direction finders of exhibit 115 are like the regenerative receivers of exhibit 114 except that there are two antenna primary circuits, one open and one closed, but both coupled to the same secondary oscillating circuit.

Exhibit 115 is by reference made a part of this finding.

LXXX. The three-electrode tube may be connected for use as an amplifier, oscillator or detector or combinations of some of these. A number of three-electrode bulbs were purchased by the United States for such uses as it saw fit to give them.

LXXXI. Before the disclaimer was filed on November 17, 1915, the three-electrode tube had been invented, as had also its connections for use as detector, amplifier, and oscillator. The United States had ordered and used substantial quantities of three-electrode vacuum tubes as detectors and amplifiers prior to November 17, 1915, when said disclaimer was filed.

LXXXII. Plaintiff has granted licenses to the following manufacturers:

(*a*) National Electric Signaling Company, dated October 5, 1914, under the Lodge and the Marconi four-circuit patents. This license terminated May 30, 1917;

(*b*) The National Electric Supply Company, dated July 14, 1914, and April 15, 1915, under the same two patents, and terminated January 24, 1916;

(*c*) Moorhead Laboratories, Inc., dated November 30, 1918, and April 30, 1919, under the Fleming patent, and terminated June 30, 1920;

(*d*) General Electric Company, dated October 22, 1919, releasing, under conditions, the General Electric Company's customers from any charge of infringement as to apparatus purchased from General Electric Company.

(*e*) The United States purchased from the plaintiff on November 26, 1918, certain apparatus and stations with a release of the apparatus so purchased, from any charge of infringement.

Exhibits 360, A-7 and B-7 are by reference made a part of this finding.

LXXXIII. It has been stipulated that the issue of reasonable compensation or damages and profits be postponed

until the determination by the court of the issues of validity and infringement of the various patents in suit.

[fol. 62] CONCLUSIONS OF LAW

Upon the foregoing special findings of fact, which are made part of the judgment herein, the court decides, as a conclusion of law—

(1) That the Marconi reissue patent #11913 has not been infringed by the defendant;

(2) That the Lodge patent #609154 is valid, and that any use of the combination described therein is an infringement, but that no recovery can be had by plaintiff for use of any such apparatus purchased or acquired prior to March 8, 1913;

(3) That the Marconi patent #763772 is invalid except as to claim 16 thereof, which is infringed by the apparatus specified in Finding LXIII and any other apparatus used by defendant coming within its terminology;

(4) That the Fleming patent #803684 has not been infringed by defendant.

Final judgment is reserved until the amount of reasonable compensation for damages or profits is determined in accordance with the stipulation of the parties.

OPINION

GREEN, Judge, delivered the opinion of the court:

The act of June 25, 1910, 36 Stat. 851, as amended by the act of July 1, 1918, 40 Stat. 705, confers upon the owner of a valid patent the right to bring suit in the Court of Claims against the United States to recover compensation for any infringement of the patent or patents by the Government. During the period involved in the suit the plaintiff was the owner of certain patents which are the basis of the suit herein, namely: Marconi Reissue, #11913; Lodge, #609154; Marconi, #763772; Fleming, #803684.

Each of these patents relates to electrical communication between different points without connecting wires, which is generally known as radio communication. It is alleged by plaintiff that all of these patents have in one or more respects been infringed by the defendant.

On behalf of the defendant it is alleged:

(1) That plaintiff has released the defendant;
(2) That plaintiff has assigned its claims herein;
(3) That the patents are invalid;
(4) That even if none of the above defenses are sustained, plaintiff cannot recover for the reason that the evidence fails to show that any of the patents have been infringed.

The questions that relate to plaintiff's right to maintain the suit will be taken up in their order. All questions relating to the validity and alleged infringement of the patents will be taken up in the order in which the patents were issued, each patent being considered separately.

It is contended on behalf of defendant that under the provisions of the contract of sale made by plaintiff to defendant of wireless and ship stations, as set out in Finding V, the suit should be dismissed as to all patents in suit except the Fleming patent #803684, it being conceded that the apparatus sold included the combinations set forth in the other patents. The finding shows that the contract released the defendant from the payment of any further sum "on account of its (plaintiff's) patent rights involved [fol. 63] in any of the apparatus hereby transferred." We think it obvious that the release applied only to the property sold and "transferred" by the contract which is not involved in the suit.

November 20, 1919, plaintiff sold to the Radio Corporation its factory, letters patent, including the letters patent here in suit, and certain land transmitting stations, reserving to itself:

"A claim against the United States Government arising from unlicensed use by and for the Government of the apparatus covered by the patents of the Marconi Company."

The agreement further provided that all amounts received in cash by the Marconi Company after paying expenses should "forthwith be paid to the Radio Corporation" which should issue therefor preferred stock, and it is argued that plaintiff's claim has been assigned and therefore no suit could be brought thereon. We do not think this follows. It is true that the ultimate effect of the agree-

ment was to enable the Radio Corporation to become the owner of all that might be recovered in this suit but it did not become the owner thereof until plaintiff had prosecuted the suit to judgment and assigned any judgment in its favor to the Radio Corporation. Up to that time the Radio Corporation merely had a contingent chose in action. It is suggested that after conveying the title to the patent and as to infringements reserving only the right to bring action against the defendant, plaintiff had lost the right to bring suit against the defendant but the general rule is that the right to sue for infringement rests with the one who was the owner of the patent at the time the infringement occurred. Some question might possibly arise as to the validity of the assignment to the Radio Corporation and with respect to the right of that company to sue for other infringements, but this is the most that can be inferred from the cases cited. We think it clear that in its transactions with the Radio Corporation plaintiff has done nothing to invalidate its right to sue for any infringement committed by the defendant prior to the time of the sale and this is all that is claimed.

The Marconi Reissue Patent #11,913

Guglielmo Marconi, an Italian scientist, is sometimes called the father of wireless telegraphy but he was not the first to discover that electrical communications could be made without the use of connecting wire. The theory upon which this art is based was first disclosed by Professor Maxwell of Cambridge as far back as 1865. Maxwell, however, did not propose any apparatus for developing its use, if indeed he had any idea that it might be made useful, and no practical demonstrations of his theory were made until Heinrich Hertz, between 1879 and 1890, discussed the Maxwellian theory and described apparatus for carrying it into effect in an article published September 21, 1888. The experiments which Hertz made public substantiated and amplified the theory of Maxwell. Hertz showed that circuits through which a current of high frequency electricity passed developed electrical disturbances in the form of waves which had many of the properties of light waves and that this radiant energy set up what might be called ether waves somewhat like sound waves which induced cur- [fol. 64] rents in other circuits not connected by wire there-

with. His apparatus consisted of a transmitter so called because it transmitted the electric wave and a receiver so named because it was put into electric vibration by electric waves from the transmitter although it was not connected with the transmitter. The transmitter included a battery and an induction coil connected with an oscillator or radiator circuit. There was a gap in the circuit where two rods which were connected to the secondary terminals ended in polished metal balls in close proximity, all so arranged that when the current in the primary coil was interrupted there was a discharge of sparks across the spark gap which resulted in the radiation of the wave. To prove the existence of the wave and its transmission Hertz used a turn or loop of wire either in the form of a rectangle or a ring, the two ends terminating in metallic knobs separated by a minute gap. When the ring or loop was held near an active oscillator, electric impulses were set up which revealed themselves by minute sparks at the gap between the balls. Thus Hertz proved the existence of the waves and the fact that they could be transmitted, but he never succeeded in producing waves which were detectable except at a short distance. His experiments created great interest in the scientific world and other scientists took up his discoveries where he left off and carried them still further.

Nearly six years later, Sir Oliver Lodge, in 1894, wrote a series of articles in the "London Electrician" describing the original and later work of Hertz and explaining it by means of diagrams.

A number of distinguished scientists continued to experiment and develop theories with reference to the transmission of electric waves without wires and methods for accomplishing such a transmission. Among these were Popoff, Tesla, Crookes, Dolbear, and Edison. Some of these men took out patents as did Lodge, although his patent was later than the patent of Marconi, and it becomes necessary to consider the effect of their discoveries and disclosures upon the patent in suit.

Marconi applied for his first patent in 1896 and it was reissued under date of June 4, 1901. The reissue patent #11,913 relates to a "complete system or mechanism capable of artificially producing Hertz oscillations and forming the same into and propagating them as definite

signals and capable of receiving and reproducing, telegraphically, such definite signals; * * *."

The subject-matter of the reissue patent was extensively used until displaced by later improvements. The plan of this system is shown by figs. 10 and 11 of the patent, reproduced in Finding IX. The same finding also shows the form of the transmitter and the receiver, and explains the diagrams and the manner in which the apparatus worked. We do not think it necessary to repeat this explanation in the opinion.

The only claim of the reissue patent which is involved in this suit reads as follows:

"3. The combination, in an apparatus for communicating electrical signals, of a spark producer at the transmitting station, an earth connection to one end of the spark producer, an insulated conductor connected to the other end, an imperfect electrical contact at the receiving station, an earth connection to one end of the contact, an insulated [fol. 65] conductor connected to the other end, and a circuit through the contact, substantially as and for the purpose described."

Figure 10 illustrated in Finding IX is a diagram of the apparatus used in the combination.

Findings X, by reference to fig. 10, locates the essential parts of the combination of the transmitting station.

The original patent having been considered to be defective because some of the claims were thought to have covered apparatus employed by Prof. Popoff, changes were made in the claims with reference to the tube *j* in the transmitting station (see fig. 11). The original patent No. 586193 stated:

"The tube *j* may be replaced by other forms of imperfect electrical contacts, but this is not desirable."

In the reissue patent the meaning of this quotation was changed by omitting the words, "but this is not desirable." No satisfactory explanation of the reasons for this change in the scope of the description of the invention has been given.

It is urged on behalf of defendant that there was nothing new in any of the apparatus described in the patent and that the combination thereof involved no inventive skill and

presented no new discovery, but was one which could be perceived by a person skilled in the art and consequently no valid patent could rest thereon. Counsel for plaintiff vigorously dispute these contentions and call attention to the fact that new results followed from its use of the Morse code for signalling with Hertz waves to a greater distance than was previously thought possible. It should be noted in this connection that the combination of the Marconi patent appears to be the first one that went into practical and general commercial use for the purpose of communication through electric signals transmitted without wires.

When we consider the evidence it shows that there was nothing new in any of the individual elements of the apparatus described in claim 3 and while counsel for plaintiff in argument endeavor to show an infringement based on some one or more of these features we are clear that the combination alone was patentable and think a reading of the claim shows that nothing more was intended. If we are correct in this, it follows that if the defendant in the apparatus which it used omitted some element of the combination of the patent and introduced other and different elements instead having a different and useful effect, there would be no infringement of the patent.

Tesla, in 1893, disclosed a practical apparatus for generating and utilizing Hertzian waves. His sending apparatus is described in what is called the Martin book, introduced in evidence, and showed that he used a powerful alternating current generator inductively coupled to a lateral charging circuit containing a spark gap and a condenser, whereby oscillations were generated and this charging circuit was inductively coupled to a distributing circuit.

Popoff, in 1896, prior to the reissue of the Marconi patent, described a receiving apparatus for detecting Hertzian electric rays. The transmission station had an earth connection and he employed a coherer substantially identical with that alleged to be disclosed in the Marconi reissue patent. [fol. 66] It was this kind of a coherer that furnished the imperfect electrical contact referred to in the claim in suit. Tesla, Popoff, Crookes, and others fully appreciated the fact that their inventions and disclosures would in the future form part of a system for the transmission of wireless messages.

In the case of *Marconi Wireless Tel. Co.* v. *DeForest Wireless Tel. Co.* (138 Fed. 657, 671), Judge Townsend, as

we think, correctly disposes of any claim for originality based upon the separate features of the Marconi reissue patent. He said:

"If now we examine the patent in suit in the light of this discussion, we shall find that every element of the claims in suit is taken from the prior art. The signaling and receiving instruments are common to the various apparatus from Dolbear, in 1882, to Popoff, in 1895; the Morse key is specifically referred to by Dolbear, Edison, and Kitsee, and is suggested by Lodge; the spark-gap, invented by Hertz for producing the Hertz oscillations, is found in Lodge and Popoff; the 1891 Branley coherer or 'imperfect electrical contact', comprising a tube with filings, and its operation by means of a tapper, are elaborately explained in Lodge's lecture, and utilized by Popoff in his experiments; and 'choking-coils' are illustrated and described by Popoff. The 'insulated conductors', described and shown as comprising elevated plates suspended on wires, were shown in Dolbear, Edison and Kitsee."

Judge Townsend held in effect that the combination was patentable, but we shall not discuss the question of whether his conclusion in this respect is correct. In the case before him, a different kind of detector was used from any involved in the instant case. It must be conceded, however, that if his reasoning should be followed it would require us to hold that the apparatus used by defendant, which comprised a crystal detector with certain forms of transmitters and receivers, constituted an infringement of the Marconi reissue patent. In this conclusion we do not agree, but hold with Judge Veeder's decision in *Marconi Wireless Tel. Co.* v. *National Electric Sig. Co.* (213 Fed. 815), a case in which the issues so far as the Marconi reissue patent is concerned were exactly the same as those in the case at bar.

A determination of the question of infringement requires a comparison of the apparatus described in the patent with that used by the defendant. The particular features of the combination set out in plaintiff's patent which are alleged to be infringed are the imperfect electrical contact and the transmitter. The imperfect electrical contact shown in the patent in suit was a device known as a coherer, which was a detector of the electrical waves. The coherer or detector used by Marconi was a tube containing metal filings which

was placed in the circuit of the receiving station. When a weak high-frequency current was passed through this circuit, these metal filings tended to cohere and from this feature the name coherer was derived. The patent contemplated such a degree of imperfection in the contact of the particles in the coherer that the local-battery circuit which included it would be broken on tapping the coherer. Means [fol. 67] were provided for tapping the coherer and thus the current would be broken by the tapping and again restored by the high frequency effect.

None of the receiving sets used by the defendant, however, used a coherer similar to that described in plaintiff's patent. On the contrary, a device altogether different, and functioning in a different manner was used. In the apparatus of defendant there was no tube containing metal filings, nor was there any imperfect electrical contact. The device used is commonly known as a crystal detector. In the crystal detector the connection is made by a fine wire which completes the circuit by being brought into contact with a crystal also forming a part of the circuit. This crystal acts as a rectifier in the manner of a one-way valve, allowing much larger portions of the high-frequency waves to flow in one direction than in the other. This constituted a great improvement on Marconi's invention as was shown by the fact that in practice it rapidly displaced the coherer. Not only was it a better detector, but it also enabled speech or music to be heard and it is still used in some of the simpler forms of the modern "radio." It is urged on behalf of plaintiff that these crystal detectors utilize or constitute "imperfect electrical contacts" within the meaning of the claim and as a matter of fact.

There is nothing in the claim or the specifications of the patent to indicate that the words "imperfect electrical contact" are used otherwise than in their ordinary signification. The meaning of the words is so plain that it cannot be aided by definition. The crystal detector does not utilize an imperfect electrical contact in the detection of Hertzian waves but requires a good small contact of such a degree of perfection that it is necessary when the contact becomes imperfect to restore the perfect contact. It is argued on behalf of plaintiff that because the crystal detector has a higher resistance than the terminals between which it is interposed it constitutes an imperfect electrical contact. On this point Judge Veeder says:

"From an electrical point of view the defendant's detectors are not imperfect electrical contacts, as the term is used by Marconi, because the electrical condition is permanent from wave to wave of electrically received impulses. Moreover, the defendant's devices are rectifiers, which means that in any complete cycle or complete wave of alternating current the positive half wave passes through the device with less obstruction or greater power than the negative half wave. This rectifying action is a definite property, which is the same from wave to wave. The defendant's detectors do not operate in the same manner as the Marconi coherer."

In a detailed statement, Judge Veeder pointed out that the coherer is a make-and-break device, whereas the crystal device is not at all of that nature but one which changes the received alternating signalling oscillations into direct current, the energy received and detected being that of the transmitted energy rather than that of a local battery.

It is also contended that the patent is infringed by the transmitters which defendant used. It is argued in effect on behalf of plaintiff that the connection with the earth described in claim 3 of the Marconi patent refers to *any* connection with a secondary circuit. But plaintiff cannot have both a general claim for any connection and a specific claim [fol. 68] for a connection made in a particular and definite way. If the claim is general it would be anticipated by prior disclosures of ground connections in wireless signalling apparatus but Marconi could not have an all inclusive right to every kind of earth connection. The patent in suit describes and claims a specific arrangement of grounded antenna. It requires one end of the spark producer and one end of the coherer to be directly connected with the earth and the other end of the spark producer and the other end of the coherer to be connected with an insulated elevated conductor.

The effect of these direct electrical connections is obviously in the case of the receiver to cause all the high-frequency current induced in the antenna circuit to pass or flow directly through the coherer and in the case of the transmitter to cause all of the energy created by the spark discharge to circulate in the antenna circuit. The transmitting circuits and receiving circuits used by defendant were quite different in their arrangement and function. All included

a transformer connection between the antenna circuit and the closed circuit; the latter circuit in the transmitter included the spark producer or gap and in the receiver included the crystal detector. The transformers were of two types: viz, those with (*a*) separate primary and secondary windings; (*b*) an auto-transformer type of winding.

In all instances in which a transformer having separate primary and secondary windings was utilized there was no direct electrical connection between the ground and the antenna and the spark producer or gap in the transmitter, or between the ground and the antenna and the detector in the receiver. With this type of transformer no physical metallic connection exists. The coupling is merely inductive in its character. This arrangement is shown in the diagram set out in Finding XXII illustrating the apparatus of the Wireless Specialty Apparatus Company. In the transmitting and receiving circuits utilizing the auto-transformer type of coupling there was a direct electrical communication between the primary and secondary winding in the coupling of the closed circuit to the open circuit, but as shown in Finding XXI this is merely incidental to the construction of the auto-transformer, the true function of which is to electro-magnetically couple the open and closed circuits together, and such electrical connection is not for the purpose of connecting the receiving antenna and the ground directly to the detector so as to pass all of the high frequency currents generated in the antenna through the detector as was done by the apparatus described in the Marconi patent. In fact this connection was merely incidental and not for the purpose of connecting the antenna and the earth directly to the spark producer or gap. In other words it functioned differently than did the apparatus of the reissue patent.

We do not overlook the fact that in the cases cited by Judge Veeder no physical contact was shown to exist between the apparatus and the ground, whereas in the case before us in part of the apparatus there was such a physical contact, although it can be said that it was made in a different manner and operated differently. But this fact does not affect the primary question here.

As stated above, plaintiff's patent is on the combination. In *Loom Company* v. *Higgins*, 105 U. S. 580, it is said: "If a new combination and arrangement of known elements

[fol. 69] produce a new and beneficial result, never attained before, it is evidence of invention." This quotation may sustain plaintiff's claim that the combination was patentable but it also shows that the patent thereon was not infringed.

At this point, keeping in mind that it has already been shown that all the elements of the reissue patent are old and that none of its individual features considered separately and alone were patentable, it becomes quite clear that a new combination made by another party presenting a new arrangement, producing new and beneficial results does not infringe a former combination by using some of the elements thereof.

In conclusion we hold that the reissue patent was not infringed:

(1) Because the apparatus used by defendant included in its combination a new element, namely, the crystal detector;

(2) Because defendant's apparatus was differently arranged in that the spark gap and detector were not in the antenna circuit where they were located under plaintiff's patent;

(3) Because the changes made in the combination by defendant had a new and beneficial result.

The Lodge Patent, #609154

The findings show that the British patent to Oliver Joseph Lodge, #11575, was filed May 10, 1897, over seven months before the United States application for the same invention, the patent in suit No. 609154, was filed. The British patent, however, was not sealed until October 25, 1898, and the United States patent to Lodge was issued August 16, 1898. The actual certificate of the British patent therefore was not issued until after the American patent had been granted. By section 3 of the act of 1897, section 4887 of the Revised Statutes was amended to read as follows:

"No person otherwise entitled thereto shall be debarred from receiving a patent for his invention or discovery, nor shall any patent be declared invalid, by reason of its having been first patented or caused to be patented by the inventor or his legal representatives or assigns in a foreign country,

unless the application for said foreign patent was filed more than seven months prior to the filing of the application in this country, in which case no patent shall be granted in this country."

Under the provisions of this statute the invalidity of the patent will not be shown merely by the fact that the application for the patent in the United States was not made until more than seven months after the application for the foreign patent was filed. It must also appear that the invention was first patented in a foreign country. In the case of the Lodge patent, if we take the dates when the patents were actually issued, we find that for some reason the date of the letters patent issued in England is subsequent to that of the one issued in the United States. We do not think, however, that this fact, when we consider the English statute and the obvious intention of the provisions of the law in the United States, is determinative of the question now before us. The complete specification for the British patent was accepted August 10, 1898, and the British [fol. 70] patent was sealed October 25, 1898. Under the British law acceptance gave "like privileges and rights as if a patent for the invention had been sealed." In *Davies* v. *Townsend*, 13 R. P. C. 265, the defendant was accused of having sold goods marked with the word "patented" when no patent had been granted. The suit was dismissed because his application had been accepted and he had the same rights as if a patent had been sealed on that day.

In *Smith* v. *Goodyear Dental Vulcanite Co.*, 93 U. S. 486, 498, the Supreme Court held with respect to an English patent: "Though the provisional specification was filed March 14, 1855, the completed specification was not until the 11th of September following. It was, therefore, on the last-mentioned date that the invention was patented."

The last clause of the statement above quoted obviously has no general application, but refers merely to the case then before the Court.

In the *Smith* v. *Goodyear case*, *supra*, the date when the British patent was granted to Goodyear was not important, except upon the question of the priority of the invention. It did not affect the validity of the patent which Goodyear took out in the United States. The question which the court was deciding was a very different one from the one in-

volved in the case at bar in which we are required to determine what is meant by the words "first patented * * * in a foreign country" as used in the statute. In Great Britain, while the rights of a patentee date back to the time when the completed specifications are filed, his rights do not become fixed and settled until the patent is "sealed." The specifications may be sufficient and approved but if the patent is not "sealed" he receives no certificate that a patent has been granted and no rights accrue to him as a patentee. We think, therefore, that the word "patented" as used in the statute refers to the time when plaintiff's right to a patent is fixed and determined and this in Great Britain would be the date when it is "sealed." In the case at bar the Lodge patent was not sealed in Great Britain until after it had been granted in the United States. We conclude therefore that Lodge's patent taken out in the United States cannot be held invalid by reason of the subsequent issuance of the British patent on the same invention.

It is urged that there was such laches in enforcing the claim for infringement under the Lodge patent as to prevent any recovery for that reason even if the patent be held valid.

Title to the Lodge patent was acquired by plaintiff on March 19, 1912, a little less than three and a half years before it expired. Mr. Marconi admitted in his testimony that his company had previously been openly infringing the patent since the time of its grant. The evidence also shows that the loading coil which is one of the basic features of the Lodge patent had been used openly by the Navy since 1903, by the Army since 1908, and by the Stone Wireless Telegraphy Syndicate in 1902. In fact, the Stone Company openly used the induction coil in its antenna for several years, but was never notified of infringement or sued under the Lodge patent. Suit could have been brought thereon as early as 1903 against the manufacturers of the apparatus manufactured by the Stone Wireless Telegraph System and other contractors who made it for the Govern-[fol. 71] ment. But this was all prior to the time that the plaintiff acquired the Lodge patent. About that time or shortly after it acquired the patent, as stated in Finding XII, the United States was orally notified with reference to the four patents in suit including the Lodge patent in the

winter or spring of 1912 at a White House conference at which the President and four members of the Cabinet were present and written notice of the two Marconi patents, and the Lodge patent, and their infringement was given by registered mail to both the Navy and War Departments on March 7, 1913, and March 8, 1913, respectively.

The facts recited above show clearly that prior to the time the plaintiff acquired the Lodge patent there had been such laches in asserting any rights thereunder that any person interested might well believe that the patent had been abandoned. The contention of the defendant is that the laches on the part of the owners of the Lodge patent prior to the time when plaintiff acquired the ownership thereof not only prevents a recovery for any use of the patented device prior to that time but in effect invalidates the patent and prevents any recovery for infringement thereof after notice was served upon defendant that it would be held liable for any infringement thereof. Several decisions are cited in support of this contention. All of them hold that the party to whom a patent has been transferred must bear the burden of the acts of his predecessors in ownership and where they have been guilty of laches the effect thereof carries on to the new owner. Consequently, where the apparatus alleged to infringe the Lodge patent had been purchased prior to the time when the notice was given by plaintiff to defendant, as shown above, there can be no recovery on account of such use. This rule we think will apply whether use was made of the patented device before or after the purchase of the apparatus used.

But as to apparatus purchased or any use of the patented device after notice of the plaintiff of intent to enforce its rights under the patent, we think the rule is different. None of the cases cited go so far as to hold that, after notice has been given that the owner of the patent will insist upon his rights, previous laches prevents any recovery for subsequent infringement arising from the use of apparatus made or purchased after the notice had been given. On the contrary, it was held in the case of *Simpson* v. *Newport News Shipbuilding & Dry Dock Co.*, 18 Fed. (2d) 318, 321, where the notice was given prior to manufacture and use by the defendant of the patented device, that previous laches on the part of the plaintiff with respect to other parties would not prevent a recovery. A recovery was denied only because the final conclusion was that the patent was invalid.

In the case of *Marconi* v. *National Co., supra,* which involved the same plaintiff and the same patent (Lodge patent), the plaintiff was not permitted to recover on account of use of the patented device prior to the suit but the patent was sustained and an injunction granted against further infringement. In this case the opinion does not show that the defendant received any notice with reference to the infringement prior to the time when the suit was begun. *Richardson* v. *Osborne & Co.*, 82 Fed. 95, is an extreme case. The suit was not begun until two months before the patent had expired. The opinion shows that the defendant had been using the patented device for nearly [fol. 72] fourteen years without being disturbed or molested and was carrying on a very large business with every reason to believe that the plaintiff would not make any claim under his patent. If the plaintiff had been permitted to maintain his suit, it is manifest that the defendant would have sustained a large loss upon investments made in good faith and the defense of laches was sustained. The opinion in this case cites a large number of cases bearing on the effect of laches generally. Only a few of these cases involve patents. The principles which relate to the effect of laches apply to all suits where laches in commencing a suit is shown and are not peculiar to patent cases. The rule of law which is applied is based upon the principle that it is manifestly inequitable to permit a plaintiff to recover upon an act of the defendant for which the plaintiff himself is largely to blame. In patent cases, while recovery is often denied on account of laches, the patent is not held invalid.

In the case at bar, we see nothing inequitable in holding the defendant liable where the apparatus alleged to infringe was made or purchased after the defendant was served with notice of plaintiff's claim, but where the apparatus was purchased or made prior to the service of such notice our conclusion is that there can be no liability.

Mere use of infringing apparatus after the notice was given, we think, is not sufficient to make the defendant liable. Where defendant purchased or made the apparatus before notice and had thus invested its money or gone to expense in good faith, having reason to believe that no claim would be made by plaintiff, we think the plaintiff would be estopped from complaining of the use of the apparatus after the notice.

Validity of the Lodge Patent

Before the Lodge patent was taken out it was known that with alternating currents of given frequency a circuit will carry its strongest current under a given pressure or voltage when there is a condition of resonance, or, in other words, when the natural period of the circuit corresponds with the frequency of the current. In the alternating-current circuit its natural period depends on the extent of its capacity and inductance, or self-inductance as it is sometimes called. It was also known that a helical coil of wire had principally inductance and an electric condenser had essentially capacity, and that variation in the amount of either the inductance or capacity changed the period of the circuit. The most important feature of the Lodge patent was the use of a self-inductance coil between a pair of capacity areas in the oscillating circuit of either or both a sending or receiving set for Hertzian wave telegraphy. As shown in fig. 9 of the patent drawings set out on page 15, Lodge made use of an adjustable coil whereby the extent of its self-inductance could be varied. The purpose of such a coil was to control the oscillations excited in the system and constitute the system a resonator or absorber of definite frequency or pitch, which acted cumulatively with a distant radiator of corresponding period also capable of acting cumulatively. By this method, as he stated in claim 5, "signalling may be effected between any two or more cor-[fol. 73] respondingly attuned stations without disturbing other differently attuned stations." (See claims 1, 2, and 5 of the Lodge patent as set out in Finding XXVIII.)

It is quite evident from the claims made by Lodge, as set out in Finding XXVIII and his diagrams of apparatus which accompanied the patent and which are set out on pages 14 and 15, that Lodge contemplated varying either the inductance or capacity or both in such a manner as to attain syntony or resonance and prolong the electrical oscillations excited in the system. An important feature of the apparatus for this purpose was the adjustable coil. The defendant, to show that Lodge offered no new invention when he proposed to tune the circuits in syntony, cites *Marconi* v. *National Co., supra*, in which Judge Veeder said: "Tuning the two circuits of a transformer was common knowledge, and was practised by Ducretet, Braun, Lodge, Tesla, and Pupin, and was described and used by Fessen-

den prior to 1900"; and also the decision of the British court in a case where the owners of the Lodge patent brought suit for prolongation of the Lodge British patent reported in Reports of British Patent Cases, vol. 28, page 365. In this case the court considered the third, fourth, and fifth claims of the Lodge patent with reference to tuning the transmitters and receivers and said:

"With regard to tuning, in the sense of varying the natural frequency of a circuit, it had long been well known that this could be done by varying either the induction or the capacity, or both the capacity and the induction of the circuit. For tuning his syntonic jars, Lodge had provided means for varying the induction. Under these circumstances, again, I cannot think that tuning by means of induction coils switched in or out as desired, or by means of adjustable induction coils can be considered in itself a great invention."

And the court refused to grant extension of these claims. Apparently the British judge considered that everyone skilled in the art would know that the effect of an induction coil could be varied by varying the number of separate turns of wire used and for this reason it was no invention to use an adjustable coil in the circuit for the purpose of tuning it. All this may be conceded and yet we think it does not render the Lodge patent invalid and ineffective as to infringement. Lodge's invention, as we view it, consisted of a new combination in which features which may be said to be old when considered apart and alone, were so associated as to produce new and valuable effects.

We do not think it is necessary to consider in detail the patents granted to Pupin, Hutin, Tesla, and Stone, referred to in the findings, although they were granted prior to the time the patent to Lodge was issued. These patents show that the laws of closed resonant circuits in general were known prior to the Lodge invention, but there is nothing in these patents which shows knowledge of the desirability of tuning an open oscillating circuit for Hertzian-wave signalling. Lodge took features that were old and combined them in such a way as to produce new and useful results which had never been accomplished before. While the laws [fol. 74] regarding the relationship of capacity and inductance to achieve the tuning of an alternating current cir-

cuit were known prior to Lodge's invention, no satisfactory evidence has been produced to show that the elevated wire of a Hertzian-wave transmitter or receiver and the ground connection were known to constitute an electric condenser in the open oscillating circuit prior to the Lodge invention. Lodge appears to have been the first to recognize that the elevated wire and ground connection constituted a condenser and was the first to realize the desirability of applying the known laws of resonance for closed circuits to a Marconi open oscillating circuit. The Marconi patent #586193 (the original patent which was reissued as the first patent in suit) contemplated the use of plates of such length that the receiver would be "electrically tuned with the electric oscillations transmitted", but there is no evidence that this method would work satisfactorily, and Lodge asserted at the time his patent was reconsidered that the method recited in the Marconi patent would not work at all. In any event, the evidence shows that if this method ever was put in use it was entirely superseded by the method which Lodge used. Lodge's invention increased the range for signalling with Hertz waves and it went into wide and almost universal use, superseding other methods.

We think on the whole that while none of the features of the Lodge patent may be said to be entirely new, Lodge had taken these features and in a new combination had so used the most useful function of each as to obtain better results than had ever before been reached. We conclude, therefore, that his patent was not void for want of novelty.

Tesla's patent #645576, the application for which was filed before that of Lodge, although the patent itself was issued later, is mentioned as anticipating the features of the Lodge patent. But the system of Lodge made use of a different combination from anything disclosed by Tesla and was operated differently.

It is said that the decision in *Marconi* v. *National Co.*, *supra*, which sustained the Lodge patent is based on erroneous assumptions, but we do not need to agree with all that Judge Veeder said in order to concur with his conclusion, which we think was well founded.

In the case of *Marconi* v. *Kilbourne & Clark Mfg. Co.*, 239 Fed. 328, the court treated the validity of the Lodge patent as being settled and held it was infringed. This case is chiefly useful as showing the improvements and special

features of the combination which Lodge used and the manner in which it operated.

The Lodge patent was also held valid in the case of *Marconi* v. *DeForest Radio Tel. & Tel. Co.*, 225 Fed. 65, affirmed 225 Fed. 373. If we are correct in holding the Lodge patent valid, then the defendant has infringed this patent by the use of the apparatus of the Wireless Specialty Company and other apparatus as more particularly set out in Finding XXXIV, and the defendant would be liable for such infringement unless it purchased or acquired the apparatus prior to the time it received notice from the plaintiff that it proposed to enforce its rights under the Lodge patent.

The Marconi Tuning Patent #763,772

[fol. 75] This patent is sometimes referred to as the "four circuit tuning patent" but is commonly called the Marconi tuning patent. The patent relates to means for providing a stronger transmitted signal in wireless telegraphy and means for rendering the receiver more selective than had resulted in the previous practice. Both the receiver and the transmitter had an open antenna circuit and a closed oscillation circuit which were tuned to the same frequency or time periods, and all four also synchronized. This resulted in having a somewhat stronger signal radiated by the transmitter and a more sensitive reception by the receiver. In this respect it was successful and went into wide use in the United States and elsewhere. It is claimed that by means of this invention there was a substantial increase in the distance of reliable radio transmission and reception and also an increase in the selectivity of radio apparatus which in turn made possible an increase in the number of transmitting stations which could be used at the same time without interfering with each other. Apparatus embodying the invention of #763,772 was employed in the first transatlantic radio signalling.

A number of claims under this patent are involved in the suit. These claims are set out in Finding XL which also contains an explanation of some of the more in portant claims in connection with the diagram contained in Finding XXXVIII. Some of these claims are directed to the transmitter, some to the receiver, and some to a communication system involving both the transmitter and the re-

ceiver. But so far as the validity of the patent is concerned it will not be necessary to consider these claims separately.

Two defenses are made against this patent, the first being that the patent is invalid and the second that there has been no infringement in any event. The alleged invalidity of the patent is based upon prior patents and disclosures.

Marconi had a great deal of difficulty in obtaining this patent. The original application for the patent was filed November 10, 1900. Before it was reached for action and on July 1, 1901, the entire original specification and all of the claims were canceled and a new specification and set of claims were substituted. The examiners who first considered the case rejected the application. During more than three years afterwards new applications and petitions for revival were filed and rejected by reason of the prior art set forth in the Braun British patent; Lodge #609154; Marconi #627650; and Tesla #645576. During the prosecution in the Patent Office of this patent, the examiner rejected all claims made therein except 15 basing his rejection on the Tesla patent #649621 and particularly said in his letter that claims 4, 13, 14, and 16, which specify a variable inductance and means for adjusting the inductance, were not patentable over Tesla because Lodge had shown that this was old, and the examiner also stated that claims 3 and 5, which specify an adjustable condenser, were not patentable over Tesla.

After this holding of the examiner, nothing was done by Marconi until October 6, 1903, when a petition was filed [fol. 76] asking that the application be revived. The examiner recommended that the petition be denied, citing as additional prior art a paper by Pupin and the Stone patent #714756 which had been issued on December 2, 1902, and on December 3, 1903, the Commissioner denied the petition to revive. At the time of filing the petition for revival on October 6, 1903, the applicant presented an amendment containing the present claims 1, 2, 3, 6, 8, 9, 10, 13, 14, 15, 16, 17, 18, and 20. Elaborate arguments and affidavits were submitted and the Commissioner submitted a long report in effect denying the application. Another petition for revival was presented on February 19, 1904, and granted by the Commissioner. The case was acted upon by a new examiner and all the claims formerly re-

jected by the other examiner except four were immediately allowed in accordance with a brief letter in which it was stated, among other things, that all claims which included the element of variable inductance were considered allowable over the Stone patent and that claims 4, 5, 6, and 7 would be allowed if amended by inserting the words "a variable inductance and" after the word "including" in line 3 of each claim.

Patent #763772 has several times been before the courts.

In the case of *Marconi* v. *National Co., supra*, this patent with other patents was in issue and was held valid and infringed as to claims 1-3, 6, 8, 10-13, 16-20. The device used by the defendant in that case had loose coupling, signifying a plain open gap. It is not clear whether the court considered the rotary and quenched gap apparatus involved in the instant case to be also infringements. Preliminary injunctions were granted in the case of *Atlantic Communication Co.* (not reported) and the *DeForest Radio Tel. & Tel. Co.*, 225 Fed. 65. In the case of *Marconi Wireless Telegraph Co.* v. *Kilbourne & Clark Mfg. Co.*, 239 Fed. 328, the validity of the patent was not determined but it was held that quenched gap transmitters did not infringe. In another case with the same plaintiff against the *United Wireless Telegraph Co.* in the Southern District of New York, claims 1 to 20 were held valid and infringed but the case has not been reported.

The British patent #7777, of 1900, corresponding to the patent in suit, was sustained as was also the corresponding French patent.

It will not be necessary to consider the claims of the patent in detail as the matter in controversy between the parties is confined to a narrow issue.

The fundamental principle of the patent is embodied in an apparatus utilizing a transmitting station of two circuits, an open antenna circuit and a closed oscillation circuit, which are coupled together and both of which are tuned to the same or substantially the same frequency or wave length; and the use of a receiving station of two similar circuits which are likewise tuned to the same or substantially the same frequency or wave length with each other and the transmitter.

All of the wireless sets of defendant made use of apparatus constructed in accordance with the principle which

formed the basis of the patent. We will, therefore, next [fol. 77] consider the question of the validity of the patent. In so doing it is important to observe that when used with reference to electrical circuits the words "tune" and "synchronize" have the same meaning and that when circuits are "tuned" or "synchronized" with each other they are said to be in "resonance."

Finding XLIII shows that the examiner who at first refused to allow the patent based his rejection on the patents of Tesla and of Lodge. Tesla obtained two patents prior to the Marconi tuning patent—#645576 and #649621. In these patents Tesla made use of an open antenna circuit and a closed oscillation circuit in both the transmitter and receiver, all of which were tuned together or synchronized. Tesla did not refer to the matter of tuning by adjustable inductance but one of the examiners who rejected Marconi's application stated that it was fair to assume Tesla intended to use either that method or a condenser, or both, to accomplish this purpose. This was necessarily so for these methods were known at the time and it could be accomplished in no other manner.

Judge Veeder in the *National Electric Sig. Co. case, supra*, says that Tesla's patent #454622 of 1891 contains no suggestion of tuning and seems to lay great stress upon that fact. This patent is not in evidence in the instant case and is not before us. Tesla's patent #645576 of date March 20, 1900, the application for which was filed before the Lodge patent, was upon a four circuit system and referred to the synchronization of the circuits no less than six times therein. In one place he says "the primary and secondary circuits in the transmitting apparatus being carefully synchronized, * * *"; and that "the results were particularly satisfactory when the primary coil or system *A'* with its secondary *C'*, was carefully adjusted, so as to vibrate in synchronism with the transmitting coil or system *AC*."

Finding LXII includes a diagram of Tesla's system as set out in his patent. The specifications show that Tesla had the two circuits in the transmitting apparatus synchronized or tuned together and the two coils in the receiving apparatus tuned together and made to "vibrate in synchronism with the transmitting coil." Further on Tesla specifies "the feature of a transmitting and receiving coil

or conductor, both connected to the ground and to an elevated terminal and adjusted so as to vibrate in synchronism."

In three other places Tesla refers to the circuits of his system being "synchronized." Just what method he proposed to use for synchronizing the circuits is not stated, but Lodge had shown how it could be done by the system of adjustable inductance and as we have specially found (see Finding LXII), anyone skilled in the art was capable of applying the Lodge method of tuning to the Tesla system. The last Patent Office examiner in his letter of March 31, 1904, giving reasons why the patent should be granted, after referring to the method used by Stone to synchronize the circuits, said:

"Applicant discloses another means whereby the same result may be effected, viz. by including a 'variable inductance' in the elevated conductor. All claims which in- [fol. 78] clude this element are considered allowable over the Stone patent.

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"Claims 4, 5, 6, and 7 will be allowed if amended by inserting the words *a variable inductance and* after the word 'including' in line 3 of each claim."

From this statement it is evident that the only basis the examiner could find for allowing the claims was the feature of variable inductance in a specific location as a means of bringing all the circuits into resonance. The examiner does not seem to have given very careful consideration to the matter at hand for he overlooked the fact that claims 10 and 12 as well as claims 4, 5, 6, and 7 contain no reference to variable inductance. He should have known that Lodge had shown and patented the use of a variable self-inductance coil to attain a condition of resonance or syntony between circuits, and it cannot be contended that the feature of variable inductance was new in itself. Marconi used it for the purpose of doing what Tesla had done without specifying the method. After Tesla had filed his application in #645,576, Lodge showed how it could be applied and advantageously used in the application for his (Lodge's) patent. Tesla filed his application for #645,576 in September 1897. Lodge filed his application February 1, 1898. Tesla therefore did not have the knowledge of the manner in which

Lodge made use of the principle of tuning by adjustable inductance, and as Lodge's patent was issued in 1898 and Tesla's #645,576 not granted until 1900, it may be that neither knew of the work of the other. But after these patents were issued it was only necessary to put them together to have the Marconi system. We think the examiners who first rejected the Marconi application were right and that the last examiner who granted the patent was wrong.

Judge Veeder in the *Nat. Electric Sig. Co. case, supra*, calls attention to a new theory propounded by Tesla in his divisional patent #649,621 and seems to consider that because Tesla's theory was different from that of Marconi, Tesla's system does not anticipate that of Marconi. But we are not here concerned with theories. What we have to deal with are Tesla's specifications, the apparatus which he described, the manner in which he proposed to use it, and the effects which it would accomplish. He may be and probably was entirely wrong as to some of his theories but there is no doubt about these essential matters. Claim 10 of the Marconi patent recites:

"A system of wireless telegraphy, in which the transmitting-station and the receiving-station each contains an oscillation transformer, one circuit of which is an open circuit and the other a closed circuit, the two circuits at each station being in electrical resonance with each other and in electrical resonance with the circuits at the other station, substantially as described."

The specifications of this claim are repeated in a different form and with different words in claim 3 of Tesla's #649621. If anything is lacking it is supplied elsewhere in other claims made in Tesla's patent. In this connection it should be said [fol. 79] that some importance has been attached to the fact that Marconi used a persistent oscillator, but Tesla also describes a persistent oscillator. Claim 10 is sometimes referred to as the "broad claim" of the Marconi patent. It is quite plain that it was anticipated by Tesla whatever his theories may have been, and so far as the other claims of the Marconi tuning patent are concerned we think we have already shown good reasons why they should be rejected.

It is sometimes said that Tesla's purpose was only to transmit electrical energy, but the electrical waves trans-

mitted by any wireless system are merely one form of electrical energy. Moreover, the specification of Tesla's patent recited that the method of energy transmission would be useful when it was desired to transmit intelligible messages great distances. In view of this statement it would be within the knowledge of those skilled in the art to interrupt the continuous generation of high-frequency energy in the transmitting system by a telegraph key and substitute for the current receiving instrumentalities disclosed in connection with the receiving system a radio signal detector device.

If we are correct in what has been stated above, the Marconi tuning patent is invalid, but it should be noted that other defenses are strongly urged by the defendant based upon the Stone patent and certain disclosures made in letters written by Stone. As stated above, Stone's application was filed prior to that of Marconi and his patent was also granted before that of Marconi, although it was not allowed until after an amendment to the specifications had been made and this amendment was filed after Marconi's application.

Stone, in the original application for his patent, discloses a four-circuit system in which the transmitting and receiving open circuits are each associated with a closed circuit and the two closed circuits are tuned in resonance with each other. As we have before stated, all of the different features of the Marconi patent considered separately and individually were old and Marconi could obtain a valid patent only by proposing a new combination of these features which produced new results and this combination also must not be one which would naturally suggest itself to one skilled in the art. Here again in connection with Stone's patent we conclude that Marconi's patent does not come within this rule. Tesla had shown the advantage of all four circuits being syntonized; Lodge had taken the two-circuit system and tuned or synchronized the open circuits in the same manner afterwards used by Marconi; Stone had disclosed in his original application a four-circuit system in which the closed circuits were tuned together. A consideration of these three systems would naturally suggest to one skilled in the art the tuning of all four circuits together by the use of the adjustable self-inductance method in the manner proposed by Lodge, and Stone put this suggestion into practice when he filed the amendment to his specifications. Marconi used the suggestion earlier in the application for his

patent, but under the circumstances as we think neither Stone nor Marconi was entitled to credit for it.

A quite unusual situation is presented by the conflicting patents of Marconi and Stone. As before stated, Marconi applied for the patent which subsequently became #763772 November 10, 1900. Stone filed the application for his patent on February 8, 1900, and on April 8, 1902, Stone filed an amendment to his specifications which proposed a four- [fol. 80] circuit system with all the circuits synchronized. His patent was allowed on December 2, 1902, while the Marconi patent #763772 was not granted until June 28, 1904. In 1899, Stone wrote two letters to a friend of his by the name of Baker in which he disclosed a four-circuit system with all the circuits synchronized, but, as we have seen, he did not actually put such a system in practice until he filed the amendment to his specifications on April 8, 1902.

The Stone patents and disclosures were not before the British court, or Judge Veeder in the *National Electric Sig. Co. case, supra*, but were before the court in the *Kilbourne & Clark Co. case, supra*, decided by Judge Neterer. In the argument for plaintiff it is said: "Judge Neterer overruled this defense." The opinion of Judge Neterer shows that he considered the Stone letters and that they disclosed a four-tuned circuit system. It was unnecessary for him to pass on the validity of the Marconi tuning patent and he did not do so for the reason that he found there was no infringement. If any inference is to be drawn from his opinion it is that it was proper to take into consideration the Stone letters.

It is contended with much force on behalf of the defendant that the letters written by Stone which are referred to in Finding LV anticipated the Marconi patent even if it otherwise be held to be valid, but it is not necessary that we should decide whether a private letter such as Stone wrote to his friend would constitute a disclosure which would affect the Marconi patent, for without considering these letters we think patent #763772 was invalid for the reasons stated above, except as to claim 16, which relates to a matter not covered by the other claims.

Some argument is made in favor of the Marconi patent, based upon the fact that Marconi made use of a persistent oscillator, but this was used in the earlier Marconi patent #586,193. The use of the persistent oscillator is, we think, important only when the question of infringement by the use of the quenched-gap apparatus is considered.

The alleged infringing apparatus may be classified in three groups: (*a*) The plain open-gap apparatus; (*b*) that having a rotary gap; (*c*) the larger group using a quenched gap.

If we are correct in holding that the Marconi patent #763,772 is invalid, there would, of course, be no infringement in any event, but if it should be held that the patent was valid then it becomes necessary to consider whether any or all of the apparatus used by defendant infringed thereon. We think it clear that the plain open-gap apparatus would be an infringement if the patent was valid, and we are likewise of the opinion that this would be true as to the apparatus using the rotary gap which, as we think, was merely a variation of the plain open gap and apparently used for the purpose of cooling the terminals used in making the gap across which the spark passed. In this connection it should be observed that Marconi did not confine his patent to any particular kind of spark producer and evidently intended that any known kind might be used. The rotary gap might in some respects have been superior to the plain open gap, but it did not function in any different manner.

The form of the device which constituted the quenched-gap spark producer and its action as such are set forth in [fol. 81] Finding XLVIII. The evidence is conflicting as to whether in its effect upon other parts of the apparatus it functioned differently from the plain open gap. In any event, it would seem that it was only another device for a spark producer and that Marconi in an earlier patent had shown a somewhat similar contrivance. It also appears that when it was used it was necessary to follow the same method of tuning as before. On the other hand, this device apparently was more efficient than the plain open gap for in a comparatively short time it largely displaced the latter system.

In view of the fact that we have found the Marconi patent #763,772 invalid except as to claim 16, we do not find it necessary to determine whether apparatus making use of the quenched gap constituted an infringement.

Claim 16 is set out in Finding XL. We shall not consider it at length as we have no doubts with reference to its validity. It relates to a different subject matter from any of the other claims and is directed to a combination of elements which is new and useful.

The claim refers to a receiving station in which the principal features are the combination of an oscillation transformer with an open circuit connected with one coil of the transformer and including an oscillation-receiving conductor at one end and capacity at the other end, with an adjustable condenser in a shunt connected with the open circuit and around the transformer coil, a wave-responsive device electrically connected with the other coil of the oscillation transformer, and means for adjusting the two transformer circuits in electrical resonance with each other. These features are shown in the diagram of the receiving station found in fig. 2 of Finding XXXVIII, where the means for adjusting the two transformer circuits in electrical resonance with each other are indicated. It may be said, however, that the purpose of the adjustable condenser in shunt with the primary winding of the transformer in the open circuit of the receiver is not described in this patent; but the specifications of the patent include tables showing the preferred adjustments in connection with the induction coil as numbered therein, and we think these tables would indicate to one skilled in the art that the use of the condenser connected in shunt with the primary winding of the transformer of the receiver was for the purpose of enabling the electrical periodicity or tuning of the open circuit of the receiver to be altered and adjusted. So far as disclosed by the evidence, prior to the Marconi patent, no such apparatus had ever been used or devised. Being new, if it was useful, it was patentable. Its usefulness, we think, is shown by the fact that the receiving apparatus of the Kilbourne & Clark Company and that made by the Telefunken Company used by the Government embodied this device. Claim 16, therefore, is valid and was infringed.

The Fleming Patent, #803684

Granted November 7, 1904

This patent is entitled an "Instrument For Converting Alternating Electric Currents Into Continuous Currents", and the nature of the invention patented is well described in the patent itself (page 1, line 11) as follows:

[fol. 82] "This invention relates to certain new and useful devices for converting alternating electric currents, and especially high-frequency alternating electric currents or

electric oscillations, into continuous electric currents for the purpose of making them detectable by and measurable with ordinary direct-current instruments, such as a 'mirror-galvanometer' of the usual type or any ordinary direct-current ammeter."

Fleming's patent was granted during a period when the development of electric communications without connecting wires was extremely active. Out of the work of electrical scientists during this period grew some of the most marvelous discoveries of the properties of electricity, and great progress was made in the art of reproducing the human voice and musical tones by means of wireless apparatus in the form of what we now call radio communications. Fleming's patent in some respects was new but the defendant contends that it was new only in the use of a discovery that had been made long before Fleming applied for his patent. The apparatus used by Fleming is not very complicated. A detailed description of it with drawings is found in Finding LXIV, but we think it will be easier to understand its fundamental principles if we go back to a prior patent.

Edison was granted patent #307,031 on October 21, 1884. In Edison's apparatus he made use of an ordinary incandescent lamp which, as everyone knows, consists of a glass vacuum tube containing a filament through which an electric current is passed bringing it to a very high degree of heat. Fig. 4 of Finding LXX shows the tube marked *A* and within the loop made by the filament a plate marked *b* which is connected with a wire which passes down and out of the tube and forms another circuit (not shown in the figure) by being connected with the lamp circuit. After Edison's patent came out scientists experimenting with his tube observed that there was a unidirectional current flow in the vacuous space between the heated electrode of the lamp filament and the plate electrode, and that if an alternating current were applied to a circuit, including the plate and filament, rectification would take place and the resultant current flow would be unidirectional. This change from an alternating current to a direct current flowing only in one way has been referred to as rectifying the current and the apparatus producing this result has been termed a rectifier. Why it passed only in one direction has never been very satisfactorily explained but the fact that it

did so pass attracted the attention of scientists the world over. Fleming himself disclosed this fact in a lecture before the Royal Society in 1890. Clark Howell in a paper read before a meeting of the American Institute of Electrical Engineers in 1897 described and illustrated the "Edison effect" and mentioned the fact that if an alternating current is used to render the filament incandescent the additional current thus produced is unidirectional, and at the same meeting Dr. Kennelly said that so far as he knew this paper pointed out for the first time that an alternating current passing through an incandescent lamp giving the "Edison effect" is capable of producing in a branch circuit through a third wire in a lamp continuous or at least unidirectional currents. These proceedings were published to the world.

[fol. 83] Edison did not mention this feature in his patent and probably was not aware of it at the time he took it out, but if an alternating current was impressed upon the hot and cold electrodes of his apparatus it would function so as to rectify the current and change it from one that was alternating to one that was continuous in the additional closed circuit.

The descriptive matter taken from the Fleming patent as originally filed and set out above shows that one of its principal features is the device for converting alternating currents into direct currents whereby his apparatus acted as a rectifier. The apparatus of the Fleming patent used for rectifying the current is shown by fig. 1 in Finding LXIV, and if we examine it with respect to the vacuum tube shown therein with its heated electrode (the filament of the lamp) and its cold electrode connected with an outer closed circuit, we find that it is substantially the same as the corresponding part in the apparatus of Edison. Edison used for his cold electrode a plate placed within the filament loop while Fleming used for his cold electrode a cylinder outside of the filament loop, but this is an immaterial variation.

It is contended on behalf of defendant that the Fleming patent involves nothing more at most than a new use which is not patentable. There seems to be much force in this contention. Fleming made no substantial change in the structure of the Edison vacuum tube with its hot and cold electrodes. His first claim as originally made when taken in connection with his specifications is merely a restatement

in different words of claim 5 of the Edison patent. It is true Fleming does not refer in claim 1 to an incandescent electric lamp as Edison does, but his explanations and specifications show he intended that an incandescent lamp should be used, also that there should be two circuits and that the terminals and connections thereof should be substantially the same as those specified in the Edison patent. In the use of the respective patents, however, there was an important difference. Edison believed that the current flow through his tube was proportionate to the degree of incandescence or candle power of the filament and connected his tube in circuit with a galvanometer or relay for indicating or controlling conditions in the filament circuit. While his apparatus was capable of rectifying an alternating current he did not make use of an alternating current. On the other hand, Fleming used an alternating current which was rectified by the Edison tube and he also made use of the rectified current in connection with additional apparatus in such a way that it operated a detector in transmitting wireless messages. In this respect his apparatus was new and useful.

As a general rule a patent cannot be based upon a new use of an old device but to this rule there are exceptions. Judge Mayer in *Marconi Wireless Tel. Co.* v. *DeForest Radio T. & T. Co.*, 236 Fed. 942 (affirmed 243 Fed. 560), held in substance that the use which Fleming made of the rectified current and the manner in which he applied it constituted invention. He accordingly upheld the Fleming patent and his decision was sustained by the Court of Appeals. We need not, however, pass upon the question of whether the Fleming patent merely sets forth a new use of an old device as there is another and more decisive objection to its validity.

[fol. 84] It must be conceded that the original application for the Fleming patent contained specifications of inventions that were not new, and upon which the applicant was not entitled to a patent. Making a claim known to be void ordinarily vitiates the entire patent. The statutes, however, provide that under certain conditions the invalidity may be avoided by a disclaimer. In the case of *Ensten* v. *Simon, Ascher & Co.*, 282 U. S. 445, 452, the Supreme Court said with reference to these statutes:

"Construed together they 'enact that where a patentee claims materially more than that which he was the first

to invent, his patent is void, unless he has preserved the right to disclaim the surplus; and that he may fail to preserve that right, by unreasonable neglect or delay to enter a disclaimer in the Patent Office.' Walker on Patents, 6th ed., Sec. 254."

We have already shown that the patent recited that the invention related to new devices for converting alternating electric currents into continuous electric currents, and Fleming stated further in his patent:

"I have discovered that if two conductors are enclosed in a vessel in which a good vacuum is made, one being heated to a high temperature, the space between the hot and cold conductors possesses a unilateral electric conductivity, and negative electricity can pass from the hot conductor to the cold conductor but not in the reverse direction."

But this was not a new invention. As stated above, Fleming himself some fifteen years before (1890), in a lecture, showed that the current flowed only in one direction when an alternating current was used in connection with the lamp of an Edison apparatus, and discussed the flow of current from the hot negative terminal of the lamp to the cold electrode of the plate, observing that negative electricity flowed from the plate into an additional circuit connected with the lamp. In 1897 similar statements made by Howell and Kennelly were published. In stating this feature in his patent specifications as new and patentable, Fleming must have known that he was making a claim that could not be sustained. There could have been no inadvertence in making this statement, and this matter alone would seem to be sufficient to render the Fleming patent invalid. True, he entered a disclaimer later, but the statutes which give relief where invention has been wrongfully claimed do so only on the condition that the inventor has not unreasonably neglected or delayed to enter the disclaimer. In the case at bar the disclaimer was not entered until eleven years after the patent had been taken out and long after other inventors had discovered other and different methods of making use of the Edison device without claiming to have invented it. We think that if ever there was a case of unreasonable delay in making the disclaimer it is presented in what is now before us and that the Fleming patent must be held invalid for that reason.

The defendant also raises the question as to whether any proper part of the patent was disclaimed, as seemed to be required in *Corn Products Refining Co.* v. *Penick & Ford*, 63 Fed. (2d) 26, and also in *Grasselli Chemical Co.* v. *National Aniline Co.*, 26 Fed. (2d) 305, but we need not determine this question as we think the patent is void in any event for failure to make disclaimer within a reasonable time.

[fol. 85] Even if the Fleming patent be held valid, it is still contended on behalf of defendant that there was in fact no infringement. The determination of this issue makes it necessary to examine more in detail the claims and specifications of the patent and the apparatus described therein.

The invention of the Fleming patent #803684 relates to a rectifier that is suitable for use as a part of a detector with very high frequencies encountered in radio signalling to permit the use of an ordinary direct-current galvanometer to indicate the presence of the signals. The diagram figures in Finding LXIV reproduce the drawings of the Fleming patent, and it will be necessary to turn to this finding to understand the drawings and the description thereof as given in the finding. This description will not be repeated here. In general, however, it may be said that the Fleming device made use of a receiver consisting in part of a vacuum bulb within which was an aluminum cylinder suspended by platinum wires from the glass bulb. Within the cylinder was a carbon filament supplied with an electric current somewhat in the same manner as in an incandescent lamp, with the result that the filament is heated to a very high temperature and the current flows or was intended to flow only in one direction between the filament and the cold electrode. The radio-frequency impulses received in the antenna are induced in the closed circuit of a transformer and rectified by the vacuum tube, with the result that half of the radio-frequency waves are lost and half pass through the vacuum tube and are effective to actuate a direct-current galvanometer. Fig. 1 of the diagrams set out in Finding LXIV shows what is called the Fleming valve because it cuts off part of the current. As this valve tends to reduce the current flow, a method is shown in fig. 2 of reducing the loss of current, and fig. 3 shows how a number of these so-called "one-way valves" may be used to increase the possible current flow.

The claims in suit under the Fleming patent are numbered 1 and 37, and are set out in Finding LXV.

On November 17, 1915, the assignee, plaintiff herein, filed a disclaimer limiting the application of certain claims including claim 1, except when used in connection with high-frequency alternating electric currents or electric oscillations, and also eliminating words which showed that the apparatus described in the patent was intended to produce low-frequency currents or to make use thereof. The word "detector" as used in Fleming's specification plainly referred to a device adapted to make feeble high-frequency impulses measurable with an ordinary direct-current mirror-galvanometer, or, in other words, the term "detector" includes both the rectifier tube and the direct-current indicator of the rectified current. The term as used in the Fleming patent, however, did not include all apparatus associated with the detector tube, and did not include any amplifying tube or tubes.

The so-called Fleming valve, as shown in the description, had only two electrodes, and did not go into any extended commercial use, only about 700 Fleming valves having been shipped by plaintiff to anyone between 1910 and 1915. While in some respects an improvement on the crystal detectors, it did not entirely displace them. There is no evidence that the United States used any sets with two electrode tubes. Instead it used the three-electrode [fol. 86] which were much superior. The Navy used what is known as the DeForest audion which had a three-electrode tube, and will be described later on to show the difference between apparatus using the two-electrode tubes, and those using the three-electrode tubes.

In *Marconi* v. *DeForest, supra*, claims 1 and 37 were held valid and infringed by an audion detector having three electrodes. In another case with the same title, 261 Fed. 393, the decree rendered in the former suit was extended and Judge Mayer held the two-electrode tube to possess the same inherent ability to generate radio waves that is possessed by the three-electrode audion, and in effect that although Fleming did not know what could be accomplished with a three-electrode tube, and did not contemplate using it, he was entitled to the benefits of the device. With this conclusion we are unable to agree for many reasons. The basis of our conclusion is what we consider to be the fundamental difference in the manner in which the two-electrode tube and the three-electrode tube function.

The three-electrode tube was invented by DeForest in 1906 and patented by him in 1908. It is so called because it interposed between the heated electrode of the filament and the cold electrode of the plate or cylinder used by Fleming a third electrode in the form of a spiral of wire called the "grid", which was connected with the closed input circuit. To bring out clearly the distinction between the two patents, it will be necessary to consider just what features were covered by the Fleming patent after the disclaimer had been filed, what effects were accomplished by it, and what results attained as compared with the three-electrode apparatus used by the Government.

The Fleming patent did not include the discovery that an alternating current could be rectified by the use of what we might call the Edison tube so that only a direct current would pass through the outside circuit, nor could his patent include the discovery that the negative electrons emitted by the heated filament were of very small mass, or that the electron stream could be controlled by the potential of the cold electrode which occurs in rectifying an alternating current. In general, it may be said that the Fleming patent did not include the discovery that the Edison two-electrode valve was a suitable rectifier to change the alternating current into a direct current, nor did it include all uses for the electron emissions from the heated electrode.

Claim 1 of the Fleming patent recites:

"1. The combination of a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for heating one of the conductors, and a circuit outside the vessel connecting the two conductors."

These features which form the foundation of the Fleming patent are each and all, as we have shown above, old in the sense that they were well known to the prior art and the patent would therefore be invalid if it were not for the disclaimer which puts these features to a new use which is made more definite by claim 37 and the disclaimer. Claim 37 applies the apparatus to "electrical oscillations of high frequency" and as a detector uses the combination stated in claim 1. The disclaimer disclaimed the combination of elements in the claims "except as the same are used in connection with high-frequency alternating electric currents or electric oscillations of the order employed in Hertzian

[fol. 87] wave transmission", and also omitted the words referring to low-frequency currents appearing elsewhere in the patent application, thereby showing plainly that it was not intended the patent should apply to electric oscillations or currents of low frequency.

The invention described in the patent was broad enough to show to one skilled in the art the desirability of using the Edison two-electrode vacuum tube as a rectifier for radio frequencies of high oscillations. By the term "detector" Fleming's specification meant to one skilled in the art a device adapted to make feeble high-frequency impulses measurable with an ordinary direct-current mirror-galvanometer, and the term "detector" includes both the rectifier tube and the direct current indicator of the rectified current, but not any amplifying tube or tubes which were not mentioned in the Fleming patent and not discovered until after it had been taken out. Apparently Fleming had not thought of their use in connection with the apparatus described in his patent.

The defect in the Fleming apparatus arose from the fact that instead of amplifying the flow of the current (alternating current so rectified as to become direct current) it was reduced. It was sought to overcome this reduction by using a number of the one-way valves as shown by fig. 3 of the patent, while the three-electrode tube used by the Government tended to amplify the current and for this reason was much superior to anything that could be effected by the Fleming apparatus. The evidence shows that in the trial before Judge Mayer the two-electrode tube was made to amplify by the ionization of the residual gas in the tube, but there is nothing in the patent to indicate that anything of this kind was contemplated nor is there any satisfactory evidence to show that a Fleming valve was ever commercially operated in this manner by anyone. On the other hand, the evidence tends to show that this method was so unstable and uncertain it could not be used commercially.

The evidence also shows that the two-electrode tube can be made to amplify by means of a field outside the tube controlling the electron flow in a specially shaped tube. The effect obtained was similar to the control exerted by the grid of the three-electrode tube, but there is nothing inherent in the Fleming valve nor in the patent descriptions and specifications that would suggest the use of such a tube. On the other hand, De Forest discovered that the

three-electrode tube had a different effect upon the current from that produced when a two-electrode tube was used, and most important of all, that when the three-electrode tube was used the effects of the current flowing in the input circuit could be greatly amplified. The invention of the three-electrode tube and its amplifying use had a greater effect on the art than the two-electrode tube and the apparatus as described in the Fleming patent. The Fleming tube did not possess any inherent ability to generate radio waves and it could not be made to amplify them, except by circuit connections never appreciated by the inventor of the patent in suit. The defendant never operated any two-electrode tubes by any of the methods above mentioned.

The alleged infringements are all based on the use or sales of three-electrode tubes and apparatus for using them. The general construction of the apparatus for using three-electrode tubes is shown in the diagram of the De Forest audion set out in finding LXXV. This apparatus was used by the Navy and contains the principal and most important features of the apparatus which made use of the [fol. 88] three-electrode tube. The same finding describes at length in connection with the diagram the special features of the apparatus and its purpose. This descriptive matter will not be repeated except to show the difference between the De Forest invention and that of the Fleming patent. One of the marked differences was that the Fleming patent contemplated detection by rectification of the full radio or high-frequency oscillations impressed upon an indicator adapted to register the strength of the rectified one-way pulsating current, while the three-electrode tube in the diagram set out in finding LXXV and marked "Exhibit 83" detects by substantially suppressing the high-frequency oscillations and amplifying principally the low or audio-frequency oscillations. In this connection it will be remembered that the plaintiff filed a disclaimer with relation to the patent now under consideration which in effect withdrew its claims except as they related to high-frequency currents or oscillations. In contrast, the De Forest audion made use of the low-frequency oscillations. Part of the reason for this was because the audion was intended to be used in connection with a telephone, and the low-frequency oscillations are better adapted for use with that instrument.

The De Forest audion introduces the new feature of the so-called "grid" (marked "G" in the diagram), illustrated in Finding LXXV, which makes a third conductor or electrode in the outer tube marked "T" which contains three conductors adjacent to but not touching each oth and means for heating one of the conductors.

The purpose of the apparatus making use of the third electrode was to effect a control of the electron stream and to furnish a means of amplifying the radio signals. This third electrode is connected to an input circuit and is separate from the output circuit, which contains an additional source of energy, with the result that a radio signal impressed on the input (grid) circuit is reproduced in amplified form in the output circuit; also the grid circuit constitu[illegible]s a means for impressing upon the plate circuit principally the audio (low) oscillations received and not the radio or high-frequency oscillations contemplated by claim 37 of the patent. These high-frequency oscillations are substantially suppressed by the grid condenser of the three-electrode tube, while the Fleming patent, as before shown, contemplated detection by rectification of the radio or high-frequency oscillations as impressed upon an indicator. The great advantage of the apparatus used by the defendant was that it could be so used as to amplify almost indefinitely the received signal and thus enable communications to be made over far longer distances and with much greater accuracy than could be accomplished when the two-electrode apparatus was used with its reducing effect.

Counsel for plaintiff cite the case of *Marconi* v. *De Forest*, *supra*, as adjudicating the validity of the Fleming patent and holding that it is infringed by the De Forest audion. On behalf of defendant it is urged that the opinion rendered therein shows that both sides were suing upon two-electrode patents but as the patents involved in that suit have not been offered in evidence this cannot be definitely determined. It does appear, however, from all of the evidence in the cases between the plaintiff and the De Forest Company that both sides represented to the court and agreed that the inherent qualities of the two-electrode tube and the three-[fol. 89] electrode tube are the same. This being admitted by counsel, the decision, of course, was based upon that conclusion. If this conclusion was not correct, and we think it was not, the decision last cited has no application to the instant case. It should be observed, however, that the case

involved ten patents, of which certain ones belonging to the plaintiff were held valid and infringed and as we understand the opinion it would seem that certain of the De Forest patents were also held valid. But we have nothing before us from which we can determine what was covered by these patents respectively and consequently cannot say how far Judge Mayer's decision went. The decision recites that the plaintiff (Marconi Co.) confessed judgment on two of the De Forest patents, and it is said that "De Forest in his three-electrode audion has undoubtedly made a contribution of great value to the art and by the confession of judgment in respect thereof defendant company may enjoy the just results of this contribution", and a type of the De Forest audion was used by defendant in the case now before us. But it is not necessary for us to determine whether any of the De Forest patents were valid. What we have to determine in this case is whether the De Forest audion and other three-electrode apparatus used by defendant as shown by the findings constituted an infringement. One other matter which should be considered on this point, as we view it, is that a comparison of the apparatus of the De Forest audion, as shown in the diagram in finding LXXV, with the Edison apparatus, as shown in fig. 4 in finding LXX, definitely establishes that the De Forest audion, with the exception of the added third electrode in the form of a grid and the additional circuit attached to the grid, used absolutely nothing but what had been pictured by Edison long before Fleming thought of it; and that the additional apparatus used by De Forest was something that Fleming had never imagined and was not suggested in any way by his patent. What De Forest accomplished thereby could never be effected by the use of the Fleming tube, except by the use of some special additional apparatus never contemplated by Fleming and never put into commercial or practical use.

The defendant not only introduced new features in the apparatus which it used but the apparatus functioned altogether differently from that of Fleming's and produced different and improved results.

Dr. Van der Bijl, a noted radio expert, was quoted with approval by Dr. Miller, a witness in the case, as follows: "In fact, the insertion of the grid into the valve resulted in a device of tremendous potentialities, one that can justly be placed in the same category with such fundamental de-

vices as the steam engine, the dynamo, and the telephone." And also, "It is hardly necessary to say that the insertion of the grid has made the audion a device of immense practical importance and enabled it to perform functions that would otherwise have been impossible."

Plaintiff's expert, Weagant, practically admits that these quotations state the fact correctly, but says that "the two-electrode Fleming valve is the foundation on which this important structure has been reared, and, as has been demonstrated in my recent tests, possesses inherently all of the characteristic capabilities of the three-electrode tube." This statement of Weagant's is the foundation of plaintiff's case. Let us see how it agrees with the facts [fol. 90] shown in evidence and the reasonable deductions that may be drawn therefrom.

We have already shown how different was the function of the three-electrode tube from the two-electrode tube, but Weagant says that the two-electrode tube can be made to function in the same manner "by means of an electrostatic field control of the electron stream." He does not explain how, but it was shown elsewhere in the testimony that it was by means of an electrostatic field being brought close to a specially shaped bulb of the Fleming valve but outside of it, the effect of which was to a greater or less extent to deflect the electron stream from the heated filament. In the De Forest apparatus the "grid" was placed inside of the bulb and not outside and, as we have seen, functioned in a very different manner. But perhaps the most complete and fatal objection to this claim for the Fleming patent is that while it was shown by tests at the trial that the Fleming tube could be made to amplify in this manner, there was nothing whatever said in the Fleming patent about such an amplification and not the remotest suggestion of setting up an outside field to produce an amplifying or oscillating effect. Apparently no one ever thought of anything of the kind until the three-electrode tube had gone into successful use—in fact, into universal use so far as long distances had to be overcome. After experiments with the three-electrode tube had shown how superior it was not only to the Fleming two-electrode tube but even to the crystal detectors some of which were much more effective than the Fleming apparatus, after a disclaimer had been filed on the Fleming

patent, and after suits had been begun for its infringement; in short after all this had taken place, someone found that some of the same results could be produced with the Fleming valve in the manner described above and demonstrations were made on the trial of cases affecting the De Forest patent. When it comes down to the case before us, we find that years have elapsed since that discovery was made and yet there is not a syllable of evidence to show that this method, which is now said to be inherent in the Fleming patent and by which the same results could be accomplished as by the three-electrode tube, has ever been commercially used, nor is there any evidence that it ever was used in a practical way, although there can be no doubt that the plaintiff would have produced testimony on that point if it could be obtained. On the other hand, although De Forest was probably not conscious of the full limits to which his invention might be extended, it is a matter of common knowledge that the three-electrode tube came into general use for long distance purposes superseding even the best of the crystal detectors. The Government at all times and especially in war times had need of the best which could be obtained and it never used any of the two-electrode tubes. All the tubes which it used were of three electrodes. In fact, only about 700 of the Fleming valve two-electrode tube sets were ever put out, so completely did the three-electrode tube surpass them.

The Circuit Court of Appeals in *Marconi* v. *De Forest*, *supra*, says that in the audion the high-frequency oscillations and their electrical result get into the indicator or battery circuit just as in the Fleming valve. This, we think, is quite incorrect. The audion excluded the high-frequency oscillations but what is more important it used two circuits in transforming the alternating current and functioned alto- [fol. 91] gether differently. It is said that a detector must act on alternating current and that this makes the defendant (De Forest) an infringer although he invented an improved detector. If by the word "detector" is meant the tube containing the heated filament, it is true that an alternating current is used both by Fleming and by De Forest in his audion. But this does not make the audion an infringement for De Forest used it in a different combination, with different apparatus and for a different purpose. It is true

Fleming discovered that Edison's apparatus could be used to transform the alternating current into a direct current, as shown by his article before referred to, but all this was several years before his patent was issued and could not be patented. The audion made use of Edison's apparatus and the discovery that the alternating current was thereby rectified, but beyond this it made use of a new device which was probably the greatest improvement that has ever been effected and upon which all long distance wireless communications still depend.

It is contended that when DeForest introduced the screen grid he merely divided the current which entered the tube and passed in and out of the heated filament and that there was no invention in so dividing it. We are not impressed with this argument. Ever since the possibility of wireless communication in some manner entered the brain of Hertz, scientists have been experimenting to ascertain what could be done with original current to extend the distance in which its effects could be felt or made manifest in a distant apparatus. In so doing, they have strengthened the current by parallel coils and condensers; they have varied it with spark gaps, with greater or less intervening space; they have transformed it from an alternating current to a direct current; and finally, by use of an apparatus in which the screen grid is essential, they have succeeded in amplifying it many thousand times. Today we can hear around the world not merely signals but the voice of man reproduced from the same current that originated in the transmitter, strengthened, transformed, and amplified. If this is not discovery or invention or both, it is difficult to understand what would be.

The other apparatus used by the defendant and alleged to infringe the Fleming patent is referred to in Findings LXXVI, LXXIX, and LXXX. Facts are set forth in these findings which, in our opinion, furnish sufficient reason for holding that such apparatus did not constitute an infringement and we think no useful purpose would be accomplished by repeating the statements contained in the findings.

Our conclusion on the whole is that there has been no infringement of the Fleming patent.

WHALEY, *Judge*; WILLIAMS, *Judge*; LITTLETON, *Judge*; and BOOTH, *Chief Justice*, concur.

[fol. 92] VI. **Final Argument and Submission of Case**

On December 2, 1941, the case was argued and submitted on merits by Mr. Abel E. Blackman, Jr., for plaintiff, and by Mr. Clifton V. Edwards for defendant.

[fol. 93] VII. **Special Findings of Fact, Conclusions of Law and Opinion of the Court by Chief Justice Whaley**—Filed April 6, 1942

Mr. Abel E. Blackmar, Jr. for the plaintiff. *Mr. Richard A. Ford*, and *Sheffield & Betts* were on the briefs.

Mr. Clifton V. Edwards, with whom was *Mr. Assistant Attorney General Francis M. Shea*, for the defendant. *Messrs. J. F. Mothershead* and *Joseph Y. Houghton* were on the briefs.

This case having been heard by the Court of Claims, the court, upon the evidence, and the report of a commissioner, makes the following

SPECIAL FINDINGS OF FACT

1. This is a patent suit filed to recover the reasonable and entire compensation for use by the United States of inventions covered by United States letters patent to Marconi, Reissue No. 11,913; to Lodge, No. 609,154; to Marconi, No. 763,772, and to Fleming, No. 803,684.

The court in its special findings of fact and opinion of November 4, 1935 (81 C. Cls. 671), held and now finds as an ultimate fact that the Marconi reissue patent and the Fleming patent had not been infringed; that the Lodge patent was valid as to claims 1, 2, and 5, and had been infringed, and that the Marconi patent, No. 763,772, was invalid except as to claim 16 thereof, which claim was valid and had been infringed by the United States.

Reasonable and entire compensation is based on the infringement of the Lodge patent and Marconi patent No. 763,772.

[fol. 94] LODGE PATENT NO. 609,154

2. Reasonable and entire compensation with respect to the Lodge patent is limited to apparatus purchased or acquired by the Government during the period extending

from March 8, 1913, when plaintiff first gave notice of infringement to the defendant, to August 16, 1915, when the patent expired.

This period will hereinafter be referred to as "the Lodge accounting period."

3. During the Lodge accounting period the United States purchased and used both complete and incomplete wireless transmitters, receivers, and sets from various contractors, including the plaintiff and its licensees; during that period the United States also acquired such apparatus by manufacturing the same and by assembling it from parts which had been either purchased or manufactured or both. It also purchased or acquired spare parts for such apparatus and auxiliary apparatus, all of which was designed and intended for use as a part of and useful only as a part of such apparatus.

4. During the Lodge accounting period wireless transmitters acquired or purchased by the United States were either of the spark type or the arc type.

The essential elements of a complete spark transmitter comprise a source of electrical power such as a motor generator for providing an alternating current of a particular frequency, usually 500 cycles, the purpose of this frequency being to provide an easily recognizable note or tone to the signals; a transmitter-transformer to step up the voltage; a primary circuit, including a spark-gap, an inductance coil (the primary of the oscillation-transformer), and ordinarily a condenser; a secondary circuit including an antenna, an inductance (the secondary of the oscillation-transformer), and a ground or earth connection; and a key or other suitable signalling means.

The essential elements of an arc transmitter were the same except that the source of electrical power provided a direct current of a proper voltage to operate the arc (usually 750 volts) so that no transmitter-transformer was required, the arc generator taking the place of the spark-gap.

[fol. 95] The essential elements of a complete wireless receiver during the Lodge accounting period and as used by the United States comprised a primary circuit, including an antenna, a ground or equivalent connection, an inductance (the primary of the oscillation-transformer), and ordinarily a variable condenser; a secondary circuit, including an in-

ductance (the secondary of the oscillation-transformer), and ordinarily a variable condenser; a suitable detector (either a crystal or a vacuum tube); in many instances a vacuum tube amplifier; and head telephones. A device known as a ticker was sometimes associated with the secondary circuit.

Except in the case of portable sets and wireless compass transmitters, the antenna was not purchased nor acquired as a part of the wireless apparatus but was always constructed and installed by the United States.

5. Claims 1, 2, and 5 of the Lodge patent, held valid and infringed by the court in its opinion of November 4, 1935, are as follows:

1. In a system of Hertzian-wave telegraphy, the combination, with a pair of capacity areas, of a self-inductance coil inserted between them electrically for the purpose of prolonging any electrical oscillations excited in the system and constituting such a system a radiator of definite frequency or pitch.

2. In a system of Hertzian-wave telegraphy, the combination, with a pair of capacity areas, of a self-inductance coil inserted between them electrically for the purpose of prolonging any electrical oscillations excited in the system, thus constituting the system a resonator or absorber of definite frequency or pitch, and a distant radiator of corresponding period capable of acting cumulatively.

5. In a system of Hertzian-wave telegraphy, the combination, with a pair of capacity areas, of a variably acting self-inductance coil, serving to syntonize such a radiator or resonator to any other such resonator or radiator, whereby signalling may be effected between any two or more correspondingly attuned stations without disturbing other differently attuned stations.

The substance of the Lodge invention, as expressed by the phraseology of these claims, is the tuning of the antenna circuits of radio transmitters and receivers to a definite fre- [fol. 96] quency or wave length by means of a self-induction coil, and to the selective tuning or syntonizing of a given transmitting antenna to a given receiving antenna, to the exclusion of other stations operating on different frequencies or wave lengths.

The basic position of the Lodge patent in the art, and with respect to the original Marconi patent, is defined by the court in its findings of fact and opinion, 81 C. Cls. 671 (Finding XXXVI), in which it is stated that—

Marconi in his patent #586193 apparently did not appreciate the desirability of tuning the primary oscillating circuit by the use of an inductance coil, and did not contemplate varying the effective tuning of the receiver to one of several transmitters.

The American Therapeutic Association publication told how to determine and vary the period of an oscillating circuit by modifying the inductance and capacity.

The patents to Pupin #640516 dated January 2, 1900, filed May 28, 1895; Hutin et al., #838545 dated December 18, 1906, filed May 9, 1894; and Stone #577214, February 16, 1897, filed September 10, 1896, show that the laws of closed resonant circuits in general were known prior to the Lodge invention, but such patents do not show knowledge of the desirability of tuning an open oscillating circuit for Hertzian-wave signalling.

No one prior to Lodge appreciated the desirability of tuning the oscillating circuits of both the transmitter and receiver for the purpose intended and in the manner performed by him. [Italics supplied.]

The selective and adjustable tuning of the antenna circuits as taught by Lodge was of fundamental importance to practical radio or wireless communication during the Lodge accounting period, and there is no satisfactory evidence of any substitute for such invention during this period, the use of which would have resulted in wireless apparatus of any practical utility.

6. All the radio transmitters and receivers and sets purchased or acquired by the United States during the Lodge accounting period utilized the subject-matter of one or more of the Lodge claims referred to in the previous finding, and such utilization gave to the apparatus substantially its entire utility and market value.

7. The tabulation on the following pages, and which is a [fol. 97] part of this finding, sets forth in itemized form the radio apparatus acquired by the United States during the

Lodge accounting period without the license or consent of the plaintiff.

Certain contracts, abstracts, and other documents, plaintiff's Exhibits 51, 57, 63, 65, 66, 406, 407, 408, 408-A to 408-D, inclusive, 432, and 459, which are by reference made a part of this finding, comprise the sources of information for this table, and the numbers given in the first column of the table identify the various items set forth in the contracts and abstracts.

The procedure which was followed in the present case to prove what infringing apparatus was used or manufactured by or for the defendant was as follows: Plaintiff filed motions for calls on the Navy Department, War Department, and the General Accounting Office for various documents, including the complete files in the General Accounting Office with respect to certain specified contracts for the purchase of radio apparatus. In order to obviate the expense of photostatic copies, it was agreed that the requested documents would be made available to a representative of the plaintiff who would examine them and make abstracts of their contents, which was done. These abstracts were submitted to a representative of the defendant for correction and the addition of any further desired material. The abstracts were then accepted in evidence in lieu of certified copies of the documents themselves. To facilitate the accounting proceeding, it was arranged that, in lieu of further formal motions for calls, plaintiff might make informal requests for the production of documents from defendant's files and that when such documents were located, the defendant would permit plaintiff's representative to examine them and make abstracts thereof in the manner above described.

8. In certain of the tabulated items liquidated damages totalling about 1% of the contract price given in the tabulation on pages 6 and 7 were assessed against the various contractors.

Such penalization of plaintiff's competitors has not been taken into account and the original contract price has been used in all instances to determine the market value.

Item	Nature of apparatus	Number of transmitters	Number of receivers	Contract price	Value of transmitters	Value of receivers	Value of parts	Entire market value
31	2 5-kw. transmitters, 4 receivers	2	4	$7,198 00	$6,198 00	$1,000 00	.....	$7,198 00
32*	1 arc transmitter, 2 receivers	1	2	52,801 04	23,080 00	1,455 00	.....	24,535 00
33	1 transmitter	1	...	7,500 00	7,500 00	.....	.....	7,500 00
34	1 transmitter, 1 receiver	1	1	2,340 00	2,090 00	250 00	.....	2,340 00
35	4 transmitters, 8 receivers	4	8	20,000 00	18,000 00	2,000 00	.....	20,000 00
36	2 transmitters, 4 receivers	2	4	8,474 00	7,474 00	1,000 00	.....	8,474 00
41*	2 transmitters, 4 receivers	2	4	9,500 00	8,500 00	939 00	.....	9,439 00
48	3 30-kw. arc transmitters, 3 receivers	3	3	31,769 00	30,494 00	1,275 00	.....	31,769 00
49	2 arc transmitters, 2 receivers	2	2	15,250 00	14,400 00	850 00	.....	15,250 00
50*	5 arc transmitters with receivers	2	2	52,040 00	19,966 00	850 00	.....	20,816 00
Pl. Ex. 407	1 receiver		1	425 00	.....	425 00	.....	425 00
52	17 transmitters, one with motor generator	17	...	18,467 75	18,467 75	.....	.....	18,467 75
A-1	5 quenched spark-gaps	...	...	1,800 00	.....	.....	$1,440 00	.....
A-3	50 rotary tickers	...	...	2,000 00	.....	.....	2,000 00	.....
A-4	4 transmitters	4	...	1,450 00	1,450 00	.....	.....	1,450 00
A-6	2 transmitters, 4 receivers	2	4	10,000 00	9,000 00	1,000 00	.....	10,000 00
A-10	15 receivers	...	15	4,080 00	.....	4,080 00	.....	4,080 00
A-11	1 5-kw. inductor type radio alternator	...	...	716 00	.....	.....	716 00	.....
A-14	1 30-kw. arc transmitter with spare parts	1	...	8,034 12	6,990 10	.....	1,044 02	6,990 10
A-15	64 ticker detectors	...	...	2,731 40	.....	.....	2,731 40	.....
A-16	34 ultra-audion detectors, 4 receivers	...	4	7,625 00	.....	2,200 00	4,200 00	2,200 00
A-19	10 transmitters, 10 receivers	10	10	10,000 00	9,000 00	1,000 00	.....	10,000 00
A-20	1 transmitter	1	...	5,775 00	5,775 00	.....	.....	5,775 00
A-21	1 motor generator	...	...	587 00	.....	.....	587 00	.....
A-22	3 motor generators, 3 transformers	...	...	3,450 00	.....	.....	3,450 00	.....
A-23	21 receivers	...	21	4,084 50	.....	4,084 50	.....	4,084 50
A-24	1 transmitter	1	...	1,096 00	1,096 00	.....	.....	1,096 00
A-25	20 motor generators, 20 transformers	...	...	19,075 00	.....	.....	19,075 00	.....
A-26	Parts for radio spark transmitter	...	...	1,957 66	.....	.....	1,451 20	.....
A-28	3 transmitters	3	...	3,825 00	3,825 00	.....	.....	3,825 00
A-29	Transmitter parts, 10 receivers	...	...	1,430 00	.....	.....	870 00	.....

A-32*	2 transmitters, 4 receivers	1	4	10,000.00	4,500.00	1,000.00	.....	5,500.00
A-33	15 transmitters, 15 receivers	15	15	15,000.00	13,500.00	1,500.00	.....	15,000.00
A-34	2 transmitters, 2 receivers	2	2	8,512.80	7,732.80	780.00	.....	8,512.80
A-35*	30 receivers	...	23	9,380.00	.....	7,462.00	.....	7,462.00
A-36	50 receivers	...	50	6,000.00	.....	6,000.00	.....	6,000.00
[fol. 99]								
A-37*	6 5-kw. transmitters with spare parts	6	...	24,900.00	24,000.00	.....	.....	24,000.00
A-38*	3 5-kw. transmitters	3	...	12,553.00	12,103.00	.....	.....	12,103.00
A-39*	5 5-kw. transmitters	5	...	19,625.00	14,718.75	.....	.....	14,718.75
A-53	4 receivers	...	4	1,560.00	.....	1,560.00	.....	1,560.00
A-54	14 receivers	...	14	4,550.00	.....	4,550.00	.....	4,550.00
A-55	15 receivers	...	15	1,938.75	.....	1,938.75	.....	1,938.75
A-56	8 2-kw. transmitters without power supply; 8 motor generators	8	...	12,400.00	12,400.00	.....	.....	12,400.00
A-80	50 oscillation transformers	...	...	3,000.00	.....	.....	3,000.00	.....
B-15	1 10-kw. transmitter without motor generator	1	...	4,200.00	4,200.00	.....	.....	4,200.00
B-24	40 receivers	...	40	2,400.00	.....	2,400.00	.....	2,400.00
B-43	Parts for quenched spark-gap transmitter	...	...	1,132.80	.....	.....	1,129.20	.....
B-44	25 spark-gaps for transmitters	...	...	550.00	.....	.....	550.00	.....
C-1	50 audion detectors and amplifiers	...	...	12,250.00	.....	.....	12,005.00	.....
C-2	24 audion detectors	...	...	1,200.00	.....	.....	1,200.00	.....
Pl. Ex. 459	4 receivers	...	4	1,017.29	.....	1,017.29	.....	1,017.29
A-27	1 transmitter, 1 receiver	1	1	2,450.00	2,020.00	430.00	.....	2,450.00
Tuckerton transmitter	1 transmitter	1	...	8,000.00	8,000.00	.....	.....	8,000.00
Eaton receivers	3 receivers	...	3	750.00	.....	750.00	.....	750.00
		102	260	.....	296,480.40	51,796.54	56,448.82	348,276.94

* See Finding 10 for explanation of items marked with asterisk.

[fol. 100] 9. Certain of the items of the above tabulation are for parts of sets. A more detailed explanation of these items follows:

(*Item A-1*).—This item is for five quenched spark-gaps at a total contract price of $1,800. The contract file shows payment during the Lodge accounting period for four of the five gaps, the total amount of the payment being $1,440.

Quenched spark-gaps were designed and intended for use as generators of high-frequency current for radio transmission, and their sole utility is for this purpose.

(*Item A-3*).—This item covers a contract to the Federal Telegraph Company dated August 18, 1913. The contract called for fifty rotary tickers at a contract price of $2,000, which was paid in full during the Lodge accounting period.

A rotary ticker is a form of wireless detector primarily designed to detect continuous or undamped waves, although it will also receive damped waves. A rotary ticker is a part of a radio receiver and it has no use or utility other than in the reception of radio signals impressed upon the antenna of a receiving set.

(*Item A-15*).—This item covers a contract with the Federal Telegraph Company dated March 27, 1914, and is for sixty-four ticker detectors, including spare parts, at a total contract price of $2,731.40. The contract file shows payment during the Lodge accounting period of the contract price with the exception of $13.90, which was withheld as liquidated damages.

The function and utility of ticker detectors have been discussed in connection with the prior item.

(*Item A-11*).—This item covers a contract with the Atlantic Communication Company dated September 22, 1913, for one 5-kw. inductor type radio alternator at a contract price of $716. The sum of $715.28 was paid during the Lodge accounting period, seventy-two cents having been withheld as liquidated damages.

An inductor type radio alternator is the source of high-frequency electrical energy for a radio transmitter, and during the Lodge accounting period such a device was useful only as a part of a radio transmitter.

(*Item A-16*).—This item calls for ultra-audion detectors which were radio detectors utilizing a form of oscillating

[fol. 101] audion. Such device is not useful in and of itself but only for use as a part of a radio receiver. The contract price of the thirty-four detectors was $4,200 and the contract price of the four receivers, $2,200. The $1,225 difference between the contract price of $7,625 and the $6,400 is for certain radio tubes or bulbs for which plaintiff does not claim compensation.

(*Item A—21*).—This item covers a contract with the Atlantic Communication Company dated June 10, 1913, and covers a motor generator, including a 5-kw. 500-cycle inductor type radio alternator. The contract price was $587, of which $579.37 was paid during the Lodge accounting period, the balance of $7.63 being withheld as liquidated damages. The motor generator is a device designed solely for the production of a 500-cycle alternating current as a source of energy in a radio transmitter, the 500 cycles being for the sole purpose and function of imparting to the transmitted radio signal a singing or musical tone characteristic, easily recognizable by the receiving operator through static. The sole utility of these motor generators at the time of the Lodge accounting was for the generation and transmission of a radio signal from a transmitting antenna.

(*Item A–22*).—This item covers a contract with F. Lowenstein, dated May 13, 1913. The contract price was $2,700 for the motor generators and $750 for the transformers, or a total of $3,450.

The contract file shows payment during the Lodge accounting period of $3,340.40, the sum of $109.60 having been withheld as liquidated damages. The purpose and function of the motor generators have been detailed in the prior item, and the sole function and utility of the transformers was to step up the voltage of the 500-cycle current from the motor generators to a suitable voltage for operating the closed oscillation circuit of the transmitter, which produces the high-frequency oscillations which are fed into the antenna circuit.

(*Item A–25*).—This item covers a contract with the Atlantic Communication Company, dated June 2, 1913, and was directed to twenty radio motor generator sets of 5-kw. and 2-kw. sizes, together with the spare parts for same, and

[fol. 102] twenty transformers for use with the same, the total contract price being $19,075.

The contract file shows payment of $18,796.44, the sum of $278.56 having been withheld as liquidated damages.

The function and utility of the motor generators and transformers have been detailed in the two prior items.

(Item A-26).—This item covers a contract with the Atlantic Communication Company dated June 3, 1913, and called for various parts and elements relating to a transmitting set, at a total contract price of $1,957.66.

The following items depend for their entire utility in the generation of high-frequency current for transmission from a radio antenna:

1 primary variometer	371.20
1 5-kw. 500-cycle motor generator	950.00
1 5-kw. 500-cycle transformer	130.00
	1,451.20

(Item A-29).—This item covers a contract with the National Electrical Supply Company dated January 23, 1914, for various radio transmitter parts, such as transformers, high tension condensers, spark-gaps, oscillation transformers, and receiving sets, at a total price of $1,430. These parts have no other utility than the generation of high-frequency current for use in a radio transmitting antenna.

The contract file shows that the sum of $870 was paid during the Lodge accounting period covering the transformers, spark-gaps, and parts. There is no evidence as to the delivery of or payment for the condensers or receiving sets. The abstract of this contract states as follows:

No record of completion of delivery of order as shown by contract files.

(Item A-80).—This item covers a contract with the National Electrical Supply Company dated September 17, 1914, and was for fifty oscillation transformers at a total cost of $3,000. Such transformers were used as a part of the radio frequency circuits of wireless transmitters, and either both coils of the transformer were used in the antenna circuit as a loading coil or the secondary coil of the transformer

[fol. 103] was used in the antenna circuit, in either instance to tune that circuit.

The contract file shows payment of the full contract price to the contractor during the Lodge accounting period.

(*Item B-43*).—This item refers to a contract with the National Electrical Supply Company dated November 14, 1914, and which called for an incomplete set of parts for a quenched-gap wireless transmitter, the aggregate contract price being $1,132.80. The parts have utility only in furnishing high-frequency current to a radio transmitting antenna.

The payment made to the contractor, however, during the Lodge accounting period was $1,129.20, due to the fact that certain small parts were furnished by the defendant. There is no proof as to when this group of small parts was acquired by the defendant.

(*Item B-44*).—This item covers a contract with William A. Knapp dated December 2, 1914, and is for twenty-five spark gaps at a total price of $550. A spark gap is an apparatus the sole utility of which, during the Lodge accounting period, was to enable the transmitter condensers to become charged and then to subsequently discharge into the local oscillating circuit with a consequent generation of high-frequency current which was transferred to the antenna circuit.

The entire amount of the contract was paid to the contractor during the Lodge accounting period.

(*Item C-1*).—This item covers a contract with the De-Forest Radio Telephone and Telegraph Company dated April 30, 1915. It included among other things fifty combined audion detectors and one-step amplifiers at a total price of $12,250. These detector amplifiers had their sole utility in the detection and amplification of the relatively weak energy received on a receiving antenna.

The contract file shows payment to the contractor during the Lodge accounting period of the sum of $12,005, covering the cost of forty-nine of the detector amplifiers.

(*Item C-2*).—This item covers a contract with the De-Forest Radio Telephone and Telegraph Company dated June 30, 1915, and included among other things twenty-[fol. 104] four audion detectors at a total price of $1,200. The utility of these detectors as to circuits and function

was the same as the detector portions of the detector amplifiers of the previous item (C–1).

The contract file shows payment in full for the twenty-four audion detectors during the Lodge accounting period.

10. In certain other items of the tabulation indicated by a single asterisk the entire market value is less than the contract price. A detailed explanation of these items is as follows:

(Item 32).—This item covers a contract for high power radio installation for the Naval Station at Caimito, Panama Canal Zone. The total contract price was $52,801.04 and included such general items as powerhouse machinery, powerhouse switchboard, wiring from powerhouse to operating house, and powerhouse wiring. The price of the "wireless apparatus" was $24,535, which amount was paid in full during the Lodge accounting period. The elements comprising the "wireless apparatus" and the prices of each are as follows:

Transmitter	
Helix	$3,000.00
Poulsen arc	11,210.00
Wave change switch and antenna	2,000.00
2 relay keys	4,500.00
2 sets choke coils	500.00
Switchboard	1,470.00
Antenna entrance	400.00
Total cost of transmitter	23,080.00

Receivers	
1 receiving cabinet, 600-3,000 m	450.00
1 receiving cabinet, 2,000-10,000 m	450.00
4 head receivers	20.00
2 110 v. tickers	100.00
1 6 v. ticker	50.00
1 triple audion amplifier	385.00
Total cost of receivers	1,455.00

(Item 41).—This item is for two radio sets at a contract price of $9,500. Payment of $9,439 was made during the Lodge accounting period, a balance of $61 being withheld

[fol. 105] because the defendant itself supplied four telephone head sets for the receivers, and the amount payable to the contractor was therefore reduced by this amount. There is no evidence to show whether the telephone head sets were acquired by the Government within the Lodge accounting period.

(*Item 50*).—This item calls for five 30-KW. arc radio sets complete with receivers at a total contract price of $52,040. The contract is in evidence as plaintiff's Exhibit 406, and shows that two of the five sets were delivered during the Lodge accounting period. Attached to the contract file were three receipts which referred to three vouchers by number and stated that they were missing. On the first page of the contract and with reference to these same three vouchers, the following memorandum appeared:

Contract 350 P. 3 Abstracted 3-14-38 GHC
On first page of contract is the following memorandum in red ink:

878	4/15 NY	19,016.00	
1731	4/15 NY	1,200.00	
2262	1/16 NY	600.00	20,816 00

There is no proof of delivery of or payment for the remaining three sets during the accounting period, which expired August 16, 1915.

(*Item A-32*).—This item covers a contract, plaintiff's Exhibit 57, which called for two 5-kw. wireless sets each with two receivers, the contract price being $10,000. The contract file shows delivery and satisfactory operating condition of one of the transmitters, together with partial payment of the same, by December 29, 1912, and therefore prior to the Lodge accounting period. Payment for the second set (contract price $5,000) and the four receivers was made during the Lodge accounting period. The receivers delivered under this contract were of the IP-76 type and were of an average price of $250 each.

(*Item A-35*).—This item covers a contract calling for thirty radio receivers at a total contract price of $9,380. The contract file shows delivery of and payment during the Lodge accounting period for twenty-three of the receivers.

There is no proof of delivery of or payment for the remaining seven receivers, the contract price for which was $1,918.

[fol. 106] (*Item A–37*).—This item covers a contract calling for six 5-kw. wireless transmitters with spare parts. The total contract price was $24,900. The contract file shows payment to the contractor during the Lodge accounting period of $24,000, which is the full contract price less $900 "for material supplied by the Navy Department." There is no satisfactory evidence as to when this material was acquired by the defendant or whether such material is already included and formed a part of the material listed in the tabulation on pages 6 and 7.

(*Item A–38*).—This item called for three 5-kw. wireless transmitters at a contract price of $12,553. The contract file shows $450 taken from the full contract price for apparatus (short-circuiting switches) supplied by the defendant. There is no proof as to when such apparatus was manufactured or acquired by the defendant.

(*Item A–39*).—This item covers a contract with F. Lowenstein dated August 4, 1914, which called for five 5-kw. wireless sets exclusive of receivers and wave meters, at a contract price of $19,625.

The contract file shows delivery of the five sets and payment to the contractor during the Lodge accounting period of 75% of the contract price, viz, $14,718.75. There is no record of payment of the remaining 25% and no record of this being withheld as liquidated damages.

11. The item on the tabulated list appearing on pages 6 and 7 designated "Plaintiff's Exhibit 459," refers to four receivers, and lists under the contract price and the entire market value the amount of $1,017.29. These four receivers were manufactured at the Washington Navy Yard and completed July 13, 1915 (within the Lodge accounting period), at a total actual cost of $1,017.29.

Plaintiff's Exhibit 459 is the Navy Yard summary of the estimated and actual costs of these sets.

(*Item A–27*).—This item refers to one transmitter and one receiver covered by a contract with the Telefunken Company dated January 29, 1913, for installation on the U. S. Army transport *Liscum*, the contract price being $2,450. While the abstract of this contract shows no record

of payment in the contract file, plaintiff's Exhibit 428, Item [fol. 107] 9, has reference to an official notice referring to this contract and indicating that this set was inspected and accepted.

(*Tuckerton arc transmitter*).—In 1914 the Navy Department installed a 60-kw. arc transmitter at Tuckerton, New Jersey, which transmitter was subsequently removed to the Naval Radio Station at Arlington, Virginia. The estimated market value of this transmitter is $8,000.

(*Eaton receivers.*—Three radio receivers were constructed or assembled from parts during the years 1913-1915; the first was assembled and used at Arlington, the second at the Naval Laboratory, and the third at Tuckerton.

These receivers were assembled from parts already on hand at the localities specified.

The approximate market value of these receivers was $750.

12. Certain apparatus, designated as follows, has been omitted from the itemized list of aparatus appearing on pages 6 and 7 as not properly coming within the accounting:

(*Item A-5.*)—This item calls for one arc transmitter and one receiver for a contract price of $5,500. The contract was with the Federal Telegraph Company under date of November 2, 1914.

The contract file contains no record either of delivery of the apparatus or payment therefor.

(*Item B-20.*)—This item covers a War Department order dated October 10, 1913, to the National Electrical Supply Company for fifteen helices, fifteen spark-gaps, and fourteen receiving sets, the total of the contract price being $982. With the exception of the fifteen helices, there is no satisfactory evidence either of delivery of or payment for these items within the accounting period.

(*Item B-21.*)—This item covers a War Department order to the National Electrical Supply Company dated October 22, 1913, for thirteen helices, fifteen spark-gaps, and five receiving sets at a contract price of $445. There is no satisfactory evidence either of delivery of or payment for these items within the accounting period.

(*Item B-52.*)—This item covers a War Department order 13967 to the National Electrical Supply Company dated

October 27, 1913. The order covers four spark-gaps, three [fol. 108] helices, and nine receiving sets at a total contract price of $449. There is no satisfactory evidence either of delivery of or payment for these items within the accounting period.

13. During the Lodge accounting period the plaintiff granted certain nonexclusive licenses to others to manufacture and sell wireless apparatus embodying the invention of the Lodge patent. These licenses (plaintiff's Exhibits 360 and 447, which are by reference made a part of this finding) were under and included both the Lodge patent and the Marconi patent No. 763,772 and are herewith summarized as follows:

(a) Under date of July 14, 1914, to National Electrical Supply Company. The license was under the Lodge patent and Marconi patent and granted a nonexclusive license to manufacture ¼-kilowatt portable wireless telegraph sets and sell them to the United States; the royalty provided for therein was $250 a set. The license was terminable by the plaintiff on 30 days' notice, and was canceled under date of January 24, 1916.

(b) Under date of April 15, 1915, to the National Electrical Supply Company. The license was under the same two patents and granted a nonexclusive license to manufacture wireless telegraph apparatus and sell it to the United States. It was stated to amend, modify, and supplement the above-mentioned agreement of July 14, 1914. The royalties provided for therein were 20 percent of the gross selling price on all sets having a capacity up to and including one kilowatt; 25 percent thereof on all sets between one and three kilowatt capacity, and 33⅓ percent thereof on all sets above three kilowatt capacity.

Article 12 of this license agreement defines in the following phraseology the base to which the license fee is applied:

Twelfth. In order to prevent any dispute between the parties hereto as to the license fee due and payable hereunder, it is agreed that the term "apparatus" or "set" as used in this agreement, shall cover and include only the following elements:

1. Primary Generator of Mechanical Power or a Primary Generator of direct or alternating electric current.

2. Switchboard (or) starting Device.
3. Transformer.
4. Spark gap and cooling device.
[fol. 109] 5. Oscillation producer (arc, Spark or other).
6. Transmitting condenser.
7. Transmitting oscillation transformer.
8. Antenna inductance.
9. Operating key and (or) equivalent relay.
10. Antenna switch.
11. Receiving oscillation transformer.
12. Receiving condenser.
13. Detector.
14. Receiving oscillation producer.

Article 12 of this license also states that if the license should sell any of the elements listed less than the whole number, then the licensee should pay to the licensor the rate of license fee previously provided. This license was terminable by either party on 30 days' notice and was canceled under date of January 24, 1916.

(c) Under date of October 15, 1914, to National Electric Signaling Company. The license was a cross-licensing agreement by which the plaintiff granted to the Signaling Company a nonexclusive license to make, use, lease, and sell wireless telegraph and wireless telephone apparatus embodying the inventions of the Lodge patent, the Marconi patent No. 763,772 and a Freeman patent, No. 773,069. Where apparatus was sold the royalty was 20 percent of the gross selling price, including sales to the United States, except that the royalty was 30 percent on sales for use on foreign ships.

The base upon which the royalty was payable was defined as the same elements listed in Article 12 in the license agreement of April 15, 1915, with the National Electric Signaling Company, with the exception that item or element No. 1 is specified as "motor generator." This license agreement also specified that if either party should sell any of the elements listed less than the whole number the licensee should pay to the licensor 20 percent of the selling price of the elements sold.

The license was terminable by the plaintiff during a certain period, on 90 days' notice, and notice of cancellation thereof was given by plaintiff on March 1, 1917, such cancellation taking effect on May 30, 1917.

[fol. 110] This agreement was entered into to settle litigation which was pending between the parties, including a suit by plaintiff against the National Electric Signaling Company on the Lodge and Marconi patents (*supra*) wherein both of these patents had been held by the United States District Court for the Eastern District of New York valid and infringed as to certain claims thereof. The agreement contained a release from all claims for damages and profits for past infringement.

The above-mentioned Freeman patent was never adjudicated. The apparatus disclosed in that patent has never gone into use and the disclosure thereof was not embodied in any apparatus purchased, acquired, or used by the United States.

(d) Under date of July 26, 1915, to Clapp-Eastham Company. The license was under the Lodge and Marconi patents (*supra*) and granted a nonexclusive license to manufacture wireless telegraph apparatus and sell it to the United States and to amateurs; the royalty provided for therein was 20 percent of the listed catalogue or gross selling price of each set.

The base upon which the royalty was to be determined was defined to include the same listed elements as are contained in Article 12 of the license agreement of April 15, 1915, with the National Electrical Supply Company. This agreement also carried the clause that if the licensee should sell any of the listed elements less than the whole number, the royalties should be those which were provided, viz, 20 percent on all sets sold to the Government of the United States.

This license was subsequently canceled, but there is no evidence as to its date of cancellation.

14. Following the expiration of the Lodge patent on August 16, 1915, the plaintiff granted numerous nonexclusive licenses under the Marconi patent alone. These licenses, copies of which are contained in plaintiff's Exhibit 447, included licenses granted to William J. Murdock & Company, Sears, Roebuck and Co., A. W. Bowman & Company, and a new license to the Clapp-Eastham Company (for prior license to Clapp-Eastham Company covering both

[fol. 111] Lodge and Marconi patents at 20 percent royalty, see Finding 13 (d)).

The license fee or royalty provided for in these subsequent license agreements was 10 percent of the lowest selling price on all sets sold to amateurs.

15. A fair and reasonable royalty for the use of the invention or inventions, as defined in claims 1, 2, and 5 of the Lodge patent and during the accounting period, is 10 percent of the selling price or market value of the radio transmitters and receivers, including such apparatus as is dependent upon the inventions thus defined for its utility.

16. A reasonable and entire compensation for the use of the Lodge invention is 10 percent of the entire market value of the apparatus tabulated on pages 6 and 7, or $34,827.70, plus an amount measured by interest at 5 percent per annum, not as interest but as part of the entire or just compensation, on $34,827.70 from August 16, 1915, to date of payment of the judgment.

Marconi Patent No. 763,772

17. The original petition in this case having been filed on July 29, 1916, and supplemental amended petitions having been filed on May 21, 1919, and June 15, 1922, the accounting period with respect to the Marconi patent, claim 16 of which was held valid and infringed, extends from July 29, 1910, to November 20, 1919, at which time plaintiff assigned the patent. Claim 16 relates to radio receiving circuits.

18. Radio receiving circuits during the period of the accounting and as disclosed and claimed in the Marconi patent comprised two circuits—the open circuit and the closed circuit.

The open circuit consisted of the elevated wire or antenna and a ground connection, together with certain associated tuning instrumentalities. The closed circuit comprised certain tuning instrumentalities and was connected to a detector apparatus to enable the received signals to be rendered audible to the operator.

The open and closed circuits were associated or coupled to each other so that a transfer of energy could take place from the open circuit to the closed circuit. This coupling [fol. 112] means in general comprised a coupling trans-

former, the primary winding of which was associated with the open circuit and the secondary of which was associated with the closed circuit.

19. All radio circuits, whether of open circuit or closed circuit type, inherently possess two electrical characteristics, i. e., inductance and capacity, and the natural frequency or periodicity of a circuit is dependent upon the square root of their product. Besides the inherent capacity and inductance of a circuit, the circuits also generally contained additional capacity and inductance, either of fixed or adjustable value.

An adjustable capacity during the accounting period usually consisted of a condenser having a series of fixed plates interleaved with a series of movable or adjustable plates so that the capacity value could be altered by the extent of the contiguous area of the plates. An adjustable inductance usually consisted of a circular coil on a form, either having taps brought out to a switch or having a movable contact adjacent the turns of the coil whereby more or less turns could be included in the circuit.

By the adjustment of either or both of these two instrumentalities the periodicity of the circuit with which they were associated could be altered or tuned. As the variation of the capacity of the condenser is continuous throughout its range, whereas the variation of inductance is by steps only (either by single turns or by multiples thereof), it follows that finer or more accurate tuning may be obtained by the use of a variable condenser.

In the utilization of such circuits for receiving purposes, during the accounting period the operator usually relied upon adjustment of the inductance for coarse or preliminary tuning and the condenser for subsequent fine adjustment.

20. Claim 16 of the Marconi patent, held valid and infringed by the court in its opinion of November 4, 1935, is as follows:

At a receiving station employed in a wireless-telegraph system, the combination of an oscillation transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, *an adjustable con-* [fol. 113] *denser in a shunt connected with the open circuit*

and around said transformer-coil, a wave-responsive device electrically connected with the other coil of the oscillation transformer, and means for adjusting the two transformer-circuits in electrical resonance with each other, substantially as described. [Italics supplied.]

As shown in Fig. 2 of the Marconi patent, herewith reproduced, the claim refers to a receiving apparatus in which

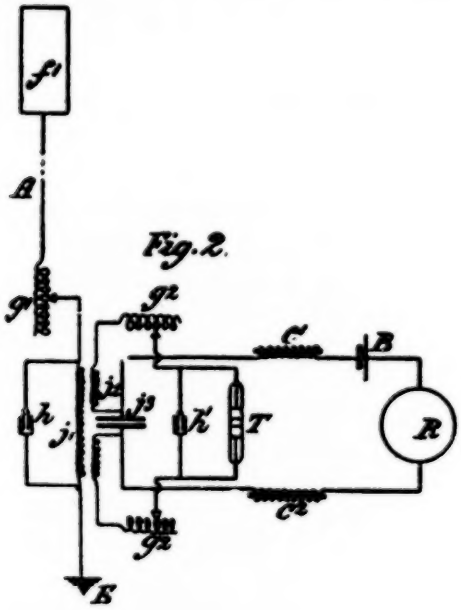


Fig. 2.

the principal elements are an open or antenna circuit adapted to receive the radiated energy from a transmitting station, and a closed circuit coupled to the open circuit by means of an oscillation transformer, the closed circuit being adapted to deliver energy to a wave-responsive device or a detector. The patent discloses means for adjusting or tuning the periodicity of both circuits with respect to each other and to the periodicity of the radio impulses received on the antenna, so that for any selected wave length or frequency of the received energy the effect on the wave-responsive device will be a maximum.

[fol. 114] These means as disclosed in Fig. 2 of the patent comprise, for the antenna circuit, an adjustable inductance g^1 and an adjustable capacity or condenser h in shunt with

the primary winding j^1 of the oscillation transformer; and for the closed circuit the adjustable inductances g^2 g^2.

21. The Marconi patent describes the preferred construction of the condenser h as—

one provided with two telescoping metallic tubes separated by a dielectric and arranged to readily vary the capacity by being slid upon each other.

The mode of operation and function of such a construction is to provide variation in the periodicity of the open or primary circuit with which the adjustable condenser is associated. In this connection the patent states—

The capacity and self-induction of the four circuits—i. e., the primary and secondary circuits at the transmitting-station and the primary and secondary circuits at any one of the receiving-stations in a communicating system—are each and all to be so independently adjusted as to make the product of the self-induction multiplied by the capacity the same in each case or multiples of each other—that is to say, the electrical time periods of the four circuits are to be the same or octaves of each other.

The degree of variation effected in the periodicity of the open circuit by the adjustable condenser is dependent upon the constants of the associated circuit (inductance and capacity) and upon the maximum-minimum values of the condenser capacity.

The size and spacing of the cylinders, and therefore the maximum and minimum values of the capacity, are not specified, but left to the design of those skilled in the art.

22. While the patent specifically states that the adjustment of the self-inductances and capacity of any or all of the four circuits can be made in any convenient manner and by employing various arrangements of apparatus, it also indicates by way of example certain preferred values of inductance and capacity, and transformer construction (size of wire and number of turns, etc.) for six specified tunes or wave lengths.

[fol. 115] These values are given in tabular form and include the number of turns in the inductances and the capacity in microfarads of the condensers. These data, so

far as the transmitting-station is concerned, give the length of the aerial conductor or antenna, and therefore indirectly give its inductance and capacity. The data with respect to the receiving antenna are not given.

While six specified tunes or wave-lengths are given by way of example, the Marconi invention, as disclosed in the specification and as defined in claim 16, is not limited to any specified wave-lengths or frequencies.

23. The court in its opinion of November 4, 1935, held and now finds that the receiving apparatus of the Kilbourne & Clark Company and that made by the Telefunken Company infringed claim 16 of the Marconi patent. The circuits of these two receivers are reproduced on page 24, and in each of the circuits the condenser h is in a shunt connection with the open circuit and around the primary of the transformer coil, in the Kilbourne & Clark circuit the tuning condenser being in parallel with the load coil and primary. The condenser h is also shown in dotted position in series with the antenna lead. This dotted position, however, is merely indicative of an alternative arrangement of these circuits in which the condenser h may be used in series connection instead of shunt connection.

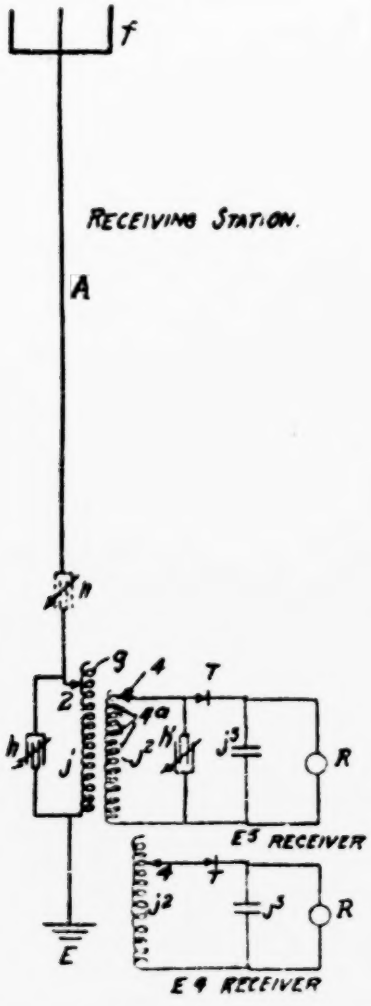
24. During the Marconi accounting period the United States purchased, acquired, or manufactured and used wireless receivers and receiving tuners having circuits in which an adjustable condenser was utilized or adapted for shunt connection with the open circuit and around the primary of the transformer coil. The adjustable condenser in such a circuit had the function and effect similar to that possessed by the adjustable condenser of the Marconi patent and in the Telefunken and Kilbourne & Clark sets found by the court to infringe and referred to in the previous finding, and was for the purpose of varying the periodicity of the primary circuit with which it was associated.

These sets are listed in the itemized schedule forming a part of Finding 32.

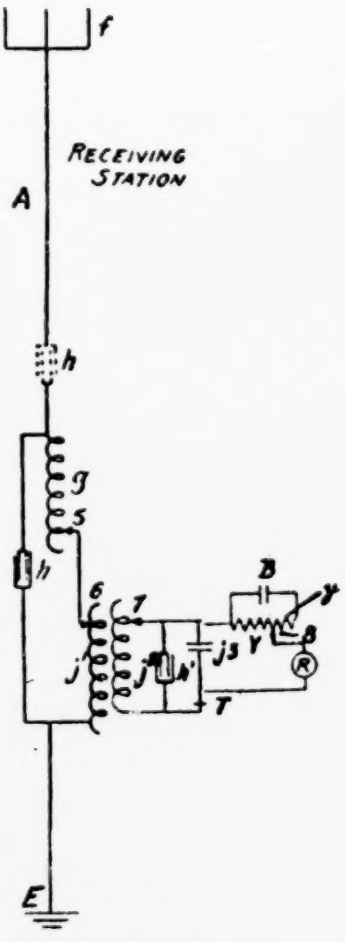
25. The contract cost of the sets thus acquired by the Government in many instances relates to the complete receiver [fol. 116] and includes detector devices and electrical apparatus more particularly directed to an effect on a signal subsequent to its passage through the tuner portion of the

receiving set, and such devices do not properly come within the accounting.

TELEFUNKEN TYPE



KILBOURNE & CLARK TYPE



Due to the difficulty of segregating the costs of the tuner portion of a receiving set from the remainder of the associated apparatus it is impossible to use the cost of the sets as a basis in establishing a fair and reasonable compensation. [fol. 117] 26. If the defendant had not utilized or made provision for the utilization of the shunt condenser connection as exemplified in the Telefunken and Kilbourne & Clark

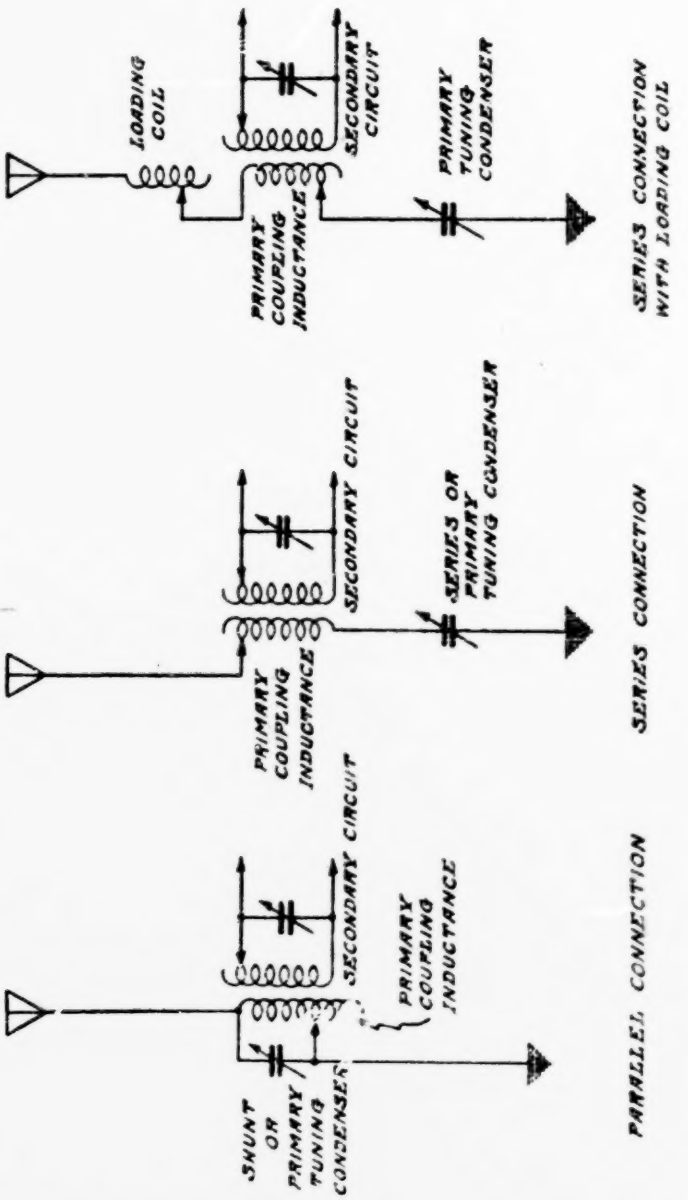
sets and covered by claim 16 of the Marconi patent, it would have been possible to accomplish substantially the same basic results by the use of another type of tuning circuit, but at an increased cost. Compensation may therefore be arrived at by ascertaining the monetary value by a comparison of these circuits.

27. The above-mentioned comparison involves the shunt circuit condenser connection hereinafter referred to as the "parallel connection" (the terms "shunt" and "parallel" being synonymous in electrical parlance), and a circuit herein termed the "series connection." Three figures are reproduced on the following page for the purpose of presenting certain effects in these comparative circuits.

The middle diagram thereof is illustrative of the series connection and shows an antenna circuit connected to one end of the primary of the coupling transformer, the opposite end of the coupling transformer being connected to the ground through a tuning condenser connected in series with the transformer winding. In this center diagram, as in the other two diagrams, the secondary circuit is shown as including only the secondary winding of the transformer and the secondary tuning condenser, the remaining elements of this circuit, such as the detecting devices and associated circuits, being omitted from these diagrams for simplification.

With the arrangement in the primary circuit as shown in the middle diagram and regardless of the maximum value of the condenser, no longer wave length can be received than could be received by omitting the condenser and connecting the primary transformer winding directly to ground, a condenser of relatively large capacity having the same effect on this circuit as an uninterrupted conductor from the lower end of the primary winding to the ground.

In other words, an adjustable condenser connected in series, as exemplified in the diagram, can be used to shorten the natural resonant wave length of the antenna circuit, but cannot lengthen it beyond what would be the resonant wave length if the condenser were not present. The maximum wave length which can therefore be received by a primary [fol. 118] circuit with the series condenser connection is dependent upon the constants (inductance and capacity) of the antenna circuit.



[fol. 119] If it is desired to receive a longer wave length with the series condenser it then becomes necessary to increase the constants or resonant wave length of the antenna circuit by inserting in the same an additional inductance in the form of what is known in the art as "a loading coil." By addition of this inductance the natural periodicity of the

antenna circuit is slowed down or decreased, thereby enabling the antenna circuit to become resonant to longer wave lengths.

It was the practice during the accounting period to use this method in the series circuit, the loading coil comprising in actual practice a circular hard rubber or bakelite form provided with plugs or binding posts so that the same could be readily plugged in or connected to a receiving set between the antenna connection of the set and the upper terminal of the primary winding of the coupling transformer.

Such an arrangement is shown in the right-hand figure.

28. In lieu of the loading coil method of increasing the resonant wave length to which the antenna circuit will respond, the same basic result may be accomplished by placing the adjustable tuning condenser in a shunt circuit around the primary of the coupling transformer. Such a parallel connection of the condenser as shown in the left-hand figure functions to decrease the natural periodicity of the antenna circuit below what it would be in the absence of the condenser, and thereby enables the primary circuit to be tuned to the relatively longer wave lengths.

29. For any given receiving installation in which the electrical constants of the antenna and the receiving set are known, the basic advantage of receivers constructed to utilize the shunt condenser connection may be ascertained in money value by calculating the size and cost of the loading coil required in the alternative series circuit to receive a signal of the same wave length. Such a calculation involves primarily the number of turns of wire necessary to provide the additional inductance. From this figure the length and cost of the wire are ascertainable, to which may be added the cost of the hard rubber coil form, together with the necessary labor cost and a profit. The total cost of the loading coil will therefore represent the monetary advantage due to the use of the shunt condenser connection.

[fol. 120] 30. Besides the monetary advantage in the receivers constructed to utilize the shunt condenser connection, as indicated in the previous finding, this type of connection as compared with the series connection, plus the loading coil, results in other advantages, as follows:

(a) The set is more compact, requires less room, and weighs less;

(b) At the longer wave lengths the sensitivity and selectivity are both greater.

This latter advantage is due to the fact that the use of a loading coil introduces additional resistance into the antenna circuit, and also an effect known as distributed capacity in which the adjacent turns on the loading coil tend to act as small capacities. The resistance tends to weaken the already feeble currents induced in the receiving antenna, and the distributed capacity effect tends to dissipate them.

These advantages, while somewhat intangible, are nevertheless of real benefit.

31. During the Marconi accounting period, especially in 1917-1919, the reception of messages, press and weather reports, enemy propaganda, etc., on the longer wave lengths was of great importance to the United States, particularly in the Naval service. As early as 1913, time signals and weather reports were regularly transmitted on the wave length of 2,500 meters. By 1915, much longer wave lengths were in use, wave lengths up to 15,200 meters having been regularly assigned. From this time on, the entire Primary System of Naval communications was carried on on wave lengths above 3,000 meters, and the regular communication wave length for the Secondary System was 952 meters. In 1919 and prior thereto practically all long-distance radio communication, such as transoceanic, transcontinental, etc., was carried on on wave lengths above about 10,000 meters. Plaintiff's Exhibit 484, which is by reference made a part of this finding, shows fifty-seven (57) orders issued by the Navy Department in 1916 for loading coils, each for a different station, such loading coils being for the purpose of increasing the wave-length range of existing sets.

32. For convenience of consideration, the receiving sets acquired and used by the Government during the Marconi accounting period and so constructed as to utilize the in- [fol. 121] vention set forth in claim 16 of the Marconi patent, are segregated into groups, as shown in the accompanying tabulation. The following tabulation carries in the last column the size of a loading coil (expressed in millihenries of inductance) which would be necessary for use as an alternative to the parallel condenser connection.

RECEIVERS WITH PERMANENTLY CONNECTED PARALLEL CONDENSER

Item No.	Contract No.	Approximate year acquired	Number of receivers	Type of receivers	Additional coil size
Pickard		1918	4	Otter Cliffs	74 3
W. Spec. App. Co.		1918	5	do	74 3
RECEIVERS WITHIN GROUP I					
15 16	35659	1919	266	SE-950	4 73
J. O.	12-Z-2252	1919	25	SE-950	4 73
17	36124	1919	288	SE-1012	1 13
J. O.	12-Z-2309	1919	25	SE-1012	1 13
21-22	40459	1919	246	SE-1012A	1 13
RECEIVERS WITHIN GROUP II					
(a) TELEFUNKEN RECEIVERS					
A-51		1910	2	(Telef.)	5 85
38	211	1911	2	GAH, KOHF	3 33
40	13549	1911	1	GAH	.5
A-60	444	1911	3	GAH or KOHF	3 33
B-31	455	1911	4	GEK-2	5 85
B-31	455	1911	3	(Telef.)	3 33
28	458	1912	2	GAH	.37
29	144	1912	3	GEK-2	4 2
39	12899	1912	38	GAH, KOHF	6 06
42	15232	1912	8	GAH, GEK-2	7 75
42	15232	1912	4	do	3
43	15294	1912	6	GAH	3 33
44	101	1912	2	GEK-2	2 34
45	16408	1912	1	do	1 0
45	16408	1912	1	do	3
45	16408	1912	1	do	2 34
46	14747	1912	15	E-5	3 33
47	256	1912	1	(Telef.)	4 2
A-76	538	1912	2	E-4	3 33
A-77	486	1912	1	(Telef.)	3 33
B-32	468	1912	1	GAH or KOHF	3 33
B-33	474	1912	1	do	3 33
30	123	1913	6	E-4, E-5	2 34
A-78	510	1913	4	(Telef.)	3 33
A-79	527	1913	1	do	3 33
34	6088C	1914	1	E-4	7 5
(b) FEDERAL RECEIVERS					
(Arlington)		1912	1	Federal	3 4
Plf. Ex. 407		1913	1	do	6 5
32	1948B	1914	1	do	10 3
48	269	1914	3	do	3 9
49	55	1915	2	do	6 5
50	350	1915	2	do	6 5
[fol. 122]		**(c) MISCELLANEOUS**			
-27	562	1913	1	IP-76 (1913)	7
35	231	1914	4	Spec. 16-R-1	18 6
A-35	19882	1914	10	IP-76 (1914)	10 5
A-35	19882	1914	13	IP-76 (1912)	4
36	225	1915	5	Spec. 16-R-1	18 6
41	20437	1915	4	do	18 6
A-7	157	1917	3	do	18 6
A-12	186	1917	1	do	18 6
Ericson		1917	1		2 27
Montcalm		1919	10		85 4
Nat. Elec. Sup. Co.		1919	2	Remodeled	615

RECEIVERS WITH PERMANENTLY CONNECTED PARALLEL CONDENSER—Continued

RECEIVERS WITHIN GROUP IIIA

Item No.	Contract No.	Approximate year acquired	Number of receivers	Type of receivers	Additional coil size
J. O.	12-Z-23629	1917	1	SE-143	16
6	31414	1918	247	do	16
10	33077	1918	150	do	16
12	1064	1918	30	SE-952	2
14	35479	1918	306	SE-143	16
18	3385	1918	27	SE-809	10
19	35979	1918	50	SE-998	7
5	31413	1919	112	SE-143	16
8 (part)	375	1919	27	SE-899	10
9	33064	1919	200	SE-143	16
13	35478	1919	200	SE-899	10
26	43723	1919	301	do	10
J. O.	12-Z-24328	1919	183	SE-143	16

RECEIVERS WITHIN GROUP IIIB

7	853	1917	100	CN-239	36
A-47	28838	1917	1	CN-208	6 25
A-47	28838	1917	1	CN-239	36
3 (part)	28735	1918	27	CN-208	6 25
3 (part)	28735	1918	40	CN-239	36
4	95	1918	200	CN-240	36
11	939	1918	1	CN-208	6 25
J. O.	12-Z-1857	1918	60	SE-95	130
8 (part)	375	1919	73	CN-240	36
20	38271	1919	300	SE-1220	30
24	42615	1919	59	do	30
Pl. Exh. 432		1919	201	do	30
Pl. Exh. 432		1919	13	SE-95A	130
A-48	34429	1919	60	SE-1220	30

NOTE.—The item numbers given in the first column of the table identify the various items set forth on the contracts and abstracts listed in Finding 7 and made a part thereof.

Where J. O. occurs under an item number, this indicates manufacture by the Government under a job order instead of purchase by contract.

33. A more detailed explanation of certain of the items included in the above tabulation is as follows:

(*Arlington Federal receiver*).—In the latter part of 1912 a Federal Telegraph Company radio receiver was acquired by the Navy Department for use at the Arlington Navy Radio Station, this receiver being used in official Navy work, and the set had a switch providing for the parallel connection of the antenna tuning condenser.

[fol. 123] (*Item A-27*).—This item refers to one receiver covered by a contract with the Telefunken Company dated January 29, 1913, for installation on the U. S. Army Transport "*Liscum.*" While the abstract of this contract shows no record of payment in the contract file, plaintiff's Ex-

hibit 428, item 9 has reference to an official notice referring to this contract and indicating that the set of which this receiver was a portion was inspected and accepted.

(*Item A–47*).—This item refers to a contract for one long-wave receiver and one short-wave receiver. By cross-reference to the contract abstracted under Item 3, these sets specified are one type CN-208 short-wave receiver and one type CN–239 long-wave receiver. These receivers were paid for by a check dated June 28, 1917.

(*Item A–48.*)—This item relates to contract No. 34429 of January 5, 1918, which as finally amended required delivery, among other things, of 60 SE–1220 receivers on a cost-plus-10 percent basis. The date of delivery of the receivers does not appear but the abstract of the contract file (plaintiff's Exhibit 408–A) indicates that the work under this contract had been completed by the contractor prior to November 20, 1919, the close of the accounting period. Out of thirteen public bills listed in the contract files only two are dated subsequent to November 20, 1919, and both of these show no payments by the defendant for "Factory overhead expense" or for "Gen. and Adm. expense" for any date later than October 31, 1919. A release dated February 16, 1920, shows full performance of the contract by the contractor and full payment by the defendant.

34. Certain apparatus designated as follows has been omitted from the tabulation given in Finding 32 as not properly coming within the accounting:

(*Item 1*).—This item relates to a contract which called for the rebuilding of a 2-kw. Telefunken wagon set. The abstract of the contract contains the statement "No evidence of receiver being supplied in rebuilding of this set." Plaintiff's Exhibit 428, abstract of papers of the U. S. Signal Corps, contains reference to a letter showing receipt and acceptance (Item 11). The wagon set as accepted contained one receiving set. There is no proof that the receiver itself [fol. 124] was rebuilt or that, if rebuilt, it embodied the parallel condenser connection.

(*Items 15–16*).—The abstract of this contract and supplemental contract shows 301 SE–950 receivers called for and the abstract, under "remarks," contains the statement "37 receivers with payment therefor not accounted for."

(*Item 17*).—This item relates to a contract calling for 300 type SE–1012 receivers. The remarks under the abstract of this contract state "Only 288 receivers of the 300 called for are accounted for in the contract file."

(*Item 50*).—This item is already referred to in detail in connection with the Lodge patent (see Finding 12). This item called for 5 sets complete with receivers and contained no proof of delivery of three of the sets.

(*Item A–35*).—This item covers a contract calling for thirty radio receivers at a total contract price of $9,380. The contract file shows delivery of and payment during the Lodge accounting period for twenty-three of the receivers. There is no proof of delivery of or payment for the remaining seven receivers, the contract price for which was $1,918.

(*Item 6*).—The abstract of this item relates to a contract calling for 600 short-wave receivers. The abstract under remarks contains the statement "only 247 sets delivered on this contract."

(*Item 14*).—This item relates to a contract dated March 7, 1918, and calling for 400 receivers type SE–143. The public bills and vouchers listed in the contract show payment for only 306 receivers and there is no proof of delivery of or payment for the remaining 94 receivers.

(*Item 5*).—This item of a contract under date of August 4, 1919, called for 250 short-wave receivers. The remarks in the abstract contain the following statement: "Only 112 receivers made."

Receivers with permanently connected parallel condenser

35. The nine receivers listed in this group in the tabulation given in Finding 32 were installed at the Otter Cliffs Station on Mount Desert, Maine. This was a radio station constructed by a Mr. Alessandro Fabri some time in the [fol. 125] summer of 1917, which station was turned over to the Navy Department later in that year. This station was subsequently manned by a Navy staff and because of its geographical position and relative freedom from static, was used extensively by the Navy to receive from the high-power long-wave European stations.

The station was originally equipped with five Wireless Specialty Apparatus Company receivers, and Professor Pickard while stationed at the Otter Cliffs Station constructed at least four other receiving sets from Navy material. All of the nine sets had the tuning condenser of the open circuit permanently connected in parallel with the primary winding of the coupling transformer and all of these sets were utilized in the regular reception of messages by the Navy Department.

Receivers within Group I

36. The receiving sets tabulated under Group I possessed a control device for progressively adding antenna inductance to the open circuit as a knob was turned. By means of a cam arrangement, when the last positions of the knob were reached, the open circuit was altered from a series condenser connection to a connection in which the tuning condenser was in parallel with the load coil and primary coil of the open circuit.

Receivers within Group II

37. This group of receivers and tuners was provided with a variable tuning condenser in the antenna circuit, and had a switch by means of which the operator of the receiver could at will connect the condenser either in series or in parallel with the inductance coils of the open circuit, including the primary winding of the coupling transformer.

The item identified as "Ericson" near the end of the tabulation of Group II was a receiver installed at the United States Naval Reserve Force Radio Station at Bath, Maine, and had a series parallel switch installed on the exterior of the cabinet at the left-hand end.

The ten receivers listed in this group under the item "Montealm" were located and were used at the United [fol. 126] States Naval Radio Station at the American Legation in Peking. The station was located within the legation grounds. The sets were built at the station, the condensers being obtained from stock at the Cavite Navy Yard, the coil forms made up by local labor, and the sets put together and assembled by Marines.

Receivers within Group IIIA

38. The receivers and receiving tuners listed within Group IIIA were designed by or under the supervision of

Navy engineers. These sets were intentionally designed to enable the operator to employ either (a) the series condenser connection alone, (b) the series connection with a load coil, or (c) the parallel connection of the antenna tuning condenser.

Several constructional features of these sets contributed to such a universal use, among which were the location of the primary tuning condenser between the antenna connection and the primary of the coupling coil instead of the customary location of the condenser between the ground and the lower end of the primary winding where stray capacity effects are a minimum; bringing out the necessary leads and wires to binding posts located on the face or panel of the receiver so that modification of the connections could be made without any alteration of connections within the receiver cabinet, and to receive a longer wave-length range than the wave-length range of the primary circuit with a series condenser connection in some instances by provision for loading coils in the secondary circuit.

The binding posts on the panel were suitably identified by engraved legends and the operators' instruction books accompanying the sets made specific reference to the parallel condenser connection, the purposes of it, and how to obtain it by suitable connections on the face of the panel. The following is quoted from the instruction book for the type SE–143 receiver, plaintiff's Exhibit 413B, which is made a part hereof by reference, this quotation being given by way of example:

The range of the primary of this receiver is 250 to 3,100 meters. The range of the tuned secondary is 250 to 6,800 meters. The primary may be increased from its nominal range of 3,100 meters to over 7,000 meters on any antenna [fol. 127] by connecting as shown in figure #1.

This places the primary variable condenser in parallel with the primary inductance. This combination is very efficient on waves longer than 3,000 meters; on short waves, it is not as efficient as the series capacity.

The change-over from shunt to series connection can be made quickly by using a double pole double throw switch as shown in figure #2.

The figures 1 and 2 referred to in the above-quoted portion are circuit diagrams visually instructing the operator what connections to make to the panel binding posts.

All of the sets in Group IIIA were accompanied by instruction books which described to the operator of the set the proper connection to the binding posts by means of which the parallel primary condenser connection could be obtained.

Receivers within Group IIIB

39. The constructional features of the receivers in this group are identical to those listed in Group IIIA with respect to being designed so that the operator could make the necessary panel connections to employ either (a) the series condenser connection alone, (b) the series connection with a load coil, or (c) the parallel connection of the antenna tuning condenser. The instruction books accompanying the receivers in this group did not indicate to the operators what connection should be made to the binding posts on the panels in order to obtain the parallel condenser connection.

There is evidence that Navy wireless operators familiar with the radio sets had knowledge of the advantages of the parallel condenser connection and utilized such circuit in the reception of official Navy communications and in accordance with orders of their superior officers in connection with the use of Group IIIB as well as Group IIIA receivers.

40. Calculation of the cost of the alternative loading coils involves a number of fixed material and labor costs, irrespective of the size or value of the loading coil, these fixed charges being set out specifically in Findings 42 and 43.

Such fixed costs make it possible to use an average load coil value for a group of receiving sets and thus simplify the calculation.

[fol. 128] The following table gives an average loading coil value in millihenries for the groups of sets tabulated, and in addition segregates the receivers acquired by contract from those manufactured by the Government or otherwise acquired:

Period	Group	Acquired by contract	Acquired otherwise	Total	Average load coil value
1910 1911	II	15		15	4 15
1912 1913	II	101		101	4 49
1914 1915	II	45		45	10 19
1917	Receivers permanently connected	5	4	9	74 3
1918	II	5		5	15 33
	IIIA	810	1	811	14 34
	IIIB	370	60	430	47 11
	I	800	50	850	2 36
1919	II	2	10	12	71 27
	IIIA	840	183	1,023	12 90
	IIIB	693	13	706	32 46
Total		3,686	321	4,007	Ave. 18 11

41. During the accounting period two types of loading coils were used, these types being designated as the "bank-wound" and "layer-wound" loading coil. The bank-wound coil was electrically more efficient in that the type of winding reduced the distributed capacity, and therefore reduced losses in the circuits. Bank winding required a particular art or skill, and there is no satisfactory evidence upon which to base the labor cost of such winding during the accounting period.

The layer-wound coils were wound on a hard-rubber spool, the second layer being wound upon a completed first layer, the third layer upon the second layer, etc. The cost estimate of the loading coils as used in the present case for a determination of just and reasonable compensation is based upon the layer-wound type of loading coil. This type of coil is not so efficient electrically as the bank-wound coil, due to distributed capacity effects. Labor costs in connection with the winding of the layer-wound type of coil are less than the labor costs of winding the bank-wound coils, and the cost figures for loading coils, given in the following findings, are for this reason conservative.

42. The cost of the layer-wound coils is divided into material and labor. The following tabulation gives the ma- [fol. 129] terial cost for the eleven sizes of loading coils set forth in Finding 40, *supra*. The cost of material for the coil form and hardware is the same for all sizes of the coil, being $1.77. The feet of wire for the different coil values are indicated on a graph (Commissioner's Exhibit CE-2, which is by reference made a part of this finding). This graph indicates the number of feet of wire

necessary for any given value in millihenries of the loading coil.

The wire which was used during the accounting period for the manufacture of loading coils is known as Litzendraht wire, and cost two cents per foot during the accounting period.

Load coil value (millihenries)	Material costs			Total material cost
	Cost of coil form	Feet of wire	Cost of wire at 2 cents per foot	
4 15	$1 77	180	$3 60	$5 37
4 49	1 77	190	3 80	5 57
10 10	1 77	310	6 20	7 97
74 3	1 77	1,025	20 50	22 27
15 33	1 77	385	7 70	9 47
14 34	1 77	375	7 50	9 27
47 11	1 77	780	15 60	17 37
2 36	1 77	128	2 56	4 33
71 27	1 77	1,000	20 00	21 77
12 90	1 77	355	7 10	8 87
32 46	1 77	625	12 50	14 27

43. The cost of direct labor of the type employed in winding, assembling, and making radio coils during the accounting period was eighty-one cents ($0.81) per hour. The length of time in minutes required to wind load coils of various sizes is shown on a graph (Commissioner's Exhibit 7, which is by reference made a part of this finding).

The following tabulation, which includes an indirect labor charge of 20 percent, is indicative of the labor costs involved in the various sizes of coils indicated. The fixed labor, as given in minutes, includes an average of seventy-five minutes for machining the coil form, and the remaining time of thirty-five minutes is inclusive of such fixed operations as getting stock, drilling for leads, mounting binding posts, placing form on arbor, tightening nut, setting turn counter, starting winding, bringing out finishing lead, clean-[fol. 130] ing and soldering leads to binding posts, removing coil and counter, baking and dipping, and testing.

Load coil value	Fixed labor in minutes	Winding time in minutes	Total time in minutes	Direct labor cost at $0.81 per hour	Indirect labor—20 percent of direct	Total labor cost
4 15	110	9	119	$1 61	0 32	$1 93
4 49	110	9	119	1 61	32	1 93
10 10	110	13	123	1 66	33	1 99
74 3	110	29	139	1 88	38	2 26
15 33	110	15	125	1 69	34	2 03
14 34	110	15	125	1 69	34	2 03
47 11	110	24	134	1 81	36	2 17
2 36	110	7	117	1 58	32	1 90
71 27	110	29	139	1 88	38	2 26
12 90	110	14	124	1 67	33	2 00
32 46	110	21	131	1 77	35	2 12

44. The following tabulation is indicative of the cost (material plus labor) of the eleven sizes of load coils given in the previous tabulations, and also contains in the last column what the approximate cost of the load coils would be if sold to the Government by a contractor, this column adding 20 percent profit to the cost of the coils:

Load coil value (millihenries)	Cost	Cost plus 20 percent profit	Load coil value (millihenries)	Cost	Cost plus 20 percent profit
4 15	$7 30	$8 76	47 11	$19 54	$23 44
4 49	7 50	9 00	2 36	6 23	7 48
10 10	9 96	11 95	71 27	24 03	28 83
74 3	24 53	29 43	12 90	10 87	13 04
15 33	11 50	13 80	32 46	16 39	19 67
14 34	11 30	13 56			

45. The following tabulation sets forth the total cost estimate of the loading coils, this being indicated both by period and group:

[fol. 131]

Period	Group	Acquired by contract	Acquired otherwise	Cost of load coil	Total value load coils	By periods	Other advantages $2.50 per set	By periods	Total
1910									
1911	II	15		$8.76	$131.40	$131.40	$37.50	$37.50	$168.90
1912									
1913	II	101		9.00	909.00	909.00	252.50	252.50	1,161.50
1914									
1915	II	45		11.95	537.75	537.75	112.50	112.50	650.25
	Receivers permanently connected	5		29.43	147.15		12.50		
	do		4	24.53	98.12		10.00		
1917	II	5		13.80	69.00		12.50		
1918	IIIA	810		13.56	10,983.60		2,025.00		
	IIIA		1	11.30	11.30		2.50		
	IIIB	370		23.44	8,672.80		925.00		
	IIIB		60	19.54	1,172.40		150.00		
						21,154.37		3,137.50	24,291.87
	I	800		7.48	5,984.00		2,000.00		
	I		50	6.23	311.50		125.00		
	II	2		28.83	57.66		5.00		
1919	II		10	24.03	240.30		25.00		
	IIIA	840		13.04	10,953.60		2,100.00		
	IIIA		183	10.87	1,989.21		457.50		
	IIIB	693		19.67	13,631.31		1,732.50		
	IIIB		13	16.39	213.07		32.50		
						33,380.65		6,477.50	39,858.15
						56,113.17		10,017.50	66,130.67

[fol. 132] 46. Other advantages in receivers constructed to utilize the shunt condenser connection, as compared to those utilizing loading coils, are set forth in Finding 30. For convenience, these advantages are reiterated:

(a) The set is more compact, requires less room, and weighs less;

(b) At the longer wave lengths the sensitivity and selectivity are both greater.

These advantages are of maximum benefit in sets constructed to receive the longer wave lengths and are of little or no value in the short-wave sets involving a load coil of only a few millihenries, with relatively few turns of wire. Referring to the average load coil value in the tabulation given in Finding 40, the maximum value is 74.3 millihenries and the minimum value is 2.36 millihenries. A fair and reasonable value of the advantages expressed in Finding 30 would be $10 per set for the long wave-length sets of 74.3 millihenries, and there would be no monetary value for a receiver which requires no load coil. The average load coil value for the 4,007 sets is 18.11 millihenries. Based on this average, the monetary value for this advantage per set for all the sets is approximately $2.50. This is included in the above tabulation as therein indicated.

47. A reasonable and entire compensation to plaintiff for use by the United States during the Marconi accounting period of the invention defined by claim 16 of the Marconi patent No. 763,772, is 65 percent of $66,130.67, or the sum of $42,984.93, together with interest at 5 percent per annum on the following sums from the respective dates given to the date of payment of the judgment, not as interest but as part of the entire compensation: $109.78 from December 31, 1911; $754.97 from December 31, 1913; $422.66 from December 31, 1915; $15,789.72 from December 31, 1918, and $25,907.80 from November 20, 1919.

Conclusion of Law

Upon the foregoing special findings of fact, which are made a part of the judgment herein, the court decides as a conclusion of law that plaintiff is entitled to recover the sum of $77,812.63, with interest at 5 percent per annum, not as interest but as part of just compensation.

[fol. 133] It is therefore adjudged and ordered that the plaintiff recover of and from the United States the sum of seventy-seven thousand, eight hundred twelve dollars and sixty-three cents ($77,812.63), with an additional amount measured by interest at the rate of 5 percent per annum on the following sums from the dates specified until paid: $34,827.70 from August 16, 1915; $109.78 from December 31, 1911; $754.97 from December 31, 1913; $422.66 from December 31, 1915; $15,789.72 from December 31, 1918, and $25,907.80 from November 20, 1919.

Opinion

Whaley, *Chief Justice*, delivered the opinion of the court:

This is a patent case now before the court for the determination of the reasonable and entire compensation to which plaintiff is entitled for the appropriation of the right to use certain inventions covered by United States letters patent to Lodge 609,154, and to Marconi 763,772.

The court on November 4, 1935, filed findings of fact with an opinion (81 C. Cls. 671), holding that the Lodge patent was valid as to claims 1, 2, and 5 and had been infringed, and that claim 16 of the Marconi patent was valid and had been infringed. This case was remanded to a commissioner of this court in accordance with the stipulation of the parties that the issue of reasonable compensation be postponed until the determination by the court of the issues of validity and infringement of the various patents in suit.

The record shows notice of the closing of proof on December 20, 1940 under the order of remand. The commissioner's report was filed June 9, 1941, and both parties have filed numerous exceptions thereto. Inasmuch as the periods for recovery differ with respect to the patents involved, and as the theory upon which reasonable compensation has been found also differs, these patents will be separately discussed.

Lodge Patent 609,154

The Lodge accounting period extends from March 8, 1913, when plaintiff first gave the notice of infringement to [fol. 134] defendant, to August 16, 1915, which is the date of expiration of the patent.

The issues presented by the parties in their exceptions to the commissioner's report with respect to this patent may

well be termed the customary or stock issues raised in a patent accounting. They may be briefly summarized as follows and will be considered in this order:

(1) The place of the Lodge patent in the radio art, i. e., whether it is commercially basic in character or whether it is merely an improvement;

(2) Whether the 10% royalty found by the commissioner is correct, plaintiff urging that this percentage is too low and defendant urging that it is too high; and

(3) Whether certain wireless apparatus should be included or excluded from the accounting or, more specifically stated (a) whether the Lodge patent relates to radio receivers sold separately; (b) whether certain spare parts of wireless appartus should be included or excluded from the accounting, and (c) the question of the burden of proof relative to the acquirement of certain items of radio apparatus.

The status of a patent in the art with which it is associated is of importance in determining the base which is to be used in an accounting. The reason for this is succinctly set forth in *Garretson* v. *Clark*, 111 U. S. 120, in which it is stated:

> When a patent is for an improvement, and not for an entirely new machine or contrivance, the patentee must show in what particulars his improvement has added to the usefulness of the machine or contrivance. He must separate its results distinctly from those of the other parts, so that the benefits derived from it may be distinctly seen and appreciated. The rule on this head is aptly stated by Mr. Justice Blatchford in the court below: "The patentee," he says, "must in every case give evidence tending to separate or apportion the defendant's profits and the patentee's damages between the patented feature and the unpatented features, and such evidence must be reliable and tangible, and not conjectural or speculative; *or he must show*, by equally reliable and satisfactory evidence, *that the profits and damages are to be calculated on the whole machine, for the reason that the entire value of the whole machine, as a* [fol. 135] *marketable article, is properly and legally attributable to the patented feature.*" [Italics ours.]

From a consideration of subsequent cases, the application of this rule relates more directly to an accounting

based upon profits rather than the type of accounting which is based on reasonable royalty and which has been followed in the present case with reference to the Lodge patent. This becomes apparent if we consider a theoretical instance, in which the profits, due to the patented portion of a machine, have on apportionment been found to be 25 percent of the total profits on the machine, the remaining 75 percent being due to extraneous elements or elements patented by others. In such a case plaintiff would be entitled only to the profits on the features or elements covered by his patent. If, however, the recovery of compensation in the same instance were measured by a reasonable royalty, such a procedure would take into consideration both the nature of the patented invention and its relation to the entire machine as a whole. Thus, in applying a reasonable royalty rule to the same situation just outlined, the differential between the patented and unpatented features of the machine would be taken into account by scaling down the percentage of royalty accordingly. It would make no difference in the ultimate compensation to plaintiff if the reasonable royalty were fixed at 5 percent of the selling price of the complete machine rather than 20 percent of one quarter of the sales price of the machine.

The Lodge patent relates to the selective tuning or syntonizing of the antenna circuits of a transmitting station with a receiving station. Plaintiff urges that the invention is fundamental or basic in character and that the entire market value rule be followed. Defendant urges that apportionment be made and that certain wireless apparatus not directly involved in accomplishing the tuning, and exemplified by arc transmitters, detectors, and amplifiers, be omitted from the base from which compensation is measured.

The three claims of the Lodge patent which have been held valid and infringed are quoted in Finding 5 accompanying this opinion, and the basic position of the Lodge patent in the art is defined in the following quotation from [fol. 136] the former findings of this court in its consideration of validity and infringement, in which it is stated that:

Marconi in his patent #586,193 apparently did not appreciate the desirability of tuning the primary oscillating circuit by the use of an inductance coil, and did not contem-

plate varying the effective tuning of the receiver to one of several transmitters. * * *

No one prior to Lodge appreciated the desirability of tuning the oscillating circuits of both the transmitter and receiver for the purpose intended and in the manner performed by him.

The ability to *selectively* and *adjustably* tune the antenna circuits of any receiving station to any desired transmitting station, or vice versa, was of fundamental importance to radio communication, and this is so obvious that it requires no lengthy explanation.

One of plaintiff's expert witnesses, Mr. Pickard, who has been engaged continuously in the field of radio communication from 1898 to the present time and during the major part of that time acted as a consulting engineer and was engaged in research and design work, testified with respect to the commercial and practical value of the Lodge invention as follows:

Q. 31. What was accomplished by the insertion of the lumped inductance in the antenna and what was its effect upon the development of the radio art and the development of radio communications?

A. What was accomplished by the lumped inductance was simply to permit any number of stations to operate within a given area, and so far as its effect upon the development of the art was concerned, it literally permitted the development of the radio art, which in the absence of such a means as the Lodge invention, would have been merely an interesting experiment.

* * * * * * *

Q. 37. Looking at the matter from the point of view of commercial utility will you in sum, so to speak, compare the utility of radio without the Lodge invention to its utility with it?

A. Without the Lodge invention radio had no practical utility. With it it had a very practical utility.

[fol. 137] One of defendant's expert witnesses, Commander Lavender, who had experience in radio communication work beginning in 1913, testified as follows in his cross-examination:

X Q. 240. Could you have built, in 1913, 1914, and 1915 a practical receiver which did not embody the Lodge invention?

A. No.

* * * * * * *

X Q. 248. And from your experience as one familiar with radio do you believe that—and I am asking for your own testimony—the Bureau of Engineering would have said that they could have gotten along without the Lodge invention?

A. I do not believe that they could have gotten along without it.

We are of the opinion that while the Lodge invention dealt primarily with tuning, the invention was of such paramount importance that it substantially created the value of the component parts utilized in the radio transmitters and receivers purchased or acquired by the United States during the accounting period, and that it therefore falls within the entire market value rule. The complete cost of the transmitting and receiving sets should be used as the base in the application of a reasonable royalty.

The commissioner found a fair and reasonable royalty on the Lodge patent during the accounting period to be 10 per cent of the selling price or market value of the radio transmitters, receivers and sets, and such apparatus as is dependent upon the invention thus defined for its utility. Defendant urges that the figure should be cut to 5 per cent and plaintiff asks that it be increased to 15 per cent. These requested values are based largely upon the opinion testimony of expert witnesses presented by both plaintiff and defendant.

The courts look with favor toward the establishment of a reasonable royalty as a measure of compensation in a patent accounting. This method usually obviates many difficulties connected with the establishing of such items as costs, profits, apportionments, expense of doing business, etc., all [fol. 138] of which are matters frequently difficult to ascertain in a legal procedure.

If the plaintiff has already established a royalty by a license or licenses, he has himself fixed the average of his compensation, and if this has been established prior to the

infringement, the task of the court then becomes easy. If such is not the case, a court will next take into consideration any act or acts of the plaintiff in connection with third parties which would tend to indicate an accepted monetary value for the use of the plaintiff's invention. Contracts made with others even during the infringing period or subsequent thereto may be considered provided there is no room for suspecting collusion and the circumstances of the contracts would seem to repel any doubt of their good faith and negative the question of whether they had been entered into for the precise purpose of establishing an excessive royalty.

In the *Cincinnati Car Company* v. *New York Rapid Transit Corporation*, 66 Fed. (2d) 592, 595, Judge Learned Hand said:

> The plaintiff had made five settlements, four of them after infringement, and upon all of its three patents, one of which we declared uninfringed. * * * Though the payments were not established royalties, we need not disregard them, any more than the master did. It is true that they were settlements for infringements, but both parties may have been influenced by a wish to be done with litigation; that consideration is a sword with two edges.

See also *Meurer Steel Barrel Co.* v. *The United States*, 85 C. Cls. 554, 562 (certiorari denied, 302 U. S. 754).

Finally, in the order of consideration is the testimony of expert witnesses, those more or less familiar with the establishing of royalty rates in any particular art. We place this last not because of any lack of credibility or integrity of witnesses who testify with respect to a reasonable royalty but more because the opinion of any one witness is based upon his own individual approach to the art or industry concerned, and would take into consideration numerous factors which a second witness, equally honest, might entirely disregard. As each party will present to the court only [fol. 139] those witnesses whose opinions in general favor their cause, such evidence, which is itself speculative, is sometimes of small help.

In Finding 13 we have set forth in detail four nonexclusive licenses which plaintiff granted to others during the Lodge accounting period to manufacture and sell wireless apparatus embodying the inventions of both the Lodge

patent and Marconi patent 763,772. These licenses all indicate a minimum royalty under the two patents of 2½ per cent of the listed catalog or selling price, and the licenses under date of October 15, 1914, to the National Electric Signaling Company, and under date of July 26, 1915, to the Clapp-Eastham Company, both provide for a royalty of 20 per cent on all sets sold to the United States.

When the Lodge patent expired on August 16, 1915, the plaintiff granted numerous other nonexclusive licenses under the Marconi patent alone. These included a new license to the Clapp-Eastham Company. The license fee or royalty fee provided for in these license agreements subsequent to the expiration of the Lodge patent was 10 per cent of the lowest selling price. Thus, these various contract agreements with third parties seem to indicate rather conclusively that the plaintiff and its licensees had in mind at that time an equal allocation of the 20 per cent royalty between the Lodge and the Marconi patents, and that 10 per cent is a just and reasonable royalty for the use of the Lodge patent alone during the accounting period. We think the commissioner is correct in his finding of 10 per cent as a reasonable royalty for this patent.

We next consider the issue of whether certain apparatus should be included in or excluded from the accounting base to which the royalty is applied. The first group of apparatus to consider comprises approximately 200 wireless receivers contained in eleven different contract items. These are receivers which were sold separately to the Government and not in conjunction with transmitting apparatus or complete station equipment.

Defendant's argument is that the claims of the Lodge patent which have been held valid and infringed by the court are directed to the capacity and lumped inductance, [fol. 140] and we quote from defendant's brief, "in the antenna at the local station and at a distant station." Insofar as we are able to follow defendant's argument, it assumes that the Lodge claims are directed to a system of wireless communication involving a transmitter and a receiver tuned thereto, and that where a transmitting set and a receiving set have been sold to the Government as a combination it is proper that they should come within the accounting, but where a receiver has been sold separately it represents an incomplete combination or a portion only of

the patented system, and therefore does not come within the accounting.

The language of the Lodge patent itself negatives this assumption of a system comprising a single transmitter cooperating with but one receiver, and instead contemplates a transmitter sending to a plurality of receivers. See lines 8-17, page 1 of the specifications, reading as follows:

> The object of my invention is to enable an operator, by means of what is now known as "Hertzian-wave telegraphy," to transmit messages across space *to any one or more of a number of different individuals in various localities, each of whom is provided with a suitably arranged receiver*, and to effect the ancillary improvements the nature of which are hereinafter more particularly described and claimed. [Italics ours.]

Defendant further argues that inasmuch as it is entitled to use certain systems involving both transmitters and receivers using the Lodge invention, but acquired *prior* to the Lodge accounting period, it has an implied license to continue the use of such systems and therefore has a right to purchase new receivers for use with the old transmitters, or, expressed in other words, defendant has a right to repair its prior acquired systems by the substitution of a new receiver for and old or worn-out receiver.

Defendant's argument is based on a false premise. The claims in suit of the Lodge patent are not limited to a system involving a combination of a transmitter with a receiver. In this court's former special findings of fact we specifically found (Finding XXVII) that:

> The Lodge patent relates to the provision of a self-inductance coil between a pair of capacity areas in an oscillating circuit of *either or both a sending or receiving set* for Hertzian wave telegraphy. [Italics ours.]

[fol. 141] Moreover, claim 5 is directed to the antenna circuit of either a transmitter or receiver, the circuit including a variable acting self-inductance serving to syntonize such antenna circuit to any other such antenna circuit.

With respect to the radio equipment acquired prior to the accounting period, defendant undoubtedly has a right, under the patent law as interpreted by the courts, to repair a system, but, on the contrary, it has no right to reconstruct

a system, and the installation of a new receiver would, in our opinion, amount to a reconstruction. (See our subsequent discussion in connection with repair parts.)

From the practical standpoint we can also see no assurance that any of the new receivers purchased separately would not be used whenever necessary to receive radio transmission from a transmitter acquired with the accounting period, and under the defendant's own theory of the Lodge invention being limited to a system, such use would then be an infringement.

We think that the receivers sold separately are properly within the accounting.

Certain extra parts are listed under a heading entitled "Value of parts" in the tabulation on pages 6 and 7 and are also individually itemized and set forth in greater detail in Finding 9. These parts, as taken from the various contracts, have a total value of $56,448.82, and defendant urges that they comprise repair parts, and therefore should be omitted from the base figure to which any reasonable royalty by way of compensation is applied.

The general theory relating to spare parts is in substance that the user of a patented machine or device having once paid the patentee a royalty or other consideration for the right to its free use and enjoyment, is thereafter entitled to keep the machine or device in repair and to replace broken or worn-out unpatented parts of its mechanism with a corresponding part not necessarily purchased from the patentee. This principle is stated in Walker on Patents (6th Edition), Sec. 350:

> A purchaser may repair a patented machine which he has purchased, by replacing broken or worn-out unpatented parts, so long as the identity of the machine is not de- [fol. 142] stroyed, provided the machine itself is not an infringement. * * * And he may improve such a machine for his own peculiar use, by substituting for an unpatented part thereof, a corresponding part originally purchased, or not purchased, from the patentee. But no unauthorized person can lawfully engage in the business of reconstructing patented machines for their owners, by omissions and substitutions of parts, where those machines do not require any repair, but are thus changed with a view to their improvement.

Reference is also made to the opinion of the Supreme Court in *Leeds & Catlin* v. *Victor, etc. Company*, 213 U. S. 325, 336, in which the question of repair or replacement parts was considered in connection with the furnishing of additional phonograph records for a sound-production apparatus, as follows:

Can petitioner find justification under the right of repair and replacement as described in *Wilson* v. *Simpson*, 9 How. 109, and *Chaffee* v. *Boston Belting Co.*, 22 How. 217? The Court of Appeals, in passing on these cases, considered that there was no essential difference between the meaning of the words "repair" and "replacement." That they both meant restoration of worn-out parts. This distinction was recognized in *Wilson* v. *Simpson, supra*, where it is said that the language of the court in *Wilson's and Rousan's Case*, 4 How. 709, did not permit the assignee of a patent to make other machines or reconstruct them in gross upon the frame of machines which the assignee had in use, "but it does comprehend and permit the resupply of the effective ultimate tool of the invention, which is liable to be often worn out or to become inoperative for its intended effect, which the inventor contemplated would have to be frequently replaced anew, during the time that the machine as a whole might last." But there is no pretense in the case at bar of mending broken or worn-out records, or of repairing or replacing "the operative ultimate tool of the invention" which had deteriorated by use. The sales of petitioner as found by the courts below, and as established by the evidence, were not to furnish new records identical with those originally offered by the Victor Company, but, to use the language of Judge Lacombe in the Circuit Court, "more frequently in order to increase the repertory of tunes than as substituted for worn-out records."

[fol. 143] *The right of substitution or "resupply" of an element depends upon the same test. The license granted to a purchaser of a patented combination is to preserve its fitness for use so far as it may be affected by wear or breakage. Beyond this there is no license.* [Italics ours.]

See also *Miller Hatcheries* v. *Buckeye Incubator Co.*, 41 Fed. (2d) 619, for a complete discussion of this question.

The ultimate question is apparently one of "repair" versus "reconstruction" and its practical determination to

a large extent rests on the purpose for which the parts were intended.

Plaintiff's witness Clark testified with respect to the spare parts as follows:

Q. 1506. Did you personally have anything to do with the requirement for the delivery of spare parts in Navy contracts or in Navy specifications?

A. Yes, sir, I did.

Q. 1507. What, Mr. Clark?

A. I wrote the specifications which called in detail for such spares to be supplied.

Q. 1508. Will you please explain the reason for the purchase of spare parts for those transmitters?

A. Spare parts were replacement parts for such things as experience had shown might be destroyed during the normal use of the set—during the normal or military use of the set.

Q. 1509. Did the supply of spare parts have any relation to keeping the apparatus available for use at all times, no matter where the ship or station might be?

A. Yes. That is what the previous question meant—the previous answer meant.

Q. 1510. Will you amplify a little, please? In the absence of spare parts could continuous service be available at all times on a ship at sea, for example?

A. No. My previous answer meant that the spares were to insure continuous operation. That means that if any part were to break down due to any reason it would be replaced immediately by the spare and therefore the set would continue to be operative.

From this it is clear that the primary purpose of these spare parts was for "a repair" instead of "a reconstruction" of the sets. It is especially vital in military use to have sufficient replacement or repair parts on hand so as to maintain substantially continuous operation at all times. [fol. 144] The question may be raised that the spare parts were furnished for infringing sets and not for radio equipment which the defendant had a right or license to use, and for this reason they do not fall within the spare parts rule and should be included in the accounting.

It is our view, however, that in the present method of awarding reasonable compensation based on a reasonable royalty and including interest from the time of acquirement of the radio equipment, defendant is placed in the position of a trustee ex maleficio, and as one who has paid a license fee at the time of acquirement and therefore is entitled to the use of the devices and also to their repair. In stating this we are not overlooking the possibility that some of these parts may have entered into the "reconstruction" of some of the sets that the defendant had previously acquired, or that even entire new sets had been built and some of these parts used. In the latter case, where satisfactory proof has been introduced, such sets have been included and form a portion of the base to which the royalty applies. In the former case we have no evidence before us which would enable any allocation of these parts to be made with reference to repairs versus reconstruction, and we must therefore depend on what is stated to be the primary purpose of these parts as set forth in the above-quoted testimony of the witness Clark.

The spare parts should be omitted from the base to which the reasonable royalty is applied.

We next come to the question of burden of proof with respect to about twelve items, this question being presented by plaintiff in that it urges that certain of these items which were omitted from the accounting should be included therein, and that certain other of these items should be given a larger market valuation than was given them by the commissioner.

A patent accounting frequently presents a problem of this nature. While it is the duty of the plaintiff in the accounting to present prima facie evidence of the number of devices and their monetary value, the evidence upon which plaintiff is forced to rely for this purpose is usually in the form of records and documents in the possession of [fol. 145] defendant, and this is especially true where the devices have been acquired by the infringer from third parties, as in the present case.

Where confusion in the books or records of the defendant is found, or where profits from the infringing device have been commingled with other profits of the defendant, it is obviously impossible for the plaintiff to proceed beyond a

certain point in its prima facie proof, and one party or the other must suffer. We find no better exposition of this subject than that given in *Westinghouse Co.* v. *Wagner Mfg. Co.*, 225 U. S. 604, 621, from which we quote at some length:

None of the cases cited discuss the rights of the patentee who has exhausted all available means of apportionment, who has resorted to the books and employes of the defendant, and by them, or expert testimony proved, that it was impossible to make a separation of the profits. This distinction, between difficulty and impossibility, is involved in the ruling by the Circuit Court of Appeals for the Sixth Circuit in *Brennan & Co.* v. *Dowagiac Mfg. Co.*, 162 Fed. Rep. 472, 476, where the *Garretson Case* was distinguished, and the court said:

"In the present case the infringer's conduct has been such as to preclude the belief that it has derived no advantage from the use of plaintiff's invention. * * * In these circumstances, upon whom is the burden of loss to fall? We think the law answers this question by declaring that it shall rest upon the wrongdoer, who has so confused his own with that of another that neither can be distinguished. It is a bitter response for the court to say to the innocent party, 'You have failed to make the necessary proof to enable us to decide how much of these profits are your own;' for the party knows, and the court must see, that such a requirement is impossible to be complied with. The proper remedy to be applied in such cases is that stated by Chancellor Kent in *Hart* v. *Ten Eyck*, 2 Johns. Ch. (N. Y.) 62, 108, where he said: 'The rule of law and equity is strict and severe on such occasion. * * * All the inconvenience of the confusion is thrown upon the party who produces it, and it is for him to distinguish his own property or lose it.'"

It may be argued that, in its last analysis, this is but another way of saying that the burden of proof is on the defendant. And no doubt such, in the end, will be the practical result in many cases. But such burden is not im-[fol. 146] posed by law; nor is it shifted until after the plaintiff has proved the existence of profits attributable to his invention and demonstrated that they are impossible of accurate or approximate apportionment. If then the burden of separation is cast on the defendant it is one which justly should be borne by him, as he wrought the confusion.

See also *Computing Scale Co.* v. *Toledo Computing Scale Co.*, 279 Fed. 648, 673, which refers to the *Westinghouse* decision as follows:

And the first fruits of the Westinghouse decision should be this: If a manufacturer, knowing of a patent, decides to chance an unlicensed use, he should realize that he may be caught by a final decree on the merits and be ordered to respond accordingly; and, so realizing, he should be held to the duty of keeping separate and accurate records of all his infringing acts; and, on his failure to keep such records, the court, in measuring the damages on account of his trespasses, should resolve all doubts against him.

In the present case there was a commendable cooperation between counsel with respect to the examination of defendant's records. In lieu of calls, the complete files in the General Accounting Office with respect to specified contracts for the purchase of radio apparatus were rendered available to a representative of plaintiff who made abstracts of them, these abstracts being submitted to a representative of defendant for correction and the addition of any material it desired. Any informal requests for the production of documents from the defendant's records that could be located were granted and plaintiff's representative permitted to examine them and make abstracts. It is from these abstracts with very few exceptions, that the plaintiff has based its proof of the number of sets and their market value.

With respect to the majority of the items questioned by plaintiff, plaintiff urges that the contract files show a contract for delivery of a certain number of radio sets at the given market value, and contain no record either of cancellation, payment for, or acquirement of the sets by the defendant, and under these circumstances plaintiff asserts that the delivery of and payment for the apparatus in accordance with the terms of the contract, and in the absence [fol. 147] of any proof to the contrary on the part of defendant, must be inferred or presumed.

In so far as three of the contested items are concerned they should be included. Item A-27 (see Finding 11) called for a transmitting and receiving set at a price of $2,450. The abstract of this contract shows no record of payment in the contract file. In plaintiff's Exhibit 428 however (Item 9) there is an official notice dated March 17, 1913, referring to this contract and stating, "The balance of the material

on order 12387 was to-day inspected and accepted." We think in this instance that the burden of proof as to the non-acquisition of this set is on defendant, and this item has been included in the accounting.

With respect to the Tuckerton transmitting set (Finding 11) there is no contract file in evidence, but plaintiff's witness Clark has testified that a 60-kw. arc transmitting set was supplied by the Federal Telegraph Company and he personally installed this set at the Tuckerton station. Mr. Clark, who also had a great deal to do with the preparation of the various Navy contracts and was well acquainted with the value of the apparatus, also gave as his opinion that the value of this set was $8,000. We think that this oral testimony of Mr. Clark is sufficient to establish acquirement of this set and its value in the absence of any proof by defendant to the contrary.

Defendant's witness Eaton described three radio receivers which he had constructed and used on behalf of and as an employee of defendant during the Lodge accounting period. The source of or date of acquirement of the various component elements used in the construction of these receivers is unknown, but even grating that the component parts of these sets were acquired prior to the Lodge accounting period, these sets did not become an entity until they were constructed or manufactured. This act took place during the Lodge accounting period. The minimum established value of a receiving set during the Lodge accounting period was $250, and these three receivers, at a total of $750, are therefore included in the accounting (see Finding 11). The defendant has presented no proof to the contrary with respect to this item.

[fol. 148] It it to be noted in connection with the first of these three items (Item A-27) that while the contract file itself indicated no proof of payment, there was separate proof of acceptance or acquisition of the radio apparatus by the defendant. We emphasize this in passing to a consideration of some of the other items which plaintiff urges for inclusion in the accounting. While admissible in evidence to lay a foundation, we do not think that the mere existence of a contract under the circumstances in the present case carries the presumption of acquirement of the apparatus specified.

In the present situation and from a consideration of the plaintiff's abstracts and documents in their entirety, it can

not be said that the Government has kept a confused or inaccurate record. Instead, we are convinced from an examination that these records as a whole are more complete and accurate than similar records kept by the average private firm or individual and relating to events occurring as far back as 1913-1915. Neither can it be said that the defendant did not extend cooperation to plaintiff in its examination of its records. We also do not think that plaintiff has satisfactorily established as a fact that where a contract file in the General Accounting Office does not show either a cancellation of the contract or a fulfillment of the contract, the records have been inaccurately kept. It would appear that this statement, upon which plaintiff predicates the shifting of the burden of proof, is more of an assumption than an established fact.

With reference to the shifting of the burden of proof to the defendant, we refer to the *Westinghouse case* cited, *supra*, directing attention to the fact that such burden is not shifted until the plaintiff has proved the *impossibility* of either accurate or approximate apportionment, this case referring to the distinction between *difficulty of proof* and *impossibility of proof* in the first paragraph of the subject-matter cited therefrom, *supra*.

We now refer to Item A-5 (Finding 12), which is one of the items plaintiff urges should be included in the accounting. This item is an abstract of a contract with the Federal Telegraph Company dated November 2, 1914, and [fol. 149] called for one transmitter and one receiver at a contract price of $5,500. The abstract of this contract states that there is no payment by public bill or any other record of payment, nor does the abstract of the contract specify the delivery date of the apparatus. From what we have previously said, we cannot assume from this abstract that defendant acquired this apparatus or that further evidence by plaintiff with respect to this item is an impossibility rather than a difficulty.

What we have said about this item applies also to the various other items set forth in detail in Finding 12 and with reference to which it is therein stated that there is no satisfactory evidence either of delivery of or payment for the items within the accounting period.

What we have said with respect to Item A-5 as to proof applies also to such items as 50 and A-35 in Finding 10. Item 50 calls for five radio sets and shows delivery of two

of them during the Lodge accounting period. There is no proof of delivery of or payment for the remaining three sets during the accounting period. Item A-35 similarly shows a contract for thirty radio receivers and delivery of and payment during the Lodge accounting period for twenty-three of the receivers, with no proof of delivery of or payment for the remaining seven.

It is unnecessary to refer in detail to the remaining items which plaintiff urges should be included or altered as to market value in the accounting (Items A-1, A-29, A-39, B-20, B-21, B-52, and C-1) and which we have set forth in detail in Findings 9, 10, and 12. The commissioner was correct in either excluding the items or in giving them the market values proved by the records of payment in the files.

From the tabulation appearing on pages 6 and 7 the entire market value of the apparatus acquired during the Lodge accounting period is $348,276.94.

We find that just and reasonable compensation is 10 percent of this entire market value, or $34,827.70, together with an amount measured by interest at 5 percent per annum, not as interest but as a part of the entire just compensation, on $34,827.70 from August 16, 1915, to date of payment of the judgment.

[fol. 150] Defendant in its exceptions to the commissioner's report has requested that the court use an interest figure of 2 percent because, and to quote from its exceptions:

> Just compensation should not include interest at a higher rate and should not include interest prior to April 8, 1936, because the plaintiff by joining the claim under the Lodge patent with claims under three other patents contributed to protraction of the litigation beyond all reason, when the claim under the Lodge patent could easily have been separated and promptly tried.

We do not follow this line of reasoning. It is apparently based on a false premise, for if the Lodge patent were to be separated, then presumably each of the other patents should likewise have been separated, with the result that there would have been four distinct suits in which a substantial part of the record would have had to be duplicated. The joinder of the four patents in one suit, all owned by plaintiff and directed to the same basic subject-matter, simplified the litigation by making it possible to consider

only once all fundamental matters relating to radio, relationships between the parties, and the facts as to the acquirement and structure of the infringing apparatus.

Defendant does not suggest that there has been any unreasonable delay in the prosecution of this case, with its necessarily voluminous record. In fact, in its objections to plaintiff's proposed findings of fact before the commissioner, filed September 9, 1940, defendant stated (p. 20):

> The highly technical character of the subject-matter, the difficulty of assembling competent witnesses, and the time required for preparation by both parties are believed to be such as to indicate reasonable speed by both parties.

We feel from a consideration of the record that 5 percent is a proper rate of interest in the present case.

Marconi Patent 763,772

Plaintiff having filed supplemental petitions, the accounting period for the Marconi patent extended from July 29, 1910, to November 20, 1919, at which time the plaintiff [fol. 151] assigned the patent. Claim 16 upon which this accounting is based relates to a particular circuit connection between the antenna tuning condenser and the primary of the transformer in a radio receiver, hereinafter referred to as the parallel or shunt connection. Findings 20 and 21 recite the claim and describe the circuit in detail.

In connection with this patent the defendant presents an issue unusual in accounting proceedings, i. e., the issue of noninfringement. The two other basic issues presented by the parties are whether certain radio receivers should be included in or excluded from the accounting, and what proportion of the monetary value resulting from the use of the invention by the defendant should be utilized in arriving at a reasonable and entire compensation.

In its opinion of November 4, 1935, on the question of validity and infringement of the Marconi patent, which was at that time before the court, the third conclusion of law of this court read as follows:

> That the Marconi patent #763,772 is invalid except as to claim 16 thereof, which is infringed by the apparatus specified in Finding LXIII and any other apparatus used by defendant coming within its terminology.

We also quote Finding LXIII, referred to in this conclusion of law:

The receiving apparatus of the Kilbourne & Clark Company, shown in exhibit 95, and the receiver made by the Telefunken Company, illustrated in exhibit 79, each has apparatus coming within the terminology of claim 16.

In connection with the presentation to the court of the question of validity and infringement, it had been stipulated that the issue of reasonable compensation for damages and profits be postponed until the determination by the court of the issues of validity and infringement of the various patents in suit.

The decision of this court relative to infringement and validity (November 4, 1935) was prior to the *Esnault-Pelterie* decision of December 7, 1936 (299 U. S. 201), which held that infringement was a question of fact rather than one of law. Prior to the *Esnault-Pelterie* decision this court [fol. 152] uniformly considered that whether or not certain apparatus came within the terms of a patent claim was a question of fact, but that whether the claim was infringed by such apparatus was a question of law.

The defendant some six years after the original decision of this court on the question of infringement, and after the expenditure of much time and money in the Marconi accounting, now for the first time argues that there was *no finding of fact* that the defendant has infringed and asks for a finding of noninfringement. Thus as we see it, defendant's present position, based upon this technicality, is that this court in spite of the stipulation that the accounting be deferred until validity and infringement had been determined, sent this case to the commissioner for the accounting without deciding the issue of infringement of claim 16. This we did not do. The meaning and intent of the prior decision on infringement was clear and was understood by the defendant who at no time by motion for a new trial or otherwise has until now questioned the correctness or the sufficiency of the court's findings or conclusions.

In its eagerness to advance this theory of noninfringement defendant has evidently overlooked the fact that should the court still consider this question as pending in Marconi patent #763,772, plaintiff could with equal facility urge that the prior conclusion of the court holding the

Marconi reissue patent and the Fleming patent noninfringed, was equally nondeterminative.

The question of infringement of Marconi claim 16 by the apparatus designated in Finding LXIII of the prior decision is not before us in the present accounting. In order to forestall further controversy, however, we have found validity and infringement as an ultimate fact (Findings 1 and 23) in our special findings of fact.

In its argument as to noninfringement defendant also attempts to rely upon a ruling of this court on defendant's motion with respect to certain calls under date of October 22, 1937. The court's order read:

> The location and function of the condenser in the Government radio sets under consideration in the present motion is a question of fact, and their identity or difference of construction and mode of operation with respect to claims [fol. 153] which have been held valid and infringed are subject to proof before the Commissioner. The within motion is overruled.

Defendant suggests that by this order the court reopened the entire subject of infringement of claim 16. This is incorrect. This order resulted from the fact that plaintiff had made motions for calls on certain Departments relating to additional apparatus which plaintiff claimed infringed claim 16 of the Marconi patent. Plaintiff's motions were allowed but defendant requested this court to reconsider its allowance of the motions, and in support of its argument numerous radio circuit diagrams were submitted to the court without any expert testimony as to what they disclosed. The court denied defendant's motion to reconsider the allowance of plaintiff's motions for calls, and left it to the commissioner to determine by means of evidence presented before him the location and function of condensers in defendant's receivers. The order in substance required the commissioner to determine whether these additional receivers should be included in or excluded from the accounting.

The defendant also argues that even though claim 16 be valid, it is limited in scope by the prior art, and as thus limited the Government receivers follow the teachings of the prior art rather than claim 16 of the Marconi patent, and therefore do not come within the accounting. Defend-

ant asserts that the commissioner failed to make certain findings bearing out this contention. This of course is but raising the question of infringement in another guise.

The court in its original decision established the scope of claim 16 when it held the same infringed by the receivers of the Kilbourne & Clark Company and the Telefunken Company, as set forth in Finding LXIII. This apparatus, its circuits and its elements establish the interpretation of the claim with respect to the accounting.

The sole purpose and function of an accounting in a patent infringement case is to ascertain the amount of compensation due, and no other issue can be brought into the accounting to change or alter the court's prior decision. With reference to the additional receivers presented, if [fol. 154] their identity of construction and mode of operation are similar to the apparatus which the court has held to be an infringement, then they also infringe, and this is as far as the proof has to go. See *Flat Slab Patents Co.* v. *Turner*, 285 Fed. 257, 273:

> The problem of the master, therefore, in ascertaining whether a new construction is to be covered by the accounting, becomes *one of comparison between that construction and the one declared to infringe*. This comparison is along the line of infringing elements or features. The identity of such elements or features and the respect in which they constitute infringements can be found by the master sometimes in his report or more often in his opinion which may be treated as an explanation of the report. No aid in understanding the action of the court can be found in facts not before the court as evidence and not judicially noticeable. Evidence of the prior art can find no initial entrance into the case through the accounting. The place of prior art in patent law is to invalidate or limit the scope of the patent. The suggestion that it can be introduced for the first time in the accounting for the purpose either of modifying or of interpreting the infringement adjudication is not sound. The duty of the master is to apply, not to alter the decision of the court appointing him, and he is not aided in understanding that decision by facts which the court did not have in mind when it acted. [Italics ours.]

It is clear from the record that the construction and mode of operation of the additional receivers were similar to

the Kilbourne & Clark receiver and the Telefunken receiver when the antenna tuning condenser was connected in the parallel position. None of defendant's witnesses has asserted to the contrary, and we have so found in Finding 24.

The technical details of construction of the various groups of receivers contained in the itemized schedule forming a part of Finding 32 are set forth in Findings 35 to 39, inclusive. The usual controversy has arisen as to the inclusion or exclusion of certain individual items of equipment. We have fully discussed the matter of proof in this respect in that portion of the opinion relating to the Lodge patent, and it is unnecessary to repeat it here. These items have been considered in accordance with our previous statement and are set forth in Findings 33 and 34.

[fol. 155] With respect to the various groups contained in the itemized schedule (Finding 32), the first group, "Receivers with permanently connected parallel condenser," needs no explanation. As constructed, these receivers have what we term for convenience "the Marconi circuit" in permanent form.

As to Group I, the receivers therein had an automatic device connected with the inductance controlling knob of the set so that when the knob was in its last positions the circuits inside the set were so arranged as to produce the Marconi circuit.

Receivers within Group II were provided with a switch so that the operator could connect at will the condenser either in series or utilize the Marconi circuit.

The item in this group identified as "Montcalm" refers to a group of receivers which were made and used at the United States Naval Radio Station at the American Legation in Peking and within the legation grounds. This item, which is trivial, as it involves only 10 receivers out of a total of 4,007, presents an apparently new issue in patent law. Does manufacture and use in such a location violate the monopoly created by the patent and which extends "throughout the United States, and the Territories thereof," as expressed by Section 4884 of the Revised Statutes?

We know of no case directly in point. *Gardiner* v. *Howe*, 9 Fed. Cases 1157, however, is a patent case in which the master of a vessel under American registry applied a device to a sail and used the same while on the high seas between

Liverpool and New York. The owner of the vessel was made the defendant in a patent suit for this act. The court held that use of the invention of a United States patent on a vessel of American registry, while it is on the high seas and without the jurisdiction of the United States, constitutes infringement of the patent. Justice Clifford said:

The patent laws of the United States afford no protection to inventions beyond or outside of the jurisdiction of the United States; but this jurisdiction extends to the decks of American vessels on the high seas, as much as it does to all the territory of the country, and for many purposes is even more exclusive.

[fol. 156] The converse of this proposition is set forth in *Brown* v. *Duchesne*, 19 How. 183, where Mr. Justice Taney held that the exclusive rights granted to a patentee do not extend to a foreign vessel lawfully entering one of our ports and that the use of the patented improvement in the construction, fitting out, or equipment of such vessel, while she is coming into or going out of a port of the United States, is not an infringement of the rights of an American patentee provided such use is lawful under the laws of the country to which the vessel belongs.

We think from these two cases the use of a United States patent on the grounds of the American Legation at Peking constitutes infringement thereof, and the ten receiving sets are properly within the accounting.

Receivers in Group IIIA were what might be termed universal receivers. These sets were intentionally designed under the supervision of Navy engineers to employ three different circuit connections at the will of the operator, who could use either a series condenser connection, a connection involving an external load coil, or the Marconi circuit. In order to accomplish this, the sets were designed with the condenser connected between the ground and the primary coil instead of its more conventional location between the antenna and the primary coil, and instead of having all the wiring of the sets permanent in character and behind the panel, the necessary wires were brought out to binding posts mounted on the face of the panel. The binding posts were identified by engraved legends, and by means of making various connections to them the operator could select any of the three modifications which he desired. An instruction book with diagrams for the operators ac-

companied these sets and this book told the operator what connections to make in order to obtain the Marconi circuit and also referred to its utility.

The receivers in Group IIIB were identical with those in IIIA as to construction and the location of the binding posts on the panel for obtaining any of the several types of receiving circuits, including the Marconi circuit. The receivers in this group, however, were not accompanied by an in- [fol. 157] struction book with specific references to the Marconi circuit.

The evidence in the case is clear that the Navy wireless operators had knowledge of the advantages of the Marconi circuit and utilized this circuit from time to time in the reception of official Navy communications and in accordance with the orders of their superior officers in the use of Group IIIB receivers as well as Group IIIA receivers. Both of these groups are therefore properly included in the accounting. See *Wright Co.* v. *Herring-Curtiss Co.*, 211 Fed. 654, 655, as follows:

> As to the other claims, in which the vertical rear rudder is an element, we are satisfied from the testimony, as was the court below, that during some parts of their flight defendant's machines use the rudder synchronously with the wings, so that by their joint action lost balance may be restored or a threatened loss of balance be averted. Such use of the rudder constitutes infringement, and a machine that infringes part of the time is an infringement, although it may at other times be so operated as not to infringe.

See also *Corrugated Fiber Co.* v. *Paper Working Machines Co.*, 259 Fed. 283.

The Marconi invention as predicated upon claim 16 relates only to a portion of the receiving set, i. e., the primary tuning condenser and its circuits. As the contract costs of sets acquired by the Government in most instances relate to the complete receiver and include detector devices and improvements which should be properly allocated to other patentees, there would be great difficulty in segregating the value of those portions of the receivers involved in this accounting. Use has therefore been made of the standard of comparison method.

If the defendant had not used the Marconi circuit it would have been possible to accomplish substantially the

same basic results by the use of another type of tuning circuit available to the defendant but at an increased cost. Compensation may therefore be arrived at by ascertaining these costs. As the detailed method and computations are set forth fully in Findings 26-30 and 40-44, inclusive, it is unnecessary to refer to this method here except to state [fol. 158] that it involved calculations of the cost of the alternate structure available to the defendant and included materials, labor, and overhead.

The final tabulation in Finding 45 gives the total cost estimate of this alternate structure, being indicated both by suitable periods of time and by groups.

The total figure is $66,130.67 for the 4,007 receivers coming within the accounting.

Plaintiff contends that it is entitled to this total value, together with suitable interest thereon, as reasonable and entire compensation. With this we do not agree. This value does not represent profits lost by the plaintiff through the failure of the defendant to purchase from it receiving sets equipped with the Marconi circuit. Nor is this figure the measure of the infringer's profits such as occurs frequently in patent litigation, where the defendant has obtained a market by the unauthorized use of an invention and which profits then become a measure of damages.

Instead, this figure represents the entire sum that it would have cost the defendant to avoid the use of the Marconi invention by accomplishing the same results in another way. If the parties to this suit had been in negotiation for the use of the Marconi invention we can readily assume that the price agreed upon would be something less than it would have cost defendant to use an equivalent device, for, unless this were done, the defendant as a party to this negotiation would receive absolutely no benefits. See *Glsson* v. *The United States*, 87 C. Cls. 642, 659, quoting from *Mamie C. Wood et al.* v. *United States*, 36 C. Cls. 418, 426:

But this court, in the leading *Case of McKeever* (14 C. Cls. R., 396; affirmed by the Supreme Court, see 18 id., 757), laid down a sufficient rule for such cases. The question to be determined is, What was the invention worth in the market? What would the parties have taken and paid if the matter had come to an express agreement? What would any person needing the invention have been willing to pay for it?

• • •

Upon the record in this case, we are of the opinion that 65 per cent of $66,130.67, the total monetary value of the utility and advantages to the Government, or the sum of $42,984.93, constitutes a reasonable and entire compensation [fol. 159] to plaintiff for the use by the United States of the Marconi invention, together with interest at 5 per cent on this amount, not as interest but as a part of the just compensation, this interest to be calculated in accordance with the periods and amounts specified in the tabulation in Finding 47.

In this accounting, which relates to Lodge patent No. 609,154 and Marconi patent No. 763,772, plaintiff is entitled to judgment in the sum of $34,827.70, with interest at 5 per cent per annum thereon, not as interest but as a part of just compensation, from August 16, 1915, until paid, as to the Lodge patent; and as to the Marconi patent the sum of $42,984.93, with interest on the several amounts and from the dates specified in Finding 47 until paid, not as interest but as part of just compensation.

It is so ordered.

Green, Judge; Madden, Judge; Jones, Judge; and Littleton, Judge, concur.

[fol. 160] VIII. JUDGMENT OF THE COURT

At a Court of Claims held in the City of Washington on the 6th day April, A. D., 1942, judgment was ordered to be entered as follows:

Upon the foregoing special findings of fact, which are made a part of the judgment herein, the court decides as a conclusion of law that plaintiff is entitled to recover the sum of $77,812.63 with interest at 5 per cent per annum, not as interest but as part of just compensation.

It Is Therefore Adjudged and Ordered that the plaintiff recover of and from the United States the sum of seventy-seven thousand, eight hundred twelve dollars and sixty-three cents ($77,812.63), with an additional amount measured by interest at the rate of 5 per cent per annum on the following sums from the dates specified until paid: $34,827.70 from August 16, 1915; $109.78 from December 31,

1911; $754.97 from December 31, 1913; $422.66 from December 31, 1915; $15,789.72 from December 31, 1918, and $25,907.80 from November 20, 1919.

[fol. 161] IX. Proceedings After Judgment

On June 23, 1942, the plaintiff filed a request for record under Rule 99(a), together with Petition for Writ of Certiorari and other parts of the evidence agreed to by parties as material to errors assigned.

[fol. 162] X. Parts of Evidence Agreed to by Parties as Material to Errors Assigned

See Volumes Nos. 1 to 7 incl., paged from 1 to 3289 transmitted herewith.

[fol. 163] XI. Order of Court Settling Record

The plaintiff having filed a petition for writ of certiorari to the Supreme Court in the above-entitled case, and both plaintiff and defendant having requested that certain portions of the evidence which were agreed to by them, and which are attached hereto be included in the record to be certified to the Supreme Court, and the court having found that said portions are accurate transcripts of the original record material to the errors assigned, the same are hereby this 27th day of June, 1942, approved as the record to be certified to the Supreme Court.

By the Court:

Richard S. Whaley, Chief Justice.

[fol. 164] Clerk's Certificate to transcript omitted in printing.

[fol. 165] In United States Court of Claims

No. 33,642

Marconi Wireless Telegraph Company of America, Plaintiff,

vs.

The United States, Defendant

Parts of Evidence Agreed to by Parties as Material to Errors Assigned

[fols. 166-167] Evidence for Plaintiff

[fol. 168] *Deposition of John Bottomley, for claimant, taken at New York, N. Y., on the 17th day of April, A. D. 1917, and subsequent dates*

Claimant's counsel, James J. Cosgrove; defendant's counsel, Henry C. Workman.

John Bottomley deposes and says that his name is John Bottomley; that he is 69 years of age; that his residence is New York City; and occupation is that of vice president, secretary, and treasurer of the Marconi Wireless Telegraph Co. of America. "I am in no wise personally interested in the claim in controversy."

John Bottomley, being interrogated by Mr. Cosgrove, testified as follows:

1. Question. For how long have you been connected with the claimant company and in what capacities?

Answer. Prior to 1902 and from 1898 I acted as assistant counsel for the company. In the year 1902 I became general manager, and from that time forward I have been variously connected with the company as general manager, vice president, secretary, and treasurer.

• • • • • • •

[fol. 169] 7. Question. If you can, please identify and state what the papers are which are now handed you, and what knowledge any of the officers of the United States Government have had in relation to the litigation over the patents in suit, so far as you know.

Answer. The first letter I identify as a press copy of a letter written by me, dated February 28, 1911, addressed to

the Bureau of Steam Engineering, Washington, D. C., informing the bureau of a complete decision rendered in the high court of England in favor of Marconi's Telegraph Co. (Ltd.), in an action brought against the British Radio Telegraph & Telephone Co., for infringement of wireless apparatus, covered by British patent No. 7777, completely covering the art of tuning, inclosing a clipping showing the decision more fully and drawing the attention of the bureau to the fact that the Marconi Wireless Telegraph Co. of America holds patents issued by the United States Government No. 763772, dated June 28, 1904, on identically the same lines as those above referred to, and bringing to the notice of the bureau the intention of my company to at once commence action to sustain the validity of this patent. I also identify a letter, dated March 3, 1911, from the Navy Department, Bureau of Steam Engineering, signed by R. S. Griffin, acting chief of the bureau, acknowledging receipt of the letter above referred to and of the notice that we were about to commence action. I also identify a letter, dated March 7, 1911, addressed to the Bureau of Steam Engineering, Navy Department, Washington, D. C., signed by myself inclosing copy of the decision. I further identify a letter, dated March 11, 1911, from the Navy Department, acknowledging receipt of the "Electrician." I further identify a letter, dated March 7, 1911, addressed to George von L. Meyer, Secretary of the Navy, signed by me as vice president, fully referring to the above judgment, and inclosing a clipping from the New York Times.

I further identify a letter dated March 18, 1911, addressed to George Von L. Meyer, Secretary of the Navy, signed by me as vice-president and inclosing a pamphlet describing the action above referred to and giving excerpts from the judge's decision. I further identify a letter dated March 22, 1911, from the Navy Department, Bureau of Steam Engineering, signed by the acting chief of bureau, acknowledging the pamphlet. I further identify a letter dated May 19, 1911, addressed to the Secretary of the Navy and signed by me as vice president, and inclosing a notice sent out to all makers and users of wireless telegraph apparatus in the United States, to establish action, setting up the validity of our American patent No. 763772, otherwise known as the "four-circuit" or tuning patent. I further identify a letter dated May 19, 1911, signed by me and addressed to the Navy Department, Bureau of Steam Engi-

neering, on the same lines as the letter last above identified. I also identify a letter dated May 23, 1911 from the Navy Department, Bureau of Steam Engineering signed by H. J. Cone, engineer in chief, acknowledging the receipt of the letter last mentioned. I also identify a letter dated March [fol. 170] 6, 1911, addressed to the chief officer of the Signal Corps, U. S. A., Washington, D. C. signed by me as vice president and drawing attention to the judgment in the action first above referred to. Also a letter dated March 18, 1911, addressed to the same signed by me and inclosing clipping and pamphlet relating to the action last mentioned. I also identify a letter dated March 23, 1911, from the War Department signed F. Allen, brigadier general, acknowledging receipt of the pamphlet. I also identify a letter dated May 19, 1911, addressed to the U. S. Army Corps, inclosing a notice in relation to American patent 763772. I also identify a letter dated October 28, 1911, signed by me as general manager, addressed to Major Squier, U. S. Signal Corps, inclosing a copy of Judge Parker's decision in the action last above mentioned. I further identify a letter dated November 3, 1911, from the War Department, signed by J. Allen, brigadier general, acknowledging receipt of the last letter.

* * * * * * *

10. Question. Please look at the document now handed you and say if you know what it is and what bearing it has on the British decision or judgment referred to in your letters forming part of plaintiff's Exhibit No. 6.

Answer. This paper which I hold in my hand is a copy of the decision or judgment rendered in the high court of justice by Mr. Justice Parker in the case of Marconi and others *v.* The British Radio Telegraph & Teiephone Co. (Ltd.) and referred to in the letters just above identified, being an action for infringement of Marconi British Letters Patent 7777 of the year 1900 for improvements in apparatus for wireless telegraphy.

Mr. Cosgrove. Claimant's counsel now offers in evidence the copy of the decision or judgment just identified by the witness and asks that the same be marked "Plaintiff's Exhibit No. 7, Mr. Justice Parker's decision."

* * * * * * *

[fols. 171-172] 11. Question. You have referred to the Marconi patent in suit, No. 763772, as the tuning or "four-circuit patent." I direct your attention to page 133 of the printed record of the hearings in the year 1917 before the Committee on the Merchant Marine and Fisheries of the House of Representatives of the Sixty-fourth Congress on bill No. 19350, to regulate radio communication, which page purports to contain a statement of testimony of David W. Todd, of the United States Navy. Do you find any reference to that four-circuit patent in that testimony; and if so, will you please read it on the record?

Answer. I find in the evidence given by Commander Todd, above referred to, the following, on page 133:

"* * * With special reference to one of the basic patents of radiotelegraphy known as 'the four-circuit patent.' This is used practically in all radio apparatus, both transmitters and receivers, and the claims of various people so overlap and have resulted in so much controversy that the Navy Department was not able to decide whether or not those claims were extravagant or real or otherwise, and the courts have not been able to do so, either. It is still in the courts, and it is on that same patent that the Government is being sued. * * *"

* * * * * * *

[fol. 173] 23. Question. Please look at the papers now handed to you and identify them if you can and state what they relate to.

Answer. Papers in my hands are press copies of letters signed by me and originals from the Navy Department, Bureau of Steam Engineering, sent during the month of October, 1910, informing the bureau that Com. G. Marconi had received perfect signals in the Argentine Republic from Clifden, Ireland, and Glace Bay, N. S., and offering to make test of reception in the Navy of distances up to 3,000 miles, without expense to the U. S. Government; a letter signed by me and sent to the Bureau of Steam Engineering authorizing installation of this receiving apparatus on the battleships *Louisiana* and *New Hampshire*, and showing that the tests were not accepted by the Navy Department but that the Marconi company offered to give the battleship the use of

our very sensitive valve receiver and asking for shipping instructions of the receiver.

• • • • • • •

[fol. 174] 25. Question. What do you know as to whether or not the valve receiver, referred to in your letter of October 25, 1910, mentioned in answer to question 23 was ever sent to the Navy Department for use or test?

Answer. The Fleming valve receiver was sent to the Navy Department on October 24, 1910, for use on the *Louisiana* or *New Hampshire*, or in such other way as the Navy Department might elect.

26. Question. Do you know whether or not this Fleming valve receiver was ever installed on the battleship *Louisiana?*

• • • • • • •

Answer. Not to my personal knowledge.

• • • • • • •

28. Question. Please look at the article now shown you and state if you know what it is and read on the record any marking it has thereon.

Answer. This is the Fleming valve receiver which was sent to the Navy Department at Norfolk Navy Yard and is marked "Marconi Wireless Telegraph Company of America, No. 5015, New York, U. S. A. patent No. 803684."

Mr. Cosgrove. Claimant's counsel requests that the receiver identified by the witness in the last answer be marked for identification "Fleming valve receiver."

29. Question. Please look at the book I hand you and state what it contains.

Answer. This is a Marconi shipping-order book and contains shipping orders, and one, No. B638, October, 1910, showing the shipment to Neil McIntyre, S. S. *Louisiana*, Norfolk Navy Yard, Norfolk, Va., of, with other apparatus, one valve CC receiver, No. 5015, which is the valve receiver last above mentioned.

[fols. 175-176] Mr. Cosgrove. Plaintiff's counsel requests that the shipping order No. B638, referred to by the witness, be marked for identification.

• • • • • • •

32. Question. To what extent has the plaintiff company supplied the United States Government with wireless telegraph apparatus manufactured by the company?

Answer. Our books show that we have sold to the United States Government and its various departments manufactured apparatus to the extent of about $350,000.

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[fol. 177] Cross-examination.

By Mr. Workman:

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42. Cross-question. Referring to the letter introduced in your evidence, plaintiff's Exhibit No. 13, dated October 6, 1910, you have no definite knowledge, have you, of the reception of signals referred to in that letter, from Clifden, Ireland, and Glace Bay, N. S., was by means of the Fleming so-called valve patent?

Answer. No; I have not any knowledge of that, not having been personally present, but we were so informed by Mr. Marconi, who conducted the test.

43. Cross-question. Could you describe a valve receiver so that the court would understand its construction and operation?

Answer. I could not.

44. Cross-question. Do you have any personal knowledge of your own that the valve receiver referred to in the letter of October 25, 1910, forming part of plaintiff's Exhibit No. 13, was the valve receiver patented in the Fleming patent in suit?

Answer. I have no actual personal knowledge on the subject; my information was derived from our chief engineer, who is our technical adviser.

45. Cross-question. Do you have any personal knowledge of your own that the exhibit marked for identification "Fleming valve receiver" was sent to the Navy Department at any time?

Answer. I have not any personal knowledge that it was so sent, but I was informed by our chief engineer that it had been sent, and I saw it in our store after it had been returned and was informed that it had been returned. I mean this identical piece of apparatus.

46. Cross-question. Have you any knowledge of your own whether or not, assuming that the exhibit referred to was sent to the Navy Department as you have testified, that when it was sent it was in the same condition as it is now?

Answer. I have not any personal knowledge.

[fols. 178-179] 47. Cross-question. I note there are two sockets on the black platform of this receiver. Do you know what they are for?

Answer. I believe these sockets were holding glass bulbs in connection with the receiver.

47. Cross-question. There is nothing in either of these sockets on this exhibit now, nor when it was introduced in evidence yesterday. That is correct, is it?

Answer. That is correct.

48. Cross-question. You have no knowledge as to whether or not the sockets had something in them when it was sent to the Navy Department, as you have testified, have you?

Answer. I have no personal knowledge.

49. Cross-question. Are you aware that there are a number of receivers used in wireless apparatus that have been called valve receivers?

* * * * * * *

Answer. I am not a technical man and I do not know what valve are supposed to be made and used and called receiving valves.

* * * * * * *

[fol. 180] "By Mr. Cosgrove. Plaintiff's Counsel offers in evidence the following:

"A certified copy, including the grant of the re-issue letters patent in suit, #11,913, dated June 4, 1901 to Marconi Wireless Telegraph Company Limited and requests the same to be marked Plaintiff's Exhibit #19, Marconi Re-Issue patent.

"Certified copy, including the grant of the letters patent in suit to Lodge #609,154, dated August 16, 1898, and requests that the same be marked Plaintiff's Exhibit #20, Lodge patent in suit.

"Certified copy, including the grant of the Marconi Letters Patent in suit, No. 763,772, dated June 28, 1904, issued

to Marconi Wireless Telegraph Company, Limited, applied for Nov. 10, 1900, Serial No. 36,010, and asks that the same be marked Plaintiff's Exhibit #21, Marconi patent in suit, #763,772.

"Certified copy including the grant of the Fleming patent in suit #803,684, dated Nov. 7, 1905, application filed April 19, 1905, Serial No. 256,483, issued to the Plaintiff Company, and requests that the same be marked Plaintiff's Exhibit #22, Fleming patent in suit #803,684.

* * * * * * *

[fol. 181] "Printed copy of Marconi British Patent #7777 of 1900, and requests that the same be marked Plaintiff's Exhibit #34, Marconi British Patent.

"Copy of the decision or judgment of Mr. Justice Eves in the English High Court of Justice in the suit of G. Marconi Wireless Telegraph Company *vs.* The Helsby Wireless Telegraph Company.

[fol. 182] *Deposition of John Brennen, for claimant, taken at New York, N. Y., on the 18th day of April, A. D. 1917*

Claimant's counsel, James J. Cosgrove; defendant's counsel, Henry C. Workman.

JOHN BRENNEN deposes as follows:

1. Question. State your name, your occupation, your age, and your place of residence, whether you have any, and if any, what interest, direct or indirect, in the claim which is the subject of inquiry, and whether and in what degree you are related to the plaintiff.

Answer. John Brennen, assistant to Mr. Sawyer, general superintendent of the maintenance, repair, and inspection division of the Marconi Wireless Telegraph Co. (New York division); 45 years of age; residing in Jersey City; no interest in the claim in controversy.

2. Question. How long have you been connected with the Marconi Wireless Telegraph Co. of America, the plaintiff herein?

Answer. Since June, 1904.

3. Question. In what capacities have you been connected with the Marconi company since June, 1904?

Answer. I was sort of actir ; as superintendent in repairing and installing apparatus, and also manufacturing when necessary.

4. Question. In what shops of the Marconi company have you been working?

Answer. 37 Water Street, New York City; 125 Front Street, 29 Cliff Street, and 25 Elm Street—that is our present place—in New York City.

5. Question. At what work were you employed by the Marconi company during the years 1904 to 1912?

Answer. I was manufacturing and general repairing wireless apparatus.

6. Question. Did your work during this period include the shipment of wireless apparatus of the Marconi company?

Answer. Yes.

* * * * * * *

[fol. 183] 43. Question. I call your attention to an article or device, marked for identification "Fleming valve receiver, E. A. Panabaker, commissioner." Did you ever see this article or device before, and if so, about when and where did you first see it?

Answer. This tuner was received by me from England in October, 1910.

44. Question. Where were you located in October, 1910, when you say this tuner was received by you from England?

Answer. At 125 Front Street, is my best recollection of this.

45. Question. And at that time the shop of the Marconi company was located at 125 Front Street?

Answer. 125 Front Street.

46. Question. And you received this tuner on behalf of the Marconi company?

Answer. Yes.

47. Question. This tuner is marked as follows: "Marconi Wireless Telegraph Company of America. No. 5015. New [fol. 184] York, U. S. A. Pat. No. 803,684." Do you know when that marking was placed upon this tuner? And if so, please give the time or the approximate time it was placed thereon and under what circumstances.

Answer. The tuner, when received by me in the early part of October, I had orders from the main office to have the name plate changed from Marconi Wireless Telegraph Co. of London (Ltd.), to the Marconi Wireless Telegraph Co. of America. I had this tuner taken to an engraver and had the new name engraved upon it.

48. Question. Did you also have the patent markings referred to engraved upon the tuner?

Answer. Yes.

49. Question. What are the parts of this tuner on which I have my hand at this present time?

Answer. The part which you have your hand on is known as an Ediswan bayonet socket for the reception of the Fleming oscillating valve.

50. Question. When this tuner was received from England, was it accompanied by any of the valves referred to in your last answer?

Answer. Yes; to the best of my knowledge there were six 12-volt valves accompanying this tuner.

51. Question. Do you know where such valves are now?

Answer. No.

52. Question. Was this tuner shipped by the plaintiff to anyone at any time to your knowledge?

Answer. Yes.

53. Question. To whom and when was it shipped?

Answer. On October 25, or thereabouts, 1910, I was given orders to ship this tuner to the U. S. S. *Louisiana* at the navy yard at Norfolk, Va., by express.

54. Question. What did you have to do with the shipping of this tuner to the *Louisiana* at the Norfolk Navy Yard, and how do you fix the date when it was shipped?

Answer. From the records in my shipping memorandum book of that date.

55. Question. Please look at the book now handed you and state what that book is?

Answer. This is shipping memorandum book of the Marconi Wireless Telegraph Co. of America.

56. Question. Please read on the record anything you find in the shipping memorandum book of the Marconi company relating to the shipping of the tuner No. 5015 to the U. S. S. *Louisiana* at the Norfolk Navy Yard.

Answer. "No. B 638. Original. Oct., 1910.

"Marconi Wireless Telegraph Company of America.

"Shipping order.

"Marconi W. T. Co. To Neil McIntyre,

"U. S. S. *Louisiana*, Norfolk Navy Yard.

"We have this day forwarded to you, carriage, the following goods per ——, Norfolk, Va.

"Kindly sign and return on receipt of goods.

1 inductance #710.

2 Witherbee batteries.

[fol. 185] 2 tungsten 12-volt valves.

1 pr. high-resistance phones.

1 Marconi disk condenser.

1 valve C. C. receiver #5015.

"Herschaft & Adams. X.

"Prepaid.

"Returned Oct. 31, 10."

57. Question. Will you please remove the shipping order B638 which you have just read on the record from the shipping order book?

(Witness removes the shipping order.)

58. Question. I notice that this shipping order does not bear the day of the month of October, 1910. How, then, do you know that this tuner referred to in the order was shipped to the Norfolk Navy Yard about October 25, 1910?

Answer. From the shipping order B637 of October 24, 1910, and also from the shipping order B639 of October 26, 1910—the one previous and the one following order B638.

59. Question. I notice that shipping order is addressed care of Neil McIntyre. Who was Mr. McIntyre and where is he now, if you know?

Answer. Mr. McIntyre at that time was in charge as operator of the Marconi wireless telegraph station, Virginia Beach, Va., and was told to carry on these tests aboard the U. S. S. *Louisiana* on account of its close proximity to the Norfolk Navy Yard and also his ability to work the valve receiver. Mr. McIntyre is dead.

60. Question. I notice that one of the items on this order reads "2 tungsten 12-volt valves." Will you please state if you know what that item refers to.

Answer. These were two incandescent bulbs with a metal band on the interior of the bulb. I have one here and which I produce, and from same is attached a small piece of platinum wire which penetrates the glass bulb and sealed and from thence a flexible lead.

61. Question. You mean by your last answer that the two tungsten 12-volt valves referred to in shipping order B638

were similar to the valves which you produced in answer to the last question?

• • • • • • •

Answer. Yes.

62. Question. When the tuner No. 5015 was sent to Norfolk Navy Yard was it accompanied by any valves; and, if so, what kind of valves?

Answer. Yes; two 12-volt tungsten valves, as heretofore described by me.

63. Question. To what part of the apparatus of tuner No. 5015 was the wire lead of the valves, above referred to, attached?

Answer. To the small upright rubber insulating post in connection with the circuit.

64. Question. I notice on the shipping order B638 "2 Witherbee batteries." To what does that item refer?

Answer. These batteries were used to light the bulb.

65. Question. Did these batteries accompany the tuner No. 5015 when sent to Norfolk Navy Yard?

Answer. Yes.

[fol. 186] 66. Question. In whose handwriting is shipping order B638, if you know?

Answer. Mr. E. M. Smith and my own—the words "Returned Oct. 31, 10," is my own handwriting.

67. Question. Is Mr. Smith connected with the Marconi company at present?

Answer. Mr. Smith severed his connection with the Marconi company somewheres around 1915.

68. Question. Will you please explain that part of the shipping order "Returned Oct. 31, 10," which you say is in your handwriting?

Answer. This was merely a notation by me showing return of the apparatus and acted as a credit against same.

Mr. Cosgrove. Plaintiff's counsel offers in evidence the valve tuner No. 5015, and requests that the same be marked "Plaintiff's Exhibit No. 28, Fleming valve receiver"; also the valve produced by the witness, and the same is marked "Plaintiff's Exhibit No. 29, Fleming valve"; also the shipping order B638, referred to by the witness, and the same is marked "Plaintiff's Exhibit 30, shipping order."

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69. Question. Do you know where the valves are which you say accompanied plaintiff's Exhibit No. 28 when it was shipped to the Norfolk Navy Yard?

Answer. No; as the life of these valves are of very short duration and require constant new ones as the old ones burn out, and therefore are thrown away when of no further use.

70. Question. Do you know whether this Exhibit No. 28, Fleming valve receiver or tuner, was installed on any vessel; and if so, what vessel and about when the installation took place?

Answer. Somewhere around 1913 this particular valve receiver was installed on the steam yacht *Aloha* for the reception of long waves or news service, and was removed when a new installation was reinstalled on October 29, 1914, as our records show.

71. Question. I notice that shipping order B638, plaintiff's Exhibit 30, contains an item, "1 valve C. C. receiver =5015." State, if you know, what the letters C. C. refer to.

Answer. The initials C. C. stands for Cape Cod station, and the purpose of that station was to transmit long-distance messages and service news.

72. Question. What relation did this Fleming valve receiver Exhibit No. 28 have to the Cape Cod station, if you know?

Answer. This tuner was designed for the reception of the waves transmitted by Cape Cod and Poldhu.

* * * * * * *

73. Question. Do you know whether plaintiff's Exhibit No. 28, Fleming valve receiver or tuner, or one similar to it, was used at Cape Cod station?

[fol. 187] Answer. Yes.

* * * * * * *

74. Question. How do you know that such a receiver as plaintiff's Exhibit No. 28 was used at Cape Cod?

Answer. This tuner, upon its return from the steamship *Louisiana*, was sent by me to Cape Cod station, South Wellfleet Mass., as directed by my superiors.

Cross-examination.

By Mr. Workman:

* * * * * * *

71. Cross-question. Is it true that you have been continuously employed by the plaintiff company since June, 1904?

Answer. Yes.

72. Cross-question. And always in the same capacity?

Answer. Yes; in the mechanical department.

73. Cross-question. You were not superintendent or acting superintendent when you first entered their employ, were you?

Answer. No; as foreman.

74. Cross-question. You started work as foreman and then was promoted to superintendent or acting superintendent?

Answer. Yes; as the firm got larger.

75. Cross-question. And it has always been in mechanical work that you have been employed, has it?

Answer. Yes.

76. Cross-question. Just what sort of things did you do as foreman engaged on mechanical work?

Answer. Upon receiving orders from my superiors I manufactured and carried on experimental work and also shipped apparatus to different parts of the country to our stations.

77. Cross-question. Did you know anything about instruments or apparatus for wireless telegraphy before you came with the plaintiff company?

Answer. I was employed in the telegraph instrument line by J. H. Bunell Co. previous to my employment by the Marconi Wireless Telegraph Co.

78. Cross-question. In that line with Bunell, or work with Bunell Co., your work was with ordinary wire-transmission telegraph apparatus, wasn't it?

Answer. Yes.

79. Cross-question. You have gained all your knowledge and experience with wireless telegraph apparatus from your employment in the Marconi company, have you not?

Answer. Yes.

* * * * * * *

81. Cross-question. Can you state when it was you were promoted to superintendent or acting superintendent in the plaintiff company?

[fol. 188] Answer. This was not an official notification from my superiors, but took place naturally as the firm grew and we were compelled to employ more help.

82. Cross-question. Well, but you have not said when this took place; that is, when you became acting — or superintendent?

Answer. I can not give the dates when I began to receive correspondence with the name superintendent attached.

83. Cross-question. I don't suppose you were superintendent or acting superintendent in the first year or two of your employ in the plaintiff company, were you?

Answer. No.

84. Cross-question. And then some time later you had the work of superintendent, and I would like to know if you can give me some idea when you first began to act as superintendent?

Answer. Yes; when Mr. Sammis took over the duties as chief engineer, the dates of which I am rather hazy on at present.

85. Cross-question. Give us as near an approximation of the date as you can from your best recollection?

Answer. That was somewhere in 1907 or 1908, to the best of my recollection.

86. Cross-question. Were you ever employed as shipping clerk?

Answer. No; only as far as the shipping of apparatus of the Marconi Wireless Telegraph Co.

87. Cross-question. Were you ever employed as packer?

Answer. No; but I also did this work in the early days of the Marconi Telegraph Co.

88. Cross-question. Were you ever employed by the plaintiff company as invoice clerk to keep shipping records?

Answer. Only as far as the apparatus which left the works of the company.

89. Cross-question. Then you both attended to constructing the instrument and entering up their shipment books, did you?

Answer. Yes; and also Mr. Sammis assisted me in looking after the records.

90. Cross-question. And you put the apparatus to be shipped in their shipping cases, too, I suppose?

Answer. Yes.

91. Cross-question. Is it usual with the plaintiff company, so far as you know, to have their instrument makers act as shipping clerk, and packers?

Answer. At the time of my beginning of employment with the Marconi Wireless Telegraph Co. this was necessary, as wireless telegraph transmission was in its infancy, and did not employ sufficient help, as same was not needed.

92. Cross-question. You did not keep shipping books or attend to packing after you acted as superintendent from 1908 on, did you?

Answer. Yes; I kept in touch with all parts of the factory output and instruments and also their records.

93. Cross-question. And at the same time visited ships and acted as inspector?

Answer. Yes. As I heretofore stated, the firm was then small and was not a very big job to attend to.

94. Cross-question. How was it, then, that you did not make the entries in the shipping book relating to this tuner, [fol. 189] plaintiff's Exhibit 28, that you say is referred to on the shipping order B638, plaintiff's Exhibit 30?

Answer. Mr. E. M. Smith was employed in the early part of 1909 as a mechanic and also to help to attend to the clerical work with me.

95. Cross-question. This shipping order B638, plaintiff's Exhibit No. 30, was, as I understand it, not made out by you?

Answer. No; but a notation on the bottom of same of the return of the valve receiver was made by me, but other orders in the book are in my handwriting.

96. Cross-question. You infer that the items mentioned on this shipping order were sent on October 25, 1910, the date not appearing on the order, from the fact that the preceding order was dated October 24 and the following order October 26, 1910?

Answer. To the best of my knowledge, yes; from the *the* records.

97. Cross-question. Why was this tuner, defendant's Exhibit 28, returned so soon from Neil McIntyre?

Answer. I do not know, as I was not informed of the conditions or reasons why this was returned, as this was a matter in the hands of my superiors.

98. Cross-question. What does this date "Returned October 31, 10," which you say is in your handwriting—does that mean the date you received it back?

Answer. That is the date on which this tuner was returned.

99. Cross-question. Did you unpack it?

Answer. That is a question I can not answer.

100. Cross-question. And how did you know it was received back on the date noted on the bill?

Answer. That would not mean necessarily that I did unpack it personally, but still make a record of same as it was turned over to me.

101. Cross-question. Then that date means that that was the date it was turned over to you, doesn't it?

Answer. Yes.

102. Cross-question. You did not personally check off each of these items on that bill when they were sent, I suppose?

Answer. Yes; I did personally.

103. Cross-question. And you know that each one of these items mentioned on that bill was the shipping box and you saw the box sealed up with them in?

Answer. Yes.

104. Cross-question. And the bulbs, or whatever they were, were in the sockets when it was shipped?

Answer. No; these were packed in a separate container invariably in cotton batting to prevent jarring or breaking of the tungsten filaments.

105. Cross-question. How many of these bulbs came with the tuner when it was received from England?

Answer. To the best of my knowledge, there were six 12-volt valves received with this tuner.

106. Cross-question. Was it tested by the Marconi company before it was shipped to Neil McIntyre?

Answer. That I do not know.

[fols. 190-191] 107. Cross-question. When was it tested on the yacht *Aloha?*

Answer. It was not merely tested but was installed as a part of the apparatus for the reception of news service in conjunction with the other receivers.

108. Cross-question. And you do not know whether it was ever used or not on this yacht?

Answer. Not to my knowledge, as I did not have anything to do with the operating end.

109. Cross-question. Did you ever actually see it on the yacht?

Answer. Yes; upon one of my visits to this yacht, at the foot of East Twenty-third Street.

110. Cross-question. Do you know who owns this yacht?

Answer. I believe Colonel James is the owner of this yacht.

111. Cross-question. At any rate it was not a Government vessel?

Answer. No.

112. Cross-question. When was it you saw it on the yacht, what year?

Answer. The date I can not give you; it was sometime in 1914.

113. Cross-question. Of course the bulbs that were then on it were not the bulbs you received from England?

Answer. No.

114. Cross-question. Nor those you say were sent to Neil McIntyre at Norfolk?

Answer. No; they were not the bulbs.

115. Cross-question. Where did you get this bulb with a piece of covered wire attached to one side of it that you produced in your direct examination?

Answer. This was taken from the works at 25 Elm Street, a number of which we still retain in stock.

116. Cross-question. When was it made, do you know?

Answer. The present valve?

117. Cross-question. This one you produced?

Answer. I can not give the exact date at present without looking up my records.

118. Cross-question. Do you know whether it was made one or two years ago, don't you?

Answer. I know this valve was made more than four years ago, that is the present type shown here.

119. Cross-question. This one that you produced is not the type you are now using is it?

Answer. No. At present we use a crystal detector on all our tuners.

120. Cross-question. This bulb that you produced here is a crude clumsy sort of a device, is it not, with this thread going around the outside of it?

Answer. The thread going around the outside of the bulb is to act as a support for the flexible copper lead so as not to break the delicate connection coming through the glass.

* * * * * * *

[fol. 192] "By Mr. Cosgrove: Plaintiff's Counsel offers in evidence the following:

"Printed copy of Marconi British Patent No. 7777 of 1900, and requests that the same be marked Plaintiff's Exhibit No. 34, Marconi British Patent.

"Copy of the decision or judgment of Mr. Justice Eve in the English High Court of Justice in the suit of G. Marconi Wireless Telegraph Company vs. The Helsby Wireless Telegraph Company, Limited, for the infringe-[fol. 193] ment of the Marconi British patent #7777 of 1900, and requests that the same be marked Plaintiff's Exhibit #35, Justice Eves Judgment.

"Copy of Judgment of the Civil Tribunal of the Seine in the case of Marconi Wireless Telegraph Company, Limited, against the Society Gen. des Transports Maritime, brought for the infringement of the Marconi French patent #305,060, (corresponding to British patent No. 7777) and requests that the same be marked Plaintiff's Exhibit #36, French judgment.

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"Plaintiff also gives notice that upon the hearing of this case, it will rely upon the following:

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"Decision of Judge Veeder of the United States District Court for the Eastern District of New York, dated March 17, 1914, sustaining the validity of the Lodge patent No. 609,154, and the Marconi patent No. 763,772, and holding it infringed by the National Electric Signal Company apparatus.

"Decision and order of Judge Veeder of the United States District Court for the Eastern District of New York, dated October 15, 1914, sustaining the Lodge patent No. 609,154, and Marconi patent No. 763,772, and granting a preliminary injunction restraining the Atlantic Communication Company apparatus from infringing upon said patents.

"Decision and order of Judge Hough of the United States District Court for the Southern District of New York, dated November 12, 1914, sustaining the Lodge patent No. 609,154, and Marconi patent in suit No. 763,722, and granting a preliminary injunction restraining the infringe-

ment thereof by the apparatus of the DeForest Radio Telephone and Telegraph Company, and the decision of the Court of Appeals of the Second Circuit affirming the said decision of Judge Hough.

"Decision of Judge Mayer, United States District Court for the Southern District of New York, dated September 20, 1916, sustaining the validity of the Fleming patent in suit No. 803,684, and holding it infringed by the audion apparatus of the DeForest Radio Telephone & Telegraph Company.

"Plaintiff's Counsel also offers in evidence the following:

"Printed copy 'Specifications for Wireless Telegraph Apparatus sets,' issued by the Navy Department May 10, 1910, No. 16-T-5, with particular reference to pages 1, 3, [fol. 194] 5, 8, 9, 10 and 12 thereof, and requests that the same be marked 'Plaintiff's Exhibit #37, Navy Wireless Specifications #16-T-5.'

"Printed copy 'Navy Department specifications Radio sets for Ship Installations January 10, 1913, #16-R-1,' with particular reference to pages 1, 2, 17, 19, 20, 25 and 30, and requests that the same be marked Plaintiff's Exhibit #38, Navy Department Wireless Specification #16-R-1.

"Printed copy 'Navy Department specifications Radio sets for ship and shore stations #16-R-1-A December 1, 1915,' with particular reference to pages 1, 2, 5, 16, 17 and 22, and requests that the same be marked Plaintiff's Exhibit #39, Navy Wireless Specification #16-R1A.

"Printed copy 'Navy Department Specifications. Radio apparatus, receiving #16-R-2, January 3, 1916,' with particular reference to pages 1, 4, 5, 6 and 7, and requests that the same be marked Plaintiff's Exhibit #40, Navy Wireless Specifications #16-R-2.

"Typewritten copy 'Specifications for portable wireless telegraph sets' proposed by the United States Navy, with blue prints 1815-L, dated 9-22-10, of the Bureau of Steam Engineering of the Navy Department attached to said specification and request that the same be marked Plaintiff's Exhibit #41, Navy Specifications for Portable Wireless Sets.

"Typewritten copy 'General specification, No. 547. (September 13, 1910)' of the Army Signal Corps for 'Wireless Telegraph Sets 2 k. w. quenched singing spark type'

and requests that the same be marked Plaintiff's Exhibit #42, Army Wireless Specification #547.

"Typewritten copy 'General Specification #566 (January 27, 1912) wireless Telegraph Station Equipment,' of the Army Signal Corps, and requests that the same be marked Plaintiff's Exhibit #43, Army Wireless specification #566.

"Typewritten copy of Army Signal Corps 'Specification for 2-kilowatts Radio Field Wagon Set (February 19, 1916),' and requests that the same be marked Plaintiff's Exhibit #44, Army Specification for Radio Field Wagon Set.

"Counsel also offers in evidence certified copies of the following contracts for wireless telegraph apparatus sold to and used by the United States:

"Garwood Electric Company with the United States Navy, No. 14,811, dated May 1st, 1911, for transmitting and receiving wireless sets under Navy Department specification #16-T-5, to be delivered to the Brooklyn Navy Yard for the U. S. S. *Jupiter*, *Neptune*, *Ammen*, *Trippe*, *Monahan*, *Walker* and *Patterson*, and requests that the same be marked Plaintiff's Exhibit #45, Garwood contract of May, 1911.

"Telefunken Wireless Telegraph Company of the United States with the United States Navy #144, dated September 20, 1911, for transmitting and receiving wireless sets, and requests that the same be marked Plaintiff's Exhibit #46, Telefunken contract of September, 1911.

"Atlantic Communication Company with the United States Army Signal Corps No. 608, dated September 29, 1913, for a transmitting and receiving wireless set under Army Specifications #566, Jan. 27, 1912, and requests that [fol. 195] the same be marked Plaintiff's Exhibit #47, Atlantic Communication Company Army contract of September 29, 1913.

"Atlantic Communication Company with the United States Navy, #89, dated August 5, 1913, for 1-k.w. Telefunken Compass Radio outfit complete, to be delivered to the Brooklyn Navy Yard, and requests that the same be marked Plaintiff's Exhibit #48, Atlantic Communication Company Navy contract of August 5, 1913.

"National Electrical Supply Company with the Signal Corps, United States Army, dated April 26, 1910, for 'one (1) field wireless pack set two-trunk type,' under Signal

Corps Specification #410, revised to bear serial number 70, to be delivered to the Brooklyn Navy Yard, and requests that the same be marked Plaintiff's Exhibit #49, National Electrical Supply Company Army contract of April 26, 1910.

"National Electrical Supply Company with U. S. Signal Corps, dated May 16, 1911, for Field Wireless Pack Sets, and requests the same be marked Plaintiff's Exhibit No. 50, National Electrical Supply Company Army Contract of May 16, 1911.

"National Electrical Supply Company with the United States Army #619, dated January 23, 1914, for 'Wireless Transmitting and Receiving Sets,' and requests that the same be marked Plaintiff's Exhibit #51, National Electric Supply Company Army contract of January 14, 1914.

"National Electrical Supply Company with the Navy Department #19,575, dated September 9, 1913, for fifteen ½-k. w. 500-cycle quenched gap sets, etc., to be delivered at the Washington Navy Yard, and requests that the same be marked Plaintiff's Exhibit #52, National Electric Supply Company Navy contract of September 9, 1913.

"Foote, Pierson and Company with the United States Army Signal Corps, dated June 27, 1910, for eight Field Wireless Pack Sets complete under Signal Corps Wireless Specification #410, number D revised, and requests that the same be marked Plaintiff's Exhibit #53, Foote, Pierson and Company Army contract of June 27, 1910.

"North American Wireless Corporation and the United States Army Signal Corps, #445, dated October 24, 1910, for one wireless telegraph set complete including crystal detector, under Signal Corps Specifications #547 and 403-A, and requests that the same be marked Plaintiff's Exhibit #54, North American Wireless Corporation Army contract of October 24, 1910.

"Wireless Improvement Company and the United States Navy Department #415, dated June 5, 1913, for one 5-k. w. high frequency quenched gap radio transmitting set complete, etc., under wireless specifications #16-R-1, to be delivered at the U. S. Naval Radio Station, Radio, Va., and requests that the same be marked Plaintiff's Exhibit #55, Wireless Improvement Company Navy contract of June 5, 1913.

"Clapp-Eastham Company with the United States Navy Department, 2 radio sets complete, except receiving appa-

ratus, etc., for Submarines E-1 and E-2, dated October 14, 1912, and requests that the same be marked Plaintiff's Exhibit #56, Clapp-Eastham Company Navy Contract.

[fol. 196] "Fritz Lowenstein with the United States Navy Department No. 14,746, dated April 22, 1911, for 500-cycle motor generator sets complete, except antenna, under specifications #16-T-5, to be delivered at the Brooklyn Navy Yard and requests that the same be marked Plaintiff's Exhibit #57, Lowenstein Navy contract of April 22, 1911.

"Fritz Lowenstein with the United States Navy Department dated November 1, 1913, for four 5-k. w. Radio sets under Navy Wireless Specification #16-R-1 to be delivered at the Brooklyn Navy Yard, and requests that the same be marked Plaintiff's Exhibit #58, Lowenstein Navy contract of November 1, 1913.

"Wireless Specialty Apparatus Company with the United States Signal Corps, dated December 7, 1911, for two wireless receiving sets type 1-P-76, and requests that the same be marked Plaintiff's Exhibit #59, Wireless Specialty Apparatus Company Army contract dated December 7, 1911.

"Wireless Specialty Apparatus Company and the United States Navy Department #133, dated September 21, 1912, for 25-k. w. 500 cycle quenched gap radio sets under Navy Wireless specification #16-T-5, and requests that the same be marked Plaintiff's Exhibit #60, Wireless Specialty Apparatus Company Navy contract dated September 21, 1912.

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"Wireless Specialty Apparatus Company with the United States Navy Department #170, dated October 14, 1912, for wireless receiving sets improved type I-P-76, containing perikon and pyron detectors, to be delivered at the Brooklyn Navy Yard, and requests that the same be marked Plaintiff's Exhibit #62, Wireless Specialty Apparatus contract of October 14, 1912.

"Wireless Specialty Apparatus Company with the United States Navy Department No. 19,882, dated Nov. 18, 1913, for receiving sets type I-P-76, 1912 series and I-P-76, 1914 series, and requests that the same be marked Plaintiff's Exhibit #63, Wireless Specialty Apparatus contract of Nov. 18, 1913.

"Federal Telegraph Company with the United States Navy Department #100 dated September 1, 1911, for one

2-k. w. quenched gap wireless telegraph set complete to be delivered at Mare Island Navy Yard, California, and requests that the same be marked Plaintiff's Exhibit #64, Federal Telegraph Company contract of September 1, 1911.

"Federal Telegraph Company with the United States #1948, dated June 30, 1913, for high powered radio station at United States Naval Reservation San Pablo Site, Camito, Canal Zone, and requests that the same be marked Plaintiff's Exhibit #65, Federal Telegraph Company U. S. contract, dated June 30, 1913.

"Federal Telegraph Company with the United States, dated June 11, 1914, supplemental agreement to contract of June 30, 1913, for the installation of a radio station at [fol. 197] San Pablo Site, Canal Zone, and requests that the same be marked Plaintiff's Exhibit #66, Federal Telegraph Company United States contract of June 11, 1914.

"Federal Telegraph Company with the United States Navy Department #269, dated April 6, 1914, for arc radio sets to be delivered at the Washington Navy Yard for Point Isabel, Texas, Guantanamo, Cuba, and Boston, Mass., and requests that the same be marked Plaintiff's Exhibit #67, Federal Telegraph Company Navy contract of April 6, 1914

"Federal Telegraph Company with the United States Navy, No. 242, dated May 6, 1915, for 30 k. w. Arc Transmitters, etc., under Navy specifications 16-R-1, to be delivered to Mare Island Navy Yard, and requests that the same be marked Plaintiff's Exhibit #68, Federal Telegraph Company contract of May 6, 1915.

"Kilbourne and Clark Manufacturing Company with the United States Navy Department #225, dated January 31, 1914, for five 5 k. w. radio sets complete for ship installation under Navy Wireless specification #16-R-1, to be delivered at Navy Yard, Mare Island, California, and Brooklyn Navy Yard, N. Y., and requests that the same be marked Plaintiff's Exhibit #69, Kilbourne and Clark Mfg. Co. Navy contract of January 31, 1914.

"Emil J. Simon and the United States Navy Department No. 24,605, dated September 2, 1915, for twenty-five ½ k. w. radio transmitting sets, etc., to be delivered at the Brooklyn Navy Yard, and requests that the same be marked Plaintiff's Exhibit #70, Simon Navy contract of September 2, 1915.

"Radio Telephone and Telegraph Company and the United States Navy Department No. 20,437, dated March 5, 1914, for radio sets under Navy wireless specification #16-R-1, to be delivered at the Brooklyn Navy Yard, and requests that the same be marked Plaintiff's Exhibit #71, Radio Telephone and Telegraph Company Navy contract of March 5, 1914.

"Radio Telephone and Telegraph Company and the United States Navy Department No. 336 dated January 12, 1914, for audion amplifiers and double bulbs for the same, etc., to be delivered at the Brooklyn Navy Yard, and requests that the same be marked Plaintiff's Exhibit #72, Radio Telephone and Telegraph Company Navy contract of January 12, 1914.

"Radio Telephone and Telegraph Company and the United States Navy Department #534, dated June 11, 1914, for audion amplifiers and double bulbs with Hudson filaments to be delivered at the Brooklyn Navy Yard, and requests that the same be marked Plaintiff's Exhibit #73, Radio Telephone and Telegraph Company Navy contract of June 11, 1914.

"Radio Telephone and Telegraph Company with the United States Navy Department No. 315, dated June 27, 1914, for ultra audion detectors Hudson filament double bulbs, receiving cabinets, etc., to be delivered at the Washington Navy Yard and requests that the same be marked Plaintiff's Exhibit #74, Radio Telephone and Telegraph Company Navy contract of June 27, 1914.

"Radio Telephone and Telegraph Company and United States Navy Department No. 46, dated July 27, 1914, for generator audion sets and bulbs to be delivered at the Wash- [fols. 198-199] ington Navy Yard, and requests that the same be marked Plaintiff's Exhibit #75, Radio Telephone and Telegraph Company Navy contract of July 27, 1914.

"DeForest Radio Telephone and Telegraph Company with United States Navy Department #508 dated June 28, 1916, for Hudson filament 6-volt bulbs with double grid, to be delivered at the Washington Navy Yard, and requests that the same be marked Plaintiff's Exhibit #76, DeForest Radio Telephone and Telegraph contract of June 28, 1916.

"Plaintiff's Counsel also offers in evidence:

"Certified copy of British Letters Patent No. 24,850 of 1904 filed Nov. 16, 1904, and requests that the same be

marked Plaintiff's Exhibit #77, Fleming British Patent #24,850.

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[fol. 200] *Deposition of William A. Graham, for claimant, taken at New York, N. Y., on the 27th, 28th, and 29th days of June, A. D. 1917*

Claimant's counsel, James J. Cosgrove and John W. Peters; defendant's counsel, Henry C. Workman.

WILLIAM A. GRAHAM deposed and said that his name is William A. Graham; that his occupation is that of radio engineer, with the Marconi Wireless Telegraph Co.; that he is 30 years of age; that his place of residence is Roselle Park, N. J.

And thereupon the said William A. Graham was examined by the counsel for the plaintiff, and in answer to interrogatories testified as follows:

Direct examination.

By Mr. Peters:

1. Question. Have you heretofore been in the service of the United States Navy? And if so, please state during what period of time and in what capacity.

[fol. 201] Answer. I entered the naval service in January, 1904, and served continuously until September, 1916. During the period of years mentioned above I served in the various grades of electrician and chief electrician in the radio branch of the service. From February, 1917, until May, 1917, I served as expert radio aid, United States naval service.

2. Question. Please explain what opportunity you had during your service in the Navy from June, 1910, down to September, 1916, when you left, to become familiar with the wireless-telegraph apparatus installed and used by the Navy.

Answer. During the period from June, 1910, to 1916 I had charge of the ship installation of wireless apparatus on several ships. I was also chief electrician in charge of the United States Navy Radio Station at San Juan, Porto Rico; also at the radio station, Sayville, Long Island, and

at the naval radio laboratory, Bureau of Standards. During my service at these various places I became familiar with a great many types of apparatus used by the Navy.

3. Question. Name some of the types which, to your knowledge, were installed and used by the Navy during the period beginning with July, 1910, and ending with September, 1916, when you left the Navy.

Answer. Of transmitting apparatus, I have knowledge of the installation and operation of the Telefunken, Marconi, National Electric Supply Co., Federal Telegraph Co., Wireless Improvement Co.; of receiving apparatus, the Wireless Specialty Apparatus Co., Telefunken, Marconi, and De Forest Co.'s apparatus, the latter including types of audion, ultra audion, and amplifier apparatus.

4. Question. To your knowledge, was there any use by the Navy during this period of Lowenstein apparatus?

Answer. While in the naval service I saw a Lowenstein transmitter in operation at the Brooklyn Navy Yard.

5. Question. About when was this and under what circumstances did you see it?

Answer. I saw the Lowenstein transmitter during the year 1914 on the occasion of an official visit to the New York Navy Yard.

6. Question. Was this Lowenstein set in use when you saw it?

Answer. It was being operated by the personnel attached to the station in the usual course of the day's business.

6a. Question. What can you say as to whether or not it was installed and used by the Navy subsequent to June, 1910?

Answer. When I saw this Lowenstein set it was in practical operation; in order to be in practical operation during the year 1914, it follows that it was installed prior to the date which I saw it in operation.

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7. Question. When you saw it in 1914, was it new apparatus recently installed, or was it an old set that had been used for several years?

* * * * * * *

Answer. It appeared to be a new set.

8. Question. I show you a volume entitled "Manual of Wireless Telegraphy (Radio) for the Use of Naval Elec-

[fol. 202] tricians, 1915," by Commander S. S. Robison, U. S. Navy. What, if anything, do you know regarding the distribution and use of this manual in the Navy?

Answer. I recognize the volume as one issued by the Navy Department and distributed to naval wireless telegraph stations on shore and on ship. As I remember, several copies were issued to each ship, one for use in the ship's library and another for use in the wireless office. On shore stations this volume was placed in the library and available for use by the personnel attached to the station.

9. Question. Reference to this volume indicates that it is a revision of earlier editions. What were the facts, if you know them, with regard to the issuance of earlier editions of this publication?

Answer. I have seen earlier editions of the volume in question, and the distribution of these volumes followed the method described for the 1915 volume.

10. Question. When, to your knowledge, was this particular edition marked "1915" issued and distributed?

Answer. I do not remember.

11. Question. Was it before you left the Navy?

Answer. I don't remember.

12. Question. I show you what purports to be an earlier edition of the same publication, having the same title and bearing a publication date 1913. What, if anything, do you know about the distribution and use of this volume by the Navy?

Answer. I recognize this volume as a copy of the publication issued to a wireless station to which I was at one time attached. The volume was for use in familiarizing the personnel attached to the station with the various types of apparatus described therein.

Mr. Peters: I offer in evidence the two volumes referred to by the witness and request that they be marked "Plaintiff's Exhibit, Navy manuals, 1913 and 1915, No. 78."

13. Question. I call your attention to plaintiff's Exhibit No. 46, a certified copy of a contract between the Telefunken Wireless Telegraph Co. and the United States, particularly to the description of the Telefunken apparatus therein, including the circuit drawing of the Telefunken apparatus, and ask you to examine the same and state what, if anything, you know with reference to the use of Tele-

funken apparatus of the type shown in this contract by the Navy Department subsequent to June, 1910?

Answer. While stationed at San Juan, Porto Rico, in the year 1914, I installed at the naval radio station there a Telefunken transmitter of a type similar to that shown in the wiring diagram of this exhibit. On the occasion of a visit to the U. S. S. *Louisiana* in the same year I saw a Telefunken transmitter and receiver of a type similar to that shown in this diagram installed on that ship.

14. Question. What do you know with respect to the date when this installation on the *Louisiana* was made?

Answer. I do not remember the exact date, but on the occasion of my visit to the *Louisiana* mentioned above the installation I have referred to was in progress.

15. Question. The contract referred to refers to two types of Telefunken receiver, known as E5 and E4, respectively. Did you see both of these types at San Juan or on the *Louisiana?*

[fol. 203] Answer. At San Juan only a transmitting apparatus was installed. On the *Louisiana* I saw two types of Telefunken receivers—the E4 and E5.

16. Question. Please describe the Telefunken apparatus you saw on the *Louisiana*, referring to a drawing of the same, if you have prepared and can produce the same?

. . . . . .

Answer. The Telefunken apparatus with which I am familiar is shown diagrammatically in the sketch which I produce. (See plaintiff's Exhibit No. 79.) The transmitter was connected to the antenna *f* through the lead A and contact 1. The transmitting apparatus consisted of the antenna loading coil *g*, antenna shortening condenser H (for use in transmitting short wave lengths only), the oscillation transformer *d* and *d'*, capacity *c*, quenched spark gap G, transformer *e*, key *b*, motor generator *a*, and earth connection E. The operation of this transmitter is as follows:

When the key *b* was depressed current from the alternator of the motor generator *a* flowed through the primary winding of the transformer *e*. The current generated in the secondary coil of the transformer *e* charged the capacity *c* through the primary of the oscillation transformer *d*. The capacity *c*, when fully charged, discharged through a circuit containing the quenched spark gap G and the pri-

mary of the oscillation transformer *d*. The variable contact 2 and 2^a were provided for tuning the closed oscillating circuit *c*, G, 2^a, *d*, 2. Current impulses set up in the closed oscillating circuit described above produced similar currents in the open oscillating circuit *f*, A, *g*, H, *d'*, and E through the medium of the magnetic coupling of the oscillation transformer *d*, *d'*.

The Telefunken receiving apparatus, with which I am familiar, was connected to the antenna *f'*, A. The receiving apparatus was of two types—the E5 and the E4. The E5 type consisted of an oscillation transformer *j*, j^2, condenser *h*, earth B, variable condenser *h'*, detector T, stopping condenser j^3, and telephone receiver R. The antenna was connected to the primary coil of the oscillation transformer by means of the variable contact 2 to the earth E. The variable condenser *h* could by means of switching arrangements be connected either in parallel to the coil *j* or in series with the lead A. Impulses set up in the primary circuit just described were transferred to the closed oscillating circuit j^2, *h'*, 4 or 4^a, by means of the coupling between the two coils *j*, j^2. Currents or impulses in the closed oscillating circuit just described were rectified by means of the detector T and received by means of the telephone receiver R. The E4 type of receiver was similar to the E5, with the exception that no tuning condenser was provided in the closed oscillating circuit of the receiver. However, rough tuning could be accomplished by varying the inductance j^2 by means of the variable contact 4.

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[fol. 204] 17. Question. While in the Navy did you ever operate or see other Navy operators adjust and operate Telefunken apparatus of the type you have been describing?

Answer. I have operated the Telefunken transmitter, which I have described, and I have seen other operators operating the receiving apparatus, although I have never operated a Telefunken receiver myself.

18. Question. Please explain, both with respect to the transmitter and the receiver, each and all of the adjustments made by an operator in getting the apparatus ready to operate and in operating the same.

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Answer. In the practical operation of a transmitter a predetermined number of wave lengths were selected and the apparatus adjusted to give these wave lengths, as it was found expedient to vary the wave lengths of a transmitter from time to time. In adjusting the transmitter to these predetermined wave lengths the amount of inductance in the coils d, d', and g was selected so as to give the proper wave lengths. In adjusting the transmitter to one of these wave lengths, the closed oscillating circuit d, G e was first adjusted to the desired wave length by means of the variable contact 2. This point on the coil d was then brought to a fixed point so that the variable contact 2 could be moved *to another position; but if at any future time it was desired* to send on the wave length to which the closed oscillating circuit had been adjusted, it would be only necessary to connect the variable contact 2 to this fixed point. Similarly other points on the coil d corresponding to the predetermined wave length could be connected in circuit by means of variable contact 2. The open oscillating circuit was then tuned with the closed oscillating circuit by varying the amount of inductance in the coils d' and g. Fixed amount of inductances in the coils d' and g were brought to fixed points to which the contacts 1^a and 1 could connect. The coupling between the circuits d and d' had to be adjusted separately for each wave length. In order to change the wave length of the transmitters, the variable contact 2 was connected with the fixed point corresponding to that wave length, the variable contacts 1^a and 1 in the open oscillating circuit were connected to the fixed points corresponding to that wave length, and the coupling d, d', was varied until the maximum radiation was obtained.

In receiving a signal on the Telefunken receivers, it was necessary to tune the antenna to the wave length of the signal it was desired to receive. This was accomplished by varying the inductance and capacity in the circuit j, h, 2. The closed oscillating circuit of the receiver was then adjusted to the wave length of the primary circuit by varying the inductance and capacity j^2, h' of the circuit. Currents generated in this circuit were rectified by the detector T, and the rectified current flowing through the receiver R caused the diaphragm of that receiver to vibrate, producing sounds which were audible to the ear.

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[fol. 205] 19. Question. In receiving signals with the Telefunken type E4 receiver, shown in your drawing, what adjustments, if any, were made in the circuit j^2, 4, T, j^3?

* * * * * * *

Answer. In the E4 type of receiver, the inductance of the coil j^2 was adjustable in increments permitting rough tuning of this secondary circuit.

20. Question. Was the oscillation transformer of the transmitting apparatus in the Telefunken apparatus at San Juan and on the *Louisiana* formed of two separate coils or was it a single coil? Please refer to your drawing and explain this point.

Answer. In the Telefunken type of transmitter, such as I have been describing, the oscillation transformer $d\ d'$ consisted of a single coil, portions of which were common to both the closed oscillating circuit and the open radiating circuit forming what was commonly called a direct coupled circuit.

21. Question. You referred to varying the coupling of the closed oscillating and the radiating circuit of the Telefunken transmitter. How was that accomplished?

Answer. Varying the coupling in the coil in question was accomplished by varying the position of the common portion of the coil in reference to the total inductance between the points 1^a and 2^a, also by varying the mutual inductance between the coils g.

22. Question. Describe the Telefunken detector shown at T, in both the E5 and E4 receiver drawings.

Answer. The detector used with the Telefunken type of receiver was of the crystal type and was composed of iron pyrites. A metallic contact was made with the iron pyrite crystal. The detector was so designed that it was possible to vary this metal contact over the surface of the crystal.

23 Question. You mentioned tuning the closed oscillatory circuit of the Telefunken transmitter and also the tuning of the open radiating circuits. To what were these circuits tuned?

Answer. They were tuned to each other and to the wave length that it was desired to operate these transmitters.

24. Question. You also mentioned the tuning of the open primary circuit of the Telefunken receiver and the closed circuit of the receiver. To what were these circuits tuned?

Answer. The primary circuit of the receiver was tuned to the wave lengths of an incoming signal that it was desired to receive. The secondary circuit of the receiver was tuned to the primary circuit.

25. Question. You have stated that the capacity H shown in the antenna lead of the Telefunken transmitter was sometimes cut out or not used. Will you please indicate on the drawing the switch for cutting that capacity out?

Answer. I have done so and marked the switch S.

Mr. Peters. I offer in evidence the drawing referred to by the witness and ask that the same be marked "Plaintiff's Exhibit No. 79, drawing, Telefunken apparatus."

[fol. 206] 26. Question. You have stated that you have knowledge of National Electric Supply Co.'s apparatus installed and used by the Navy in the period beginning July, 1910, and ending September, 1916. In what year was this apparatus installed and where was it installed and used?

Answer. While I was attached to the U. S. S. *Georgia* as chief electrician from the latter part of 1912 to the early part of 1914, a portable field set, manufactured by the National Electric Supply Co. was furnished the vessel on which I was serving. This apparatus was contained in two trunks and could be set up and operated either on board ship or on shore. It was provided for use with landing parties.

27. Question. During the time you were attached to the S. S. *Georgia* did you set it up and use it?

Answer. On several occasions I set up and operated this set, once at the naval camp at Guantanamo Bay, Cuba, and another time on board ship at Vera Cruz, Mexico, for test with a vessel stationed at Tampico, Mexico, the object being to determine the reliability of the set to transmit great distances.

28. Question. Did you have a drawing made showing this National Electric Supply Co.'s apparatus?

Answer. I have prepared a drawing, showing diagrammatically the circuit connections for the portable set I have been discussing, and produce the same.

29. Question. Will you please describe this National Electric Supply Co. apparatus by reference to the drawing (P. Ex. 80) you have produced?

Answer. This apparatus consisted of a motor generator *a*, sending key *b*, transformer *c*, capacity *e*, quenched spark

gap G, oscillation transformer *d*, *d'*, antenna A, and earth connection E. The receiving portion of this set consisted of an oscillation transformer j^1, j^2, shortening condenser *h*, detector T, stopping condenser j^3, and telephone receiver R. The transmitting and receiving apparatus were mounted together in a trunk; the motor generator was mounted alone in a small trunk.

30. Question. What provision if any was made in this apparatus for tuning the several circuits?

Answer. The transmitting portion of the apparatus was provided with an oscillation transformer having two coils *d*, *d'*—the amount of inductance of these coils and the value of the coupling between them could be varied so that it was possible to tune both the closed oscillating circuit and the open radiating circuit to any wave length in the range of the instrument. In the receiving portion of the apparatus an oscillation transformer j^1 j^2 was provided. The value of the inductance in the coils j^1 j^2 could be varied, also the coupling between these two coils. This made it possible to vary the wave length of the receiver over the entire range of the instrument.

31. Question. What provision was made for tuning or adjusting the time period of the closed or secondary circuit of the receiver?

Answer. The inductance of the coil j^2 could be varied by means of the contact 5, thus changing the time period of the circuit in question.

[fol. 207] 32. Question. Describe the detector supplied with this National Electric Supply Co. apparatus, shown at T on your drawing.

Answer. The detector supplied with this apparatus was of the crystal type known as galena. It consisted of a galena crystal and a fine-wire contact. The mounting of the fine wire was so designed that it could make contact with any part of the surface of the galena crystal. It was also possible to vary the pressure of this contact against the crystal.

33. Question. Was the oscillation transformer forming part of the transmitter of the apparatus you have just referred to formed of two separate independent coils or of a single coil? Please state what the facts were.

Answer. The oscillation transformer was composed of two separate coils without metallic connection between them, forming what was known as an inductive coupling.

34. Question. As I read the drawing you have produced, it shows but a single coil, a portion of which is included in the closed oscillatory circuit. If I am right in this, will you have your drawing corrected to show two independent coils?

Answer. I have corrected it in pencil and will have it inked in later.

35. Question. I call your attention to your twenty-ninth answer, in which in enumerating the elements of the receiver you omitted to mention an antenna. Was this omission intentional?

Answer. The omission was an oversight; it should have been included in my answer to Q. 29. The antenna of the portable set I have been describing was also a portable affair and was used for both transmitting and receiving.

36. Question. In the actual operation of this National Electric Supply Co.'s apparatus, what use was made of the means for tuning the several circuits of the apparatus referred to in your previous answers?

Answer. The tuning of the transmitting portion of the portable sets made it possible to select a wave length which the set operated at best. Also, if for any reason it was desired to send on a different wave length, change of wave length could be easily and rapidly accomplished. In tuning the receiver it was possible to pick up signals over considerable range of wave lengths.

37. Question. You have referred to the tuning of the closed oscillatory circuit forming a part of this transmitter. To what was this circuit tuned?

Answer. The closed oscillating circuit of the transmitter was tuned to the wave length that it was desired to transmit.

38. Question. How about the open radiating circuit? To what was that tuned?

Answer. The open radiating circuit was tuned to the closed oscillating circuit of this transmitter.

39. Question. To what were the circuits of the receiver tuned?

Answer. The primary or antenna circuit of the receiver was tuned to the wave length of the signal which it was desired to receive. The secondary circuit of the receiver was tuned to the primary circuit.

40. Question. What type of spark gap was used in this apparatus?

Answer. A quenched gap type was used.

[fol. 208] Mr. Peters. I offer the drawing as corrected and as described by the witness in evidence, and request that the same be marked "Plaintiff's Exhibit No. 80, drawing, National Electric Supply Co. apparatus."

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41. Question. I show you plaintiff's Exhibit No. 57, being a certified copy of a contract between Fritz Lowenstein and the United States, and call your attention to the description of the transmitting apparatus contained therein and as shown in the annexed drawings, and particularly the drawings marked "T-8." Please examine this and state whether or not during your service in the Navy you saw apparatus of this type installed and in use; and if so, under what circumstances.

Answer. I recognize the sketch on sheet marked "*r-4s*" and "T-8" as the Lowenstein transmitter, which I saw on the occasion of an official visit to the New York Navy Yard station in the latter part of 1914.

42 Question. Was the Lowenstein transmitter referred to installed and in operative condition? If so, what can you say as to whether or not it had been installed subsequent to June, 1910?

Answer. The apparatus referred to was installed and in operation at the time I saw it, namely, the latter part of the year 1914.

43. Question. What can you say as to whether this particular set was installed at the navy yard prior or subsequent to June, 1910?

Answer. I do not know the date of installation of this apparatus, but do know that it was in operation during the latter part of 1914.

44. Question. Just where in the navy yard was it installed and in operation?

Answer. It was in operation at the radio station building, near the navy-yard gate, at the time I saw it.

45. Question. Please describe this transmitter briefly, referring, if necessary, to drawing T-8 (see P. Ex. No. 57), and applying reference numerals to this drawing if necessary.

Answer. The characteristic features of this transmitter were the wave changing switch A, the combination inductive and conductive oscillation transformer B, and the quenched

gap. The wave changing switch consisted of a number of points which were connected to various points on the coupling and loading inductances and an arm containing contacts which connected to these fixed points. Quick change control was effected by selecting the points to which the switch arm connected. The quenched spark gap was notable because of its design. It consisted of a number of concentric cylinders arranged on a circular piece of insulating material, with a switch to control or select the number of individual gaps that it was desired to use in circuit. An air blast from a fan kept these gaps cool. This fan is shown at C.

46. Question. What are the other elements of the circuit comprising the element marked on this drawing "primary condenser"?

Answer I do not understand the question.

47. Question. Did this Lowenstein transmitter you saw comprise an open radiating circuit? If so, will you please state what elements there are in this circuit?

[fol. 209] Answer. When I saw this Lowenstein transmitter I did not follow out the circuits, but merely noticed the characteristic features of the set as described in my previous answer.

48. Question. At the time you examined this Lowenstein transmitter was the function of the wave-changing switch explained to you?

Answer. It was.

49. Question. And what was the function of this switch?

Answer. The function of this switch was to effect a quick change in the values of the inductance in the open radiating circuit and in the closed oscillating circuit of the transformer, thereby effecting quick changes in the wave lengths emitted by the transmitter.

50. Question. What type of detectors have been most generally used by the Navy, so far as you know, since 1910?

Answer. Various types of crystal detectors, such as iron pyrites, silicon and arsenic; the pericon detector, composed of chalcopyrites and zincite; the galena and carborundum detectors; plain audion, ultra audion, and ticker were also used as detectors.

51. Question. You stated that while in the Navy service you became familiar with the Federal Telegraph transmitting apparatus, and in this connection I call your attention to "The Proceedings of the Institute of Radio Engineers,"

volume 4, No. 5, October, 1916, and particularly to an article purporting to have been published by Capt. William H. Bullard, U. S. N., which describes and illustrates a Federal Telegraph transmitter installed at Arlington. Please examine this article and state whether or not you are familiar with the Federal Telegraph transmitter illustrated and described therein.

Answer. During the early part of the year 1915 I was stationed at the Arlington Radio Station under instructions and saw the Federal arc transmitter, described in this pamphlet, in operation at that station.

* * * * * * *

53. Question. At the time you saw this Federal transmitter did you examine it sufficiently to understand the circuit connections and also the essential elements of the apparatus?

Answer. While stationed at the Arlington Radio Station under instruction a complete and thorough knowledge of the Federal arc transmitter, including construction, circuit connections and operation, was required by the students in the regular course of their instruction. I studied the design and construction of the apparatus, connections, and operation of the transmitter, as required by the instructor.

54. Question. Will you now please describe this apparatus first without reference to Bullard's article and the drawings and photographs contained therein.

[fol. 210] Answer. The apparatus consisted of a motor generator, the generator of which supplied direct current at a pressure of 500 volts to the terminals of an arc through choke coils in both generator leads and an auxiliary resistance, which reduced the generator voltage on starting. The arc itself consisted of a chamber in which were located the arc electrodes. The positive electrode was made of copper and connected to the positive terminal of the generator. This electrode was water cooled; the negative electrode was of carbon and connected to the negative terminal of the generator through a series magnet. The electrodes were so arranged in the chamber that the pole pieces of this series magnet caused a magnetic flux to flow across the path of the arc. The arc chamber was of air-tight construction, and means were provided for introducing hydrocarbon vapor in this chamber. This was accomplished by dropping alcohol into the arc chamber from a small reservoir mounted

on top of the apparatus. The antenna was connected to the positive electrode through an antenna loading coil. The ground was connected to the negative terminal through a hot-wire ammeter. A battery of Leyden jars was shunted across the arc terminals for the purpose of increasing the stability of the arc. The choke coils in the generator lead were provided to localize the oscillations produced by the arc in the antenna circuit to keep them from reaching the generator. An ammeter and voltmeter were provided in the generator circuit to give indications of the value of voltage and current in this circuit. A switch was also provided in the generator circuit so that the continuity of the circuit from the generator to the arc could be controlled.

55. Question. Just how were the signals transmitted with this set?

Answer. The signals were transmitted by short circuiting a number of turns in the antenna-loading inductance. This was accomplished by means of a key. In sending signals by this method the circuit was not broken but radiated energy continually. By short-circuiting a number of turns in the antenna-loading inductance the wave lengths of the signal being transmitted was varied, the amount of variation depending upon the number of turns shortcircuited.

56. Question. Referring again to the article purporting to be by Capt. William H. Bullard, in the October (1916) proceedings of the Institute of Radio Engineers, do you know the Captain Bullard referred to? And if so, who is he?

Answer. I know Capt. W. H. G. Bullard, United States Navy. He was at the time I knew him superintendent of the naval radio service, with offices at the radio station, Radio, Va.

57. Question. I call your attention to Figure 13, on page 436 of the article. State, if you know, what this figure shows.

. . . . . .

Answer. This figure is a photograph of the Federal arc transmitter installed in the engine room of the radio station, Arlington.

58. Question. Please compare the circuit diagram of the Federal apparatus (fig. 14), shown on page 437 of this publication (P. Ex. No. 81), with the apparatus as you actually saw it installed and used.

[fol. 211] Answer. This figure is a wiring diagram of the circuit connections of the Federal arc transmitter as I saw it while at the Arlington station.

59. Question. Please point out on this diagram the several elements you have already stated form the parts of this apparatus.

Answer. This figure shows diagrammatically the following elements: Antenna loading coil *g*, sending key *b*, condenser *c*, arc electrodes and magnet *x*, starting resistance *w*, switch *s*, generator *a*, choke coils *y*, earth connection E, hot wire or radiation ammeter *p*, and voltmeter and ammeter in generator circuit A and V.

60. Question. Was the condenser or capacity shown at *c* in this drawing fixed or variable?

Answer. The condenser or capacity shown at *c* in the figure consisted of a battery of Leyden jars. The value of this capacity in this battery was adjusted for individual wave lengths.

61. Question. What does the arrow shown at 1 on this drawing indicate?

Answer. The arrow shown at 1 in this figure indicates a variable connection to the antenna-loading coil *g*.

62. Question. What use was made of this variable contact 1 and of the loading coil *g* in the operation of the set?

Answer. The position of the variable contact 1 on the loading coil *g* determined the value of the inductance in the coil *g*, on which depended the oscillation constants of the circuit *f*, *g*, copper, carbon, *p*, E, and the shunt circuit *c*. The wave length of the oscillations set up in this circuit was dependent on the oscillation constants of the said circuit.

Mr. Peters: I offer the article by Captain Bullard, containing the photographs and drawings to which the witness has referred, in evidence and request that the same be marked "Plaintiff's Exhibit No. 81, Bullard Institute of Radio Engineers article."

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63. Question. I show you an instrument bearing a maker's name plate reading in part as follows: "DeForest Audion, Radio Tel. & Tel. Co., N. Y., U. S. A." To your knowledge, were instruments like this installed and used by the Navy subsequent to June, 1910?

Answer. While I was stationed at San Juan, P. R., in the year 1914, an instrument similar to the one on exhibit was supplied to that station, installed, and operated under my direction.

64. Question. Have you seen them in use at other naval stations?

Answer. I have seen them in use at other naval stations.

65. Question. State where and give the dates as near as you can.

Answer. I also saw one of these instruments in operation at the wireless station Brooklyn Navy Yard in the year 1914. I also saw several of these instruments in use during the year 1915 at the Arlington Radio Station.

66. Question. Please examine this instrument carefully and compare it with the one you installed and used in 1914.

Answer. After a careful examination of this instrument I find it to have connections similar to the connection of the instrument I installed and operated at San Juan.

[fol. 212] 67. Question. How do the several elements in the arrangement of elements compare with the one you installed?

Answer. They are identical.

68. Question. What name is this instrument known by in the naval service?

Answer. In the naval service this instrument was termed an audion control box.

69. Question. Have you made a drawing showing diagram-atically this instrument as used by you in the naval service in 1914? If so, will you produce the same?

Answer. This instrument could be used in several different ways, namely, as a plain nonoscillating audion, as an oscillating audion, or ultra audion, as it is called. I have prepared a sketch showing the circuit connections for use with this audion control box, utilizing it as a plain nonoscillating audion, and produce the same. I also have a copy of instructions issued by the Navy Department to me, giving descriptive matter and diagrams relating to the use of this audion control box as a ultra audion, and produce same.

69a. Question. When you installed and used one of these devices in 1914 in which of the several ways you have referred to did you install and use it?

Answer. I used it in both ways—that it, as a plain audion and as an ultra audion. When connected as a plain audion I used it for receiving damped or spark signals, and

while using it as an ultra audion, I copied or had copied undamped or arc signals.

70. Question. Please describe how you used this instrument as a plain audion for receiving spark signals, referring to the drawing you have produced if necessary.

Answer. The circuits f, A, g', j^1 and earth E and j^2, h' (P. Ex. No. 83) were the ordinary primary and secondary circuits of the regular receiver in use at the station. The circuit containing the elements j^3, T, B^2, R, B^1 were the circuits of the audion control box. One lead from the condenser h' was connected through the condenser j^3 to the grid G of the audion T. The other lead from the condenser h' connected to negative terminal of the filament F of the audion T. The battery B' was connected to the filament F as indicated.

71. Question. Will you please identify on the instrument referred to the part designated T in the drawing?

Answer. The part designated T on my diagram represents the audion or bulb element of the audion control box. This element is composed of a plate, grid, and filament mounted in a glass bulb from which the air has been exhausted. Leads from the outside of the bulb connect to the various elements mentioned.

72. Question. There are two of these lamps or bulbs on the instrument and only one shown on the drawing. How do you explain this?

Answer. The drawing I have produced is a diagrammatic one and shows the scheme of connections. The audion-control box is provided with two bulbs and duplicate control, only one of which is in operation at a time.

73. Question. The audion bulbs on this instrument appear to have only single grids and single plates—do they correspond in this respect to the ones you used or saw used? [fol. 213] Answer. The audion bulbs are made in two styles—one style having but a single plate and single grid. The other style having a double plate and double grid. I have used both styles.

74. Question. Plaintiff's Exhibit No. 71, certified copy of contract by the Radio Telephone & Telegraph Co. with the United States, on page a-2, contains a proposal on the part of the company to supply "the audion detector, P. N. type." Do you recognize that type of detector as having been used in the Navy?

Answer. I recognize the instrument on the exhibit as a general type of apparatus supplied by the De Forest company. The makers' name plate on these instruments described them as P. N. type. In the naval service, however, this type of instrument was generally called the audion-control box.

Mr. Peters. I offer the instrument referred to by the witness in evidence, including the two audion bulbs forming a part of the instrument, and ask that it be marked "Plaintiff's Exhibit No. 82, De Forest P. N. audion used by Navy."

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Mr. Peters. * * * Plaintiff does not contend that this particular instrument was ever in the naval service or used by the Navy.

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75. Question. * * * I will ask you again to compare this instrument both as to construction and as to circuit connections with those used by you in the Navy.

Answer. The instrument I have examined is identical in design, construction, and connections with the one I used in the naval service.

Mr. Peters. The exhibit is again offered in evidence and it is requested that it be marked as above indicated.

I also offer in evidence the drawing last referred to by the witness and request that the same be marked "plaintiff's Exhibit No. 83, drawing, De Forest P. N. audion used by the Navy."

76. Question. I now call your attention to plaintiff's Exhibit No. 74, certified copy of contract between Radio Telephone & Telegraph Co. and the United States, which is dated June 27, 1914, and which calls for the delivery, among other items, of "Item 1, 30 single ultra audion detectors, complete, with 6-volt Hudson filament, and double bulb, without telephone receiver." While in the Navy, did you see any apparatus of this kind installed and in use; and if so, where and when?

Answer. As I stated in a previous answer, the so-called audion-control box could be connected with a receiver by

means of a circuit known as the ultra-audion circuit. Written instructions and diagrams of circuit connections were issued by the Navy Department, showing how the audion-control box could be connected with a receiver to produce this ultra-audion circuit.

[fol. 214] 77. Question. The instructions you have produced and referred to in one of your preceding answers are entitled "The ultra audion—its use with the various models of the 1-P-76 receivers in the U. S. Navy radio stations on board ship and on shore." State the time as near as you can when these instructions were issued to you.

Answer. These instructions were issued to me some time between November, 1914, and March, 1915.

78. Question. And when and where was it you installed and operated these ultra-audion instruments as described in these instructions?

Answer. I installed and operated and directed the operation of the apparatus described in this circular at the naval radio station, San Juan, Porto Rico, after having had received the instructions referred to in the preceding answer and prior to March, 1915.

79. Question. Have you seen these ultra-audion arrangements in use at other naval stations?

Answer. I saw this ultra-audion circuit in operation at the Arlington Radio Station during May, 1915.

80. Question. Please compare the ultra audion as you used it and saw it used in the naval service, with the description of the ultra audion and directions in the pamphlet referred to.

Answer. The ultra-audion circuit which I installed at San Juan was identical with the diagram on sheet 9 of the pamphlet under discussion. I installed this circuit at San Juan according to the instructions and diagrams contained in the pamphlet which had been officially issued to me.

81. Question. Is the pamphlet referred to an official publication or pamphlet of the Navy Department?

Answer. This pamphlet was issued by the Bureau of Steam Engineering and contained the official number RE-3A-101A.

Mr. Peters. I offer the pamphlet referred to in evidence and request that the same be marked "Plaintiff's Exhibit No. 84, official instructions for use of ultra audion."

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82. Question. The contract last referred to also calls for the delivery, under item 5, of 200 Hudson filaments, 6-volt double bulbs for use with item 1. What was called for by this item?

Answer. I do not understand the question in reference to "double bulbs."

83. Question. I call your attention to plaintiff's Exhibit No. 72, contract dated January 12, 1914, between Radio Telephone & Telegraph Co. and the United States, which provides for the delivery to the United States, among other items, of "10 audion amplifiers complete." While you were in the naval service, did you install and use any audion amplifiers? If so, where and when?

Answer. While I was stationed at the naval radio station, San Juan, P. R., a De Forest audion amplifier three stage was supplied to the station between November, 1914, and March, 1915.

84. Question. Did you examine the same sufficiently to understand its construction and circuit connections?

Answer. I did.

85. Question. Have you seen the devices in use at any other stations? And if so, name some of them.

[fol. 215] Answer. I saw the De Forest audion amplifier in use at the Arlington Radio Station in May, 1915, also at the Tuckerton Radio Station after that station had been taken over by the Government in April, 1917.

86. Question. Have you prepared a drawing showing the De Forest audion amplifier? And if so, will you please produce the same?

Answer. I have prepared a drawing (P. Ex. No. 85) showing the wiring diagram of the De Forest audion amplifier used by the Navy and produce the same.

* * * * * * *

87. Question. Please describe the De Forest audion amplifier as used by you and others in the Navy in 1914 and 1915, referring, if necessary, to the drawing you have prepared and produced.

* * * * * * *

Answer. The DeForest audion amplifier as used by myself while in the Navy was of the three-stage type; each stage consisted of an iron-ore transformer, 1, 2, 3, three-

element audion T, battery B^2, resistance ∩ switch S, telephones R, and a filament lighting battery B′, which was common to all three stations. These elements were mounted in a wooden cabinet and the variable portions of the apparatus were operable on the outside. The terminals X Y were connected to the telephone binding posts or terminals of a receiver. The battery B′ was a separate piece of apparatus and connected to terminals on the amplifier. The amplifier element T was renewable. The circuit connections used are as shown in the diagram.

88. Question. At the time you were in the naval service did you receive any instructions as to the way the DeForest audion amplifier could be connected and used? By "connected" I mean connected to the antenna or receiver circuit?

Answer. I remember reading instructions published by the Navy Department and referring to the DeForest audion amplifier in which it was stated that the first stage of the amplifier could be used as an audion or ultra audion, the remaining two stages performing their usual function as amplifiers.

89. Question. Have you a copy of the instructions?

Answer. I have not.

90. Question. Did you ever use the amplifier or see others use the amplifier in this way while in the naval service?

Answer. I never found it necessary to use the amplifier in this manner, nor have I seen it used. The instructions I have referred to stated that it was possible to use the first stage of the amplifier after this fashion.

91. Question. When you used the amplifier how did you connect it to the wireless system?

Answer. The terminals X Y, drawing, DeForest audion amplifier, were connected to the telephone terminals of the receiver, the signals of which it was desired to amplify.

[fol. 216] 92. Question. Can you produce an illustration or photograph of the amplifier such as you used and saw used in the naval service?

Answer. A photograph of the DeForest audion amplifier similar to that used by me in the naval service is shown on page 192 of Bulletin A-14, apparently published by the Radio Telephone & Telegraph Co.

Mr. Peters. I offer in evidence the drawing produced by the witness and identified as showing the circuits of the

DeForest audion amplifier, and request that the same be marked "Plaintiff's Exhibit No. 85, drawing, audion amplifier used by the Navy Department."

I also offer in evidence the DeForest circular referred to by the witness with respect to page 192, containing the illustration of the amplifier, and request that the same be marked "Plaintiff's Exhibit No. 86, illustration, DeForest audion amplifier used by Navy."

93. Question. You have referred in your testimony to type IP-76 receiver. Do you know the maker of that receiver?

Answer. I referred in my testimony to a Wireless Specialty Apparatus Co.'s receiver also known as type IP-76.

Cross-examination.

By Mr. Workman:

* * * * * * *

94. Cross-question. In what capacity did you enter the Navy Department?

Answer. I enlisted in the United States Navy on January 6, 1904, as apprentice, third class.

95. Cross-question. Previous to entering the Navy Department, what electrical education or training had you had?

Answer. None.

96. Cross-question. At what time after entering the Navy Department did you begin working as electrician.

Answer. In May 1908, I was ordered to the Naval Electrical School at the Brooklyn Navy Yard, from which I graduated as electrician, second class.

97. Cross-question. That training in the Electrical Naval School had to do only with electrical power and lighting machinery, hadn't it?

Answer. It had to do with the practical application of electricity for use on board ships, also a theoretical general knowledge of electricity, and included in addition thereto a special course on radio telegraphy.

[fol. 217] 98. Cross-question. How long were you in the electrical school before you graduated?

Answer. I do not remember. A record of the length of time and my proficiency marks while attending this school could possibly be obtained from the Navy Department.

99. Cross-question. Was there not some fixed term after entering the school before graduation—wasn't it a three years, or a four years, course, or something like that, that was required for graduation.

Answer. There was a fixed period of instruction, but was less than a year.

100. Cross-question. Can't you give us some idea as to how long you were in this school—whether it was less than a year or a year or two or more?

Answer: It was about six months.

101. Cross-question. After leaving the school what position or duties were you assigned to?

Answer. I was assigned to the U. S. S. *Prairie*, as junior radio electrician.

102. Cross-question. Do you mean that you began radio work at once after leaving the school?

Answer. Upon my assignment to the *Prairie*, after leaving the school, I began at once the practice of radio telegraphy.

103. Cross-question. You weren't put at handling wireless apparatus, were you, at once after leaving the school in 1904?

Answer. I stated I did not begin my course of instruction at the school until May, 1908. When I was assigned to the *Prairie* after graduating from the school, I stood regular watch alternating with the electrician in charge and operated and kept in repair the wireless apparatus that was installed on the vessel.

104. Cross-question. Do you mean to give us to understand that with only six months' training, you not only learned the subject of electricity so as to be an electrician, but you also learned telegraphy and still further knew the subject of wireless telegraphy and its instruments and circuits?

Answer. During the period from the time I entered the service in 1904 until the time I was assigned to the electrical school for instruction, a period of approximately four years, I studied the subject during my spare time and received the assistance of several naval officers and electricians. It was necessary before being admitted to the electrical school to pass a preliminary examination to show that the applicant had some knowledge of the subject of electricity. My knowledge of electricity and of operating wireless apparatus is indicated by the fact that I graduated with the

rate of electrician, second class, instead of the ordinary graduation to electrician, third class. After being assigned to my duties on shipboard, I took a correspondence-school course in electrical engineering and graduated and received a diploma as an electrical engineer from this school. My knowledge of wireless telegraphy has also been augmented by the study of the various publications issued by the Navy Department and by the study of standard textbooks on the subject.

[fol. 218] 105. Cross-question. How much of your six months in the electrical school was devoted to the subject of wireless telegraphy?

Answer. Approximately one-third of the time.

106. Cross-question. You were a full-fledged wireless man when you were assigned to the *Prairie*, were you?

Answer. My rate was electrician, second class; my duties were junior radio electrician on board the *Prairie* and an electrician, first class, was the senior and I worked under his orders.

107. Cross-question. An ordinary electrician knows little or nothing about wireless apparatus and its operation, does he, unless he has made a study of the subject?

Answer. I am not prepared to answer a question of that nature except as it refers to myself.

108. Cross-question. Well, would you take an ordinary electrician and put him on wireless instruments without knowing whether or not he had studied the subject or had experience in it?

Answer. I do not understand the term "ordinary electrician." In the naval service electricians were rated in classes, their rate depending upon the extent of their knowledge and experience.

109. Cross-question. My question hadn't any reference to the Navy. I will ask you whether or not you would regard a man without any study or experience in wireless instruments and apparatus as able to handle, adjust, or operate such apparatus or understand its working?

* * * * * * *

Answer. A man without any knowledge whatsoever of the subject naturally could not be expected to perform the functions specified in the question.

110. Cross-question. Is the Lowenstein apparatus or transmitter referred to by you in your questions 4 to 8 the same one you again mentioned in questions 41, 42, etc.?

Answer. It was.

111. Cross-question. How do you fix the time as during the year 1914 that you saw a Lowenstein transmitter in the New York Navy Yard?

Answer. Because I was ordered from San Juan, Porto Rico, to the navy yard, Philadelphia, via the New York Navy Yard, for the purpose of examination for promotion. My orders required me to report to the New York Navy Yard, from whence I was later sent to the Philadelphia yard. It was during this visit to the New York yard that I saw the Lowenstein set in question.

112. Cross-question. You have no knowledge of how long that set had been there, I suppose?

Answer. Only from the fact that the instruments were new and had not been in operation for a great period of time.

113. Cross-question. And you don't know whether or not the Government has used other Lowenstein sets elsewhere prior to this time?

Answer. I have no knowledge of the installation or operation of any other Lowenstein transmitters.

114. Cross-question. This was the first one you ever saw?

Answer. This was the first Lowenstein transmitter I had ever seen.

[fol. 219] 115. Cross-question. What was there about it that you recognized as the Lowenstein set?

Answer. I had read descriptions of the Lowenstein apparatus and the characteristic features of same, and I recognized the set by these features. The operator in charge of the station at the New York Navy Yard explained the set in detail to me, also pointing out its characteristic features, such as spark gap, oscillation transformer, etc.

116. Cross-question. Well, doesn't every wireless set have a oscillation transformer and a spark gap—that is, of course, I mean those that don't use an arc or an audion or something like that in place of a spark gap?

Answer. Some form of spark gap and oscillation transformer is the essential part of spark or damped wave transmitters. There is a multiplicity of designs of this apparatus.

117. Cross-question. You have said that the Telefunken apparatus had a quenched spark gap and also an oscillation

transformer (at Q. 16). So there was no difference in this respect between the Lowenstein set you referred to and the Telefunken, was there?

Answer. The Telefunken set I referred to had a spark gap and oscillation transformer, but of an entirely different type than the one I saw on the Lowenstein transmitter.

118. Cross-question. And this difference readily appears at a glance, does it, so that you can instantly tell a Lowenstein set from a Telefunken set?

Answer. The difference between the spark gap and oscillation transformer of a Telefunken set and the same on the Lowenstein set was strikingly apparent. A person having seen the two could not possibly mistake one for the other.

119. Cross-question. Then this difference, as I understand you, is apparent on a mere glance of the apparatus without taking any of it apart or looking at the inside of the casings or anything of that kind. Is that correct?

Answer. The design and construction of the two types were apparent at a glance—that is, it was possible to recognize either one by the features of construction. However, they serve the same purpose in the closed oscillating circuit of the transmitter. The Lowenstein gap would operate in a Telefunken circuit and similarly the Telefunken gap would work in the Lowenstein circuit. It was only the design and construction of the two that differed.

120. Cross-question. As I understand it, any receiving apparatus will detect and receive signals from any kind of transmitting apparatus. Is that correct?

Answer. Any receiver can be made to receive and detect within its range any form of signal—that is, damped or undamped oscillations—provided proper auxiliary appliances are supplied; that is, to detect damp oscillations in a receiver some form of rectifying detector must be used, such as the various forms of crystal detector, Fleming valve, or what is called the plain audion; to detect undamped oscillations in a receiver, some form of beat producer or ticker must be used, such as the ultra audion, heterodyne, or ticker.

121. Cross-question. You referred to certain contracts in your direct examination, for example plaintiff's Exhibit 46, [fol. 220] Telefunken contract of September, 1911. You have no knowledge, I suppose, as to whether or not the apparatus specified in that contract was actually supplied to the Government, have you?

Answer. I have no knowledge of the various contracts specified in the direct examination. I confined my description of apparatus to that which I actually saw in the naval service, irrespective of under what contract the apparatus in question was purchased.

122. Cross-question. That is, you don't know whether this contractor, the Telefunken company, actually shipped to the Government the thing specified in that contract or not?

Answer. I have no knowledge of the delivery by the contractor to the Government of any apparatus whatsoever.

123. Cross-question. And if it did deliver it to the Government under this contract you have knowledge as to whether or not the apparatus it delivered was in accordance with the specifications of that contract?

Answer. The apparatus which I have described follows the specifications and diagrams shown in this exhibit. I have no knowledge as to whether the apparatus I described was the identical apparatus that the contractor delivered to the Government under this contract.

124. Cross-question. As to this sketch in the diagram you introduced of Telefunken apparatus, did you make that yourself?

Answer. The drawing I produced of the Telefunken apparatus was drawn by a draftsman according to instructions and pencil diagrams which I had approved.

125. Cross-question. Your drawing of the Telefunken set does not appear to be like the drawing accompanying the contract, plaintiff's Exhibit No. 46 of the Telefunken company, to the ordinary eye. Is it your testimony that your sketch agrees with this drawing in the contract?

Answer. The sketch which I have produced is a simplified, schematic drawing, such as is used in general practice to indicate the circuits of wireless telegraph apparatus. The drawing in the exhibit is a detailed diagram of connection. The two drawings are elementarily the same.

126. Cross-question. Did you observe that in a letter dated August 22, 1912, forming part of this exhibit contract of the Telefunken company, that that company states as follows:

"The sets covered by our bid are not in accordance with specification 16-T-5, etc., and we are unable to comply strictly with the other paragraph of the specification 16-T-5 without seriously impairing not only the usefulness but also the efficiency of the set as a whole."

And various other parts of this letter indicating differences between what was specified and what was offered to be furnished?

* * * * * * *

Answer. I have read over the exhibit, including the certified copy of the letter dated August 22, 1912, relating to differences between what was specified and what was offered to be furnished.

127. Cross-question. When was it you made the pencil instruction for the draftsman of this diagrammatic sketch of the Telefunken apparatus?

[fol. 221] Answer. The draftsman was instructed to prepare the diagrammatic sketch of the Telefunken apparatus from pencil notes and verbal instructions on Tuesday, June 26, 1917, and on the following day several necessary changes were made.

128. Cross-question. Did you obtain the necessary data to give to the draftsman for this drawing from your memory?

Answer. The data given to the draftsman for the preparation of these drawings was given from my memory.

129. Cross-question. You took none of this data from instruction pamphlets or other diagrams or from some of the drawings that were furnished you, did you?

Answer. I obtained no data from reference books or descriptive pamphlets in the preparation of this diagram. As I was charged with the responsibility of the installation of a Telefunken transmitter while at San Juan, a knowledge of the circuit connections of this apparatus is quite firmly impressed in my mind.

130. Cross-question. Then as I understand you made your transmitting apparatus on this sketch from your memory unaided of the one you installed at San Juan. Is that correct?

Answer. The instructions and data I furnished the draftsman for the preparation of this diagram—that is, as it relates to the transmitting portion of the same—was entirely a product of my memory.

131. Cross-question. What was the occasion for your leaving the naval service?

Answer. I left the naval service because of expiration of enlistment and because of physical disability.

132. Cross-question. In describing these various wireless installations and apparatus you have used, of course, many technical terms which the ordinary layman and possibly the court will not understand. Will you please therefore state what is meant by "wave lengths"? For example, you say in describing this Telefunken apparatus that H is a "shortening condenser for use in transmitting short wave lengths only." (Q. 16.)

Answer. By "wave length" is meant the length from crest to crest of an electromagnetic wave radiated from the antenna of the transmitter. The frequency of an electromagnetic wave in cycles per second is analogous to wave lengths. To produce a given wave length with a transmitter the closed oscillating circuit has to be adjusted, that is the value of the inductance and capacity in that circuit must be so chosen that the natural period of that circuit will be the same as the frequency (cycles per second) of the electromagnetic wave that it is desired to produce. The antenna or open radiating circuit of the transmitter has also got to be adjusted to this frequency. It is sometimes desired to transmit a wave length smaller than the natural or fundamental wave length of the antenna. In order to accomplish this, the natural wave length or period of the antenna has to be reduced. The condenser H in the diagram referred to accomplishes this purpose, that is, reducing the fundamental or natural period of the antenna so that it is possible to transmit wave lengths of a shorter length than the natural wave lengths of the antenna.

133. Cross-question. A wave length of a given dimension is a wave of a corresponding definite frequency. Is that right?

[fol. 222] Answer. A wave of a given length corresponds to a certain definite frequency. Knowing the frequency, it is very easy to calculate the wave length—in fact the wave length is almost apparent from inspection. Knowing the velocity of the wave, and the number of waves per second, dividing the former by the latter, will give the wave length.

134. Cross-question. Instead of speaking of wave lengths, you could just as well express the same thing as accurately by giving the frequency, couldn't you?

Answer. Frequency and the wave length mean essentially the same thing. In general practice, both terms are used as a designation of this phenomena.

135. Cross-question. You speak of the radiating circuit or the open radiating circuit in this Telefunken apparatus, and I understand that to be the circuit which includes antenna *f*, conductor A, coil *g*, switch S, coil *d'*, and earth E. Is "radiating" "circuit the common name or term for this circuit as used by wireless men?

Answer. This circuit is designated by either one of the following terms: "Open circuit," "radiating circuit," and "open radiating circuit," to distinguish it from the closed or closed oscillating circuit of the transmitter. This circuit is "open" in the sense that it is not a continuous metallic circuit and "radiating" in the sense that a portion of this circuit is used in the radiation of electromagnetic waves. All these terms are used in general practice as a designation for this particular circuit.

136. Cross-question. As a matter of fact this circuit that we have just referred to is not an open circuit at all and it doesn't radiate. Isn't that correct?

Answer. On the contrary, it is both an open circuit and also a radiating circuit.

137. Cross-question. Well, whatever takes place in this circuit has to reach the receiving station, doesn't it? Otherwise your apparatus is useless.

Answer. A portion of the electromagnetic field set up around this circuit due to the current impulses induced in this circuit by the closed oscillating circuit of the transmitter is radiated off into surrounding space. These radiated electromagnetic waves are the ones that are picked up by the receiving station.

138. Cross-question. But your sketch of the Telefunken apparatus shows both these circuits at the transmitting and receiving stations, respectively connected to earth, doesn't it?

Answer. The connection to earth E shown on my diagram is an essential part of the open circuit of both the transmitter and the receiver.

139. Cross-question. Isn't it necessary to connect both the transmitting and the receiving antennae to the common conductor, earth to transmit signals from one to the other?

Answer. It is not necessary to connect the earth connection E to a common conductor. Take the case of airplane, where the earth connection is made to the metal framework of the airplane, while the antenna consists only of a hang-

ing wire. The receiving station receiving signals transmitted by this airplane has no common connection with the transmitting apparatus the signals of which it is receiving.

[fol. 223] * * * * * * *

140. Cross-question. Then it isn't correct what is stated in this Instruction Manual of Wireless Telegraphy for the Use of Naval Electricians for 1915, which, I understand, was one of your instruction books, where it states on page 62, "The expanding rings touch the earth and are guided by it as by any other conductor." Would you say that?

Answer. According to this theory of the propagation of electromagnetic waves, as written in the instruction book referred to, it is probably true that the waves act in the manner described therein. These waves, however, are waves in the so-called medium ether and not currents of electricity, as I understand it.

141. Cross-question. Then your closed oscillating circuit, so called, of this Telefunken apparatus, *c*, G, 2', *d*, 2, isn't closed at all, is it, any more than the antenna circuit?

Answer. When current is flowing in this so-called oscillating circuit it is, in fact, a closed circuit. When current is not flowing in this circuit the circuit is open at the point G.

142. Cross-question. But this circuit is open at what you have called a capacity *c*, isn't it? No electrical current flows across *c*, does it?

Answer. It is a closed circuit for alternating or oscillating current, but not a close circuit for direct current. However, as only alternating or oscillating current is ever used or produced in this circuit, it remains a closed circuit, as far as practice is concerned.

143. Cross-question. And it isn't oscillating or alternating current that occurs in the antenna circuit. Is that what you mean?

Answer. Alternating or oscillating current also occurs in the antenna circuit.

144. Cross-question. Capacity *c* is only another name for condenser *c*, isn't it?

Answer. Capacity at the point *c* is obtained by the use of condensers at this point—in other words, condensers have concentrated capacity.

145. Cross-question. There are different terms used for what look the same things on the drawing. I merely want to clear this up for the benefit of the court. In your answer

to Q. 16, you refer to "condenser H;" also "capacity c," and in the receiving circuit "condenser h, condenser j^3." These are all condensers, are they not?

Answer. They are all various forms of condensers.

146. Cross-question. And a condenser is a number of plates of metallic or conducting material separated one from the other by some intervening nonconductive or insulating material. Is that right?

Answer. They are the elements which form a condenser.

147. Cross-question. In the Telefunken apparatus you have referred to, what did the condenser or capacity c consist of?

Answer. The condenser or capacity c referred to consisted of a bank of Leyden jars.

[fol. 224] 148. Cross-question. This Telefunken set to which you have referred and made a sketch of does not seem to agree with an illustration of the Telefunken apparatus which I find on page 107, Figure 46, of the Manual of Wireless Telegraphy for Naval Electricians, 1915, does it?

Answer. The arrangement of the elements of the Telefunken apparatus, Figure 46 in the manual referred to, is slightly different than shown in my sketch; however, the manual does not state that Figure 46 is the type of Telefunken wiring that was used at the San Juan station, while I have stated that I drew my sketch of the Telefunken apparatus from my memory and according to the manner in which I installed this set while at San Juan. I did not obtain any data from the manual referred to in connecting up the transmitter I installed.

149. Cross-question. You have referred to what you called a quenched spark gap G in this Telefunken apparatus. What does this mean—"quenched spark gap"?

Answer. By "quenched spark gap" is meant a type of gap that effects the quenching or stoppage of the flow of current in the closed oscillation circuit after the amplitude of the discharge from the condenser c falls below a certain value.

150. Cross-question. What is the effect of this quenched spark gap on the so-called waves that are sent out from the transmitting station as distinguished from those that are sent out when an ordinary or unquenched spark gap is used.

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Answer. The quenched spark gap quenches the discharge of the condenser in the closed oscillating circuit after the discharge of this condenser has reached a certain point. After the quenching action has occurred, the transformer c again builds up the charge on the condenser c until that charge is of a value sufficient to again break down the resistance of the gap. This action is repeated indefinitely as long as the sending key is closed. In the case of the open or nonquenching type of gap no quenching action occurs; that is, in the sense of quenching the discharge of the condenser after it has fallen to a certain value—in other words, the condenser discharge flows through the closed oscillating circuit for a greater period of time than is the case with the quenched gap. The wave trains in a circuit containing an open, or nonquenching, gap have a greater number of oscillations per train. In the quenched form of gap, greater radiating surface is provided for cooling the elements. This has the effect of maintaining a practically constant resistance in the gap. In the quenched gap the spark occurs in practically an air-tight chamber, in which conducting vapors are at a minimum. This feature also serves to help [fol. 225] maintain a constant gap resistance. In the open, or nonquenching, gap little provision is made for cooling the electrodes. The spark also occurs in open air and it is claimed that the spark ionizes the air and vapors in the vicinity of the spark; these vapors, being conductive, reduce the resistance of the gap. The decrement of the oscillations is effected by this variation in gap resistance. From the foregoing, it is readily seen what effect on the radiated waves of a transmitter the two different types of gap have.

151. Cross-question. As I understand your testimony, the Telefunken apparatus which you installed at San Juan was only a transmitting apparatus. Is that correct?

Answer. Yes, sir.

152. Cross-question. What did they use for receiving at that station at that time?

Answer. The following equipment was supplied to the San Juan station to which I was attached: Three I. P. 76 Wireless Specialty Apparatus Co.'s receivers, one audion control box with spare bulbs, one DeForest audion amplifier with spare bulbs, two Edison nickel-iron storage batteries for use in connection with the audion control box and De-

Forest amplifier; a number of spare crystal detectors was also a part of the equipment.

153. Cross-question. Were all these various types of instruments installed and used at this time for receiving at San Juan?

Answer. These various types of instruments were all used at various times for receiving signals.

154. Cross-question. And how about the apparatus you saw on the *Louisiana*—was that Telefunken apparatus both transmitting and receiving?

Answer. I do not remember if the transmitting apparatus on the *Louisiana* was of the Telefunken type, but am inclined to believe that it was. The receiving apparatus included the Telefunken receiver I referred to.

155. Cross-question. What was the occasion of your visit to the *Louisiana* when you saw the Telefunken apparatus you have referred to? Was this merely a casual visit to the ship?

Answer. I visited the *Louisiana* on the invitation of a friend who was in charge of the wireless on that vessel to look over the new installation of wireless apparatus that was being installed at the time.

156. Cross-question. How long were you on the ship on this occasion?

Answer. Probably several hours.

157. Cross-question. Is all this apparatus represented in your sketch of the Telefunken apparatus—for example, located in one room or on one table or panel?

Answer. The receiving apparatus I saw on the occasion of my visit to the *Louisiana* was mounted on a desk or shelf.

158. Cross-question. You did not take any of the apparatus apart on the *Louisiana*, I suppose, nor remove any covers or casings?

Answer. I did not take any of the apparatus apart or remove any part of same, as the entire Telefunken receiver was available for close inspection without the necessity of resorting to such procedure.

159. Cross-question. Well, how can you tell what the wiring of the circuits is by merely looking at an apparatus on a shelf?

[fol. 226] Answer. The wiring on a Telefunken receiver is apparent from inspection. The shelf I referred to was a long table or shelf built across the wireless room and was used as an operating desk. The receivers, sending key,

and various other parts of the apparatus were also mounted on the shelf.

160. Cross-question. And are the coils *d d'* also mounted in full view on this shelf?

Answer. These coils were mounted near the top of the receiver and were not inclosed in any way—in fact, it was necessary at times to substitute coils of various inductance, so that the coils had to be readily available in order that the operator might effect the change. The foregoing refers to the receiving apparatus. The coils I refer to as *d d'* should have been referred to as *j* and j^2. I do not remember, while on my visit to the *Louisiana*, of observing the coils *d d'*, as these coils are a part of the transmitting apparatus.

161. Cross-question. You saw both Telefunken transmitting and receiving apparatus on the *Louisiana*, as I understand it. Is that right?

Answer. I saw the Telefunken receiving apparatus on the *Louisiana*, but paid no particular attention to the type of transmitting apparatus.

162. Cross-question. As a matter of fact the transmitting apparatus on the *Louisiana* on this occasion might have been some other type than Telefunken, so far as you remember. Is that true?

Answer. Possibly.

163. Cross-question. I understand that on the *Louisiana* you saw two types of Telefunken receiving apparatus E4 and E5. Were these both installed and in use or for use, or was one of them not connected up?

Answer. The two types of receivers mentioned were in the wireless room, but, as the ship was in the navy yard undergoing repairs, the wireless apparatus was not being used. As this particular wireless station was undergoing change, it is possible that these receivers were not actually connected with the antenna. I merely state that I saw these receivers on board this vessel.

164. Cross-question. In your Q. 18 answer, these adjustments that you spoke of, such as varying the wave lengths—was that what you call tuning?

Answer. By tuning a transmitter is meant the adjustment of that transmitter to a given wave length. Changing the wave length does not necessarily require tuning at every change, as it is possible to tune a transmitter to any predetermined number of wave length and at some later

time operate the transmitter at any one of these wave lengths.

165. Cross-question. You choose the frequency of oscillation or wave length you desire to use, and to do so you change this variable contact 2; is that what is meant by the first part of your answer to Q. 18?

Answer. By changing the position of the variable contact 2 on the coil *d*, you choose an amount of inductance in this coil *d*, and thus set the closed oscillating circuit *d*, *c*, G, 2^a, to a definite wave length. In order that the transmitter [fol. 227] as a whole operate on this wave length it has been necessary to tune the open oscillating circuit, which is coupled to the closed oscillating circuit.

166. Cross-question. Why don't you shift the contact 2^a for doing this?

Answer. It is also possible to shift the contact 2^a, the main requirement being that the amount of inductance in the coil *d* between the points 2 and 2^a be sufficient in conjunction with the capacity *c* to give the wave length required in this closed oscillating circuit.

167. Cross-question. You then say in your answer to Q. 18, "the open oscillating circuit is then tuned with the closed oscillating circuit by varying the amount of inductance in the coils *d'* and *g*." Now if this coil *d d'* is in fact only one coil, as I understand, how can you then tune the open oscillating circuit by varying the amount of inductance in the coil *d'* when you have already got that set to your wave length when you tune the closed oscillating circuit?

Answer. The amount of inductance in the coil *d'*, that is, the inductance in the open oscillating circuit, is shown in the diagram as between the point figure 1^a and the point 2^a, while the amount of inductance in the coil *d* is between the points 2 and 2^a. It being a single coil, it follows that the inductance between the points 2 and 2^a is common to both the closed oscillating circuit and to the open radiating circuit. This form of connection is generally known as the direct coupling.

168. Cross-question. Well, if you shift the contact 1^a on the coil to tune the open circuit with the closed circuit you also change your inductance in that closed circuit from what you had first set it?

Answer. Varying the contact 1^a and consequently the amount of inductance in the open oscillating circuit has no

effect whatever on the positions of the contact 2 and 2^a, which contacts alone determine the amount of inductance in the closed oscillating circuit. The amount of inductance in the open radiating circuit is contained on the coil *d'* between the points 2^a and 1^a.

169. Cross-question. Do you mean to say that varying 1^a changes the inductance in the coil *d'* when it is considered as being in the open circuit but doesn't change its inductance if you consider it as being in the closed circuit, it being the same coil all the time?

Answer. Varying the inductance of the coil *d'* varies the inductance between the point 1^a and 2^a. Varying the inductance in the loaded oscillating circuit varies the inductance between the points 2 and 2^a. These are two separate and distinct circuits, and while they have currents in common the inductance or change of inductance in one does not affect the amount of inductance in the other.

170. Cross-question. You don't mean to say, do you, that changing the contact point 1^a on the coil *d'* doesn't effect the action of that coil as a whole or all parts that are included between the contact point 1^a and the contact point 2^a?

Answer. The amount of inductance in the coil *d'* between the points 1^a and 2^a determine the value of the inductance of that portion of the coil in the open circuit. The amount of inductance on the coil *d* included between the points 2 and 2^a determine the value of the inductance of that portion of the coil in the closed circuit. The portion of the coil in- [fol. 228] cluded between the points 2 and 2^a is that portion of the coil which is common to both the closed circuit and the open circuit. The value of the inductance in the closed circuit is not changed by varying the point 1^a, nor is the value of the inductance in the open circuit changed by varying the contact 2.

171. Cross-question. But doesn't the inductance as determined by the contact 1^a react upon the inductance as determined by the contact 2? Don't these two circuits react one upon the other?

Answer. These two circuits react one upon the other, as is the case between any coupled circuits. The value or amount or number of turns of inductance in common to the two circuits determines the degree of coupling between those circuits.

172. Cross-question. It wouldn't be possible, would it, to send any intelligible wireless signals from any wireless

apparatus if you could not adjust the frequency or period of the antenna circuit to what you call the closed oscillating circuit? In other words, if you could not tune these circuits one to the other?

Answer. It might be possible to obtain an intelligible wireless signal under the conditions mentioned, but I never made any experiments of that nature.

173. Cross-question. Well, if the periods of oscillation in the two circuits were different, wouldn't one interfere with the other; counteract the other? And wouldn't you get a confused effect?

Answer. I have never carried on experiments to demonstrate the possibility or probability of the operation in the circuits described.

174. Cross-question. In this same answer you say that in receiving a signal on the Telefunken receivers it was necessary to tune the antenna to the wave length of the signal it was desired to receive. Do you mean to state that this is a peculiarity of the Telefunken receiver, and that it doesn't apply to all wireless receivers?

Answer. The receivers which I have seen and operated all embrace some form of tuning of the primary circuit.

175. Cross-question. You have mentioned in your direct testimony somewhere about various forms of detectors—some of which you called rectifying detectors, and others I believe you referred to as nonrectifying. Was the detector T in this Telefunken receiver a rectifying or a nonrectifying detector?

Answer. It was a rectifying detector of the single crystal type.

176. Cross-question. What does this mean, rectifying or nonrectifying detector?

Answer. I don't believe I referred to any type of detectors as being nonrectifying. A rectifying detector is one which will permit the passage of a current in a unidirectional way.

177. Cross-question. Referring to the National Electric Supply Co.'s apparatus, was this set set up and operated by you both as to the receiving and transmitting apparatus?

Answer. It was.

178. Cross-question. And who made this drawing of this National Electric Supply Co. that you put in evidence -you yourself or some one that you directed?

Answer. This drawing was prepared by a draftsman under my direction and upon data supplied by myself.

179. Cross-question. Did you give him any rough sketch to work from?

[fol. 229] Answer. I gave him a pencil sketch or diagram which had been approved by me.

180. Cross-question. Was such data or sketch as you gave him made from your memory of this apparatus which you saw on the *Georgia?*

Answer. The data for the preparation of this sketch was supplied to the draftsman from my memory of the connections of the set that I operated on the *Georgia.*

181. Cross-question. And you are able to keep in your memory the various devices, circuit connections, and apparatus of a number of different types for a number of years, are you?

Answer. Not the complete wiring diagram, but elementary sketches of connections.

182. Cross-question. Who was associated with you on the *Georgia* in this work with the National Electric Supply Co.'s apparatus?

Answer. I was the chief electrician in charge of the radio installation on board the *Georgia,* and I worked under the orders of the radio officer, who was an ensign in the Navy; several electricians of lower rating were under my orders.

183. Cross-question. Do you remember the name of this officer that you have referred to as ensign?

Answer. The radio officer was changed every six months, and while on the *Georgia* I was under the orders of several of these at various times. I do not remember their names.

184. Cross-question. Can you give me the name of anyone who was either your superior or under you in this work of testing the field set of the National Electric Supply Co. we are referring to?

Answer. I can not recall their names at the present time, but if I saw their names in print would recognize them. The Navy Department possibly has a record of the men referred to.

185. Cross-question. You spoke of this National Electric Co.'s set as having a crystal detector and a fine-wire contact. Was the crystal one member of the contact and the fine wire the other member?

Answer. The fine wire made contact to the surface of the crystal.

186. Cross-question. Just what was the nature of this contract? Was fine wire coiled about the crystal, or, briefly, just how was it?

Answer. The end of the fine wire made contact to the surface of the crystal—the area of contact being extremely small.

187. Cross-question. This was also a rectifying detector, wasn't it?

Answer. As I understand it, it was.

188. Cross-question. What enabled you to remember the date you gave for having seen this National Electric Supply Co.'s apparatus? Is that also a matter of memory?

Answer. I remember the date of having seen this set by reason of it having been received on board the ship just prior to the ship's being ordered to Vera Cruz, Mexico, to protect American interests during the revolution which was in progress in Mexico at that time, also due to the fact that this set was sent to the *Georgia* a short time after I myself had been sent there.

189. Cross-question. Referring to the Lowenstein apparatus in plaintiff's Exhibit No. 57 the contract, you have no means of knowing whether any apparatus was supplied under that contract or not, have you?

[fol. 230] Answer. I have no knowledge of the delivery of apparatus under any contract.

190. Cross-question. The date of your visit to the New York Navy Yard in the latter part of 1914—you gave that as a matter of memory, did you?

Answer. I was ordered North for examination for promotion, as I stated in one of my previous answers, and I have a copy of my orders in my personal files, which gave the date I mentioned.

191. Cross-question. How long did you spend examining this apparatus at the New York Navy Yard on that occasion?

Answer. Possibly several hours.

192. Cross-question. Why do you call the oscillation transformer B of the sketch in the Lowenstein contract a combination inductive and conductive transformer?

Answer. Because of its peculiar form of connection which I had never seen before used on any other type of transmitter.

193. Cross-question. Where in this drawing do you see the secondary transformer?

Answer. The secondary of this oscillation transformer is the portion of the circuit shown in the diagram A, loading inductance, quick change control B, B, A, hot wire ammeter earth connection.

194. Cross-question. Then you have also got the loading inductance, as both the loading inductance and the secondary of the oscillation transformer?

Answer. The diagram shows the loading inductance, primary inductance, and transmitter coupling adjuster as being in the same field.

195. Cross-question. And the way it is on this sketch is just the way it was on the apparatus you saw. Is that right?

Answer. As I remember it, it is.

196. Cross-question. Then according to this, the loading inductance is in the circuit of the so-called closed oscillating circuit, is it?

Answer. It is not.

197. Cross-question. Well, in this Lowenstein apparatus as shown on the sketch, what is called the loading inductance is also at the same time part of the oscillation transformer. Isn't that correct?

Answer. It is partially correct—strictly speaking only the coils marked primary inductance and transmitting coupler adjuster form what is generally known as an oscillation transformer—however, the coil marked loading inductance is also in the field of the other two coils.

198. Cross-question. There was one form of detector referred to in your Q. 50 called the tickler. What sort of a detector is this?

Answer. The form of detector known as the ticker was composed of a rotating metal disk upon which a fine wire contact was made.

199. Cross-question. Referring to the audion transmitter, produced in evidence, in the DeForest audion, what is the purpose of the part you have called a grid?

Answer. The function of the grid is to receive the charge of the grid condenser.

200. Cross-question. The audion is used both for the spark propagated waves as well as for what you have called the undamped or continuous oscillation. Is that correct? [fol. 231] Answer. The plain audion can only be used in connection with damped oscillations, or spark signals.

201. Cross-question. Just what do you mean by "damped" and "undamped" oscillations or waves?

Answer. By "damped oscillation," I mean a series of wave trains, each wave train being composed of an oscillating wave each succeeding oscillation being damped or reduced a certain amount. By "continuous or undamped oscillation," I mean oscillations each succeeding wave of which is of equal amplitude.

202. Cross-question. To put it another way, would it be correct according to your ideas to say that a damped oscillation was one that gradually died out and an undamped oscillation is one that continued and doesn't substantially die out?

Answer. Damped oscillations are oscillations, each succeeding oscillation being of smaller amplitude, until the series of oscillations gradually cease altogether. A number of these surges, so to speak, form what is called a wave train. Undamped oscillations are oscillations that are continuous and have no damping.

203. Cross-question. Can you explain why or how it is, if I understand it correctly, that the same instrument or audion can be used to receive sparked or damped signals or oscillations and as an ultra audion can only be used for receiving continuous or undamped waves?

. . . . . .

Answer. The plain audion can be used only for receiving damped or spark signals, while the ultra audion can be used for receiving both damped and undamped signals. An audion bulb can be so connected in a circuit that it will act either as a plain audion or as an ultra audion. The audion is an ultra audion only by virtue of the fact of the proper connections.

204. Cross-question. Have you testified in other patent suits relating to wireless telegraphy?

Answer. I have not.

205. Cross-question. Now, these various types of apparatus, for example, the Telefunken, you have referred to, one feature of the apparatus is a loading coil, and in the Lowenstein apparatus we found that this was partly in the transformer between the antenna and the oscillating circuit. How did you recognize this as a loading coil in these apparatuses.

Answer. An antenna loading coil is a coil having inductance that is used to increase the wave length or natural period of the antenna.

206. Cross-question. Would you call any coil you found in the antenna circuit a loading coil?

Answer. Any coil performing the function of increasing the natural period of the antenna and not used for the purpose of coupling to another circuit is in general called a loading coil.

207. Cross-question. Then you have to identify parts of the apparatus not so much by their appearance as by what they may be used for or their function?

[fol. 232] Answer. In naming a piece of apparatus, its function is generally taken into consideration. In the case of the antenna loading coil its function is to load or increase the natural period of the antenna.

208. Cross-question. And if you found an audion in a piece of wireless apparatus, you wouldn't necessarily know from its mere presence there whether it was an audion or an ultra audion, would you?

Answer. Not without an examination of the circuits.

Redirect examination.

By Mr. Cosgrove:

209. Redirect question. Was the Telefunken you installed at San Juan Navy Station a new set?

Answer. It was a new set; that is, the apparatus had never been used before except possibly for test purposes.

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210. Redirect question. How were you able to determine that this set had not been used before?

* * * * * * *

Answer. By the condition of the various parts of the apparatus.

211. Redirect question. Was the portable sets of the National Electric Supply Co. delivered aboard the *Georgia* new sets?

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Answer. The portable set received on board the *Georgia* while I was stationed on that vessel was apparently a new one, and as far as I know had never been used before.

212. Redirect question. Referring to the wave-changing switch in the Lowenstein apparatus, referred to by you, why did this switch change both circuits; that is, the open-radiating and the closed-oscillating circuits?

Answer. So that a change from one wave length to another could be effected by means of one operation.

213. Redirect question. Did this change keep the circuits in tune?

Answer. The amount of inductance involved in the change from one point to another was fixed when the set was originally tuned to the predetermined wave length. When the wave-length switch was changed from one point to another, it affected a change in the value of inductance in both circuits, but the two circuits were in tune with each other.

214. Redirect question. You have referred on your cross-examination to audion bulbs having single plate and grid and others having a double plate and grid. While in the Navy, did you use both styles for detecting spark signals?

Answer. While in the Navy I used both styles for detecting both spark and arc signals.

Deposition of Ralph Herbert Langley, for claimant, taken at New York, N. Y., on the 30th day of June, A. D. 1917, and subsequent dates.

Claimant's counsel, James J. Cosgrove and John W. Peters; defendant's counsel, Henry C. Workman.

Ralph Herbert Langley deposed and said that his name is Ralph Herbert Langley; that his occupation is that of electrical engineer, with the Marconi Wireless Telegraph [fol. 233] Co.; that he is 29 years of age; that his place of residence is Roselle Park, N. J.; that he has no interest, direct or indirect, in the claim in controversy; and that he is not related to the plaintiff.

And thereupon the said Ralph Herbert Langley was examined by the counsel for the plaintiff, and in answer to interrogatories testified as follows:

Direct examination.

By Mr. Peters:

1. Question. What education, experience, and training have you had, if any, which qualifies you to testify regard-

ing the construction and operation of wireless telegraph apparatus?

Answer. I took a degree as electrical engineer at Columbia University in 1913, having completed a special course under Doctor Pupin on radiotelegraphy. I was engaged in the laboratory of Doctor De Forest in the same year; later by the National Electric Signaling Co., then by the Wireless Improvement Co. and by the Wireless Specialty Apparatus Co., and then finally by the Marconi Wireless Telegraph Co. of America. While I was with the Wireless Improvement Co. I was in charge of the design and construction of wireless telegraph transmitting apparatus. During the last six months that I was with the company —was chief engineer.

2. Question. It appears from plaintiff's Exhibit No. 60, contract by Wireless Specialty Apparatus Co. with the United States, dated September 21, 1912, that the Wireless Specialty Apparatus Co. contracted to deliver two 5-kw. 500-cycle motor-generator quenched-gap radiotelegraph sets to the Navy Department. Have you any knowledge or information regarding the manufacture and sale of sets of this kind by this company to the United States?

Answer: The two sets in question were built in Boston and shipped directly to the navy yard at New York. I saw these two sets at the navy yard and assisted in the acceptance tests, which were made there.

3. Question. When was it you assisted in the acceptance tests at the navy yard?

Answer. In the summer of 1913.

4. Question. What opportunity have you had to familiarize yourself with the receiving sets made and sold by the Wireless Specialty Apparatus Co. since the year 1910?

Answer. I have seen these receiving sets many times and have had used the same in experimental work. While I was with the Wireless Improvement Co., Col. John Firth, who was owner of the Wireless Improvement Co., was at the same time second vice president of the Wireless Specialty Apparatus Co. and was their New York agent. The receiving sets in question were always to be seen in his offices and that is where I became familiar with their construction.

5. Question. The contract last referred to also calls for the delivery, among other items, of the following receiving apparatus:

"(*a*) One highly selective receiver of special design for receiving wave lengths up to 10,000 meters, to be furnished with a variable condenser in primary circuit with loads which can be operated by switches to put this condenser in series or in parallel with inductance or to cut it out.

[fol. 234] "(*b*) One highly selective receiver with variable condenser, for primary circuit as required for (*a*), for receiving waves from 300 to 3,000 meters for ship communication.

"(*c*) One simplified receiver, range 300 to 3,000 meters, to consist of variable primary inductance, variable secondary, with means for varying the mutual inductance between the two circuits, and variable series condenser."

Are you familiar with any of the Wireless Specialty Apparatus receivers referred to above?

Answer. No; I am not familiar with the receiving apparatus mentioned in this contract. • • •

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6. Question. Why do you say it was probably shipped to the Washington Navy Yard?

Answer. For some time past most receiver work has been done in Washington, and since I have no knowledge that these receivers passed through the New York offices, I assume they were shipped directly to Washington.

7. Question. Understanding that you did not see these particular receivers, I will ask if you, at the time this contract was made, September, 1912, were familiar with the various types of I-P-76 receivers manufactured by the Wireless Specialty Apparatus Co.?

Answer. At the time mentioned I was not familiar with these receivers, but the delivery on the contract in question was not made until over a year later and at the time I was familiar with these receivers.

8. Question. Plaintiff's Exhibit No. 62 calls for the delivery by the Wireless Specialty Apparatus Co. to the Navy of "8 I-P-76, series of 1912, receiving sets." Are you familiar with that particular type of receiver?

Answer. Yes.

9. Question. Plaintiff's Exhibit No. 63, among other apparatus, calls for the delivery by the Wireless Specialty Apparatus Co. to the Navy "10 radio receiving sets complete, type I-P-76, 1914." Are you familiar with that type of apparatus?

Answer. Yes, sir.

10. Question. What information, if any, have you regarding the delivery of any of these Wireless Specialty receivers to the United States Government subsequent to the year 1910?

Answer. I have no definite information that any of these receiving sets were actually delivered to the Navy Department, but Colonel Fiith on many occasions informed me of the award to the Wireless Specialty Co. of contracts for these receiving sets, discussed with me the prices which the Wireless Specialty Co. were getting and on many occasions I saw a journal which he kept at the New York office in which these sales to the Government were recorded.

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11. Question. When you saw the Wireless Specialty Apparatus Co. transmitters at the Brooklyn Navy Yard were they assembled for operation?

Answer. They were assembled for operation and were repeatedly actually in operation. They were at that time con- [fol. 235] nected to an artificial antenna in order that their testing might not interfere with other radio work at the navy yard, but were obviously intended to be used with a real antenna.

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12. Question. Have you prepared and if so will you produce a drawing showing the Wireless Specialty Apparatus Co.'s transmitters which you tested at the Brooklyn Navy Yard, and also the Wireless Specialty Apparatus Co.'s receivers known as the I-P-76 type, about which you have testified?

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Answer. This drawing (P. Ex. 87) which I produce, entitled "Wireless Specialty Apparatus type transmitting station and receiving station," is a correct elementary diagram of the transmitting and receiving apparatus in question. On the drawing, both the receiver and the transmitter, are shown connected to an antenna *f*, although of course these antennae were not supplied with the equipment. The transmitting equipment consisted of a variable connection 1 from the antenna to a loading coil *g* and a variable connection 2 from this loading coil to the secondary of an oscil-

lation transformer d^1. The lower end of the oscillation transformer secondary was connected to the earth E. The primary of the oscillation transformer d was inductively related to the secondary d^1 and was in series with a quenched gap G and a condenser e. The connection from the quenched gap G to the oscillation transformer primary d was made by means of a variable contact 3. Connected across the condenser e there was a transformer secondary, the primary of the transformer C being energized by the generator of a motor generator set A though a telegraph key b. The receiving sets known as the type I-P-76 were all alike, so far as the elementary wiring diagram is concerned. The difference between 1912, 1913, and 1914 models was merely a question of mechanical design and refinement. These receivers consisted of a variable contact 4 from the antenna f to a loading coil g^1. A second variable contact 5 from the loading coil to the oscillation transformer primary j^1 and a third variable contact 6 from the oscillation transformer primary to the earth E. The secondary of this oscillation transformer j^2 was inductively coupled to the primary and was in series with a variable condenser h^1, the connection between the variable condenser h^1 and the oscillation transformer secondary j^2, being accomplished by the variable contact 7. In series across the variable condenser h^1, there was a crystal detector T and a small stopping condenser j^3. Across this stopping condenser was connected a pair of telephone receivers a portion of this circuit consisting of a potentiometer P, this potentiometer being connected across a local battery B.

The method of operating the transmitter would be as follows:

Before the equipment could be used to send radiograms it would be necessary for the operator to make certain adjustments. The Navy Department has certain conventional wave lengths which they use. The operator would proceed by the use of a wave meter to adjust the variable contact 3 so that the wave length in the primary circuit e, G, d would [fol. 236] have the desired value. In the actual transmitter the variable contact 3 consisted of several contacts all adjustable and so connected to a switch that any one could be chosen. The operator would then set the contact 2 in such a position as to provide sufficient inductance for proper coupling in the oscillation transformer secondary d^1 and would then vary the position of the contact 1 on the load-

ing coil g until the two circuits e, G, d and f, A, g, d^1 were in resonance with each other, thus obtaining a maximum current in the antenna f. It is to be noted that the variable contacts 1 and 2 also consisted of several contacts, similarly connected to a switch, so that any of these contacts might be chosen, this switch being driven by the same handle and operating simultaneously with the switch controlling the contact 3 in the primary circuit. Thus the complete transmitter was adjusted to several different wave lengths, in accordance with the Navy convention, and could subsequently be changed at will to emit any one of these wave lengths. The chief feature of the apparatus in question was this wave-length changing switch and the means by which the proper tuning of the several wave lengths in the primary and secondary circuits could be accomplished.

The type I-P-76 receiving sets were operated as follows:

By including practically all of the inductance in the oscillation transformer secondary j^2 the operator would be able to hear almost any incoming signal. When a signal which it was desired to read was so heard, the operator would adjust the variable contacts 4, 5, and 6 on the loading coil g^1 and the oscillation transformer primary j^1 so that this circuit would be in resonance with the incoming signals. He would then proceed to adjust the variable contact 7 on the oscillation transformer secondary j^2 and the variable condenser h^1, so as to produce resonance between this and the primary circuit, thus obtaining a maximum response in the telephones R. The crystal detector T would require to be adjusted to a sensitive point, the surface of the crystal varying greatly in this respect, and the tap on the potentiometer P would also be adjusted to produce the best response in the telephone R.

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13. Question. Does your drawing and description of this I-P-76 receiver apply and are they correct with respect to the 1912, 1913, and 1914 models or do they relate to only one particular model?

Answer. To the best of my information and belief the drawing and my description of it apply equally to all three models of the type I-P-76 receiving set. The 1912 receiving set was, of course, the first one I saw and when samples of the new models were sent to the New York office in 1913 and

1914 my colleagues and I had the opportunity of examining them and noticing the changes which had been made. These changes consisted entirely of new arrangements of the component parts of the set and different construction of the parts themselves and of the switches by which they were adjusted.

Mr. Peters: I offer in evidence the drawing referred to and request that the same be marked "Plaintiff's Exhibit No. 87, drawing, Wireless Specialty Apparatus Co. apparatus."

[fol. 237] 14. Question. I show you a pamphlet entitled "Wireless Specialty Apparatus Co., Instructions for I-P-76 set." Do you recognize this pamphlet? And if so, what is it?

Answer. I do recognize this pamphlet; it was, as the title states, a book of instructions supplied with the receiving sets in question and intended as a guide to the operator for using the set. Copies of this pamphlet were always on hand at the New York office of the company. This pamphlet was revised and reprinted each year, so as to describe the new model of the receiving set.

Mr. Peters. I offer the pamphlet referred to in evidence, and request that the same be marked "Plaintiff's Exhibit No. 87a, Wireless Specialty Apparatus Co., Instructions for I-P-76 set."

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15. Question. I now call your attention to plaintiff's Exhibit No. 55, a contract by the Wireless Improvement Co., dated June 5, 1913, and which calls for the delivery at the U. S. Naval Radio Station, Radio, Va., among other items of "Item 1, 1 5-kw. high-frequency quenched-gap break-key motor generator, radio transmitting set, complete." What, if anything, do you know with reference to the manufacture and delivery of this apparatus?

Answer. I assisted in the design of this particular equipment; was present at the factory while it was being constructed and saw it packed for shipment to the Naval Radio Station at Radio, Va.

16. Question. Have you prepared and will you produce a drawing showing schematically the transmitting set in question?

Answer. I produce this drawing entitled "Wireless Improvement Co. type transmitting station." (P. Ex. No. 88.)

17. Question. Will you please describe this Wireless Improvement Co. set?

Answer. Although of entirely different mechanical design and arrangement, the fundamental wiring arrangement differs from that of the Wireless Specialty Apparatus type in only one essential particular, namely, the variable contacts 2, shown on the oscillation transformer secondary d^1 of the Wireless Specialty Apparatus Co. type, was not supplied or used on the Wireless Improvement Co. type. It is also to be noted that the wave-length switch arrangement on the Wireless Improvement Co. type—that is to say, on the 5-kw. transmitter mentioned in the contract—was not as complete as the wave-length switching device of the Wireless Specialty Apparatus type, that is to say the two 5-kw. transmitting sets which I saw and tested at the New York Navy Yard. This wave-length switch is not shown on either of these drawings, and it is to be noted that in both cases provision was made for accurately adjusting both the primary and antenna circuit, so as to produce resonance between the two, and thus obtain a maximum current in the antenna.

18. Question. Describe briefly the mode of operation of this Wireless Improvement Co. transmitter.

Answer. The adjustment and method of operation of his transmitter differed in no essential particulars from the method given for the Wireless Specialty Co.'s type.

[fol. 238] 19. Question. Please state what each of the elements shown on your Wireless Improvement Co. drawing represents.

Answer. *a* is a motor generator, *b* is a transmitting key, C is a power transformer, *e* is a condenser, G is a quenched spark gap, *d* is the primary of the oscillation transformer, d^1 is the secondary, *g* is the loading coil, *f* is the antenna, and E the earth connection.

Mr. Peters. I offer in evidence the drawing referred to by the witness and request that the same be marked "Plaintiff's Exhibit No. 88, drawing, Wireless Improvement Co. apparatus."

20. Question. What do you know with reference to the purchase by the U. S. Navy of apparatus from Emil J. Simon?

Answer. At the time of the organization of the Wireless Improvement Co. Mr. Simon was engaged by them as engineer. I worked with Mr. Simon for two years and over in the design and production of wireless transmitting equipment. The major part of this time was occupied in developing a ½-kw. equipment for use on submarine vessels. At the end of this period Mr. Simon left the Wireless Improvement Co. and proceeded to build and sell to the Navy Department ½-kw. transmitting sets of substantially the same design as those produced by the Wireless Improvement Co.

20a. Question. Have you seen any of these Simon transmitting sets at Navy stations; and if so, when and where?

Answer. The first low-powered wireless transmitter which Mr. Simon produced was built while he was with the Wireless Improvement Co. and was subsequently installed at the New York Navy Yard on the submarine *G-1*. It was found necessary after the set had been installed to provide it with an extra loading coil in order that its wavelength range might be increased. I visited the *G-1* at this time, then in dry dock at the New York Navy Yard; saw the transmitting set in question, and assisted in installing the additional loading coil. This was in 1913.

After Mr. Simon had left the Wireless Improvement Co. my duties required frequent visits to the New York Navy Yard, and on two of these visits I saw one ½-kw. equipment built by Mr. Simon in the radio laboratory at the navy yard. On one of these visits one of these sets was actually under test, and on another visit I saw what was probably 20 of these equipments lined up in the corridor awaiting test. This was in 1915.

21. Question. Have you prepared a drawing of the Simon transmitter which you state was supplied to the Navy? And if so, will you please produce the same and describe the transmitter?

Answer. I produce this drawing, entitled "Simon type transmitting station." (P. Ex. No. 89.) While Mr. Simon's transmitter differed materially in size and mechanical design with the two 5-kw. Wireless Specialty transmitters, which I have described, it will be noticed by comparison of the drawings that the fundamental wiring diagrams of the two types of transmitter differ in only one essential particular, namely, that in the Simon type the secondary of the transformer C is connected across the

quenched gap G instead of across the condenser c, as in the Wireless Specialty type. It is well known that the processes taking place in the transmitter are entirely unaffected by changing the transformer secondary connection from one position to the other, and in Mr. Simon's transmitter the choice was perfected by the mechanical arrangement of the parts.

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[fol. 239] 22. Question. Please describe the mode of adjusting and operating this Simon transmitter.

Answer. While I am not familiar with the mechanical features which Mr. Simon employed to accomplish the various adjustments of the transformer set after he left the Wireless Improvement Co., I can state that the method of adjusting and operating this equipment would differ in no essential particular from the method which I have given for the adjustment and operation of the Wireless Specialty apparatus or Wireless Improvement Co. type. The Wireless Improvement Co.'s and Mr. Simon's ½-kw. transmitters were provided with five and in some cases six wave lengths—that is to say, points on a wave-length switch—but this device did not affect the necessity of adjusting the primary circuit with a wave meter to each of the desired wave lengths and then adjusting the antenna circuit to resonance with the primary circuit for each of these wave lengths.

* * * * * * *

24. Question. Did you ever examine any Simon sets supplied to the Navy by him sufficiently to ascertain the apparatus and methods employed for tuning?

Answer. On the occasions which I have mentioned, when I saw Mr. Simon's sets at the New York Navy Yard, my examination of the equipment was not close. I did, however, identify the various parts of the set and the wave-length switching and tuning mechanism, which I referred to in my description of the method of operating the set.

25. Question. Please now refer to the drawing and state what adjustments were provided in the set for tuning the circuits.

Answer. Since my answer to this question must involve to a greater or less degree the purely mechanical features of the equipment, I can only answer with reference to the

equipment which I have stated that I saw on test at the navy yard. The twenty-odd equipments which I saw later were of a different type, and I am not in a position to state definitely what the mechanical features of the tuning mechanism were. On the first set, however, the variable contact 3 shown in the drawing consisted actually of five leads connected to an equal number of points on a wave-length switch, these leads having clips for connecting to points on the primary of the oscillation transformer *d*. The variable contact 2 shown on the drawing consisted of a single lead connected to the end of the loading coil *g* and arranged to be connected onto the secondary of the oscillation transformer d^1 at any suitable point. The variable contact 1, shown in the drawing, consisted actually of five leads similar to those in the primary of the oscillation transformer, similarly connected to an equal number of points on a switch and similarly arranged to be connected each to a suitable point on the loading coil *g*. The switch arms on the two switches mentioned, namely, the switch on the [fol. 240] oscillation transformer primary, and the switch on the loading coils were both actuated simultaneously by a single front of board-handle. In adjusting the equipment it was first necessary to adjust the position of each of the leads corresponding to the variable contact 3 shown in the drawing by the use of a wave meter to give the desired wave length in the oscillation transformer primary, and then to adjust the position of each of the leads represented by the variable contact 1, shown in the drawing, so as to produce resonance between the closed oscillating circuit *d*, *c*, G and the antenna or radiating circuit *f*, *g*, d^1, E for each of the desired wave lengths.

Mr. Peters. I offer in evidence the drawing referred to by the witness, and ask that the same be marked "Plaintiff's Exhibit No. 89, drawing, Simon apparatus."

26. Question. Plaintiff's Exhibit No. 60, contract of September 21, 1912, with the Wireless Specialty Apparatus Co. calls for receivers furnished with standard perikon and silicon arsenic detectors. Plaintiff's Exhibit No. 62, contract of October 14, 1912, with the same company, calls for receivers containing perikon and pyrone detectors. Are you familiar with these types of detectors of the Wireless Specialty Apparatus Co.?

Answer. Yes, sir.

27. Question. Will you please briefly describe the elements of these detectors and their construction?

Answer. These detectors consisted either of a single crystal or of two crystals of certain minerals. The perikon detector consisted of zincite and chalcopyrite. The pyrone detectors consisted of iron pyrites and the silicon-arsenic of silicon and arsenic. The detectors were mechanically arranged so as to produce a contact between a single crystal and a small metal wire or between the two crystals in the case of the double-crystal detectors. Since the operation of the device depended upon a delicate adjustment of this contact, various mechanical arrangements were employed in different types of detectors in order that the adjustment might be easily and accurately made.

28. Question. Will you endeavor to procure one of the types of Wireless Specialty Co. detectors referred to in your last answer and forward it to the commissioner who is taking this testimony, with a letter stating that it is such detector, and of the type referred to in your last answer.

Answer. I will be glad to.

• • • • • • •

29. Question. I hand you two paper-covered pamphlets, entitled "Radiotelegraphy, U. S. Signal Corps, revised May, 1915," and one revised October, 1916, and one canvas-covered book entitled "Circular No. 1, Office of the Chief Signal Officer, 1914, Radiotelegraphy, U. S. Signal Corps, 1914." Please state if you know what these publications are.

• • • • • • •

Answer. These pamphlets, like similar booklets issued by the Navy Department were issued to department operators [fol. 241] in charge of wireless-telegraph equipment and were intended as an introduction to the study of radiotelegraphy and as a guide to installing and operating radio equipment. These booklets were also issued to the general public and formed part of the library at my disposal while I was with the Wireless Improvement Co.

30. Question. If you know, please state by whom they were issued?

• • • • • • •

Answer. Copies of the pamphlets could be obtained through the office of the Chief Signal Officer, and I therefore assume they were issued by that office, since the title so states. So far as I know, they could not be obtained from any other source.

* * * * * * *

31. Question. Can you state what different branches, departments, or service of the Government since June, 1910, made use of wireless telegraph apparatus?

* * * * * * *

Answer. I am quite sure that the Navy Department has used a large quantity of wireless-telegraph apparatus, and I also know that the Treasury Department and the Navy Engineering Department and the Signal Corps of the Army use wireless-telegraph apparatus.

32. Question. I call your attention to plaintiff's Exhibits Nos. 37, 38, 39, and 40. Will you please look at these exhibits and state whether or not you are familiar with any of them; and if so, what they are?

Answer. The four exhibits in question are specifications issued by the Navy Department to contractors wishing to bid on schedules calling for the construction and delivery of wireless-telegraph sets. Exhibit No. 37, the Navy designation of which is 16-T-5, is dated May 10, 1910, and antedates my connection with the production of apparatus for the Navy. Exhibits 38, 39, and 40, however, are well known to me, and I have designed and built sample sets to be delivered to the Navy and have designed and built sets under contract with these specifications as a guide. The specifications enter into the construction of equipment in great detail and leave very little to the designer's discretion, and in all cases they call for equipments, both transmitting and receiving, in which an open or radiating circuit is inductively coupled to a closed oscillating circuit.

33. Question. In what connection were the sample sets, referred to in your last answer, delivered to the Navy? Was it in connection with bids made under the specification referred to, or what is the practice in that respect?

* * * * * * *

Answer. Since my connection with the production of radio equipment for the Navy—that is to say, since June, 1913—the practice has been as follows:

The Navy Department would send to all different contractors what was known as the schedule. This schedule would call for the delivery at some navy yard, usually New York Navy Yard, of a definite quantity of wireless-telegraph sets, either transmitters or receivers, or accessories, and sometimes of all three. The schedule would state that the apparatus was to be built under specifications issued by the Navy Department, and the number of these specifica- [fol. 242] tions would be given. The schedule would also call for delivery of the apparatus in question a definite number of days after the date of the contract, and where possible would require each contractor to submit a complete sample equipment to a designated navy yard for competitive test prior to the award of the contract. In cases where a particular contractor had supplied under previous contract satisfactory apparatus of the same size and design, it was not necessary for him to submit a sample under the new schedule.

Mr. Cosgrove: Plaintiff's counsel offers in evidence the "Radiotelegraphy" for the years 1914, 1915, 1916, identified by the witness in answer to Q. — and requests that the same be marked "Plaintiff's Exhibits Nos. 90, 91, and 92, Radiotelegraph, 1914, 1915, 1916," respectively.

Cross-examination.

By Mr. Workman:

* * * * * * *

34. Cross-question. As I understand it you were a student in Columbia University up until 1913. Is that correct?

Answer. Yes, sir.

35. Cross-question. At what time in the year did you finish at Columbia University?

Answer. I received my degree early in June, I believe it was on the 6th.

36. Cross-question. And after leaving the university, where did you first go?

Answer. I took a short holiday and went to work for the Wireless Improvement Co., about the 1st of July, 1913.

37. Cross-question. What was it, the usual four-year course, or more, that you took at Columbia University?

Answer. At the time, the course in electrical engineering was a four-year course. I entered the university in 1908,

but was compelled to leave in January, 1910, and when I returned to college in the fall, I repeated the studies of the sophomore year.

38. Cross-question. How long did you remain with the Wireless Improvement Co.?

Answer. Until October 1, 1916.

39. Cross-question. And then did you go with the Wireless Specialty Apparatus Co.?

Answer. No, sir; I went with the Marconi Wireless Telegraph Co.

40. Cross-question. Then the Wireless Improvement Co. and the Marconi company are the only companies that you have been employed with?

Answer. That is not entirely true. When I left college in 1910, I worked during the spring and summer with the DeForest Radio Telephone & Telegraph Co.—during the following summer, that is the summer of 1911, I worked with the National Electric Signaling Co. During the summer of 1912, I worked for the Wireless Improvement Co. After my graduation from college and while I was with the Wireless Improvement Co., I did considerable work for the Wireless Specialty Apparatus Co. on a time basis, that is to say, when they had work which required the attention of an engineer in New York City, Colonel Firth, being second vice president of the Wireless Specialty Apparatus Co., [fol. 243] would direct me to take charge of the work and the Wireless Specialty Co. paid me for this work by the hour.

41. Cross-question. All your work with these various companies was in and around New York City, wasn't it?

Answer. It was chiefly in New York City, although of course I did make business trips to Washington.

42. Cross-question. When you said that the radio telegraph sets of plaintiff's Exhibit No. 60, contract between the Wireless Specialty Apparatus Co. and the United States, were built in Boston, you were guessing weren't you?

Answer. I did not see these sets actually in construction at the Wireless Specialty Apparatus Co.'s factory in Boston. The New York office of the company was constantly in telegraphic communication with the Boston office and particularly so at the time of shipment of these equipments, and I am therefore willing to testify that they were built there.

43. Cross-question. You had no connection with the packing up and shipping of wireless-telegraph sets of the Wireless Specialty Apparatus, did you?

Answer. Not with the shipment of transmitters, but very frequently receiving sets were held in stock at the New York office and I myself have assisted in packing and shipping several from that place.

44. Cross-question. Was the Wireless Improvement Co. and the Wireless Specialty Apparatus Co. all the same concern? Or what was the connection between the two?

Answer. The Wireless Improvement Co. was organized and owned by Col. John Firth. Whether this company was ever legally incorporated I do not know. I believe that the Wireles Specialty Apparatus Co. was also organized by Colonel Firth and was owned by him at one time. At the time of my connection with the Wireless Improvement Co., however, Colonel Firth signed himself on checks and other documents as the second vice president of the Wireless Specialty Apparatus Co. I might also state that at the time when Mr. Simon left the Wireless Improvement Co., in March, 1915, Colonel Firth turned over to the Wireless Specialty Apparatus Co. the designs and drawings which had been produced by the Wireless Improvement Co. and that the Wireless Specialty Apparatus Co. proceeded to build and sell wireless equipment from these designs and drawings. I was therefore not entirely correct in saying that I had never been connected with the manufacture and shipment of transmitters sold to the Navy by the Wireless Specialty Apparatus Co., because when the designs and drawings were turned over, as I have stated, we built in New York City several ½-kw. transmitters for the Wireless Specialty Apparatus Co. and some of these transmitters were eventually sold to the Navy.

45. Cross-question. What date was it, if you remember, when Mr. Simon left the Wireless Improvement Co.?

Answer. March, 1915.

46. Cross-question. Are we to understand from your testimony that the Wireless Improvement Co. up to the time Mr. Simon left it at any rate was handling the apparatus of the Wireless Specialty Apparatus Co.?

[fol. 244] Answer. No, sir; the Wireless Improvement Co. never handled the apparatus of the Wireless Specialty Co., but Colonel Firth, who acted as New York agent for the Wireless Specialty Co., did handle their apparatus.

There is only one exception to this; that is, that in some cases the Wireless Improvement Co. supplied Wireless Specialty Apparatus Co. receiving sets with their transmitting sets, purchasing these from the Wireless Specialty and reselling them to the customers.

47. Cross-question. How are you able to state that delivery under contract, plaintiff's Exhibit No. 60, with Wireless Specialty Co. was not made until a year later than the date of the contract?

Answer. I have seen the copy of the contract which forms the exhibit mentioned and note that it is dated 1912. I know that the acceptance tests of these two sets were made in 1913, having assisted in these tests myself. Apparatus of this nature is entirely special, and for two equipments of this size and complexity one year is quite usual.

48. Cross-question. Do you intend to say that you are familiar with all the wireless apparatus that the Wireless Specialty Co. has furnished the Government or the Navy?

Answer. Not at all. The two 5-kw. transmitters in question are the only transmitting equipments built by the Specialty company in their own factories and sold to the Navy Department which I have ever seen.

49. Cross-question. But as you didn't see this transmitting apparatus, how do you know it was built by the Wireless Specialty people at all; how do you know they didn't purchase it from some one else?

Answer. Which transmitting apparatus is referred to in this section?

50. Cross-question. We have all the time been talking about the contract of 1912 with the Wireless Specialty Apparatus Co., plaintiff's Exhibit No. 60.

Answer. I did see the apparatus called for in the contract. The address of the Wireless Specialty Co. is given in the contract as 81 New Street, New York, this being the office of Colonel Firth and the place where I worked for the Wireless Improvement Co. I had direct knowledge of the award of this contract, and, as I have already stated, assisted in the tests of the sets after they were delivered.

51. Cross-question. In your answer to Q. 5 you stated you were not familiar with the receiving apparatus mentioned in this contract, and that it was probably built in Boston and shipped directly to Washington. This seems to be quite different from what you have just stated. Do you wish to clear up this contradiction?

Answer. My answer to the preceding question applied only to the transmitting sets, the receiving sets being only a small portion of the contract. It may very well be that the receivers called for in this contract were delivered long before the transmitting sets were. This I do not know, but the delivery on a contract was, of course, not completed until the transmitters had been delivered and accepted by the Navy.

52. Cross-question. Why do you speak of the transmitters of this contract as two 5-kw. transmitters? What is there in the contract that specifies this power of apparatus? [fol. 245] Answer. This is the designation by which they would be known to a wireless man. This is the normal rating of the equipment which would be indicated on the power-measuring device supplied with the set, and the contract under item 1 calls for a 5-kw. radiotelegraph set, complete.

53. Cross-question. None of these wireless apparatus that you have mentioned in your direct deposition included any antennae, did they?

Answer. They generally did not.

54. Cross-question. And as to the receiving sets which you have spoken of in your direct deposition, you have no knowledge, have you, as to what transmitting sets were used in connection with them?

Answer. No; I have not.

55. Cross-question. As a matter of fact, most receiving sets supplied to the Navy may be and are used to receive from various other makes and types of transmitting apparatus. That is correct, isn't it?

Answer. It is correct, but it is quite frequent to use the receiving set supplied with any transmitter for making the original adjustments on the transmitter, in which case it is used in exactly the same manner as it would be to receive a signal from a distant transmitter.

56. Cross-question. As I understand it, you did no work in constructing the apparatus under either of the contracts you have referred to as plaintiff's Exhibits Nos. 60, 62, or 63?

Answer. No; I did not, except that on the two transmitters referred to in Exhibit 60 several parts became inoperative during test and had to be replaced with new parts, and my assistants and I did the work in putting these parts in their proper places.

57. Cross-question. What does type I-P-76 mean? Do these letters and figures have any particular significance?

Answer. The letter "P" in the type number is, I believe, a reference to Doctor Pickard, who, I understand, designed these receiving sets. The letter "I" has no special significance, so far as I know, and was often read as "one." The remaining part of the type numbers is a serial designation to distinguish the apparatus from other kinds.

58. Cross-question. This drawing of the Wireless Specialty Apparatus type that you produced—did you make this yourself?

Answer. No, sir; but it was made under my direction.

59. Cross-question. Made from your memory?

Answer. The fundamental wiring diagram of a wireless transmitter or receiver is as familiar to a wireless man as his own signature.

60. Cross-question. And out of the numerous types he has them all at his finger ends and can draw any one of them as easy as he can write his signature?

Answer. It is only necessary to remember that such and such a set had such and such an arrangement for changing connections between the various parts in order that this may be accurately shown on the drawings.

61. Cross-question. Did you put the reference letters on this drawing?

[fol. 246] Answer. The reference letters used on this drawing were chosen at the suggestion of counsel in order that all the various drawings used in this case might be alike in this respect, thus making reference to them more easy.

62. Cross-question. Why do you call *g* a loading coil and do not call *d'* a loading coil?

Answer. The coil *d'* is known as the secondary of the oscillation transformer because it is placed in the set near the primary of the oscillation transformer; that is to say, near the part of the equipment in which the oscillations are actually produced. It is so placed in order that it may absorb or take up these oscillations and is arranged so that its nearness to the primary coil may be varied at will. The coil *g*, however, is not placed near the primary of the oscillation transformer and is not arranged to be inductively related thereto. Its sole purpose is to increase the electrical constants of the open radiating circuit in such a way as to make possible an adjustment for resonance between these two circuits, the constants of the radiating circuit without the

use of this extra coil in general not being such as to produce this condition of resonance. It is therefore known as a loading coil.

63. Cross-question. If the coil *g* were placed as you express it near the primary of the oscillation transformer and was arranged to be inductively related thereto you would not have called it a loading coil, would you?

Answer. No. It becomes a loading coil only when it is necessary, as I have stated, to increase the constants of the circuit in order to produce resonance. It very frequently happens that when adjusting to a short wave length the constants of the circuit, without the use of a loading coil, may be made correct for resonance, but since all transmitters are arranged to be used at longer wave lengths, the loading coil is supplied. The purpose of arranging this so that it is not inductively related to the primary is to make the adjustments of the set simpler. The oscillation transformer secondary being used to absorb the energy, or as we say to produce coupling between the two circuits and the loading coil being used without directly affecting the degree of this coupling to tune the circuit to the period of the primary circuit; that is to say, to produce resonance between the two.

64. Cross-question. The constants of the circuit that this what you have called loading coil affects is the inductance of the circuit, isn't it?

* * * * * * *

Answer. Chiefly, yes; although no inductance can be built which has no capacity effect.

65. Cross-question. And you wouldn't call *d'* in this Wireless Specialty Apparatus drawing an inductance coil?

* * * * * * *

[fol. 247] Answer. I would call all the coils shown in this drawing except possibly the coil marked, which is a potentiometer coil and presumably has no inductive effect, inductance coils, if that were a proper name for any of them. They are more usually referred to by the names which I have given you. They all, however, possess inductance, and also to a limited degree the property known as capacity.

66. Cross-question. You can't have an inductance coil in the circuit without affecting the inductance constant of that circuit, can you?

* * * * * * *

Answer. So far as I am able to state, without referring to the extensive literature on the subject, you can not.

67. Cross-question. There is no difference, is there, between the apparatus as you have represented it in this drawing of the Wireless Specialty Apparatus and the drawing you produced of the Simon type?

Answer. There is the one difference which I mentioned, namely, that in the Simon set the secondary of the transformer is connected across the quenched spark gap instead of across the condenser as in the Wireless Specialty type.

68. Cross-question. To which transformer are you referring in this last answer?

Answer. I am referring to the power transformer C, which is a device with an iron core and is the seat of currents whose frequency of alternation is 500; the frequencies present in the oscillation transformer are of a different nature and of a much higher order.

69. Cross-question. In both the Wireless Specialty Apparatus and the Simon type apparatus spark gap G is in the closed oscillation circuit, isn't it?

Answer. Yes, sir.

70. Cross-question. And it makes no difference whether this spark gap is as shown in the Wireless Specialty Apparatus type or whether it is as shown in the Simon type?

Answer. No, sir.

70a. Cross-question. Notwithstanding the fact, as you say, that the oscillations are of a very different order in the circuit of the oscillation transformer *b* than they are in the circuit of the transformer C?

Answer. No, sir.

71. Cross-question. Then you can tell by merely looking at the apparatus whether the spark gap G for example is in the position shown in the Wireless Specialty Apparatus sketch or whether it is in the position shown in the Simon type?

Answer. Yes, sir.

72. Cross-question. And you don't have to look at the wiring on these sets to find that out?

Answer. To look at the set is to look at the wiring of it.

73. Cross-question. You mean that all this wiring that is shown on these various sketches is apparent at a glance at a wireless apparatus?

Answer. The secondary of the power transformer and beyond, that is to say, through the gap, condensers, oscilla-

tion transformer, and loading coil, is all high tension. The [fol. 248] conductors are therefore almost invariably without insulation and are spaced well apart so that the circuit of which they form a part can be very easily traced.

74. Cross-question. Isn't it a fact that an ordinary wireless set consists of a number of instruments on a board or a shelf and you can't see their connections unless you carefully trace them out?

Answer. Just what would be considered an ordinary wireless set I do not know, but in the specific cases in question it was a matter of no difficulty to notice how the circuits were made.

75. Cross-question. There aren't any wireless sets that you are aware of, are there, that don't have oscillation transformers?

* * * * * * *

Answer. There have been many such sets built and I presume some of them are still in existence.

76. Cross-question. What kind are these you have just referred to?

* * * * * * *

Answer. It would be like trying to name all the other makers of automobiles than the Ford.

77. Cross-question. Do you know of any such that have been in practical use for transmitting signals in a practical way?

* * * * * * *

Answer. None of commercial or military importance except such stations at Sayville and Tuckerton, where high-frequency generators have been used.

78. Cross-question. Have been used for actual transmission of signals or just experimentally?

* * * * * * *

Answer. For the actual transmission of intelligence.

79. Cross-question. And these high-frequency generators were used with spark gaps, were they?

* * * * * * *

Answer. No, sir.

80. Cross-question. Well now let us confine ourselves to the kind of wireless apparatus that you have referred to in

your direct examination and in the drawings you have produced. Do you know of any wireless apparatus that employed a spark gap of some kind or other that didn't have an oscillation transformer?

• • • • • • •

Answer. Yes, sir.

81. Cross-question. Well, what type of wireless apparatus do you refer to in your last answer?

• • • • • • •

Answer. A great many amateur stations have been so constructed, and if I am not mistaken apparatus which would answer this general description can be purchased from the amateur supply people to-day.

82. Cross-question. In the class of apparatus you have just referred to, how are the oscillations got into the radiating circuit, as you call it?

• • • • • • •

[fol. 249] Answer. There is but one circuit in these transmitters and the antenna forms a part of it, and the oscillations, although of an entirely different nature from those produced in the transmitter which I have described, are produced in that circuit.

83. Cross-question. Is the amateur apparatus you have just referred to merely an educational apparatus or is it used for practical emission of signals intended to be received at a distance?

• • • • • • •

Answer. It is actually used for the transmission of signals.

84. Cross-question. What are the constants that you have referred to in the circuits of wireless apparatus, as, for example, in answer to cross-question 62?

• • • • • • •

Answer. I used the term constants in that case to mean what we call the inductance and capacity of the circuit.

85. Cross-question. Is it a fact that any oscillating circuit must have inductance and capacity in it in order to be such a circuit?

• • • • • • •

Answer. Yes, sir; so far as I know.

86. Cross-question. Then, any wireless apparatus would have in its transmitting portion an inductance coil corresponding to the coil *d* marked on these drawings?

* * * * * * *

Answer. No, sir.

87. Cross-question. Isn't that coil *d* one of the constants you have referred to as being necessary in an oscillating circuit; isn't it a fact that it is the inductance of that circuit that includes it?

* * * * * * *

Answer. It is true to be sure that the coil *d* is the seat of a portion of the total inductance of the circuit of which it forms a part, but it is not true that the circuit could not be made the seat of oscillations if the coil *d* were removed.

88. Cross-question. You have spoken of tuning on your direct examination. What do you wish to be understood as meaning by tuning with reference to the apparatus in these various sketches you have produced?

Answer. The process of adjusting the closed circuit so that it will have a definite desired frequency and of adjusting the open or radiating circuit so that it will have independent of the closed circuit the same frequency. Since the theory of this process is very involved, my answer is as definite and complete as any brief statement could be made.

89. Cross-question. Am I correct in thinking that a circuit for emitting intelligible signals by wireless telegraphy requires that that circuit have a definite number or a predetermined number of so-called electrical oscillations in a given unit of time?

* * * * * * *

Answer. No, sir.

[fol. 250] 90. Cross-question. I will repeat the question with the qualification that the circuit referred to is intended to transmit or receive what is known, if I am correct, as spark signals.

* * * * * * *

Answer. The same answer is still correct.

91. Cross-question. Then you can have in a practical wireless apparatus a circuit at the transmitting station that

radiates or sends out oscillations irregular in period and can transmit intelligible signals therewith. Is that correct?

• • • • • • •

Answer. I should prefer to say complex rather than irregular.

92. Cross-question. Then if that be true your tuning is not at all necessary, is it, in wireless apparatus, and there is no reason for having adjustable contacts 1, 2, 3, etc., shown on your drawings?

• • • • • • •

Answer. It is entirely necessary if the maximum result for a given expenditure of energy is to be obtained.

93. Cross-question. Isn't the term "resonance," which you have employed, practically the same thing as tuning?

• • • • • • •

Answer. The two terms are not entirely synonomous, one referring to a process and the other to the result produced by it.

94. Cross-question. Isn't it a fact that unless your receiving circuit, for example, is tuned to the oscillations emitted from the sending stations, you will get no intelligible signals from that station?

• • • • • • •

Answer. No, sir.

95. Cross-question. Isn't it a fact that by certain adjustments in your receiving apparatus you can exclude the reception of certain incoming oscillations from a sending station?

• • • • • • •

Answer. Not always and seldom entirely.

96. Cross-question. Isn't it a fact that the Government has prescribed certain definite oscillation frequencies for Government signals or certain definite wave lengths to be used by the Government only, and not to be used by private stations?

• • • • • • •

Answer. Yes, sir.

97. Cross-question. Then, isn't it a fact that tuning to receive wave lengths of definite frequency or definite fre-

quency of oscillations is necessary and involved in any wireless apparatus?

* * * * * * *

Answer. Desirable and beneficial, but not necessary.

98. Cross-question. You would not say it was a mere whim on the part of the Wireless Specialty Apparatus or of the Simon type of apparatus or of the Wireless Improvement Co. apparatus that the various contacts 1, 2, and 3 were made adjustable for tuning, would you?

Answer. The companies in question had no choice in the matter. The specifications issued by the Navy Department [fol. 251] and under which these equipments were built required that such provisions for tuning be made.

99. Cross-question. Do you mean to say that *in* apparatus supplied by these companies to private parties does not include any of these adjustments?

* * * * * * *

Answer. I have no definite knowledge that any of the companies mentioned sold wireless apparatus to private parties.

100. Cross-question. The only difference between the transmitting station of the Wireless Improvement Co. and that of the Wireless Specialty Apparatus Co., illustrated on the drawing you have produced, is that in the latter there is an adjustable contact 2 for the coil *b'*, whereas there is none in the Wireless Improvement Co. apparatus. Is that correct?

Answer. So far as the fundamental wiring diagram as exhibited in these two drawings is concerned; yes.

101. Cross-question. To make these last two drawings last referred to consistent, as you said was the intention putting the particular reference characters used on them, contact 2 in the Wireless Improvement Co. should be "3," should it not?

Answer. I believe that this change would help to make the drawing more consistent.

102. Cross-question. Just what do you mean by "fundamental wiring diagram" as applied to the apparatus supposed to be represented on these drawings? Do you mean that these drawings do not completely represent the apparatus referred to?

Answer. All wireless transmitters are machines or devices for converting electrical energy in some form which

is available into the form of electromagnetic waves. No single drawing could completely represent such a device, but a fundamental wiring diagram is a drawing showing diagrammatically those pieces of apparatus essential to the several transformations of energy required and the arrangement of the connections between them.

103. Cross-question. You described the operation of the Wireless Specialty Apparatus set represented on your drawing, and referring to the operation of the receiving set, would you state that any operator would proceed to make the adjustments as you have given them and in the order that you have given them, or would some operators adjust the different coils and condensers in a different order?

Answer. I personally have had very little contact with wireless operators. From their general reputation, however, I should say that the method by which they would make these adjustments would be entirely irregular and not capable of description which would be at all brief. The method given, however, is the method which I believe to be best suited for quickly obtaining satisfactory results with the apparatus in question. In this connection I would call attention to my answer to Q. —, in which I mentioned the involved nature of the theory of this process.

104. Cross-question. What is the purpose of the potentiometer P on the drawing of the Wireless Specialty Apparatus receiving station?

Answer. It is supplied in order that the detector may be adjusted to a condition of maximum sensitiveness.

[fol. 252] 105. Cross-question. Referring to your former answer concerning the ready identification of a wireless apparatus as to its wiring and circuits, I call your attention to Figure 99 in the 1913 edition of the Navy Manual of Wireless Telegraphy. Isn't this a clear representation of what a wireless set looks like?

Answer. No, sir. It represents what wireless sets used to look like, but none of the apparatus referred to in my testimony had such an appearance.

106. Cross-question. Well, isn't what that photographic reproduction shows in that 1915 manual, Figure 99, about what one sees when he looks into the wireless operator's room at a wireless station, namely, a set of instruments on a table or against the wall?

Answer. No, sir.

107. Cross-question. Is none of the apparatus that you have shown on these drawings which you have produced inclosed in casings with merely binding posts visible?

Answer. The type I-P-76 receiving sets of whatever model were all inclosed in a cabinet and the wiring was concealed. I have, however, as already stated, had ample opportunity to dissemble these sets and examine their internal connections minutely. The transmitting sets referred to in my testimony were never inclosed and consisted in general of a panel supported on an angle-iron frame with the various parts described in the equipment mounted on a panel, and the high-tension wiring, which is indicated diagrammatically in my drawings, would be in plain sight and could be seen from the rear or from either side of the equipment.

108. Cross-question. The drawing of the Simon type apparatus represents only the transmitting apparatus. Was the Simon type apparatus that you saw in the radio laboratory at the navy yard also transmitting apparatus?

Answer. Yes, sir.

109. Cross-question. How are you enabled to state that the 20 of the Simon equipments that were lined up in the corridor awaiting test were in fact of the type represented in your drawing?

Answer. I had knowledge that Mr. Simon had been awarded a contract to supply these sets. I recognized them immediately as transmitters and saw a very conspicuous name plate, reading "Emil J. Simon," on each one of them.

Redirect examination.

By Mr. Cosgrove:

110. Redirect question. In your answer to XQ. 53 you state that none of the wireless apparatus referred to in your direct examination included any antenna. Was any of this apparatus intended and adapted for use with the antenna? If so, what means or construction were provided in or with the apparatus for combining the same with an antenna?

* * * * * * *

Answer. The specifications under which these equipments were built, namely, the specifications offered in evidence as

Exhibits 37, 38, 39, 40, give the electrical dimensions of the antenna with which these equipments were intended to be used, and the design of the equipment was in every case largely effected by these dimensions. Each set before shipment to the Navy Department and also after its delivery to them is tested with artificial antenna arranged to duplicate [fol. 253] the electrical dimensions of the antenna with which it is intended to be used. All these sets had a binding post usually located on what was called an antenna send-receive switch, which was marked to show that that was the place where the antenna was to be connected. The instructions supplied with the equipment told the operator to connect the antenna at this place. It is also to be noted that unless the equipment was so connected to antenna, either real or artificial, no oscillations could be produced in the secondary circuit.

111. Redirect question. About when was the Wireless Improvement apparatus referred to in your deposition and called for in plaintiff's Exhibit No. 55, contract of June 6, 1913, with the Wireless Improvement Co., shipped to the Navy radio station at Radio, Va.?

Answer. In October of the same year.

112. Redirect question. Is that station sometimes known as the Arlington Station?

Answer: Yes, sir.

Recross-examination.

By Mr. Workman:

113. Recross-question. On what do you base your statement that the apparatus of Exhibit No. 55, contract of June 6, 1913, was shipped in October of that year? Does your memory carry back some three or four years to a particular month for a particular shipment?

Answer. I have refreshed my memory by referring to notes which I personally made at that time.

The examination by counsel being concluded, the witness, in compliance with the rule of the court requiring him to state whether he knows of any other matter relative to the claim in question, and if he does, to state it, says he does not.

Deposition of Roy A. Weagant, for Claimant, Taken at New York, N. Y., on the 18th and 19th Days of July, A. D. 1917.

* * * * * * *

ROY A. WEAGANT deposed and said that his name is Roy A. Weagant; that his occupation is that of chief engineer of the Marconi Wireless Telegraph Co. of America; that he is 36 years of age; that his place of residence is Douglas Manor, Long Island; that he has no interest in said cause except to the extent of being an employee of the plaintiff company; and that he is not related to the plaintiff.

* * * * * * *

Direct examination.

By Mr. Cosgrove:

1. Question. What education, experience, and training have you had in the construction and operation of radio wireless telegraph apparatus?

Answer. I was educated at McGill University, Montreal, where I took the four years' course in electrical engineer-[fol. 254] ing. For the past five years I have been engaged in the design and construction of wireless telegraph apparatus for the plaintiff, Marconi company, and also in research and investigation work. For the past year and a half I have been chief engineer in the Marconi company. Prior to that time I was employed by the National Electrical Signaling Co., and my work with them consisted in designing and research work and general wireless telegraph work. I was employed by them for a period of about four years. Prior to that time I was engaged for some three years in other branches of electrical engineering work, during which time I was in the employ of the Westinghouse Electrical Manufacturing Co., of Pittsburgh, Pa., and of the DeLaval Steam Turbine Co. of Trenton, N. J. I am a fellow of the Institute of Radio Engineers, a member of its board of directors, and a member of the standardization committee.

2. Question. Will you please state what, if any, experience you have had in offering to supply and in supplying radio apparatus to the United States Government?

Answer. I have done a great deal of this sort of work and have made out and submitted to the Government a large

number of bids for wireless apparatus in accordance with specifications supplied by the Navy Department and Signal Corps, the Coast Guard Service, and the Department of Insular Possessions.

3. Question. Please examine the plaintiff's Exhibits Nos. 42, 43, and 44 and state whether you are familiar with them and what these exhibits are.

Answer. I have examined these plaintiff's Exhibits Nos. 42, 43, and 44 and find them to be specifications prepared by the United States Signal Corps covering wireless telegraph apparatus. I am quite familiar with the specifications, of which these are specimens and which are supplied by the United States Signal Corps to contractors for the purpose of securing bids on wireless telegraph apparatus.

4. Question. Have any of the departments of the United States Government, since June, 1910, manufactured radio apparatus? And if so, please state what departments and the sources of your knowledge and information as to such manufacture.

* * * * * * *

Answer. Two departments of the United States Government, to my knowledge, have manufactured wireless telegraph appartus during this period—nameiy, the Navy Department and the Signal Corps. I know that the Navy Department has manufactured wireless telegraph apparatus, because the Chief of the Bureau of Steam Engineering, in his report for the year 1915, on page 345, has so stated: also because Commander Todd, in the hearings of the Committee on Merchant Marine and Fisheries of the House of Representatives in relation to a bill to regulate radio communication in January, 1917, has so stated on page 20. As regards the apparatus made by the Signal Corps, I have been told by representatives of the Signal Corps that they did make certain apparatus, and I have been asked to consider the matter of building duplicate apparatus in the factory of the Marconi company.

* * * * * * *

[fol. 255] 5. Question. Have you ever seen any of the radio apparatus manufactured by the Navy Department of the United States on exhibition anywhere? And if so, please state when and where and under what circumstances you saw such exhibition.

Answer. Yes; I have seen apparatus manufactured by the Navy Department which was exhibited at the electrical show in the Grand Central Palace, New York City, some time during the winter of 1916-1917.

6. Question. Was the exhibit referred to in your last answer an official exhibit of the Navy Department's work?

Answer. I so understood it to be, as there were signs in the vicinity of the apparatus indicating that fact and my recollection is that there were name plates on the apparatus stating that it had been manufactured by the Bureau of Steam Engineering.

7. Question. Was the exhibit by the Navy Department at the Grand Central Palace installed or set up so that it was capable of operation?

Answer. Yes; it was.

8. Question. Did you examine or inspect the construction of this radio exhibit?

Answer. Yes; I did.

9. Question. Please briefly describe the construction of the exhibit by the Navy Department, which you inspected at the Grand Central Palace, the arrangement of the circuits and adjustments, producing and referring to any drawing you may have thereof, explaining the character of the drawing.

Answer. The apparatus which I saw comprised a complete receiving and transmitting equipment. I produce a drawing (P. Ex. No. 93), showing the circuit arrangement in schematic form, of the transmitter and receiver. Referring to the left-hand circuit, marked "Transmitting station": This consisted of an antenna *f*, a connecting lead therefrom marked A, a variable inductance or loading coil marked *g*, having variable contacts thereon, marked 1 and 1ª, a second inductance coil *d'*, having variable contact, such as 3, which constituted the primary of the oscillation transformer. Leading from this oscillation transformer primary was a connection to earth E. All of the above-mentioned elements formed the open-radiating circuit. In addition, there was a closed-oscillating circuit, comprising a spark G of the quenched-gap type, a condenser *c*, an inductance coil *d*, which constituted the primary of the oscillation transformed, and which was arranged in inductive and operative relation to the inductance coil *d'* in the open-radiating circuit. Attached thereto was a variable contact 2, which provided means for varying the

amount of this inductance in use at any time and consequently the period of this closed circuit. The transmitter also comprised a power transformer *c*, whose secondary or [fol. 256] high-tension terminals were connected to the condenser *c* and whose primary or low-tension terminals were connected through an operator's key *b* to an alternating current generator *a*. Both of the oscillation circuits referred to, namely, the open-radiating circuit, shown in black line, and the closed-oscillating circuit, or reservoir circuit, shown in red line, had the necessary means for adjusting the two circuits to the same time period.

Referring now to the diagram at the right, marked "Receiving station": The receiving apparatus comprised an antenna *f*, a connecting lead therefrom A, a condenser *h*, an inductance *j'*, a variable contact 5, and a connection to earth E. This circuit shown in black constituted the open radiating circuit, whose time period was adjustable as desired by means of the variable condenser *h*, and the variable inductance *j'*. Associated with the above-described circuit, was a second, comprising an inductance j^2, having thereon a variable contact 4, and a variable condenser h'^2. To the terminals of the condenser *h'*, were connected a detector T, a blocking condenser j^3. These elements constituted the closed oscillating circuit of the receiving system. Connected across the condenser j^3, was a telephone receiver R. The closed oscillating circuit of the receiver was so arranged as to be inductively coupled through the coil j^2 to the coil *j'* of the open radiating circuit, and by means of the variable elements, namely the variable condenser *h'* and the variable inductance j^2, its time period could be adjusted to be the same as that of the open radiating circuit.

10. Question. Will you briefly describe the operation of the apparatus referred to in your last answer and illustrated in the drawings produced by you and state what adjustments an operator would make in the normal working of the apparatus and for what purpose?

Answer. In the operation of the transmitting apparatus referred to, an operator first causes oscillations to take place in the close oscillating circuit marked in red; he then makes adjustments of the variable contact 2, until the time period or wave length is the desired one, as indicated by the usual measuring instrument known as the wave meter. He then makes adjustments of the contact 1, 1^a, 3, in the cir-

cuit shown in black, or open radiating circuit, until an indicating instrument in this circuit shows that a maximum current is flowing therein. He also makes further adjustments of the distance between the coils *d* and *d'* until the best spacing as shown by this same instrument is found. When he realizes this condition, the apparatus is tuned and the time periods of the open radiating circuit and the closed oscillating circuit are then identical. In adjusting the receiving apparatus, he makes adjustments of the condenser *h* and the contact 5 in the open radiating circuit shown in black of the contact 4 and the condenser *h'* in the closed reservoir circuit, until the response to the desired signal in the telephone receiver R is a maximum. When he has completed these adjustments, the time period of the open radiating circuit and the closed reservoir circuit are identical.

[fol. 257] Mr. Cosgrove: Plaintiff's counsel offers in evidence the drawing produced by the witness and requests that the same be marked "Plaintiff's Exhibit 93, type of radio apparatus manufactured by the Navy."

11. Question. What was the make or type of the detector T, indicated on the drawing, plaintiff's Exhibit No. 93?

Answer. Two types of detectors were present and adapted to be connected in circuit—one was the incandescent lamp detector, known as the audion, and the other was a crystal detector of common form. The former was manufactured by the De Forest Radio Telegraph & Telephone Co., and the latter by the Wireless Specialty Apparatus Co.

12. Question. Was the incandescent lamp detector referred to in your last answer known as the De Forest audion?

Answer. Yes; it was.

13. Question. Please look at the article now handed to you and state if you know what it is?

Answer. This article is a crystal detector manufactured by the Wireless Specialty Apparatus Co., and known as the silicon detector. It is a type which is in common use.

Mr. Cosgrove: Plaintiff's counsel offers in evidence the detector identified by the witness and requests that the same be marked "Plaintiff's Exhibit No. 94, Wireless Specialty Apparatus Co. silicon detector."

14. Question. Do you know or what is your information as to about when the Navy Department commenced the manufacture of the radio apparatus testified to by you and illustrated in the drawing, plaintiff's Exhibit No. 93?

Answer. I was first aware of this fact in 1912.

15. Question. Your attention is called to plaintiff's Exhibit 69, contract of January 31, 1914, between the Kilbourne & Clark Manufacturing Co. of Seattle, Wash., and the Navy Department, for 5-kw. radio sets for ship installation in accordance with specification 16-R-1, except as modified in the contract. Are you familiar with the type of radio apparatus referred to in this contract? And if so, please state when and where and under what circumstances you became familiar with this type of radio apparatus.

Answer. Yes; I am familiar with this type of apparatus, because I saw one set which was supplied under the contract referred to in your question on board the steamship *Achilles* of the Panama line and I had an opportunity to inspect it.

16. Question. Will you please state the circumstances under which you inspected the Kilbourne & Clark type of radio apparatus on board the steamship *Achilles;* stating where the steamship was located at the time you made the inspection and how long you knew that the ship belonged to the Panama line, giving the full name of the steamship company, if you know it?

Answer. At the time the *Achilles*, which was at her dock at Sparrows Point, Md., was about to make her trial trip, her builders the Maryland Steel Co. requested the Marconi [fol. 258] company to supply an operator to work the wireless equipment during this test and I went on board the ship with the operator. The name of the steamship company owning the ship, if I recollect, was the Panama Steamship Co., and I believe the name was painted on the ship.

17. Question. Do you know anything of the relations, if any, between the Panama Steamship Line and the United States Government?

Answer. It is my understanding that the United States Government owns the controlling interest in that company.

18. Question. What knowledge or information have you of the sale by the Kilbourne & Clark Co. of the type of radio apparatus installed on the steamship *Achilles*?

* * * * * * *

Answer. Mr. Simpson, general manager of the Kilbourne-Clark Co. stated in my presence that this particular equipment was made *his* his company and sold to the Navy Department. It is my recollection also that the name plate on the apparatus, which I saw had the same contract number as that of the contract which you have handed me for inspection.

19. Question. Please briefly describe and explain the construction and arrangement of the Kilbourne & Clark type of apparatus installed on the *Achilles* and its mode of operation and such adjustments as would be made by an operator in the normal working of the set, producing and referring to any drawing you may have of the same.

* * * * * * *

Answer. The Kilbourne & Clark apparatus on board the steamship *Achilles* consisted of complete transmitting and receiving apparatus. I produce a diagram (P. Ex. No. 95) showing the circuit connections. The sketch marked "Transmitting station" shows the transmitter circuits and consists of an open radiating circuit, shown in black, and a closed oscillating or reservoir circuit, shown in red, together with a power supply circuit shown in yellow. The elements of the open radiating circuit are an antenna *f*, a connecting lead therefrom, A, and inductance *g*, with a variable contact 1, an inductance *d'* with a variable contact 2 and a connection to earth E. The closed circuit elements are a spark gap G, a condenser *c*, a variable inductance *d* and *d'*, having variable contacts 3 and 4. This closed oscillating or reservoir circuit was coupled inductively through the coil *d* to the coil *d'* in the open radiating circuit. The power transformer C and its high tension terminals connected to the spark gap G and its low tension terminals through an operator's key *b* to an alternating current generator *a*.

The method of operation of this transmitter is identical with the method of operation of the transmitter manufactured by the Navy Department which I have referred to. By opening and closing the key *b* the operator interrupts the flow of current in the open radiating circuit, causing a series of dots and dashes, and therefore intelligible signals, to go out from the antenna *f*. The receiving apparatus of the Kilbourne & Clark type on board the *Achilles* consisted of an open radiating circuit, shown in the attached diagram [fol. 259] in black, a closed reservoir circuit shown in red

and an indicating circuit shown in green. The elements of the open radiating circuit are an antenna *f*, a connecting lead therefrom A, variable condenser *h*, which was adapted by means of a suitable switch to be connected in the position shown in dotted lines in the diagram or in the position shown thereon in solid lines, a variable inductance *d'*, contacts 5 and 6, a variable inductance *j'*, a connection to earth E, the closed oscillating or reservoir circuit comprised the inductance coil j^2, with its variable contact 7, the variable condenser *h'*, the stopping condenser j'^3, and the detector T. This circuit was coupled to the open radiating circuit through the coils j^2 and *j'*. Attached to the terminals of the blocking condenser is a telephone receiver R, which is connected through a variable contact 8 to a potentiometer *g*, to which is connected a battery B. The method of adjusting and using this receiving apparatus is identical with the method of using and adjusting the apparatus manufactured by the Navy Department, which I have described above.

20. Question. What can you say as to the tuning of the transmitting station and the tuning of the receiving station of this Kilbourne & Clark type of apparatus and means for accomplishing this?

Answer. This transmitter of the Kilbourne & Clark apparatus could be tuned, in so far as the open radiating circuit is concerned, by varying the amount of the inductance coil *g* and the inductance *d'*, included in the circuit by the variable contacts 1 and 2. The closed oscillating transmitter of the circuit could be tuned by adjusting the amount of the inductance *d*, *d'*, included in the circuit by means of the variable contacts 4 and 3.

The receiving apparatus could be tuned in so far as the open radiating circuit is concerned by adjusting the variable condenser *h* and the variable inductances *g'* and *j'* by means of their variable contacts 5 and 6. The closed circuit could be tuned by adjusting the inductance j^2 by means of its variable contact 7 and the variable condenser *h'*.

Mr. Cosgrove. Plaintiff's counsel offers in evidence the drawing produced by the witness in answer to Q. — and requests that the same be marked "Plaintiff's Exhibit No. 95, drawing, Kilbourne & Clark type of radio apparatus."

* * * * * * *

21. Question. One of the previous witnesses has referred to radio apparatus used by the Navy, manufactured by Fritz

Lowenstein. What, if any, opportunity have you had to become familiar with the construction and mode of operation of radio receivers of the type made by Fritz Lowenstein for the United States Navy Department?

Answer. I saw some of these receivers in process of manufacture in the works of the Electrical Industries Co., New York City.

22. Question. Please state about when you saw the Lowestein type of receivers in the process of manufacture, as referred to in your last answer, and how you knew they were being made for the United States Navy.

Answer. I saw these receivers some time in 1912 and was informed by the maker that they were Lowenstein receivers and were intended for use by the Navy Department.

* * * * * * *

[fol. 260] 23. Question. Did you inspect and understand the construction and the intended mode of operation of the Lowenstein type of receivers referred to in your previous answers?

* * * * * * *

Answer. Yes; I did.

24. Question. Briefly describe or state what the construction and intended mode of operation was of these Lowenstein type of receivers, producing and referring to any drawing or diagram you may have thereof.

Answer. I produce a diagram (P. Ex. No. 96) entitled "Lowenstein type of receivers." This receiver comprised an open circuit, shown in black line, a closed oscillating circuit, shown in red lines, and an indicating instrument circuit, shown in green lines. The open circuit comprised the antenna f, the inductance g', the inductance j', the variable contacts 1 and 4, and the variable condenser h and the connection to earth E. The closed oscillating circuit comprised inductance j^2, having a variable contact 2 and inductance j^4, having a variable contact 3, a condenser h', a detector T, and a stopping condenser j^3. Connect-d across the detector T was a telephone receiver R. This closed circuit was coupled to the open circuit through the coils j^2 and j', and could be tuned to a desired period by the adjustment of either of the inductances j^2 or j^4, or the variable condenser h', or both. The open circuit could be tuned to a desired period by vary-

ing the variable inductances *g'* and *j'*, or the variable condenser *h*, or both. The method of operating this receiver was identical with the method of operating the Navy receiver previously described.

25. Question. I call your attention to plaintiff's Exhibit No. 57, contract of April 22, 1911, between Fritz Lowenstein and the Navy Department, and particularly to the description and illustration of the receivers called for by that contract, the particular illustration being marked "Appendix III—Alternative receiver, proposal 1," and marked "R-R-8." How did the Lowenstein type of receivers you have testified to and which are illustrated in the drawing thereof and produced by you compare with the Lowenstein alternative receiver No. 1 of the contract referred to?

Answer. The two are substantially the same, and the diagram which I have produced is a simplified diagram which is electrically identical with that shown in Exhibit No. 57, drawing R-8.

26. Question. Do you recollect what the type of detector which formed part of the Lowenstein receivers you have referred to was?

Answer. The detector was of the crystal type.

27. Question. What was the type of detector forming part of the set of the Kilbourne and Clark apparatus installed on board the *Achilles?*

Answer. It was a crystal detector very similar in general construction to the crystal of Exhibit No. 94 and was manufactured by the same company, namely, the Wireless Specialty Apparatus Co.

Mr. Cosgrove. Plaintiff's counsel offers in evidence the drawing produced by the witness and requests that the same be marked "Plaintiff's Exhibit No. 96, drawing, Lowenstein type of receiver."

[fol. 261] 28. Question. Are you familiar with and do you understand the construction and mode of operation or intended mode of operation of the radio apparatus manufactured by the U. S. Signal Corps, referred to in your answer to question 4, and which you were asked by the Signal Corps to consider the matter of duplicating?

Answer. Yes; I am familiar with the pack set made by the Signal Corps, more particularly with the same equip-

ment made for the Signal Corps by the National Electric Supply Co. of Washington. I saw one of these sets exhibited by the Signal Corps at an electrical show in the Grand Central Palace about two years ago, as I remember it.

29. Question. Do you know about when the Signal Corps commenced to manufacture the radio pack sets referred to in your last answer?

* * * * * * *

Answer. No; I do not know, except that in a general way I have known for the last couple of years, I should say, that they manufactured these sets themselves.

30. Question. How did the radio pack sets manufactured by the United States Signal Corps that you referred to compare in construction and mode of operation with the radio sets manufactured by the Navy, concerning which you have testified to and which are diagrammatically illustrated in plaintiff's Exhibit No. 93?

* * * * * * *

Answer. Electrically, the sets are substantially identical, as is also their mode of operation. Mechanically, of course, they differ quite widely.

31. Question. How do you know the pack set referred to in your answer to Q. 28 as being made for the Signal Corps by the National Electric Supply Co., of Washington, and which you saw exhibited by the Signal Corps at the electrical show at the Grand Central Palace, was made for the United States Signal Corps by the National Electric Supply Co.?

Answer. As I recollect it, there were name plates on the apparatus, stating the manufacturer's name and, I think, also the fact that the apparatus was made for the Signal Corps. The sign in the immediate vicinity of the apparatus indicated that it was being exhibited by the Signal Corps.

32. Question. Did you make an examination or inspection of these radio sets made by the National Electric Supply Co. for the United States Signal Corps?

Answer. Yes; I did.

33. Question. What in general did these sets consist of?

Answer. They consisted of a complete transmitting and receiving equipment, except the aerial, and both the transmitter and receiver had two tuned circuits each.

34. Question. I call your attention to plaintiff's Exhibit No. 51, contract dated January 23, 1914, between the National Electric Supply Co. and the Signal Corps of the United States Army, and particularly to the drawing annexed thereto, No. 988, and marked "Field radio pack set, model 1914"; also to plaintiff's Exhibit No. 90, Radio [fol. 262] Telegraphy, 1914, and the drawing on page 109 thereof. Please state how the radio apparatus referred to in said contract and illustrated in the two drawings referred to compare in construction and mode of operation with the National Electric Supply Co.'s field pack sets made for the U. S. Signal Corps, which you saw and inspected at the Grand Central Palace.

Answer. These are identical in all respects.

35. Question. Was the radio apparatus manufactured by the Navy, concerning which you have testified, and which is shown diagrammatically in plaintiff's Exhibit No. 93, operated in your presence when you inspected it at the Grand Central Palace in the city of New York?

Answer. The receiving apparatus was, but I do not recollect clearly whether or not the transmitting apparatus was.

36. Question. What was the type of detector forming part of the pack set of the National Electric Supply Co. made for the United States Signal Corps which you saw exhibited at the Grand Central Palace?

Answer. A crystal detector.

Cross-examination.

By Mr. Workman:

The witness was then cross-examined by the counsel for the defendant, and in answer to interrogatories testified as follows:

37. Cross-question. When and where was your first experience with practical wireless telegraphy?

Answer. 1908, at Brant Rock, with Professor Fessenden.

38. Cross-question. Was this at the time you were employed by the National Electric Signaling Co.?

Answer. Yes.

39. Cross-question. And from service with that company you went to the plaintiff, Marconi Wireless Telegraph Co., did you?

Answer. Yes.

40. Cross-question. It was no new service or employ-

ment when you went with the Marconi company, was it; the Marconi company took over the National Electric Signaling Co. and continued your employment?

Answer. It was new employment, and the National Electric Signaling Co. was not taken over by the Marconi company, but still exists as a separate concern.

41. Cross-question. Was there any interim between your employment by the National Electric Co. and the Marconi company?

Answer. Yes; about a month.

42. Cross-question. Your work with the Westinghouse company had nothing to do with wireless telegraphy, had it?

Answer. Not directly; no.

43. Cross-question. And your employment with the DeLaval Turbine Co. was of mechanical and not of an electrical nature, was it not?

Answer. It was more mechanical than electrical, but consisted of both.

44. Cross-question. The electrical part of it had nothing to do with wireless telegraphy I suppose, did it?

[fol. 263] Answer. With one exception, no; the exception being that I did some work on a high-frequency alternator which the DeLaval company was building for the National Electric Signaling Co.

45. Cross-question. In what other suits for patent infringements relating to wireless installations or apparatus have you testified?

Answer. Marconi *v.* National Electric Signaling Co.; National Electric Signaling Co. *v.* Marconi; Marconi *v.* Radio Telegraph & Telephone Co. and Lee DeForest; Marconi *v.* Kilbourne & Clark Manufacturing Co. Those are all I recollect at this time.

46. Cross-question. The suit in which you testified, of Marconi against the National Electric Signaling Co., was in the matter of the so-called four-circuit tuning patent, was it?

Answer. Yes; that patent was involved.

47. Cross-question. And it was also involved in the Kilbourne & Clark suit, was it not, in which you testified?

Answer. Yes.

48. Cross-question. Was it not the so-called Lodge or loading-coil patent also involved in the Kilbourne & Clark suit in which you testified?

Answer. Yes.

49. Cross-question. And the Fleming patent for the so-called valve detector was involved in one of these suits you have mentioned, was it not?

Answer. Yes.

50. Cross-question. Which of the suits was the Fleming valve patent involved in?

Answer. Marconi *v.* DeForest Radio Telegraph & Telephone Co.

51. Cross-question. In the suits with the National Electric Signaling Co. which party called you as witness in those two instances?

Answer. The Marconi company.

52. Cross-question. You referred to having done a great deal in offering to supply the Government with radio apparatus and submitting a large number of bids. Were any of these bids accepted?

Answer. Yes; quite a number of them.

53. Cross-question. Were such bids for Marconi apparatus?

Answer. They were for apparatus manufactured by the Marconi company, in accordance with the specifications and requirements of the various Government departments.

54. Cross-question. Did you make this drawing produced in your direct testimony, marked "Plaintiff's Exhibit No. 93, type manufactured by the Navy"?

Answer. No. It was made by a draftsman from information which I supplied to Mr. Peters, I think, and it was approved by me after it was made.

[fol. 264] 55. Cross-question. The Mr. Peters you have referred to is associated with the firm of Sheffield & Betts, counsel for the plaintiff herein?

Answer. Yes.

56. Cross-question. When was it you supplied the information for this drawing?

Answer. I don't just remember, but some months ago.

57. Cross-question. It was on just a casual visit to the electrical show at the Grand Central Palace that you happened to see the wireless apparatus which you stated was exhibited by the Navy Department and which I understand you also to say that this plaintiff's Exhibit No. 93 is a schematic drawing?

Answer. Yes.

58. Cross-question. Do you recall how much time you spent examining the apparatus referred to?

Answer. An hour perhaps.

59. Cross-question. Who was in charge of the exhibit, if you know, at the time you saw it?

Answer. I don't know.

60. Cross-question. Did you talk with anyone in charge of the exhibit on this occasion?

Answer. Yes; I think I did.

61. Cross-question. The apparatus was explained and described to you by some one in charge?

Answer. Well, I think the questions which I asked were answered.

62. Cross-question. Then you actually saw all the apparatus, that you have indicated in this drawing you have produced of the apparatus, exhibited on that occasion?

Answer. The major portion of it; yes.

63. Cross-question. You actually saw the antenna *f* in that exhibit?

Answer. Yes.

64. Cross-question. Is the same feature that you have referred to in your answer at the aerial?

Answer. Yes.

65. Cross-question. It isn't usual, is it, to have the antenna or aerial in a room?

Answer. No; quite unusual, but this particular aerial was supported outside on the building and I saw it from the street.

66. Cross-question. You didn't trace its connections with the particular apparatus in the exhibit room, did you?

Answer. Yes; I did, as the connections were open and easily seen.

67. Cross-question. You mean you could plainly trace the electrical circuit in an aerial which had to be outside of the building, do you, with the particular instruments of this exhibit?

Answer. Yes; because a part of the aerial and its connection to the instrument could be seen through a window, through which or near which the antenna connections came from the outside to the inside.

68. Cross-question. And you actually saw, did you, the alternating current generator *a* which you have so marked in this exhibit drawing?

Answer. Yes; I think I did.

[fol. 265] 69. Cross-question. The exhibit drawing No. 93 would indicate that there were two separate aerials *f*, one

for receiving and one for transmitting. Is this what you actually saw.

Answer. The sketch does not purport to indicate the mechanical construction—but merely electrical circuits. In so far as the electrical circuit is concerned, the drawing shows what I saw. There was, of course, only one actual aerial structure, which was connected as desired to either the transmitter or the receiver.

70. Cross-question. There is nothing on this Exhibit 93 drawing to show this interchangeable connection of the single aerial, is there?

Answer. No.

71. Cross-question. In speaking of the left-hand circuit, marked "Transmitting station," you have mentioned the parts antenna *f*, connecting lead therefrom marked A, variable inductance or loading coil marked *g*, having the variable contacts marked 1 and 1', second inductance *d'*, having variable contacts, such as 3, which you say "constituted the primary of the oscillation transformer." Is that correct or doesn't this circuit constitute the secondary of the oscillation transformer?

Answer. The inductance *d'* does constitute the secondary of the oscillation transformer and I really think that is what I said, although the transcript reads "primary."

72. Cross-question. Would the fact that there was actually only a single aerial or antenna in the set which you saw instead of two, as the drawing represents, have anything to do with your calling the circuit last referred to the primary?

Answer. Nothing whatever. If I did call it the primary, it was merely a slip in words.

73. Cross-question. On the receiving side of this drawing, Exhibit No. 93, the circuit aerial *f*, antenna A, condenser *h*, inductance *j'*, and earth E, that is in fact, is it not, the primary of the oscillation transformer?

Answer. It is the primary of the oscillation transformer circuit—the coil *j'* alone is called the primary of the oscillation transformer.

74. Cross-question. In the actual apparatus that you saw on the occasion referred to, were there two separate and distinct and different coils *d'* and *j'*, or was there only one such coil, similarly as in the case of the antenna *f*?

Answer. These were two separate and distinct coils.

75. Cross-question. As a matter of fact, isn't it true that on looking at an exhibit of wireless apparatus that all you see is a set of instruments, such as a coil or coils, some switch handles, a button, and the like, and you don't see the actual run of the circuits or connections at all any more than you do when looking at a telephone instrument or the front of a switchboard?

Answer. No; that is not the fact. Actually in an average wireless outfit, particularly the transmitter, you could see every part of a circuit complete from one end to the other.

76. Cross-question. Do you mean to say you can see all this without removing or displacing the exhibit or parts of the exhibit?

Answer. Yes; so far as the transmitter is concerned, in the particular sets referred to everything was open, except the power transformer, and in this the usual terminals were visible.

[fol. 266] 77. Cross-question. By the power transformer, do you mean the coils represented as *d*, *d'* on the exhibit drawing 93?

Answer. No; I mean the power transformer C in yellow lines.

78. Cross-question. What was the actual physical character of the condenser *e* on this exhibit drawing No. 93?

Answer. It consisted of a number of glass jars, with metallic coating inside and outside, commonly called Leyden jars.

79. Cross-question. And were the condensers *h*, *h'*, and j^3 on the receiving side of the drawing of this same character?

Answer: No; they were not.

80. Cross-question. Were these condensers last mentioned all alike in physical character?

Answer. *h* and *h'* were alike—j^3 was of different physical character.

81. Cross-question. How did you know that they were condensers at all?

Answer. Partly from the markings on the instrument—partly from my general knowledge of this receiver—and as I recollect it the panel was stamped "primary condenser," indicating *h*, and "secondary condenser," indicating *h'*.

82. Cross-question. All these last three objects that you have called condensers were mounted on the same base or panel, were they?

Answer. The condensers h and h' were—the condenser j^3 was mounted externally, I think, on a different support.

83. Cross-question. And you mean to say, do you, that the wire or circuits leads to and from these various features of the apparatus were not concealed underneath or at the back or base of the panel on which they were mounted, after the fashion of the back of the base of this crystal detector, Exhibit No. 94?

Answer. No; I do not mean to say so—most of the connecting leads of the receiver were visible only at their terminals.

84. Cross-question. I note you have referred to the coil g in this exhibit drawing 93 as a "loading" coil. What was your reason for connecting that term to that particular coil?

Answer. Simply that it is the conventional name for it, and a name that is commonly employed by people in wireless work.

85. Cross-question. Why isn't the coil d' a loading coil, or why wouldn't it be correct to call this also a loading coil?

Answer. I expect it would be correct, but it isn't used, as that coil is commonly called the secondary of the oscillation transformer.

86. Cross-question. This exhibit of wireless apparatus which you say was made by the Navy Department, purported to be represented in the exhibit drawing 93, was not operated when you saw it on that occasion, was it?

Answer. The receiver was—I am not quite sure of the transmitter.

87. Cross-question. But you said there were two types of detector there. They were not both connected in the circuit, were they?

Answer. I said in my direct that they were so arranged that either could be connected as well.

88. Cross-question. Why did you refer to the condenser j^3, in this exhibit drawing, as a "blocking condenser"?

Answer. Because that is the conventional term employed by everyone in wireless.

[fol. 267] 89. Cross-question. Has it any connection with its function or mode of operation?

Answer. Yes; it has, when a battery is used with the detector as in the drawing marked "Kilbourne & Clark type," Exhibit 95. It prevents the direct current from the battery

from being short-circuited instead of going through the detector.

90. Cross-question. In connection with the Kilbourne & Clark type of apparatus just referred to exhibit drawing 95, you have referred to condensers j^3 as the "stopping" condenser. Does this term indicate the same character of condenser, its operation or function as the term "blocking" condenser?

Answer. Yes—the two words have the same meaning, when used with respect to this condenser.

91. Cross-question. Referring to the exhibit illustrated in exhibit drawing 93, Navy type, the arrangements for connecting either the crystal form of detector or the audion form, did not affect the connection of the blocking condenser j^3, did it, in the circuit?

Answer. That I am not sure of. It might leave it in the same position when either type of detector is used or it might remove it when the audion is used.

92. Cross-question. What I want to know is not what might be done, but what was the fact when you saw this exhibit, as to this. As I understand you, the various circuits and connections were all the time plainly apparent to you.

Answer. As I have already stated, I did not particularly notice the details of the transfer arrangements, as they were of no particular interest to me.

93. Cross-question. In the apparatus you saw exhibited at the Grand Central Palace, represented in the exhibit drawing No. 93, I understand you think you saw the alternating current generator *a*. Where was this with reference to the other parts of the apparatus?

Answer. I don't remember exactly, except in a general way that it was some little distance from the rest of the apparatus.

94. Cross-question. You didn't see any transmitting done from this apparatus, did you?

Answer. Well, as I said before, I think I did, but I am not quite sure.

95. Cross-question. But you did see receiving done. Is that correct?

Answer. Yes.

96. Cross-question. And you don't know whether this was done with the audion in circuit or with the crystal detector in circuit?

Answer. The audion certainly was used and I am fairly sure that the crystal also was used when I saw it working.

97. Cross-question. You didn't receive anything by using the apparatus yourself, did you?

Answer. I heard some of the signals, although I didn't actually copy any messages.

98. Cross-question. Those in charge allowed you to put the telephone to your ears, did they?

Answer. No; the signals were very loud, and one of the men with the apparatus held the telephone receivers near where I was standing.

[fol. 268] 99. Cross-question. That isn't at all the usual way of hearing wireless signals, is it?

Answer. It is a very common way if the signals are very strong; if the signals are weak, then it is necessary to put the telephone receiver closely against the ear.

100. Cross-question. In your description of the operation of this device in answer to Q. 10, you don't mean to say, do you, that you witnessed all these several adjustments being made as you have stated them, do you?

Answer. So far as the receiver is concerned, yes; so far as the transmitter is concerned, probably not; but my recollection is not very clear as to whether or not the transmitter was operated while I was there.

101. Cross-question. As a matter of fact, what you have described regarding the operation is no more than the stereotyped method of operation of almost any wireless installation, isn't it?

Answer. I have described what I know as the result of some considerable experience to be the method of operation of the particular apparatus referred to, and so far as the receiver is concerned, the actual method of operation which I saw.

102. Cross-question. Anyone desiring to operate any wireless transmitting installations will adjust his oscillating circuit until he gets the desired wave length, won't he?

Answer. Yes.

103. Cross-question. And he will adjust his antenna circuit to correspond, won't he?

Answer. Yes; I think he will, if he intends to get the best results.

104. Cross-question. And the inductance coils or the coupling coils are the things usually adjusted to get this effect, are they not?

Answer. Yes.

105. Cross-question. And if you are operating any receiving installation any intelligent operator will adjust his condensers and inductances until the response to the signal he is receiving is a maximum, won't he?

Aswer. Yes; generally, although there are exceptions, such as, for instance, when he wishes to receive one station to the exclusion of some other interfering station, in which case to get maximum freedom from interference he may not adjust for maximum signal strength, but rather for the sharpest possible tuning.

106. Cross-question. Well, doesn't sharpest possible tuning mean the same thing as maximum response to the signal to be received?

Answer. Not necessarily; no.

107. Cross-question. At any rate, even in that case, the adjustments are made until the best response is secured to the signal desired to be received. That is correct, isn't it, whether this may be the sharpest tuning or not?

Answer. In a general way; yes.

108. Cross-question. Isn't it a fact that in receiving wireless signals the receiving circuit has to be so adjusted as to be in resonance to the incoming signals?

Answer. Yes; most certainly, for best results.

109. Cross-question. And the only way of securing such resonance is by adjusting the condensers or the inductances or both. That is correct isn't it?

[fol. 269] Answer. It is correct, in so far as it refers to a receiver designed to work at a considerable number of wave lengths. A receiver easily can and often is made without adjustments; that is, it is built with fixed condensers and inductances and intended to operate at one wave length only; that is to say, it is as manufactured already in tune for some particular wave length.

110. Cross-question. Any resonant circuit, in order to be such, has to have in it capacity and inductance. That is correct, is it not?

Answer. Yes.

* * * * * * *

111. Cross-question. On what do you base your statement that you were aware of the fact that the Navy Department commenced to manufacture radio apparatus corresponding to that illustrated in the exhibit drawing No. 93 in 1912?

Answer. I don't think I put it just that way. I said that I was first aware of the fact that they were making apparatus of this kind in 1912—that is to say, my personal knowledge commenced with that date—and I do not mean that they commenced to manufacture at that date, because I do not know when they commenced making their own apparatus.

112. Cross-question. Do you recollect when it was you saw the Kilbourne & Clark type of radio apparatus on the S. S. *Achilles?*

Answer. About Decoration Day 1915.

113. Cross-question. I suppose you were not the operator referred to in your answer to question 16 that the Marconi company was requested to supply for this equipment?

Answer. No; I was not.

114. Cross-question. Was such operator actually supplied by the Marconi company?

Answer. Yes.

115. Cross-question. What was your connection with that equipment?

Answer. Well, I inspected it and gave the operator some instructions in the matter of handling it.

116. Cross-question. Is it usual for the Marconi company to supply operators for wireless equipment that are not of their own make?

Answer. I think so; yes; although it is not a particularly frequent occurrence.

117. Cross-question. Why did you employ the term "reservoir circuit" to the circuit shown in red on the left or transmitting side of drawing, Exhibit 95, Kilbourne & Clark type?

Answer. It is a conventional term and has a real physical meaning, as indicating the circuit in which energy is stored to be later dissipated in the radiation from the open radiating circuit.

118. Cross-question. What was the reason you didn't employ this term with reference to the corresponding red circuit in exhibit drawing 93, type manufactured by Navy?

Answer. No particular reason that I know of—the same term applies equally there, and I could have used it with equal appropriateness.

[fol. 270] 119. Cross-question. And this term would be equally appropriate to any closed oscillation circuit that was connected to transfer its energy to a radiating circuit?

* * * * * * *

Answer. As to that I couldn't say in a general way—it might or might not be appropriate, depending on the conditions of a specific case.

120. Cross-question. When did you make this exhibit drawing 95, Kilbourne & Clark type?

Answer. That I don't remember exactly; it was quite a while ago.

121. Cross-question. As long ago as Decoration Day 1915?

Answer. I may have made a sketch essentially the same as this drawing about that time.

122. Cross-question. You haven't any present recollection that you did make such sketch about that time?

Answer. Well, I know that within a comparatively short time after that I made sketches showing the circuits of this transmitter and receiver.

123. Cross-question. Can you produce those sketches now?

Answer: No; I don't think I can.

124. Cross-question. You didn't actually make this exhibit drawing 95 yourself, did you?

Answer. It was made from information which I supplied and checked by me, but a draftsman did the actual work of making the lines.

125. Cross-question. As you are not able to produce original sketches made at or shortly after the time you saw this installation, I suppose those sketches were not the ones or the information that you gave the draftsman for this Exhibit No. 95, were they?

Answer. As to that I don't remember.

126. Cross-question. Do you mean to say that you don't remember that the sketches or whatever it was you furnished the draftsman for making exhibit drawing 95 were the ones you made shortly after the time you saw this apparatus?

Answer. No; I don't remember definitely.

127. Cross-question. What's the reason the condenser *h* on this Exhibit No. 95 is shown in dotted lines?

Answer. To indicate that this particular connection is alternative to the connection of condenser *h*, indicated by the solid line.

128. Cross-question. You didn't see this apparatus operated, did you?

Answer. No; I did not.

129. Cross-question. When you saw it was it installed for operation?

Answer. Yes.

130. Cross-question. You didn't mention what the character of the detector T was in this Kilbourne & Clark receiver?

Answer. It was a crystal detector, identical in form with the detector of plaintiff's Exhibit No. 94.

131. Cross-question. Referring to drawing No. 93, type manufactured by the Navy, I observe that there does not [fol. 271] appear to be any potentiometer in the green circuit as there is in exhibit drawing 95. Is this an omission in the former drawing?

Answer. No; it is common practice to use crystal detectors either with or without a potentiometer.

132. Cross-question. And there appears to be no battery in exhibit drawing No. 93, as there is in exhibit drawing No. 95 in the green circuit or for that matter in the receiving circuit at all. Is that an omission in drawing No. 93?

Answer. No; the battery and potentiometer go together and when it is not used the other is not used with the crystal detector.

133. Cross-question. And as to this Exhibit No. 95, do you mean to have it understood that it had two antennæ or aerials *f*, as indicated on the drawing—one for transmitting and one for receiving?

Answer. No; one antenna only and a switch for connecting either to transmitter or receiver as well.

134. Cross-question. Who installed this Kilbourne & Clark apparatus on the *Achilles*, if you know—the Marconi company or the Kilbourne & Clark people?

Answer. I am not sure, but I don't think either company did.

135. Cross-question. As a matter of fact, all you saw of this installation were the instruments mounted on the panels or baseboards, was it not?

Answer. No. I saw practically every detail of this set, including the inside of the receiver and the various con-

necting wires, switches, etc., and also a complete wiring diagram and instructions supplied by the maker of the apparatus with it.

136. Cross-question. On examining the drawing marked "Appendix 3—Alternative receiver, proposal No. 1," part of Exhibit No. 57, I fail to observe the coil corresponding to the coil you have marked on the diagram you have produced Exhibit No. 97, Lowenstein type of receiver, corresponding to g' on that diagram.

Answer. Referring to the Exhibit 57 which you have referred to the two coils shown at right angles and marked "Primary variometer" correspond to the coil g' of the Exhibit No. 97.

137. Cross-question. Is it your understanding that the coils marked II, III, and IV are in the closed oscillation circuit, referring to Appendix 3, R-8 drawing, part of Exhibit No. 57?

Answer. Coils II, III, and IV are in the closed oscillating circuit.

138. Cross-question. Referring to the pack sets stated by you to be made by the Signal Corps that you say you saw at an electrical show about two years ago, in what condition were these sets when you saw them—packed up for transportation?

Answer. No. They were in practically complete condition for operation, except that I don't recollect any connection to the antenna.

Redirect examination.

By Mr. Cosgrove:

139. Redirect question. Referring to Plaintiff's Exhibit No. 94, Wireless Specialty silicon detector, do you know whether that type of detector has been used by the Navy since 1910?

Answer. Yes; I know that has been the standard form of detectors with them since that time.

140. Redirect question. In your answer to X Q. 53, you referred to apparatus being manufactured by the Marconi company under specifications and special requirements of [fol. 272] the Government departments. Did those specifications include plaintiff's Exhibits Nos. 37, 38, 39, and

40, Navy wireless specifications to which your attention is now directed?

. . . . . .

Answer. Yes.

141. Redirect question. How did the Marconi apparatus supplied to the Government under these specifications or any of them compare electrically and in mode of operation with that manufactured by the Navy and concerning which you have testified to?

. . . . . .

Answer. They were substantially identical.

142. Redirect question. Was the Kilbourne & Clark apparatus, which you inspected on the S. S. *Achilles* new?

Answer. Apparently so; yes.

The examination of counsel being concluded, the witness, in compliance with the rule of the court requiring him to state whether he knows of any other matter relative to the claim in question, and if he does to state it, says he does not.

. . . . . .

[fol. 273] "By Mr. Cosgrove: Claimant's Counsel offers in evidence the following:

"Pamphlet entitled 'Radiotelegraphy' U. S. Signal Corps, revised 1916, forming part of the said report of the War Department filed on May 16, 1917, and requests that the same be marked *Plaintiff's Exhibit 'Radiotelegraphy. 1916.'*

"Also drawings marked No. '642-1, U. S. Signal Corps January 1908, as revised and drawing 741-1, U. S. Signal Corps November 23, 1908,' forming part of the said report of the War Department, and requests that the same be marked Plaintiff's Exhibits No. 97 and No. 98, *Signal Corps Drawings, Field Wireless Pack Set.*"

Deposition of Frank N. Waterman, for claimant, taken at New York, N. Y., on the 24th day of August, A. D. 1917, and subsequent dates.

FRANK N. WATERMAN, deposed and said that his name is Frank N. Waterman; that his occupation is that of consulting engineer; that he is 51 years of age; that his place of residence is Summit, N. J.; and that he is not interested

in the claim in question and that he is not related to the claimant.

Direct examination.

By Mr. Cosgrove:

1. Question. Please state what theoretical and practical experience you have had in electrical matters, particularly with the subject of wireless telegraphy, which would tend to qualify you as an expert in such matters?

Answer. I graduated from the course in electrical engineering at Cornell University in 1899. Prior to my graduation I had had practical electrical engineering experience in the employ of the Waterhouse Electric & Manu- [fol. 274] facturing Co., and upon my graduation I entered the employ of the Westinghouse Electric Co. and was with that company in various capacities until the fall of the year 1900. During this connection with the Westinghouse company I was engaged in the development of alternating current motors, of arc lighting apparatus, electric railway apparatus, also in the installation of electrical plants of various sorts. I was afterwards engineer of the New York office and subsequently engineer to the legal department. [fol. 275] Since 1900 I have been engaged in the profession of consulting engineer, and during this period have frequently testified in litigations involving electrical matters and apparatus.

For many years I have been engaged in the study and investigation of the subject of wireless telegraphy and have for at least five or six years owned and operated for experimental purposes a complete wireless telegraph station and a laboratory suited to the investigation of wireless telegraph problems.

I am a practical operator and have held, though I do not at the present time, a first-grade commercial operator's license. I also held a license to operate an experimental station granted by the United States Government up to the time when all licenses were revoked on account of the war. I have testified as an expert in a number of litigations involving wireless telegraphy and its appliances, and have conducted many investigations into the mode of operation of such appliances.

2. Question. Have you read the depositions of Messrs. Graham, Langley, and Weagant, taken on behalf of the

plaintiff herein, and examined the exhibits referred to by them or introduced in connection with their respective depositions, and do you understand the construction and mode of operation of the wireless telegraph apparatus and devices referred to in said depositions and said exhibits?

Answer. I have and do.

3. Question. Have you read and do you understand the Navy wireless specifications 16-T-5 and 16-R-1, marked "Plaintiff's Exhibits Nos. 37 and 38," and the Army wireless specifications Nos. 547 and 566, marked "Plaintiff's Exhibits 42 and 43"?

Answer. Yes.

4. Question. Have you read the patents here in suit, and do you understand the respective inventions thereof as described therein and illustrated in the drawings thereof, particularly as embodied in claim 3 of the Marconi reissue patent No. 11913; claims 1, 2, and 5 of the Lodge patent No. 609154; claims 1, 2, 3, 6, 8, 10, 11, 12, 13, 14, 16, 17, 18, 19, and 20 of the Marconi patent No. 763772; and claims 1 and 37 of the Fleming patent No. 803684?

Answer. I have read the patents and believe that I understand what is there disclosed and particularly as specified in the claims referred to in the question.

5. Question. Please look at the sheets of colored drawings now handed you and state, if you know, what such drawings represent.

Answer. I do. They illustrate in diagrammatic way, distinguishing different parts by the aid of colors, the apparatus as referred to in the Marconi reissue patent, the Lodge patent, and the Marconi later patent, all in suit.

Mr. Cosgrove. Plaintiff's counsel offers in evidence the three sheets of drawings just identified by the witness and requests that the same be marked "Plaintiff's Exhibit No. 99, Waterman diagrammatic drawings of Marconi and Lodge patents in suit."

* * * * * * *

6. Question. In order that the court may understand the subject matter of the inventions of the claims in issue of the Marconi and Lodge patents in suit referred to in Q. 4, will [fol. 276] you please explain as briefly as you can the art to which those inventions relate and the way any devices or apparatus you may refer to function or operate, defining and explaining such technical or scientific ideas and terms

used in the art and in said patents, and making use of any exhibits already introduced herein and such drawings or sketches as you may find necessary to make in order to give a full and intelligent understanding of such subject matter?

Answer. The three patents inquired about relate to the transmission of intelligence by means of Hertzian waves and the apparatus concerned comprises, generally speaking, a transmitting station at which is located the apparatus for generating and radiating these waves, and a distant receiving station which receives and detects the transmitting waves and produces thereby some interpretable evidence of their passage, such as a printed tape or some audible or visible indication intelligible to the operator. In the earlier commercial types the message was received in the form of dots and dashes printed upon a tape, but in present-day practice the more rapid method of reading the signal by its sound is more customarily used, or a visual indicator can be employed if preferred.

Hertzian or electric waves.—These wireless waves, which are radiated from the transmitter, are of the same nature as light waves, and they are transmitted through the same medium which serves for the propagation of light waves, namely, the so-called universal ether, but they differ therefrom in being of greater wave length.

We have sense organs capable of receiving and detecting ether waves, having that range of wave length known as light. Shorter wave lengths are known to exist which are detectible by the photographic plate, such, for example, as the so-called ultra-violet light and X rays.

We also have sense organs for perceiving ether waves, somewhat longer than light waves, namely radiant heat. When, however, ether waves longer than radiant heat waves exist the human senses are unable to detect their presence, and the receiving wireless telegraph station comprises apparatus for effectively receiving, detecting, and rendering perceptible such transmitted waves.

A wireless telegraph transmitter is thus a sort of lighthouse, which emits light of an invisible nature, and just as it requires energy to produce light so power is consumed at the wireless telegraph transmitter to furnish the energy for the transmitted Hertzian or wireless-telegraph waves.

When light is sent out from the lighthouse and falls upon an object in its field, that object absorbs the energy coming to it, if it is not transparent, and thereby casts a shadow.

In similar manner objects which are not transparent to the Hertzian waves intercept these waves and cast a shadow, thereby absorbing the energy intercepted. It is thus the function of the receiving antenna to intercept the transmitted waves and absorb the minute amount of energy which reaches any particular spot where the receiver is located, and it is the function of the remainder of the receiving apparatus to turn to practical account the energy so received.

High-frequency oscillations and wave lengths.—The means employed to set up these wireless-telegraph waves radiated by the transmitter is an oscillating electrical [fol. 277] charge. If a stick of amber glass or hard rubber be rubbed, for instance, with a silk handkerchief, it will become electrified—that is, it acquires an electric charge—and the evidence of such a charge is seen in the fact that it will attract bits of paper or other light particles and is capable of imparting an electrical charge to other bodies.

There are two opposite sorts of electrical charges. Thus, when a stick of amber is rubbed, the bit of silk with which it was rubbed tends to stick to it, but if a portion of the charge acquired by the amber is imparted to some light object, that object which was at first attracted will be repelled. These two sorts of charges are commonly referred to as positive and negative charges, respectively.

I assume that everyone is now familiar with the elevated network of wire that indicates the presence of a wireless-telegraph station and which is seen stretched between the masts of ships or otherwise supported at an elevation, from which one or more wires lead downward into the operating room. These wires are of metal, and hence are good conductors of electricity. If we imagine a charge of electricity imparted to such an elevated conductor, it will, of course, immediately rush to the earth, because these elevated conductors are connected to the earth at their lower ends. In so doing the electrical charge will travel approximately at the speed of light—that is to say, about 186,000 miles per second. For reasons which I will not now stop to consider, this traveling charge moving at the high velocity of light will display the property of inertia and so will, so to speak, overtravel. Thus, if it was a positive charge that was imparted to the overhead wire, the rush of electricity to earth will not only reduce this charge to zero but a negative charge will take its place. The negative charge in turn will rush to earth and be succeeded by a positive charge, thus

completing a cycle of electrical charges in the elevated wire or antenna after the charge has four times traversed the length of the aerial or antenna wire. Since in one complete cycle or charge of the oscillatory charge the length of the antenna is traversed four times and then the same process is repeated, it is customary to refer to this as the wave length, and this wave length is therefore approximately four times the length of the antenna or elevated wire, and one may thus form a definite approximate conception of the order of magnitude of these wireless-telegraph waves.

From these facts we may also at once ascertain what is the speed or frequency of oscillation of the electrical charge and hence of the resulting electrical waves, for since the electrical charge and electrical waves both travel with the speed of light, it is evident that the number that would occur if the operation continued for one second would be equal to the speed of light divided by the wave length. If, for example, the wave length was one-tenth of a mile, then evidently the number of oscillations per second or the rate of oscillation would be 186,000 divided by one-tenth, or 1,860,000. In commercial practice the standard wave length is 600 meters, or a little short of 2,000 feet, and hence the frequency of oscillation is 500,000 per second.

Other frequencies are also in use, ranging from 1,500,000 per second, or a wave length of 200 meters, up to very long [fol. 278] wave lengths, such as a frequency of 30,000 per second, corresponding to a wave length of 10,000 meters, or something over 6 miles.

Difference of potential or voltage.—To understand how an oscillating electric charge causes an electrical wave to be produced and to form some idea of what an electric wave is it is necessary to have in mind what is going on in the space surrounding a moving charge. Whenever we have a positive electric charge we must also have a negative charge. For example, if we rub an amber rod with a silk handkerchief, one of these elements acquires a positive charge and the other acquires a negative charge. If these elements were conductors, a current would flow from one to the other when they were in contact. Between the two there exists an electrical pressure or difference of potential which is measurable in terms of a unit called a volt, and is evidence of a tendency for a current to flow. This electrical pressure is sometimes called the "voltage" of the circuit.

If we examine the condition of the space surrounding bodies between which there is a difference of potential, or, in other words, bodies that are charged, the condition of affairs indicated diagrammatically in Figure 1 of plaintiff's Exhibit No. 92, "Radiotelegraphy," issued by the Army, page 5, will be found to exist. * * * If two wires, one charged positive and the other negative, are passed upward through a sheet of paper and a very light-powdered nonconducting material be sprinkled upon the paper, the particles of powder will arrange themselves as shown by the curved lines of this figure, which originate in the wire marked with the plus sign and that marked with the minus sign. These curved lines denote lines of ether strain, this strain being caused by the presence of electric charges, or, in other words, by the difference of potential between the wires. It is a strain resulting from the electrical pressure upon the ether. If for example the difference of potential or "voltage" between the two be, say, 100 (as, for example, 100,000 volts), then along each one of these lines the pressure will diminish, so that a short distance from the positive wire on each one of these lines it will be 90, farther away it will be 80, and still farther 70, until when the negative wire is reached it will be zero. It will of course be understood that we might tip the paper at any angle with respect to the wires and we would still get similar lines extending from one to the other. In other words, the entire space surrounding a line connecting two points having a difference of potential has these lines in it. These lines are referred to as electrostatic lines of force, and the space so affected is referred to as an electrostatic field. Sometimes also the term "electrostatic field" is used as applying to the lines themselves.

Production of electric waves.—If we now imagine an elevated conductor as having a charge imparted to it so that with respect to the earth the elevated wire is positive while the earth is negative, then the electrostatic lines of force, which are brought into existence by the charge, will extend from the wire to the earth, as shown in Figure 3, on page 6, of Exhibit No. 92. * * * It will be noted that the particular arrangement of the lines of force is somewhat dif-
[fol. 279] ferent from that of the preceding figure, because in this instance the vertical wire is positive, while the whole earth surrounding it is negative.

Remembering the illustrations given above, it will be seen that if the wire has a charge of 100 with reference to the earth taken as zero, then points in the surrounding space will have differences of potential with respect to the earth of 90, 80, 70, etc., as already explained.

If, now, a path to earth be provided for the charge stored in the wire, the charge will rush to earth with the speed of light. It is evident that as the charge moves there would be for each position a new system of electrostatic lines and that each point in the surrounding space will acquire a new difference of potential with respect to earth; that is to say, one which is different from that which it had a moment before. It is this rapid changing in the potential of the surrounding space which gives rise to the electric waves.

When the charge of electricity passes to earth electricity is moving from one point to another, and such a movement of electricity is called an electric current; it is measured in terms of a unit called the "ampere." When electricity so moves—that is, when a current flows—there is another set of ether strains produced. This is shown in Figure 4, on page 7, of the plaintiff's Exhibit No. 92 • • •. If the wire carrying the current were passed through a sheet of paper and iron filings were sprinkled upon the paper, the filings would assume a circular arrangement which is roughly indicated by a circle in this figure. It is interesting to note that the circles representing the electromagnetic field at any instant, as shown in this figure, connect points in space on the electrostatic lines of force which are of equal potential with respect to earth. The electrostatic lines and the electromagnetic lines are thus related to one another very much as are the lines representing longitude and those representing latitude on a globe.

The instant that the charge assumed to exist in the vertical wire begins to move earthward the electrostatic lines begin to disappear or collapse and the magnetic lines begin to appear and expand (thereby marking the exchange which is taking place in the electrostatic field). The sorts of strains then existing in the space around the wire are fragmentarily indicated in Figure 6, on page 8 of Exhibit No. 92 • • •. On this diagram lines such as S indicate electrostatic lines; those such as M indicate electromagnetic

lines. It will be understood that these constantly change in position as the charge moves, and when a negative charge is ascending the wire (immediately following the descending positive charge) then a similar cycle of events is passed through, as might be indicated by Figure 6, if all the arrow heads thereon were reversed in direction. (This is actually illustrated in Figure 7, page 9, of Exhibit No. 92.)

As the current passes down the wire in the above assumed case the ends of the electrostatic lines which originally terminated upon the wire ultimately are brought down to and terminate upon the surface of the earth. Since the collapsing of the field can not be entirely completed, it thus comes about that these electrostatic lines become entirely detached from the wire and are crowded off into space by the reversed motion of electricity in the wire, namely, [fol. 280] by the upward motion of the succeeding negative charge, so that a set of fluctuations of electrical potential exist in the space around the wire, and these are shot out into space with the velocity of light. They constitute rapid changes of electrical and magnetic conditions of the ether, moving outward just as the waves caused by dropping a stone into a still pool of water move outward from the spot where the stone fell. Every one has, of course, observed that long after the water where the stone was dropped has again become substantially quiescent the train of waves caused thereby is still traveling outward. This outwardly traveling motion of the water waves continues until the energy imparted to them by the falling stone has all been dissipated. In a similar manner the detached electrical waves just referred to travel outwardly, constituting an ever-enlarging set of circles, until their energy has been so reduced as to make them imperceptible. This energy never returns to the conductor.

It is clear that as the electrical charge oscillates up and down in the vertical wire, as just described, it is all the time parting with its energy in the form of electric waves (part of the energy is also lost as heat in the conductor). When the energy is exhausted so that the oscillation of the charge in the antenna ceases, then no further disturbance exists in the ether surrounding the wire but the "train of waves" set up by the oscillations continues to travel upward.

A fragmentary illustration of how such a train of waves may be thought of, as viewed in cross section, is shown in Figure 9, on page 11 of Exhibit No. 92. * * * In this figure the lines and arrows indicate partial cross sections of the traveling electrostatic fields as they might be at some particular instant, while the dots represent the cross sections of the electromagnetic lines. The phenomena occurring between an instant when the top of the wire is positive and the next time that the same point is positive are indicated by one double group of strain lines. In the figure herewith reproduced this distance is denoted by arrows marked "Wave lengths."

Wireless telegraph apparatus.—Passing now from the consideration of the sort of natural phenomena which are involved in wireless transmission, I will refer briefly to some of the apparatus employed and the principles upon which it is based.

The electric waves are radiated from and received by a vertical conducting structure, usually consisting of some considerable altitude, known as the antenna or aerial system, often called aerial for short. It commonly consists of an elevated structure, such as a network of wires, connected by a vertical wire or wires to the earth through appropriate intervening apparatus within the station. The particular form which the elevated network or "capacity aerial" takes is immaterial, although of course there will be specific or detailed differences of minor character following from different specific constructions.

Associated with the antenna at the transmitting station there is necessarily provided some suitable source of electrical energy. This may take the form of a primary battery or chemical generator of electricity or a secondary battery, wherein electricity previously generated has had its energy [fol. 281] stored by chemical change to be again given out when needed as a current of electricity. Such a battery is known as a storage battery.

For larger stations it is generally preferred to produce the electrical energy needed by means of a dynamo or mechanical generator of electricity driven by an engine, motor, or other source of power.

It is preferable and indeed essential that the antenna should be charged at a fairly high pressure, and hence it is necessary to have a means of furnishing this high

pressure. This usually takes the form of an induction coil (otherwise known as a Rhumkorff coil) or transformer.

Since these devices are not peculiar to wireless telegraphy but are used for other purposes as well, it will doubtless be sufficient to say that each consists of two coils of wire (or a single coil used for two circuits) associated upon an iron core, so that when a current flows in one coil it produces a magnetic field which affects the other coil. I have already pointed out that when a current flows a magnetic field, that is magnetic lines of force, are produced around the conductor. By suitably varying such a magnetic field it is possible to generate a current in an affected circuit. It thus becomes possible in an induction coil or transformer to generate a current of low pressure, safe and easy to handle, and by means of an induction coil or transformer produce another current of high potential suitable for charging the wireless telegraph transmitting antenna. In the case of the induction coil the necessary changes in the magnetic field are produced from a current of constant direction of flow by a mechanical current-interrupting device, known as an interrupter or vibrator, while in the case of the transformer the currents supplied to it are originally generated as currents alternating in direction.

When a current flows continuously in one direction, as is the case, for example, in the currents produced by a battery, the current is known as a direct current or continuous current, but when the current flows alternately in opposite directions in its circuit, because the terminals of the generator are caused to become alternately positive and negative, it is known as an alternating current. As employed in wireless telegraphy the number of alternations of the current produced by the generator has varied in commercial practice from 120 to 1,000 or more per second.

It is customary to regard a current flow first in one direction and then in the other as one complete cycle of change which is continuously repeated thereafter. Hence two such successive currents, i. e., a flow of electricity first in one direction succeeded by a flow in the opposite direction constitute one cycle, and it is customary to designate the current employed by the number of cycles as, for example, a current alternating 120 times per second is known as a 60-cycle current and one alternating 1,000

times per second is known as a 500-cycle current. The significance of the number of cycles, as will further appear, is merely that it determines how many charges are imparted to the antenna and radiated in any given period during which the operating key is held depressed by the operator.

In order to understand the patents in suit and the individual pieces of apparatus referred to therein it is necessary to understand some of the properties of an electric circuit, and I will, therefore, briefly outline these.

[fol. 282] *Properties of electric circuits.*—When a current flows in a wire it encounters an obstruction known as resistance. A fine wire will have a higher resistance than a coarse wire and a long wire a higher resistance than a short one. Some materials have higher resistance than others. For example, if we have silver, copper, aluminum, and iron wires of the same length and diameter, the silver wire will be the best conductor—that is, it will have the lowest resistance. Copper wire will be next, while the resistance of the aluminum and iron wires will be progressively higher, that of iron being the highest.

This property of resistance is thus characteristic of the material, and this resistance is experienced by both direct and alternating currents. It is measured in "ohms."

Inductance: An electric conductor has another property, and one which is of great importance in wireless telegraphy, which does not depend upon the material of the wire and not to any large extent upon its diameter, but depends substantially only upon the length of the wire and the way it is arranged. This property is known as the inductance of the wire, and it is analogous to inertia in mechanics.

For example, it is very difficult to suddenly start a heavy object in motion, but after such an object has acquired a considerable velocity it is very difficult indeed to quickly stop it.

Similarly the inductance of an electric circuit prevents a current from instantly rising to its full value in a circuit when an electrical pressure is applied, and it prevents the current from instantly stopping when the circuit is broken.

A straight wire has a certain amount of inductance, but this is small as compared to the inductance that the same wire would have if it were formed into a coil. It is thus possible to vary the inductance by varying the way in

which the wire is arranged. The unit of inductance is the "Henry."

A coil of wire arranged in the form of a coil, whether helical or spiral, in order that its property of inductance may be utilized in the circuit, is known as an induction coil. This must not be confused with the expression "inductance coil," as the term induction coil applies, as already defined, only to a structure designed to produce a high-tension current from a low-tension source of supply.

Capacity: Another property of an electric circuit, which is of great importance in wireless telegraphy, is that property by virtue of which it is possible to impart to it an electric charge. This property is known as "capacity." Capacity is measured in "farads" or "microfarads."

A structure built to display this property is known as a condenser.

If two plates of metal are placed one on each side of a piece of glass, the apparatus so constituted is a condenser, and a charge of electricity may be stored in it by connecting the two plates to the two terminals of a suitable source.

Another form of condenser which is familiar to most people consists of a jar or glass coated inside and out with tin foil or copper or silver plating.

All conductors possess capacity to a greater or less extent. For example, a coil of wire of itself possesses some capacity. A vertical wire or antenna possesses capacity, [fol. 283] and it is by virtue of this fact that it is possible to produce wireless waves at all. It is the capacity of the wire which enables it to be charged, and the amount of energy which can be imparted to the wire in such a charge is equal to the capacity of the antenna multiplied by one-half the square of the charging pressure or voltage.

Capacity in a circuit is analogous to elasticity in mechanics, and hence when inductance and capacity are associated in a circuit the circuit has properties analogous to a mechanical apparatus having inertia and elasticity. It is by virtue of these properties that the current of the circuit is able to oscillate.

When energy is imparted to a capacity—that is, to a condenser—the energy is stored in the electrostatic field which is produced and which I have already described. When a current flows in a circuit, its energy is stored in the magnetic field produced by the flow of the current, and the

energy of this magnetic field is equal to the inductance of the circuit producing it multiplied by one-half the current flowing.

Losses due to resistance: When a current flows in a conductor and overcomes its resistance, heat is developed in the conductor and a certain amount of the energy is wasted in this heat. The amount of energy so consumed is equal to the resistance of the conductor multiplied by the square of the current. It is this heat development through the flow of the current which makes possible the incandescent lamp, the incandescent lamp being simply a device in which the energy is consumed in producing heat in order that light may result. In this case a certain amount of the energy is consumed in producing the light waves, but the greater part is expended in maintaining the temperature.

Properties of waves and oscillations: Since in dealing with the subject of wireless telegraphy we have to do with oscillatory motion in electric circuits and with waves in the ether, it is important to bear in mind the fundamental properties that are essential alike to waves and to free oscillatory motion. In order that a body or a circuit may oscillate or vibrate when energy is imparted to it, it must display the property of inertia, in order that it may acquire momentum, and it must also have elasticity or some equivalent restoring force. When a pendulum swings, it is the inertia of the bob which enables it to swing upward and it is the restoring force of gravitation which causes it thereafter to swing downward, and these two properties are essential to its motion. If I clamp a bit of spring wire by one end horizontally in a vise and attach a small weight to the end of it, it will vibrate or oscillate to and fro when once started by springing the end to one side. The reason it vibrates is because first the elasticity tends to restore the wire to its normal position and then the momentum of the weight carries it beyond that position, and this continues until the energy has been dissipated.

Similarly in order that there may be waves, whether in water or in air, or in the ether, there must be these two properties, inertia and elasticity. When the wind disturbs the surface of a body of water waves result, which continue for some time after the wind has ceased to blow. When a wave rises it is due to the momentum of the water and when it falls it is due to the action of gravitation tending

to restore the level. Such waves are gravital waves. [fol. 284] Everyone who has fished in still water has noticed that the motion of the line causes tiny ripples to spread outward. In this instance it is the elastic action or surface tension of the water which causes the ripples. Similarly sound waves in air are due to the fact that the air has inertia and also elasticity.

Similarly waves in the ether result from the fact that the ether displays the properties of inertia and of elasticity, and the free oscillation of energy in an electric circuit is due to the fact that the circuit possesses the properties of inductance and capacity corresponding to inertia and elasticity.

The length of time that will be occupied by one oscillation of a mechanical body or an electric circuit depends upon the magnitude of the inertia and elasticity and hence upon their product. The time period of oscillation of a circuit therefore depends upon the product of its inductance and capacity.

The foregoing are, I believe, the more important of the fundamental facts necessary to an understanding of the subject matter of the Marconi and the Lodge patents in suit and if they are borne in mind the comprehension of the subject matter of the patents will be facilitated.

7. Question. Please explain first the particular scientific nature of the invention set forth and illustrated in the Marconi reissue patent No. 11913, as claimed in claim 3 thereof, and the way the devices of said invention function or operate; second the particular scientific nature of the inventions illustrated and described in the Lodge patent in suit, No. 609154, as claimed in claims 1, 2, and 5 thereof, and the way the devices and elements of said inventions function or operate; and third, the particular scientific nature of the inventions illustrated and set forth in Marconi patent in suit, No. 763772, as claimed in claims 1, 2, 3, 6, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, and 20, and the way the elements or devices in said inventions function or operate, defining and explaining such technical and scientific terms found in those patents which you may not have already explained, and referring in your answer to any exhibits introduced herein and making any drawings or sketches which may simplify your explanation.

* * * * * * *

Answer. *Marconi reissue patent No. 11913.*—The Marconi reissue patent No. 11913, as I understand it, discloses ways of organizing and operating electrical apparatus so as to constitute a means of producing and propagating electric waves and for receiving and detecting the existence of such waves at a distant station, together with means for correlating the waves so as to form an intelligible code of signals, whereby wireless telegraphy may be practiced.

The patent sets forth a number of forms of apparatus at the transmitting and receiving stations, respectively, but the descriptive recital of claim 3, to which my attention is called, applies to only one of these, namely, that more particularly described with reference to Figures 10 and 11. I will therefore deal only briefly with the others.

[fol. 285] The introductory portion of the specification, which is found on page 1, states, in substance, that the invention relates to the transmission of electrical signals by means of oscillations of high frequency, known as "Hertz rays" or "Hertz oscillations"; that is, to what are at the present time commonly referred as "Hertzian" or electric waves, and by this means the patentee states that all line wires such as are used in ordinary telegraphy may be dispensed with.

The specification states (page 1, line 16) that at the transmitting station the patentee prefers to employ a Ruhmkorff coil, having at its primary circuit a telegraph instrument known as a Morse key or other signaling device, and at its poles appliances for producing the desired operation. He says, however, that the Ruhmkorff coil may be replaced by any other suitable source of high tension electricity. The Ruhmkorff coil is diagrammatically indicated in the drawings, as for instance, Figures 1, 9, and 10, at *c*. As already stated, this is a device consisting of two coils of wire, associated with one another upon an iron core. One of these coils is short and of heavy wire, and is known as the primary circuit; the other is known as the secondary coil, and consists of a very large number of turns of fine wire. The two ends are led out to the terminals, referred to in the specification, which are indicated at *c'*, Figure 1. The telegraph instrument is shown in Figure 1 at *b*, and the source of current is indicated diagrammatically as a battery *a*. The telegraph instrument and battery are connected in the primary circuit and there is also a circuit in-

terrupter c^3, connected in this circuit. It consists of a pair of contacts, one of which is caused to vibrate by the magnetism produced in the iron core of the coil, the other of which is rotated by a small motor c^4, this being merely a device to prevent the contact points from sticking together.

After suggesting an alternative arrangement the specification refers, page 1, line 33, to the receiving station and points out that there is there located a local battery circuit containing any ordinary telegraph-receiving instrument, together with an appliance for responding to the received signals.

Transmitting apparatus: The specification then proceeds to describe three general arrangements of the transmitting and receiving apparatus. The first is that shown in Figures 1, 2, and 2a, which show a transmitter apparatus for comparatively short Hertzian waves, arranged to be projected in a definite direction by means of a reflector.

To this end the high-tension terminals c' of the inductance coil c are connected to an oscillator and spark producer, more fully shown in Figure 2a, comprising a series of spheres d, e, four in number. When the outer spheres d are charged by the coil, when the operator presses the telegraph key, the electrostatic field, such as I have already [fol. 286] described in my foregoing answer, is set up between these balls and a certain amount of energy is thus stored as a result of the ether strain thereby produced. According to the description, the apparatus is so arranged that a spark passes across through the sphere e, thereby causing a collapse of the electrostatic field and the production of Hertzian waves of so short a wave length that they may be directed in any direction by means of the metallic reflector f (seen in plan view in fig. 2 and in front view in fig. 1). The electric oscillation of energy between the balls d, e, will continue until all of the energy has been dissipated either as electric waves or as heat, and thus a train of waves will be sent out. There will be one such train of waves for each charge imparted to the oscillator, and there will in general be one charge for each vibration of the interrupter c^3. By holding the telegraph key b closed for a longer or shorter time a larger or smaller number of these trains or groups of waves will be sent out, and thus a group comprising a considerable number of these wave trains corresponds to a dash in the telegraph code and a smaller number to a dot.

Receiving apparatus: The apparatus at the receiving station is indicated in Figures 4 to 8, the arrangement of Figure 4 being the particular receiving apparatus designed to operate with the transmitter of Figure 1. In this figure the receiving apparatus is located in a similar parabolic reflector, similar to that used at the transmitting station. The receiving apparatus itself comprises a pair of plates, *k*, which are constructed of such a length as will make them adapted to the reception of waves of the particular length being transmitted. This is described in the specification, page 3, but, as it is not a part of the subject matter of claim 3, I will not dwell upon it.

Between these plates *k* is located a sensitive tube *j*, which, in the particular form described in detail on page 2, consists of a small glass tube with silver plugs fitted into it and having between the plugs a few filings of silver and nickel mixed. This particular form of wireless telegraph detector is particularly adapted for use where it is desired to have a printed record of the messages.

Associated with this sensitive tube *j* is a local circuit consisting of a battery *g* and the telegraph instrument *n*. This telegraph instrument, in its turn, controls another battery *r* and a suitable printing device *h*. The plates *k* constitute the means of receiving the electric waves, and the sensitive tube the means for detecting the fact that they have been received. In its normal or unaffected state the tube *j* has a very high resistance, so that the battery *g* is unable to send through it any appreciable or significant amount of current. When, however, electric waves are received the sensitive tube immediately changes its resistance to a lower value, so that a sufficient current flows from the battery *g* to actuate the telegraph instrument or relay *n*, which thereupon actuates the printer *h* to initiate the recording of a dot or dash.

The detector: The particular detecting device *j*, used when it is the purpose to record the printed message, is one which having once had its resistance lowered by the [fol. 287] reception of an electric wave remains at that lowered resistance until restored to its initial condition. This is done by tapping or jarring the tube by means of a tapping device *p* seen just above the sensitive tube in Figure 4. The particular details of construction of this tapping device, I understand, are immaterial for present purposes and it will be sufficient to say that it is connected

with the telegraph instrument *n* and battery *r*, so that upon the detection of a received wave the tapper is set in operation, thus restoring the sensitiveness of the tube unless electric waves are continuing to arrive, in which case the resistance is reduced by the electric wave as fast as it is restored by the tapper and the printing instrument continues the making of a dot or dash as long as the waves continue to arrive.

Modifications and details of apparatus: A modified arrangement of the transmitting station is shown in Figure 9 where two plates *t'* are shown suspended in the air from an upright framework *t t'*. This arrangement produces longer waves and is stated by the specification to be useful where greater distances are to be covered than could be effectively reached by the short wave apparatus of Figure 1.

Figure 10 shows another transmitting arrangement, and this as I understand it is the form designated by the description of claim 3 referred to in the question. In this form of apparatus the spark producer *d*, *e* is connected to a vertical wire, which terminates in an elevated capacity areas in the form of a plate *u* and at its other end is connected to the earth at *e*. The Rhumkorff coil or source of high-tension electricty *c* is connected to the two terminals of the spark-gap device and the telegraph-key apparatus is supposed to be associated therewith, as in Figure 1. Upon the closing of the key the source of current is set in operation and a high potential electric charge is communicated to the elevated conductor system, and upon the passage of the charge to the elevated conductor an electrostatic field is produced, as is indicated in Figure 3 of Exhibit No. 92.

Upon the passage of a spark across the spark gap, which will occur as soon as the elevated conductor is fully charged, the passage of the charge to earth takes place and electric waves are set free by the resulting oscillations of current in the antenna, these being such waves as are indicated in Figure 9 of Exhibit 92.

The electric waves caused by this arrangement of Figure 10 are somewhat different in form from those caused by the transmitter of either Figure 1 or Figure 9, since those produced by the arrangement of Figure 10 are sometimes referred to as earthed waves, while those due to the arrangement of Figures 1 and 9 are free waves. To illustrate

this difference in form I refer to Figures 31 and 33 of Exhibit 78, being Manual of Wireless Telegraphy for the Use of Naval Electricians, 1913 edition, as found on pages 60 and 62 thereof. Figure 31 shows free electric waves sent out by an oscillator which is not connected to the earth, while Figure 33 shows the earthed waves radiated from an oscillating system which is connected to the earth.

[fol. 288] Figure 11 of the Marconi patent, No. 11913, shows diagrammatically the arrangement of the sensitive tube in connection with the antenna circuit. One end of the tube is connected with a vertical wire terminating in a plate or capacity area *w*, while the other end is connected to earth, and connections *k'* are shown leading to the local circuit apparatus, which is similar to that already described with reference to Figure 4.

The earth connected arrangements, shown in Figures 10 and 11, are those which have proved particularly useful in practical wireless telegraphy, and the specification points out particular advantages of this arrangement. For example, it is pointed out on page 4, line 25, that the larger the capacity areas *u* and *w* and the higher they are raised above the earth, the greater is the distance at which it is possible to communicate. It is for this reason that present-day wireless telegraph stations designated to communicate over great distances have very large capacity areas, elevated to a great height.

Again it is pointed out in the specification at page 4, line 130, that it is not necessary with this arrangement to have the two stations in view of each other, but that signals may be transmitted even though there are intervening mountains. By this means, therefore, it is possible to overcome the curvature of the earth so that stations at great distance from one another may still communicate, even though the curvature of the earth intervenes to prevent one station from being visible from the other. I may note in this connection that the words found on page 4, line 132, "in view of each other," do not in an electrical sense imply human vision, because electrically the transmitting and receiving station would be in view of each other, even though there might happen to be buildings between, because ordinary building structures are transparent to the electric waves, just as glass is transparent to light. Obstacles like mountains, however, are not transparent to the waves, and two

stations separated by a mountain or by the curvature of the earth are not in view of each other in the electrical sense. This is what I understand the descriptive matter to mean in saying that the arrangement of Figure 10 does not require that these stations should be in view of each other but that communication may be carried on even though mountains intervene.

I have pointed out in considering Figure 4 that the patentee directs that the receiving plates *k* should be so adjusted that the whole circuit comprising these plates and the detector will be in tune with one another and the patentee refers to them as tuning plates. In the same way he also directs that the elevated conductors Figures 10 and 11 should be tuned to one another. Thus at page 1, line 49, he refers to the plates as "preferably electrically tuned with each other," and in describing the structure on page 4, line 123, he speaks of the elevated conductor *w* as "preferably similar to *u*." The patentee explains on page 3 that the maximum effect at the receiving station will be obtained when this tuned construction of the receiving and radiating devices is carried out.

[fol. 289] Mode of operation: The specification on page 5, lines 39 to 94, describes the operation of the apparatus as follows:

"The operation of my apparatus and system of communication or signals is as follows: The Ruhmkorff coil or other source of high-tension electrically capable of producing Hertz oscillations being in circuit with a signaling instrument—such as a Morse key, for instance—the operator by closing the circuit in the way commonly employed for producing dots and dashes in ordinary telegraphy will cause the oscillator to produce either a short or a more prolonged electric discharge or spark or succession of sparks, and this will cause a corresponding short or more prolonged oscillation in the surrounding medium corresponding in duration to the short or longer electrical impulse which in ordinary telegraphy produces a dot or dash. Such oscillations of defined character will thereupon be propagated as such throughout the medium and will affect a properly constructed instrument at a distant receiving station. At such station the imperfect contact instrument is in circuit with a relay, and when oscillations from the transmitting station reach and act upon such imperfect contact, its resistance is reduced, and the circuit is thereby closed during the con-

tinuance of the oscillation and for a length of time corresponding thereto. The closing of the relay circuit causes the sounder or other signal apparatus to act in accordance with the particular oscillation received, and the oscillation also immediately starts the action of the shaking or tapping device, which so shakes the powder in the imperfect contact instrument as to cause it to break circuit as soon as the oscillation ceases which has closed the circuit and produced a movement of the signaling instrument corresponding thereto. I am therefore enabled to communicate signals telegraphically without wires by thus artificially forming oscillations at the transmitting station into definite signals by means of a signaling instrument and receiving and reading the same at a receiving station by an imperfect contact instrument, which when acted upon by such defined oscillations operates, first, to close the circuit in accordance with the received oscillation and produce a corresponding movement of the receiving instrument, relay, or sounder, and also to operate a shaking device to automatically reopen the circuit immediately after the reception of each oscillation, thereby preserving the results of its defined character in the action of the receiver."

In this description the sensitive tube is referred to by the alternative term "imperfect contact instrument," and the telegraph instrument at the receiving station is referred to as a "relay," while the apparatus *h* is referred to as a "sounder or other signal apparatus."

Simplified diagrammatic showing: Plaintiff's Exhibit 99 shows in the figures, under the heading "Marconi reissue No. 11913", the transmitting and receiving apparatus of Figures 10 and 11 of the Marconi patent, which I have just been considering, in simple diagrammatic form, employing colors to designate the different portions of the apparatus. In this figure the vertical wire is indicated at *a* with the capacity areas at the top, these two being connected to the upper terminal of the spark producer G, and the lower terminal of this spark producer is connected to the earth at E. These are shown in black. The yellow circuit of this diagram shows the source of electrical power, by which the [fol. 290] antenna is charged. It comprises the transforming device *c*, or Ruhmkorff coil, a battery or suitable source of current *a*, and telegraph key *b*. The receiving station has a similar elevated conductor connected to one end of the sensitive detector T, whose other end is connected to

the earth at E. The green lines indicate diagrammatically the local circuit, B being the local battery, R the sounder or other signal apparatus, C' and C^2 are the protective coils described in the specification.

Referring to the terms employed in claim 3, I understand that the spark producer is shown at *d*, *e*, in Figure 10 and diagrammatically at G in Exhibit 99. The earth connection to one end of the spark producer is shown at E in both figures, and the insulated conductor connected to the other end is shown in Figure 10 by the vertical wire and capacity area *a* and in exhibit 99 by the vertical wire A and capacity area *f*. The imperfect electrical contact at the receiving station is shown at *j*, in Figure 11, and at T in Exhibit 99. The earth connection to one end of the imperfect contact is shown at E, and the insulated conductor connected to the other end is shown as the vertical wire and capacity area *w* in Figure 11, and as the vertical wire A and capacity area *f'* in Exhibit 99. The circuit through the contact is that fragmentarily indicated in Figure 11, at *k*, *k'*, and more fully shown in Figure 4, and it is the green circuit in Exhibit 99. The terms "spark producer" and "imperfect electrical contact," used in claim 3, designate, as I understand, the same parts as referred to by like terms in the specification. The spark gap, as shown at *e*, *e*, in Figure 9 and *d*, *e*, *e*, *d*, in Figure 10, is the spark producer, a device for permitting the passage of the spark, as I have already described. The imperfect electrical contact is the sensitive tube device, namely, a device for detecting the arrival of electric waves, in this instance a device for changing the electrical resistance of a circuit and so enabling a local indication of the signal to be given.

Lodge patent No. 609154.—I have already explained how it is that the rapid oscillation of electrical energy in the elevated conductor system of the Marconi patent 11913 gives rise to the production and radiation of electric waves. In practical experience the arrangement of this early Marconi patent, being in general such an arrangement as is shown in the first figure of Exhibit 99, reproduced above, has proved so efficient a radiator of electric waves that the entire energy which could be imparted to the antenna was radiated in a very few swings. The antenna, in other words, so rapidly parted with its energy to the atmosphere —that is, to the ether—that after a few oscillations there

was no further energy left. Just as a ship's propeller parts with its energy to the water and stops revolving as soon as steam is shut off—that is, after a very few turns—so that antenna parted with its energy by sending it out into space after a very few oscillations, and had to be again charged before another train of waves could be produced.

General arrangement of apparatus: The Lodge patent, to which my attention is directed in the second portion of the seventh interrogatory, is directed to the incorporation in such a wireless telegraph system of means for prolonging the oscillations. In Figure 1 of the Lodge patent, there is [fol. 291] shown what the patent calls "a complete installation of Hertzian wave telegraphy * * * in its simplest form" (page 1, line 62). It will be seen that this is a slightly modified form of an arrangement similar to Figures 1 and 4 of the Marconi reissue patent. Such an arrangement, Lodge says, page 1, line 72, will "emit one or two waves before they are damped out," i. e., before the charge is all dissipated.

The Lodge patent points out that the difficulty with an arrangement emitting very short wave trains, having only a few waves, is that the receiving station is not as effectively acted upon as it might be with more waves and that other receiving stations not intended to receive a message are more affected by it than they ought to be. This, Lodge explains, is because the energy is radiated in too few oscillations, hence the wave trains are too short.

To overcome this difficulty he proposes two general arrangements which correspond, respectively, to the arrangement of Figures 9 and 10 of the Marconi reissue patent, in that one arrangement has two elevated capacity areas and has no earth connection and the other has one elevated capacity area, while the other terminal is connected to earth. These may be taken as typically illustrated in Figures 5 and 7 of the Lodge patent, and the general commercial arrangement is shown in Figure B of plaintiff's Exhibit 99, which I will use as a convenient means of description, since the circuits are distinguished by colors.

* * * * * * *

Before referring to the earth-connected type shown in Figure 7 of the Lodge patent and others, and illustrated in simplified diagram in Figure B of Exhibit No. 99, I call attention to Figure 5, which is the nonearthed form. This

figure shows at the left a transmitting and at the right a receiving station. Two capacity areas, which correspond to the areas c^2 d^2 of Figure 9, Marconi patent 11913, already explained, are in Lodge's Figure 5, represented by two opposed metallic cones, h, h', between which is located the spark producer in the case of the transmitter and the detecting device in the case of the receiver.

In Figure 7 of the Lodge patent the elevated conductor or capacity area is shown at h and corresponds to the elevated capacity area u of the Marconi patent 11913, Figure 10, already explained. In Figure B of Exhibit No. 99 this capacity area is indicated at f in the transmitting station f' in the receiving station.

The Lodge coil, its arrangement, function, and effect: The feature of construction which Lodge added is the coil of wire h^4 of Figure 7, which in Figure B of Exhibit No. 99 is marked g at the transmitting station and g^1 at the receiving station, and sometimes termed a "loading coil."

[fol. 292] The effect of this coil is very remarkable in that, assuming a given quantity of energy to be imparted in the form of an electric charge to the elevated conductor, this charge will, in the absence of the coil h^4 be radiated in a very few waves, whereas when the coil is present the same charge will be radiated in a much greater number of waves.

In the accompanying sketch which I have drawn I have roughly indicated the effect of this Lodge coil. In this sketch the upper figure, a, illustrates the radiation of 3 waves from an antenna, not provided with a Lodge coil, and the lower figure, b, a train of 12 waves, such as might be produced by the radiation of the same energy from the same antenna when provided with such a coil. This sketch I have marked "Waterman sketch No. 1, effect of Lodge coil." It should be understood that this is merely a free-hand sketch and hence is not to scale.

Referring further to Figure 7, it will be observed that the spark producer consists of a spark gap having ball terminals h^2 h^3; that on one side of this spark gap there is inserted in the antenna a coil of wire of a few turns h^4, mounted upon an insulator y, within the coil. From the two spark gap terminals wires not lettered lead off as appears from the description to the source of power, which the Lodge patent says may be a Ruhmkorff or a Tesla coil, or a

Wimshurst or other known or suitable high-tension machine.

In plaintiff's Exhibit No. 99, Figure B, the arrangement is shown with the elevated conductor *f*, inductance coil *g*, spark producer G, and earth connection E, in black, and the power source consisting of a Ruhmkorff coil or transformer *c*, a battery *a*, and a key *b*, drawn in yellow. At the receiving station, Figure B, Exhibit 99, which is arranged according to Figure 3 of the Lodge patent, which is a fragmentary drawing only, the capacity area *f'*, inductance *g'*, and earth connection *e* are shown in black, while the detector circuit comprising the detector T, indicator R, and battery B is shown in green.

I have already explained that the wave length radiated from a given antenna depends, like the period of vibration of a mechanical body, upon its inductance and capacity, corresponding to its weight or inertia and its elasticity. The Lodge inductance coil h^4 in the patent drawings and *g* in Exhibit No. 99 possesses a considerable amount of inductance, and hence the insertion of such a coil in a given antenna structure adds to the total inductance of that structure and increases the wave length.

This Lodge coil therefore has two effects upon the wireless telegraph transmitter: First, it increases the number of waves which will be radiated as the result of a given charge imparted to the antenna, and, second, it increases the wave length which the radiated waves will have.

To bring out more clearly the effect of this coil, I call attention to the fact that the wave length of an antenna could be increased by simply making it higher. This would increase the length of the wire, and hence the inductance, and to some extent the capacity, and so increase the wave length. To increase the wave length in this manner, however, would not materially affect the number of waves radiated for a given energy imparted to the antenna. Taking the crude analogy which I suggested of a propeller wheel revolving in the water, it is evident that a propeller could be [fol. 293] made to revolve more slowly for a given power driving it by merely making it larger and hence heavier, but this would not cause it to revolve an appreciably longer time after steam was cut off from the engine driving it. If, however, a flywheel were added to the propeller shaft inside the ship, then, upon cutting off the steam, the propeller would continue to revolve much longer, notwithstand-

ing the fact that its motion would be resisted by the water surrounding it which would absorb its energy.

In a similar manner to that suggested by this rough analogy, the Lodge inductance coil placed in the antenna acts as a local storage means for energy in a way which could not be effected by merely increasing the size of the antenna, and so causes a longer train of waves to be radiated.

As shown by Waterman sketch No. 1, the waves radiated from an antenna without the Lodge coil will at first be more powerful than those radiated from the same antenna with the same charge after the Lodge coil has been inserted. This is because the same amount of energy is in this case spread out in a larger number of waves. This will not necessarily have the effect of decreasing the distance at which communication can be effected with a given amount of energy, because at the receiving station there will also be such a Lodge coil, which will more effectively gather and conserve the energy on account of the larger number of waves.

The greatest practical advantage of the Lodge construction, however, is the greater accuracy of tuning which is possible; that is to say, the more perfectly can the signal from a given transmitting station be restricted to the particular receiving station for which it is intended and the less will be the effect on other receiving stations tuned to different wave lengths.

Thus by employing this Lodge construction in each of a number of transmitting and receiving stations, but arranging them for different wave lengths, interference between messages is very much reduced.

This matter is of so much practical importance that Congress has by law forbidden the use of a so-called broad wave —that is to say, of a transmitter radiating only a very few waves—and has required that longer wave trains shall be used to reduce interference between stations, the shortest wave train permitted being one having 24 waves, or twice the number shown in Figure B of Waterman sketch No. 1.

The presence of the Lodge coil at the receiving station, as shown for example in Figure 5 of the Lodge patent, diagrammatically illustrated in Figure B of Exhibit 99, is also important, for not only does it prevent excessively rapid reradiation and loss of the received energy, [fol. 294] but by giving to the antenna system a stronger tendency to prolonged vibration in a definite period, that

is with a definite frequency or rate of vibration, it enables the antenna to resist being set in vibration by received waves of other frequencies to which it is not intended to respond.

Thus at both stations the insertion of the Lodge coil tends to "syntony," as stated, for example, at page 1, line 101, that is, it tends to the prevention of interference, or conflict of messages between a plurality of stations operating at the same time.

Lodge's variably acting coils: In order that this effect may be under control, and that the same station may at will use different transmitting wave lengths, Lodge describes what he calls "variably acting" coils. Two arrangements are shown in Figures 9 and 10, respectively, that in Figure 9 providing means for cutting out a portion or portions of the winding, constituting the coil h^4, and that of Figure 10, consisting in the arrangement of a plurality of coils, any one of which may be cut into service by means of a switching device, shown in Figure 11, diagrammatically indicated in Figure 10, at the point A^1, B^1, C^1. In Figure B of Exhibit 99, means for varying the number of turns in service of Lodge coils g, g', are indicated by the arrows at 1 and 3, respectively, the method of varying being that illustrated in Figure 9 of the Lodge patent.

The Lodge patent also provides for the use of the antenna at a wireless telegraph station either for the purpose of transmitting or for receiving. Figure 3, for example, shows fragmentarily the portion of the apparatus within the station as arranged for transmitting or receiving. As shown, the transmitting spark gap, h^2, h^3, is cut out of action or short-circuited by a switch h^9, and receiving apparatus, consisting of a detector e, battery f, and indicator g, which the specification indicates may be either a telegraph instrument or a telephone. Means for charging the same antenna at the transmitter are also shown at h^6, h^7.

Lodge's claims 1, 2, and 5: Claim 1 of the Lodge patent reads as follows:

"1. In a system of Hertzian-wave telegraphy, the combination, with a pair of capacity areas, of a self-inductance coil inserted between them electrically for the purpose of prolonging any electrical oscillations excited in the system and constituting such a system a radiator of definite frequency or pitch."

Referring to the plaintiff's Exhibit 99, Figure B, the pair of capacity areas is constituted by the elevated structure *f*, E, at the transmitting station, and *f'*, E, at the receiving station, and in Figure 7 of the Lodge patent, by the elevated conductor *h*, and the earth, to which the lower end is described as connected.

The Lodge patent explains in a number of instances that the earth may constitute one of the capacity areas. For example, at page 2, lines 96 to 107, it is stated:

"As charged surfaces or capacity areas spheres or square plates or any other metal surfaces may be employed; but I prefer, for the purpose of combining low resistance with great electrostatic capacity, cones or triangles or other such diverging surfaces with the vertices adjoining and their larger areas spreading out into space; or a single insulated [fol. 295] surface may be used in conjunction with the earth, the earth or conductors embedded in the earth constituting the other oppositely-charged surface."

Various arrangements of capacity areas are shown. Thus, two conical capacity areas, without earth connection, are shown in Figure 5. A single vertical plate with earth connection is shown in Figure 6, a horizontal plate with earth connection in Figure 7, and a rooflike structure in Figure 8.

Referring further to claim 1, the "self-inductance coil inserted between them electrically" is illustrated in Figure B of Exhibit No. 99, by the coils *g*, *g'*, and in the figures of the patent by the coil h^4. This coil is, as the patent states, for the purpose of prolonging electrical oscillations excited in the system and constituting the system a radiator of definite frequency or pitch. This latter expression means that it is one which radiates or responds to a more prolonged series of waves so as to affect or be affected very little by other stations.

Claim 2 reads as follows:

"2. In a system of Hertzian-wave telegraphy the combination with a pair of capacity areas, of a self-inductance coil inserted between them electrically for the purpose of prolonging any electrical oscillations excited in the system, thus constituting the system a resonator or absorber of definite frequency or pitch, and a distant radiator of corresponding period capable of acting cumulatively."

Claim 2 is similar in its description to claim 1, save for the last clause, which calls for a distant radiator of corresponding period capable of acting cumulatively. The specification explains that the insertion of the Lodge coil in the antenna system enables it to act cumulatively if it has the same natural period of vibration; that is to say, if the coil h^4 therein is so adjusted that the whole antenna system will have any charge communicated to it set into vibration at the same period as that of the received waves; for example, the specification says, page 3, lines 92 to 101:

"The receiver or resonator consists of a similar pair of capacity areas connected by a similarly shaped conductor or self-inductance coil, the whole constituting an absorber arranged so as to have precisely the same natural period of electrical vibrations as the radiator in use at the corresponding emitting station, so that it can accumulate the received impulses; that is to say, can act cumulatively."

Claim 2 thus adds to the recitation of claim 1 a distant radiator adjusted to the period of the receiving station and capable of acting cumulatively.

Claim 5 reads as follows:

"In a system of Hertzian-wave telegraphy the combination, with a pair of capacity areas, of a variably-acting self-inductance coil serving to syntonize such a radiator or resonator to any other such resonator or radiator, whereby signaling may be effected between any two or more correspondingly-attuned stations without disturbing other differently-attuned stations."

Claim 5 refers descriptively to the same elements heretofore defined, but specifies that the self-inductance coil shall be variably acting, as illustrated in the drawings and set forth in the specification, particularly on page 3, lines [fol. 296] 72 to 91, whereby, as the claim describes, signaling may be effected with any one of several other stations without disturbing the stations tuned to different frequencies. In Exhibit 99, figure B, these variably acting coils are shown at g, g', with the variable means indicated by arrows 1 and 3, respectively, for making the adjustment referred to in claim 5. As I have already pointed out, such means are shown in the patent in figures 9 and 10.

Marconi four-circuit or tuning patent No. 763772.—The specification of this patent states in the opening paragraph of the description, page 1, lines 10 to 20:

"My invention relates to apparatus for communicating electrical signals without wires and by means of Hertz oscillations or electric waves; and the object of the invention is to increase the efficiency of the system and to provide new and simple means whereby oscillations or electric waves from a transmitting station may be localized when desired at any one selected receiving station or stations out of a group of several receiving stations."

It appears from this statement that this invention of Marconi's also relates to telegraphy without wires by means of electric waves and that it has two objects, namely, to increase the efficiency of the system, by which he means, as appears from other portions of the specification, not only the economy but the effectiveness of a wireless telegraph system, and, second, to improve the ability to localize messages at an intended receiving station, with reduced interference with other stations.

The elementary diagrams of the arrangement are shown in Figures 1 and 2, wherein Figure 1 is the transmitting station diagram and Figure 2 the receiving station diagram.

It will aid the understanding of the patent to note at once that (referring to fig. 1) there is the elevated capacity area *f*, connected by a wire *a* to a variably acting inductance coil *g*, which in turn is connected to the earth at E just as already described with reference to the Lodge patent, and that similarity, with respect to the receiving station, there is (fig. 2), the elevated capacity area *f'*, connected by wire A, to variably acting inductance coil *g'*, which in turn is connected to the earth at E, being again the receiving arrangement of the Lodge patent, No. 609154, just above considered.

I therefore understand that Marconi starts with the syntonic arrangement of Lodge and that it is the efficiency and syntony, or selectively, as it is sometimes called, of this arrangement which his invention is designed to improve, as set forth in the above-quoted paragraph.

The specification, comparing the arrangement of the present invention with that of the earlier Marconi patent (page 1, lines 20 to 47), states as follows:

"In my prior United States patent No. 586193 (reissue No. 11913, dated June 4, 1901) I have shown and described the combination at a transmitting station of an oscillation producer, such as an induction coil, having one end of its secondary coil connected to one contact of a spark producer and to the earth and having the other end of the said secondary connected to the opposite contact of the spark producer [fol. 297] and to a vertical wire or elevated plate, and I have further shown at a receiving station an imperfect contact connected in circuit with a vertical receiving wire and with the earth. According to the present invention the system includes at the transmitting station the combination with an oscillation transformer of a kind suitable for the transformation of very rapidly alternating currents, of a persistent oscillator, and a good radiator, one coil of said transformer being connected between the aerial wire or plate and the connection thereof to earth, while the other coil of the transformer is connected in circuit with a condenser, a producer of Hertzian oscillations or electric waves shown in the form of a spark producer, and an induction coil (constituting the persistent oscillator) controlled by a signaling instrument."

Referring to Figures 1 and 2, the oscillation transformer referred to, consists in Figure 1 of the coils *d*, *d'*, the latter consisting of two turns of wire being in the antenna itself, while the coil *d*, consisting of a single turn of wire, is connected in a local circuit. Similarly, in Figure 2 the oscillation transformer consists of the coils j', j^2, the former being connected in the antenna circuit and the latter (which, as shown, is divided into two windings) is located in a local circuit, there being four oscillatory circuits, two in the transmitter and two in the receiver.

Referring to Figure 1 or, for convenience, to Figure C of Exhibit No. 99, which is identical with Figures 1 and 2 of the Marconi patent, save for the use of colors to distinguish the circuits, the coil *d* is seen to be connected in a local circuit comprising also a condenser *c* and a spark gap, not lettered in the patent, but marked "G" in Exhibit No. 99. This circuit is indicated in red, in Exhibit No. 99, and so is easily identified.

Transmitting apparatus and station: I call particular attention to the difference between these two circuits at the transmitting station. The black, or antenna, circuit in-

cludes one coil (d') of the oscillation transformer, and the coil g, and is connected at the top to the elevated capacity area f, while at the bottom it is connected to earth. The two ends of the circuit in other words do not approach one another closely, but are widely separated, and the circuit is what is known as an open circuit. The red or local circuit, on the other hand, comprises the coil d, condenser c, and spark gap G. This red circuit is therefore a circuit which, when current is flowing across the spark gap, is a completely closed circuit.

These two sorts of circuits have very different properties.

Good radiator and persistent oscillator: I have already explained by diagrams how an antenna circuit connected to earth, as are these antenna circuits of the Marconi patent, produces a widely extending electrostatic field, which, upon collapsing, gives rise to and emits electric waves, and, in explaining the Lodge patent I have called attention to the fact that such a circuit is too perfect a radiator of such waves, so that for practical purposes it is used in conjunction with the Lodge coil to make it radiate more sustained wave trains.

The closed circuit, shown in Figure 1 of the Marconi patent, and that indicated in red in Figure C of Exhibit No. 99, on the other hand, has its capacity concentrated in [fol. 298] the condenser c. It therefore produces no external electrostatic field that is appreciable, and hence the oscillation of current in such a circuit does not produce electric waves.

One of these circuits, namely, the black circuit of Exhibit No. 99, therefore, possesses in large measure a property which the other, namely, the red circuit, does not possess at all, and for this reason the open or black circuit loses its energy by sending it off into space while the closed or red circuit by itself can not radiate any of its energy, but the current will oscillate in the circuit until consumed by the resistance of the circuit, including that of the spark gap.

For this reason the open or radiating type of circuit has sometimes been called a "good radiator" or a "radiating circuit," while the other or closed type has sometimes been referred to as a "persistent oscillator" or "non-radiating circuit" to distinguish it from the radiating oscillator or open circuit.

This is what is meant in the above quoted portion of the specification, as I understand it, by the use of the expression "a persistent oscillator" and "a good radiator." Both circuits contain inductance and both contain capacity, hence both may be able to cause charges imparted to them to oscillate, but one circuit can discharge its energy in the form of electric waves and the other can not.

These two circuits Marconi associates by placing the coils *d* and *d'* sufficiently close together, so that one can experience the magnetic effect of the other, and the two thus become an oscillation transformer and are so designated in the above-quoted passage from the specification.

Oscillation transformer: Marconi's purpose in associating these two opposite kinds of circuits is, as will appear from portions of the specification to be referred to, to have one circuit proportioned and devoted to the storage and setting in oscillation of a desired quantity of energy larger than could conveniently be imparted to the other circuit, and another circuit proportioned to have the desired radiating qualities without being restricted in its construction by having to directly receive and store all of the energy, but which it is capable of taking and radiating that energy from the first circuit.

The means of transferring this energy from the first or closed circuit to the second or open circuit is the association of inductance coils in the two circuits in such a manner as to constitute an oscillation transformer. The coils *d d'* are the two inductance coils so associated.

As I have already explained, currents flowing in a wire create a magnetic field which appears when the current appears and disappears when the current disappears. It is a well-known physical fact that conversely if a magnetic field can be made to appear in the vicinity of a coil or circuit in which a current can be set up a current will in fact be created and when the magnetic field disappears a current in the reverse direction will be created. Broadly considered this is the principle upon which mechanical generators of electricity are built and upon which induction coils, transformers, and oscillation transformers operate. It is known as the principle of electromagnetic inductance.

In ordinary transformers, such as are used as sources of power and for electric lighting and the like, the mag- [fol. 299] netic field is set up by currents flowing in one

coil surrounding an iron core, and the second or induced current is caused to be produced in another coil wound on the same core, and in general the characteristics of this second current depend upon the ratio of the number of turns in the second coil as compared to the first. If, for example, the first coil having a certain number of turns is supplied with current having a quantity of, say, 10 amperes which is forced through the coil by a pressure or voltage of 100 volts, then if the second coil has ten times as many turns, the current produced in that second coil will have ten times as high a pressure, namely, 1,000 volts, but only one-tenth as much current, namely 1 ampere.

In the sort of transformer, which Marconi calls an oscillation transformer and which is used in wireless telegraphy, this relation existing in ordinary transformers does not hold, and the particular characteristics of the current produced in the second coil are found not to be determined to any appreciable extent by the ratio of the number of turns, but rather are determined by the characteristics of the two circuits as a whole, and as Marconi later points out, by their resonant relation to one another.

The particular oscillation transformer, which Marconi shows in Figure 1, and more particularly in Figures 3 and 4 has in its primary coil *d* only a single turn of wire and in its secondary circuit only two turns of wire. Notwithstanding this fact, however, the current produced in the open circuit may have an electrical pressure or voltage several or many times as high as that which is introduced into the primary circuit. It is the function of the oscillation transformer to transfer the energy imparted to the primary circuit over into the open or radiating circuit with results determined by the adjustments of the two circuits.

In the receiving apparatus also Marconi shows an oscillation transformer having a primary coil j' in the antenna circuit and a secondary coil j^2 divided into two parts in the local circuit. In his instance the oscillation transformer so constituted is composed for greater convenience of a larger number of turns of smaller size, and the purpose of the transformer is to transfer the energy received by the open antenna circuit of the receiving station over into a local circuit where it is detected and used, and the purpose in this instance also is to permit of the effective construction of the two circuits, the open circuit for effectively receiving the waves and gathering their energy and the

second or local circuit, which also is closed, for the purpose of effectively utilizing this energy, and the action of one circuit upon the other depends upon the proportions and adjustment of the two.

In neither the transmitting nor the receiving apparatus does the oscillation transformer have any iron core and it is characteristic of the transformer of the patent and as used in practical wireless telegraphy that the oscillation transformer have no iron cores.

Continuing the specification, beginning at line 47, page 1, recites the various features found in what he calls "the complete system," and under this heading he recites the presence of the inductance coil such as g, g', to which I have already referred, and he says of this complete system, page 1, line 62, "By this arrangement of apparatus I am [fol. 300] able to secure a perfect 'tuning' of the apparatus at a transmitting station and at one or more of a number of receiving stations."

In other words, Marconi states that by such means, assembled as here described, he is able to effectively syntonize the transmitting and receiving stations and accomplish that one of the objects, already referred to in the quoted passage, whereby "electric waves from a transmitting station may be localized when desired at any one selected receiving station."

At page 1, line 77, to page 2, line 5, the transmitting station is described as follows, and reference may be conveniently had to plaintiff's Exhibit No. 99, Figure *c*, transmitting station, reproduced above, which is identical with Figure 1, save for the colors, which will aid in tracing the circuits described:

"The transmitting station is provided under my present invention with a source *a* of current electrically connected in circuit with the primary of an induction coil *c* and with a circuit-closing key *b* or otherwise controlled by a signaling instrument. In the secondary circuit of said induction coil the spherical terminals or other contacts of a spark producer are included with a shunt therefrom, in which shunt is included the primary coil *d* of an oscillation transformer such as d^2. A condenser *e*, preferably one provided with two telescoping metallic tubes separated by a dielectric and arranged to readily vary the capacity by being slid upon each other is included in one

connection from the induction coil to the transformer winding *d*. The secondary coil *d'* of the transformer is connected (at one end) to the earth E and at its other end to a vertical wire A or an elevated plate *f*.

"It is obvious that instead of the induction coil and associated parts for producing the electric waves or oscillations I may use any other proper means for producing such waves or oscillations such, for instance, as a generator of alterating electric currents."

Referring to Exhibit No. 99, the yellow circuit comprising the battery or alternating current generator *a*, referred to above, the operator key *b* and the induction coil or transformer constitute the power source by which a charge of electrical energy is imparted to the red circuit where it is stored in the condenser *c*. To set this energy, which is stored in static or quiescent form, into oscillation a spark producer, shown as a spark gap G, is provided in the circuit.

No specific instructions are given in the specification for the construction of this spark gap, but it is referred to in the above quotation as "a spark producer or other electric wave or oscillation producer," and in practice it is constructed in various specific forms, all having the same general purpose, namely, to suddenly release the energy stored in the condenser and permit it to oscillate in the closed circuit until that circuit has fulfilled its purpose in the structure for the time being, namely, has furnished its stored energy to the antenna circuit to be radiated. In general the spark gap or spark producer consists of two or more terminals of some appropriate form in air or some other gas, and its operation depends upon the property of gases by virtue of which they are very perfect insulators up to a certain point—that is, up to a certain electrical pressure determined by the construction of the gap—but when this point is reached the insulating property of the gas is destroyed and it becomes momentarily conducting, permitting a spark or discharge to [fol. 301] pass, and hence permitting the circuit to oscillate until so much energy has been transferred to the other circuit that the pressure no longer is sufficient to keep the gap in its conducting condition.

Operation of transmitter: The operation of the transmitter is therefore as follows:

Upon the closure of the operating key a current of the desired charging pressure is produced at the terminals of the transformer *c* and flows to the red circuit, thereby charging the condenser *e*. As electrical energy accumulates in the condenser the pressure across its terminals, and hence across the spark gap G, increases until it is sufficient to break down the insulation of the air or gas in the spark gap. At this point the stored energy from the condenser flows across the gap, starting a current which oscillates back and forth in the circuit.

Each such oscillation of current through the coil *d* creates a magnetic field which, acting upon the coil *d'*, sets up a current therein and transfers energy thereto. If the circuits are correctly proportioned and adjusted, as Marconi describes, energy will be effectively transferred and an oscillating current of a desired high pressure will be set up, charging the capacity area *f* to a high potential and causing the alternate development and collapse of an electrostatic field whereby electric waves will be sent out.

The characteristics and properties of the oscillatory circuits: The characteristics of the circuits of transmitter and receiver are described on pages 2 and 3, and on pages 3 and 4 there are specifically described various modes of constructing and associating the circuits for particular illustrative examples. I will refer briefly to the proportioning and adjustment of circuits as set forth on page 2. For example, at page 2, lines 6 to 24, the patentee defines in general the characteristics of the circuit as follows:

"The illustrated arrangment of parts at a transmitting station enables much more energy to be imparted to the radiator *f*, the approximately closed circuit of the primary being a good conserver and the open circuit of the secondary being a good radiator of wave energy. My experiments have demonstrated that the best results are obtained at the transmitting station when I use a persistent oscillator—an electrical circuit of such a character that if electromotive force is suddenly applied to it and the current then cut off electrical oscillations are set up in the circuit which persist or are maintained for a long time—in the primary circuit and use a good radiator—i. e., an electrical circuit which very quickly imparts the energy of electrical oscillations to the surrounding ether in the form of waves—in the secondary circuit."

Further, at page 2, lines 39 to 49, the specification says:

"For the best results and in order to effect the selection of the station or stations whereat the transmitted oscillations are to be localized I include in the open secondary circuit of the transformer, and preferably between the radiator *f* and the secondary coil *d'*, an inductance coil *g*, figure 1, having numerous coils, and the connection is such that a great or less number of turns of the coil can be put in use, the proper number being ascertained by experiment."

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[fol. 302] I call particular attention to the fact that the above-quoted passage referring to "the illustrated arrangement of parts" describes it as based upon Marconi's experiments and as involving the employment of two sorts of circuits, one of which he styles "a persistent oscillator" and the other of which he designates "a good radiator." Further, he defines these circuits respectively. A persistent oscillator is a circuit in which if oscillations are set up by the sudden application of electric charge and the source of charge is then cut off the circuit must oscillate until it is deprived of its energy by some other means than radiation. The other circuit is distinguished from this first circuit in that it has the power to get rid of its energy by radiation and is indeed a good radiator.

As I understand this, it does not say or imply that when the two circuits are associated as shown the oscillations in the primary or closed circuit persist for a long time or for any particular time nor does it say that the open or secondary circuit radiates very rapidly. Indeed, the second quotation above expressly states that "for the best results" the inductance coil *g* is employed for the purpose of preventing too good radiation.

These definitions in the first of the two quotations above distinguish two different kinds of circuits, which are to be associated and they are defined as having two distinguishing properties, namely, one, a circuit which can not radiate and hence must oscillate until its energy is consumed within itself, and the other, one which will not oscillate until it consumed its own energy because it will radiate that energy in space.

What happens when the two sorts of circuits are associated is briefly stated in the passage beginning at line 25 page 2, as follows:

"In operation the signaling-key *b* is pressed, and this closes the primary of the induction-coil. Current then rushes through the transformer-circuit and the condenser *c* is charged and subsequently discharges through the spark-gap. If the capacity, the inductance, and the resistance of the circuit are of suitable values, the discharge is oscillatory, with the result that alternating currents of high frequency pass through the primary of the transformer and induct similar oscillations in the secondary, these oscillations being rapidly radiated in the form of electric waves by the elevated conductor."

It will be observed that this statement says that upon the closure of the telegraph key, current rushes through the circuit and charges the condenser *c*. It is then stated that "if the capacity, inductance and resistance of the circuits are of suitable values the discharge will oscillate in the circuit. If they are not of such values as to cause oscillation then all the energy will be dissipated in a single rush. How many oscillations exist in the circuit in actual operation therefore depends upon the quantity.

To ascertain what the number of oscillations will be in any practical construction, it is necessary to consider first the relations of these quantities and second the matter [fol. 303] stated in the latter portion of the above quotation, namely, how fast the energy is transferred to "induct similar oscillations in the secondary" or antenna circuit.

Considering first the operative characteristics of the primary circuit, it will be seen from the description of the transformers found on page 3, lines 25 to 47, that the wire of which these transformers are made is of good size and is short in length so that its resistance is quite low. It is therefore clear that the resistance of this primary circuit as determined in accordance with the last quotation almost entirely by the character and adjustment of the spark gap. This is found to be the case in actual practice and the number of oscillations or indeed whether there are any oscillations at all after the initial rush of the current across the gap depends entirely upon the resistance of spark gap.

There is in such a closed circuit or persistent oscillator—that is, nonradiator—another relation which also determines how many oscillations can take place, whether there is a spark gap present or not, and that is the size of the condenser as compared to the size of the inductance coil.

Looking at the drawings, Figures 1 to 4, and at the description of these figures, it will be seen that the inductance coil *d*, which also serves as the primary of the oscillation transformer, consists of a single turn of wire, of comparatively small area. Inductance of the circuit as illustrated is therefore very small indeed, which means that in order that a certain wave length shall be radiated, the condenser must be comparatively very large.

Marconi says, in the last-quoted paragraph, that the oscillatory character of the circuit is determined by the inductance, capacity, and resistance and the relation is such that a large capacity and small inductance means a very few oscillations, as compared to the number that would exist if the reverse were true. To give an idea of these relations, for example, taking the first one of the illustrative examples given in the table on page 4, the wave length of which I have found to be approximately 200 meters, and calculating from the value of the capacity given in the table, I find that assuming the resistance of the spark gap to be 1 ohm, the circuit if oscillating by itself, would have three complete oscillations—if the current continues to oscillate until it fell 1 per cent of its original value. This shows that a circuit such as the patent describes as illustrative of the invention, being number 1 of the table on page 4, may have the capacity, inductance, and resistance of the circuit of such values as to cause a comparatively few oscillations to take place.

When the two circuits are associated, and with the spark gap in operation, the number of oscillations which will take place is less than that which will take place in the same circuit of like capacity and inductance and with a fixed resistance for two reasons. The first is that owing to the resonant relation between circuits hereafter described the oscillation transformer quickly transfers its energy to the antenna circuit in accordance with the above statement of Marconi, "these oscillations being rapidly radiated in the form of electric waves by the elevated conductor." If the energy is thus rapidly taken away from the primary circuit and radiated, it of course results that the number of oscillations in the closed circuit is decreased.

[fol. 304] The second reason why, when the circuits are associated and the spark gap is in operation the number of oscillations in the closed circuit is reduced, is that the passage of the spark across the gap requires that there shall

exist at the spark gap terminals a certain critical voltage, dependent upon the condition of the spark gap and the amount of current which has just previously passed through it. As the circuit oscillates the current decreases, and as the current decreases, the electrical pressure required to cause the current to again pass increases. The oscillation, however, continually reduces the charge in the condenser and so reduces the electrical pressure at the gap, and hence it quickly results that there is no longer a sufficient pressure in the circuit to cause the spark to jump the gap, and the oscillation of current in the circuit therefore ceases as soon as this condition is reached.

Briefly summarizing, therefore, the transmitter of the patent as thus far described consists of a circuit which can not radiate, combined with a circuit which can radiate in such a manner that energy imparted to the first circuit may be transferred to the second upon the flow of current across the spark gap contained in the first circuit. The number of oscillations which can take place in the first circuit is determined for a given wave length or frequency of oscillation by the size of the condenser in that circuit and by the resistance of the spark gap and the number of oscillations which will actually occur in the operation of the apparatus depends upon the characteristics of the spark gap and the current flowing across it and upon how closely the two circuits are associated, and therefore how rapidly the energy is transferred from one circuit to the other. In modern terminology, this association of the circuits one with the other is termed "coupling."

Purpose of two circuits in the transmitter: The purpose of employing two circuits at the transmitter, as above described, is stated in the passage which I have quoted from page 2, line 6, to be that it "enables much more energy to be imparted to the radiator." The reason why it enables more energy to be imparted is, first, that an antenna of given dimensions has a small capacity and hence can have only a small charge imparted to it at a given pressure or voltage, whereas the closed circuit associated therewith can by selecting a suitable condenser have a large capacity, and hence at the same or even at a lower voltage can have a much larger charge and hence "much more energy" imparted to it. The second reason is that by reason of the resonant relation of the circuits, later described in the

specification, the energy can be efficiently transferred to the radiating circuit while radiation is taking place, and hence this larger store of energy imparted to the primary or closed circuit can by this means be effectively converted into electric waves.

The amount of energy that can be imparted to a given antenna in a single charge depends upon the capacity of the antenna and the voltage that can be used to charge it. The size of the antenna is in general determined approximately by the wave length which is to be radiated, and since the size determines the capacity, other things being equal, it is evident that the capacity is fixed by other considerations.

The pressure that can be used to charge an antenna containing a spark gap like that of the early Marconi patent, [fol. 305] reissue No. 11913, is limited by the qualities of the spark gap. If the spark gap is too long its action is irregular, and good signals can not be made. If the spark gap is shorter, then the voltage across it, and hence the charge that can be put in to the antenna, must be reduced, and the signal will be of good quality but weak. Hence the amount of energy, and consequently the distance that could be reached with a given wave length by the original Marconi arrangement having the spark gap in the antenna, was limited by the small capacity of the antenna and the low charging pressure that could be applied to it on account of the presence of the spark gap.

This difficulty Marconi overcame by the association with the antenna circuit of a closed nonradiating circuit, into which he put the spark gap, and into which he could put a condenser of so large a capacity that with a proper spark-gap pressure a much larger electrical charge could be imparted to this circuit than to the antenna circuit direct and by devising a way of efficiently transferring this energy to the antenna circuit, this closed nonradiating primary circuit became a reservoir for the antenna.

This "illustrated arrangement of parts at a transmitting station enables much more energy to be imparted to the radiator" for two reasons. First, because the closed primary circuit not being able to radiate of itself and having a large capacity can receive and conserve a much larger charge of electrical energy; and, second, because there being now no spark gap in the antenna the latter can be charged from the primary circuit to a considerably higher

pressure, namely, to such a pressure as the insulation of the antenna will safely take care of. This is a much higher pressure than can be used across a spark gap in the antenna if good results are to be obtained.

Further, the spark gap of itself necessarily involves the production of a large amount of heat, light, and noise, and these all consume energy. With the spark gap in the antenna all the energy thus consumed was taken from the charge which had been imparted to the antenna, and consequently less remained to be radiated. By putting the spark gap in the local circuit and using therein a large capacity it was possibly to supply this necessarily wasted energy as a purely additional energy supply, which therefore did not subtract from and waste energy transferred to the antenna. All that it is necessary to do is to make the condenser in the primary circuit enough larger to receive and store this energy in addition to that received and stored for the purpose of the signal.

It therefore results that by associating with the antenna circuit a reservoir circuit of large capacity in such a manner that the energy of the reservoir could be efficiently transferred to the antenna and the transfer continued while the antenna was radiating until all of the energy transferred Marconi provided the means for imparting much more energy to the radiator, for using the energy so imparted more efficiently, and producing longer and more sustained waves than could be produced when the energy losses of the spark gap had to be subtracted from the energy imparted t the antenna.

He thus attained both of the objects set forth in the introductory statement of the specification, namely, greater efficiency, both in the sense of economy and effectiveness, and greater selectivity; that is, better localization of signals at the intended receiving station to the exclusion of [fol. 306] reception by stations not desiring to receive or desiring simultaneously to receive from some other transmitter.

Resonant transfer of energy: The mere association of a closed circuit having a large capacity, with an antenna circuit, does not of itself enable more energy to be imparted to the radiator, nor would it produce a commercially feasible wireless telegraph system for the reason that it is impossible by this means only to efficiently transfer the energy from the closed to the radiating circuit. To effect the de-

sired result Marconi found that it was necessary to so adjust the inductance and capacity of the two circuits as to give them substantially the same time period of oscillation; that is to say, to put them substantially in resonance with one another. The process of doing this is commonly referred to as the tuning of the transmitter or receiver, as the case may be.

I have already noted the fact that the time it will take the charge to oscillate in any given circuit will depend upon the numerical values of the inductance and the capacity of the circuit, being in fact proportional to the square root of their products. Two circuits are in resonance when they have the same time period of oscillation; that is to say, when electrical charges imparted to them complete one oscillation to and fro in the same length of time. In order that this may be the case it is not necessary that the two circuits have the same inductance and capacity, but that the products of the inductance and capacity in the two circuits should be alike. This is set forth in the specification, more particularly at page 2, line 118, as follows:

"The capacity and self-induction of the four circuits, i. e., the primary and secondary circuits at the transmitting station and the primary and secondary circuits at any one of the receiving stations in a communicating system are each and all to be so independently adjusted as to make the product of the self-induction multiplied by the capacity the same in each case or multiples of each other; that is to say, the electrical time periods of the four circuits are to be the same or octaves of each other."

The term "self-induction," used in this quotation, is identical in meaning with the more modern term "inductance." The terminology of the electrical art has changed rapidly and new terms are constantly coming into use. This is merely one instance of such change, but there is no confusion introduced thereby in this particular instance, because it so happens that the term "inductance" has been merely substituted for the term "self-induction," and neither has any other meaning. In brief the self-induction or inductance of a circuit is simply the total number of magnetic lines of force cutting the total number of turns or total length of wire for each unit of current flowing in the circuit. The significance of the prefix "self" in the term

"self-induction" is that the magnetic lines, referred to in the definition, are magnetic lines produced by current flowing in the circuit itself, as distinguished from magnetic lines due to a current flowing in some other circuit.

The foregoing statement quoted from the patent therefore states that the circuits are to be adjusted so as to have like products of capacity and inductance in the two circuits so that the two circuits have the same electrical time periods or time periods which are multiples of one another. The [fol. 307] electrical time period of the circuit is, as above noted, the length of time taken for discharge imparted to the circuit to make one complete oscillation to and fro therein.

By this means it is possible for the apparatus illustrated in the patent to effect an efficient transfer of energy from one circuit to the other, this transfer being continued while electric waves are being radiated, until the energy has all been transferred from the reservoir or persistent oscillator circuit to the antenna or radiator circuit, and thereafter, if the circuits are properly adjusted, the closed circuit ceases entirely to operate while the antenna circuit continues to radiate until its energy has been dissipated.

Current oscillation and energy transfer: Illustrating the oscillation of current in a circuit by a sinuous or wavy line, as I have already done in the case of Waterman sketch No. 1, I illustrate by Waterman sketch No. 2 the oscillation of current in the two circuits of a transmitter, properly adjusted as described in the specification.

On this sketch the upper figure (*a*) illustrates the oscillations of a charge in the primary circuit and the lower figure (*b*) the transfer of the charge to the secondary circuit and a portion of the train of oscillations therein. In these figures the horizontal line *o*, *x*, indicates the progress of time and the sinusoidal line indicates the oscillations of the charge. At the time *o* there is a maximum charge in the primary circuit and no charge at all in the secondary or antenna circuit. Upon the passage of a spark across the spark gap in the primary circuit the charge begins to oscillate in the circuit and energy is transferred to the primary circuit, building up a charge therein. As soon as the charge begins to flow in the secondary circuit, electric waves begin to be emitted. The oscillation of the charge in the primary circuit continues, however, to transfer energy to the secondary circuit until finally at the time *y*, indicated in the

upper figure, so much of the energy has been transferred to the secondary circuit that the electrical pressure does not rise high enough in the condenser to any longer jump the spark gap. I have indicated by a dotted line *z* in the upper sketch the pressure corresponding to that necessary to cause current to flow across the gap, and since the voltage at the time *y* fails to rise to that necessary the primary circuit ceases to have current oscillating in it.

The current in the secondary circuit, however, continues to oscillate, and there being no spark gap in the antenna circuit to waste energy the oscillation continues until it has been radiated in the form of electric waves. Theoretically this oscillation would go on forever, but practically of course the waves die out, and it is customary to state the number of oscillations taking place as the number which has occurred when the oscillating charge has fallen to 1 per cent of its maximum value. It will be understood that the Waterman sketch No. 2 is merely a free-hand sketch, not drawn to scale, and that it illustrates the whole of the operation of the primary circuit and the most significant part of the oscillations of the secondary circuit.

In this manner, as a result of the resonant relation of the two circuits, energy is first taken in the primary circuit which cannot radiate it, and is transferred from that circuit in the form of resonant oscillations set up in the secondary [fol. 308] circuit. If the circuits are properly adjusted and also properly associated with one another, this transfer takes place as indicated in the sketch No. 2, the antenna circuit gradually taking over the energy from the primary circuit and then radiating it in this space. It will be seen that this corresponds to the description of the specification which I have quoted from page 2, lines 25 to 38, which says in the last sentence:

"If the capacity, inductance, and the resistance of the circuit are of suitable values, the discharge is oscillatory, with the result that only currents of high frequency pass through the primary of the transformer and induce similar oscillations in the secondary, these oscillations being rapidly radiated in the form of electric waves by the elevated conductor."

Degree of coupling or association of circuits: The association, or as it is called at the present time the coupling of

the two circuits, must not be too close if the best results and the precise results indicated in Waterman sketch No. 2 are to be obtained. The desired looseness of association or coupling is obtained in the illustrated arrangement of the patent by using in the secondary of the oscillation transformer *d'* only two turns of wire and only a single turn in the primary circuit. A similar result can be obtained of course by using more turns and increasing the separation between the two circuits.

The transfer of energy from one circuit to the other occurs, as I have explained, as a result of the "cutting" or "threading" of the secondary circuit by magnetic lines of force produced by the other. The closest association of the two circuits which could exist would be the condition in which every line of force produced by either one is so located as to cut the other. It is customary to express the coupling in terms of a percentage and the condition just mentioned where every magnetic effect produced by one circuit was experienced by the other would be stated as 100 per cent coupling. Such a coupling is neither possible nor desirable. It is not possible because many of the magnetic lines of force produced in this circuit must of necessity be produced by portions of the circuits not in proximity to one another, and it is not desirable because a too close association of circuits will result in a retransfer of energy from the antenna back to the primary circuit, thus producing a great waste of energy and also a disturbance of the regular and rapid radiation of waves of which the patent speaks.

The percentage of coupling existing in the transmitter is expressed as the ratio of the number of lines of force actually common to the two circuits to the maximum number possible. This at least is as nearly an accurate statement as can be made in simple terms. In mathematical terms the coupling is equal to the mutual inductance of the two circuits divided by the square root of the product of their self-inductances. Mutual inductance is the effective number of lines of force produced by one circuit, which is linked with the second circuit for each unit of current employed in the first circuit.

In view of this definition of coupling, it is apparent that the coupling or association between the two circuits can be affected by varying either the number of turns in the oscillation transformer or by varying the number of turns in the

coil outside of the oscillation transformer, as for instance the coil *g* in Figure 2 of the Marconi patent. It can, as stated, also be varied by varying the separation of the coils. [fol. 309] All three of these methods are employed in practice in obtaining the most advantageous degree of association of the two circuits.

If the circuits are too closely associated, defects of operation occur as the result of the reaction of the secondary circuit back upon the primary circuit. It will be seen that since two circuits are associated so that energy may be transferred from the nonradiating circuit, to which the charge is initially given, over into the radiating circuit it necessarily follows that the oscillations occurring in the secondary circuit would have a tendency to react and produce oscillations in the primary circuit and thus transfer the energy which the antenna circuit has received back into the primary circuit instead of radiating it. If the association of the two circuits is so close that this tendency to the backward transfer of energy is great enough to cause the spark gap in the primary circuit to be broken down, then energy will be retransferred back to the primary, thus wasting it in the spar gap instead of radiating it as an electric wave.

It is evident that such radiation as takes place in the antenna under such circumstances will be very much less than would take place with a proper association of the circuits; and further, such a retransfer of energy to the primary circuit disturbs the radiation which does occur, so that the circuit behaves as though it were radiating two waves at once instead of only one. Further, neither of these is the correct wave which it should radiate.

It is important, therefore, in order that the efficient radiation to which the patent refers may be secured that the association between the two circuits should not be so close as to permit the secondary circuit to break down the spark gap by reaction upon it. When the association is a proper one the oscillation of the primary circuit will cease, as shown in Waterman sketch No. 2, as soon as the primary circuit has transferred its energy to the secondary and the more quickly this can be done the better, because the smaller will be the energy consumed in the primary circuit itself and the greater will be the amount remaining to be radiated.

It will be observed that the resonant relation between the two circuits, as set forth in the patent, is stated in some-

what mathematical terms—that is, as equality of the products of the capacity and the self-inductance in the two circuits. It must not be understood from this that effective operation requires a rigidly or mathematically exact adjustment of the two circuits, nor that the mathematical statement expresses the way of doing it, for neither of these things is true. No mathematically exact or precise equality between the circuits is realizable in practice, but it is important to the efficient transfer of energy that this equality should be approximately or substantially attained.

Circuit-adjusting means: The specification says, on page 3, line 12:

"The adjustment of the self-inductance and capacity of any or all of the four circuits can be made in any convenient manner and employing various arrangements of apparatus, those shown and described herein being preferred."

Referring to Figure 1 of the patent, or Figure C of plaintiff's Exhibit No. 99, it will be seen that the inductance of the antenna circuit is made variable by the adjustment of [fol. 310] the contact point thereon so as to include in the circuit more or less of the turns of wire constituting that coil. The primary circuit is described as preferably provided with an adjustable condenser whereby the products of capacity and inductance in that circuit may be adjusted. Thus the specification says, page 1, line 88:

"A condenser *e*, preferably one provided with two telescoping metallic tubes, separated by a dielestric and arranged to readily vary the capacity by being slid upon each other, is included in one connection from the induction coil to the transformer-winding *d*."

In practice it is customary to either build or adjust one of the circuits to the desired wave length or frequency of oscillation and then adjust the other to it after the apparatus is set up ready for operation. If it is not desired to change the wave length, no further adjustment is required. If it is desired to sometimes operate at one wave length and sometimes at another, then if good results are to be desired both circuits must be changed to the desired wave length. Sometimes this is done by providing a switch or switches by which, after the initial adjustments for each position of the switching apparatus have been made, changes can be quickly

made from one wave length to another with a certainty that the two circuits are always in resonance with one another.

Illustrative transmitters of the patent: I have called attention to the fact that the specification refers to the use of the inductance coil *g* in the antenna circuit as optional or "for the best results," and that it refers to the complete system as one provided with all of the described adjuncts. By way of illustration of various ways of embodying the invention the specification gives, on page 4, in tabular form various arrangements marked "tune 1," etc., six arrangements being described.

Plaintiff's Exhibit No. 99 gives, in Figures D, E, and F, the several combinations indicated in this table, the indication being, of course, in diagrammatic form. Thus tunes 2 and 4 are illustrated by Figure D, tunes 1, 3, and 5 by Figure E, and tune 6 by Figure F. It will be noted that tunes 2 and 4 employ the inductance coil *g* in the antenna circuit, while tunes 1, 3, 5, and 6 do not. Tunes 1 to 5, inclusive, have an oscillation transformer, having only one turn in its primary and two in its secondary, while tune 6 has a number of turns in both the primary and secondary windings.

Receiving apparatus: Referring now more particularly to Figure 2, the receiving apparatus, there illustrated, shows the complete arrangement with all of the adjuncts and tuning devices necessary for the most complete and perfect realization of the several objects of the invention. On page 4, there is given a table of receiving station arrangements in which the several instrumentalities shown in Figure 2 and described in the specification are combined in various ways and in simpler combination than in the complete apparatus of Figure 2. Most of these variations have to do merely with the presence or absence or completeness of the adjusting means provided for the resonant adjustment of the two circuits.

In Figure 2 the means for collecting energy from the radiated waves as they pass the receiving station is the elevated wire A and capacity area *f'*. For the purpose of getting the desired degree of resistance and also correctly determining the wave length, the coil *g'* is inserted in this circuit. Instead of placing the detector in the an- [fol. 311] tenna circuit as in the arrangement of the prior Marconi patent No. 11913, referred to in the specification, an oscillation transformer primary coil *j'* is inserted, and as a further means of tuning the circuit, a condenser *h*

whose capacity is variable is employed, if desired. Thus, the specification says, page 2, line 83:

"In a shunt around said primary j' I usually place a condenser h."

This condenser is said to be similar to the condenser e, which is described as adjustable. The word "shunt" used in the above quotation means a by-path, and the application of the term is evident from the drawing.

This condenser h has no important or modifying effect on the general mode of operation, but is merely a means for varying the capacity of the antenna circuit and hence of providing a way of altering or adjusting the wave of length of the circuit to agree with that of a signal to be received.

The secondary or local receiving circuits are arranged in such manner in the drawings as appear to be more complex than they really are, and I therefore have made a sketch illustrating Figure 2 without altering the essential relation of the parts or their mode of operation. In preparing this drawing I have used the same letters of reference as are used in the patent but I have in some instances varied the symbols employed to correspond with more ordinary present-day conventions, particularly as there are already in the record many circuit diagrams which employ these newer conventions.

Referring to the sketch, which I call "Waterman sketch No. 3." Marconi simplified receiving circuit, the antenna circuit, which is shown for the sake of completeness is in no way modified. It comprises the capacity area f, vertical wire A, variable loading coil g', tranformer primary j', variable condenser h, and earth connection E. Associated with the primary of the oscillation transformer is the secondary winding j^3 whose two ends are connected with variable inductances or secondary loading coils g^2. In the figure of the patent this secondary winding is divided in the middle to permit the connection therein of the condenser j^3. This, however, has no essential relation to the mode of operation but is merely a refinement, and I have therefore not shown the parts arranged in that manner in my sketch.

Across the terminals of the secondary and the adjustable inductances g^2 is a variable condenser h', regarding which the specification says page 2, line 109:

"A condenser h' is sometimes included in a shunt around the detector T."

The use of this condenser is therefore not required, but it is employed as a convenient mode of varying the time period or wave length of this local circuit, and thus bringing about the adjustment to resonance, which the specification describes. In any case it is merely an exterior capacity added to the capacity of the secondary circuit itself, and it is employed because such a small condenser can easily have its capacity varied when desired, while only the inductance of a coil can conveniently be altered. Means for altering the inductance in the circuit is shown at g^2.

The terminals of the secondary coil are connected, in this instance through the inductance coil g^2, to the detec- [fol. 312] tor T, the condenser j^3 being in series therewith, as in Figure 2 of the patent. The purpose of this condenser j^3 is merely to afford a convenient way of associating the indicating device or telegraph instrument I with the circuit without interfering with the oscillations set up therein by the wireless waves. The most advantageous construction of an indicating or telegraph instrument device for such purpose is generally incompatible with good results if it is placed directly in the high-frequency oscillating circuit. It is therefore customary to connect it in the manner shown by Marconi, namely, with a condenser, such as j^2 connected across its terminals. If this condenser is of considerable size, it has very little effect upon the oscillatory currents in the circuit, but it compels the battery current of the local battery to take its proper course through the detector and so permits the indicating device to respond.

It is a curious fact which must be borne in mind in dealing with wireless telegraph circuits that for the purposes of the high-frequency oscillatory currents a large condenser acts almost like a continuous wire, and when placed in a circuit in series or tandem relation with a small condenser it has very little effect.

Around this condenser j^3 is connected the indicating device R, with its local battery B and two small "choking" coils $c' c^2$. The purpose of these coils is merely to exclude the oscillatory currents from the indicating device. In modern practice these coils are usually omitted because the indicating device itself can just as well be constructed

to exclude the oscillatory currents by giving it a sufficient amount of inductance.

In connection with Figure 2, I call attention to the reproduction thereof in plaintiff's Exhibit No. 99, Figure C, where the antenna circuit is shown in black lines, the path of the oscillatory currents through the secondary circuit is indicated in red, and the local indicating circuit is shown in green. In this arrangement the condenser j^3 is connected into the middle of the secondary coil, but this is entirely immaterial, as it may be put anywhere else in the circuit, so long as it takes with it when it is moved the terminals of the indicating or green circuit.

Operation of receiver: The operation of this complete apparatus is as follows:

When the wireless waves are sent out from a transmitter they pass the receiving station, moving with the speed of light. Being of conducting material the antenna circuit, raised high in the air, is not transparent to the waves, but intercepts that portion of them passing the point where it is located and absorbs the energy of that portion with the result that a charge is communicated to the antenna which oscillates in the form of a current therein. The oscillation of the current through the primary coil j' produces a magnetic field which threads the secondary coil j^2 and sets up therein another current which oscillates by virtue of the inductance and capacity of the secondary circuit. Across this secondary circuit is connected a detector T which, responding in any appropriate way to the electromotive force thus brought to bear upon it, causes the indicator R to act.

Character of detector: As to the particular character of this detector or, as the specification also calls it, "responder," the specification says on page 2, lines 57 to 77:

[fol. 313] "As a responder to electric waves I may use at the receiving station any of the now well-known forms of such devices, such as those which depend for their action on the reduction of the resistance of a metallic microphone by the action of electric waves or 'coherers,' one form of which is disclosed in my patent No. 586193, or I may employ one which depends for its action on the increase of the resistance of the device under the influence of the electric waves or 'anticoherers,' such as described by Branly in

La Lumiere Electrique of June 13, 1891, or I may use those which depend upon the action of an electric wave as a magnetizing or demagnetizing agency, such as I have disclosed in my application, serial No. 132974, filed November 28, 1902, or I may use various other well-known devices, such as the electrolytic, electrothermal, electromagnetic, or electrodynamic responders."

Again, on page 2, lines 106 to 107, the specification refers to the device as "a coherer T or other detector of electrical oscillations."

It is therefore evident that the precise action which takes place in the detector depends upon the particular character of the detector employed. The mode of operation of many of the detectors in common use is not well understood, but most of them appear to operate by reason of some change in their resistance produced as a result of the arrival of the electric waves. Some of these detectors in commercial use require the presence of a local battery B; others may be used either with or without it, and some work better without it.

If the detector employed is a coherer or sensitive tube, just as was most commonly employed at the date of the patent, then the effect of the charge imparted to the secondary circuit and by it to the tube had the effect of lowering the resistance until a sufficient current was able to flow from the battery B to operate the indicator R. If the detector is of the electrolytic or electrothermal type, such as the crystal detector, for instance, then it acts apparently to permit the flow of current in one direction through it but to exclude a flow in the opposite direction. This permits or crosses a variation of current through the indicating device R, if there is a local battery present, or causes the flow of a portion of the current received from the waves through the indicator if there is no local battery present.

Illustrative receivers of patent: As the specification points out, in order to obtain good results it is essential that the received energy should be effectively transferred from the antenna circuit to the secondary circuit, and to produce this result the patent states that the secondary circuit must be placed in resonance with the antenna circuit by the adjustment to the proper value of the products of inductance and capacity in that circuit.

As I have already pointed out, this does not mean the two circuits must have the same inductance and the same capacity, but only that their product should be the same. This makes it possible to construct the two circuits, each to best fulfill the purpose to which it is put and to provide fixed adjustments or variable adjustments as may be most convenient for specific installations.

As illustrating these various ways in which the elements useful in a receiving apparatus may be combined a table is included on page 4 which, taken in connection with the descriptive matter on pages 3 and 4, specifies six illustrative arrangements.

These illustrative arrangements are diagrammatically shown in plaintiff's Exhibit No. 99, Figures G, H, I, and J. [fol. 314] Figure G illustrates the combination of elements specified in the table as to tunes 1, 5, and 6. Examination of Figure G and a comparison with Figure C (or with Figure 2 of the patent), shows that the arrangement of these tunes differ in that the coil g' and condenser h are omitted from the antenna circuit and the condenser h' is omitted from the secondary circuit. Remembering that the condenser j^3 in the secondary circuit is merely a means of connecting the indicating device it will be seen that in this instance the secondary circuit has no condenser at all but the entire capacity utilized in making the circuit resonant to the antenna circuit is the capacity of the devices themselves. It will also be noted as to the arrangement of Figure G that there is omitted from the secondary circuit the adjustable inductance coil g^2 and in fact that in neither of these circuits is there any adjusting device.

This arrangement of tunes 1, 5, and 6 is therefore the simplest possible arrangement of the apparatus which is specified. Such a receiving station arrangement would be used at a station designed always to receive waves of one wave length only and both circuits would be constructed to be of this wave length, the adjustment of the capacity and self-induction for both circuits being made once for all in the setting up of the installation.

Figure H illustrates the arrangement of tune 2. In this arrangement both circuits have adjusting means, that of the antenna circuit being found in the coil g^1 and that of the secondary circuit being the variable condenser h'. The arrangement differs from the complete system shown in Figure 2 in that the variable condenser h is omitted from

the antenna circuit and the variable inductances g^2 from the secondary circuit.

Figure I shows the arrangement specified as to tune 3. In this the primary circuit—that is the antenna circuit—is identical with that of Figure 2, but the secondary circuit has no means of variability since it has neither the inductance coil g^2 nor the variable condenser h'. In this instance the secondary must be constructed to be in tune for a particular wave length by having its parts so constructed as to have the desired capacity and inductance built into them. To efficiently receive some other wave length for which the antenna circuit might be readjusted by the variable adjusting device which it contains another secondary circuit might be substituted or another oscillation transformer and its adjuncts.

Figure J differs from Figure 2 only in that the variable condenser h' is omitted, and differs from Figure I in that the variable inductance coils g^2 are added. In this arrangement, therefore, as in Figure 2 and in Figure 8, both of the two circuits have variable means of adjusting the time periods of the two circuits to resonance with one another.

As to all of these arrangements as well as the arrangement of Figure 2 (the latter showing the receiving station in its most complete form), the description of the specification applies, namely, that the two circuits are so adjusted with reference to one another as to be in electrical resonance, that is to have like products of capacity and inductance.

As in the case of the transmitting apparatus, it should be borne in mind that this adjustment is not a mathematical but a manipulative operation and that it is indeed [fol. 315] very difficult to know precisely what the capacity of either circuit or their inductance of either circuit is in numerical terms. In any case, therefore, the construction or adjustment is made by reference to a known standard or to response to a given wave. Further, this adjustment is not one requiring mathematical precision nor indeed is such precision attainable, but in general substantial attainment of the resonant relation is essential to the best results and the nearer it is attained the better will be the result.

On page 3 the specification gives specific directions for the construction of a number of receiving-station oscillation transformers, descriptions being made in connection with

Figures 5 to 8. The figures show various mechanical arrangements which, I take it, it will not be necessary to consider specifically. I will merely point out, therefore, that in Figure 8 the primary and seconda-y coils are wound upon separate insulating tubes, one of which is arranged to slide into and out of the other for varying the "coupling" or association of the two circuits. This is a mode of construction which has been most commonly employed in practice.

Of the claims referred to in the question, claims 1, 3, 6, 8, 11, and 12 descriptively relate to the transmitting station, claims 2, 13, 14, 16, 17, 18, and 19 to the receiving station, and claims 10 and 20 to both. I here quote these claims in groups as above recited:

Transmitting-station claims:

"1. At a station employed in a wireless-telegraph system, a signaling instrument comprising an induction coil, the secondary circuit of which includes a condenser discharging through a means which automatically causes oscillations of the desired frequency; an open circuit electrically connected with the oscillation producer aforesaid and a variable inductance included in the open circuit, substantially as and for the purpose described."

"3. At a station employed in a wireless-telegraph system, a signaling instrument comprising an induction coil, the secondary circuit of which includes a condenser discharging through a means which automatically causes oscillations of the desired frequency, and the primary circuit of which includes a generator; means for varying the primary circuit; an open circuit electrically connected with the oscillation producer aforesaid, and a variable inductance included in the open circuit, substantially as and for the purpose described."

"6. At a transmitting station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating conductor at one end and capacity at the other end, and whose primary is connected to a condenser circuit discharging through a means which automatically causes oscillations of the desired f-equency, and means for adjusting the oscillation period of each of the two circuits connected with the transformer to bring them into accord with each other, substantially as described."

"8. At a transmitting station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating conductor at one end and capacity at the other end, a variable inductance being included in said circuit, and whose primary is connected to a condenser circuit discharging through a means which automatically causes oscillations of the desired frequency, substantially as described." [fol. 316] "11. In apparatus for communicating electrical signals, the combination with an oscillation transformer, at a transmitting station, of an induction coil; an electric circuit containing the secondary of said coil, a condenser and the primary coil of the oscillation transformer; a producer of electric waves of high frequency electrically connected with the secondary of the induction coil; a signaling instrument in circuit with the primary of the induction coil; the secondary coil of the oscillation transformer electrically connected, at one end to capacity and, at the other end, to an inductance, and an aerial conductor connected to the inductance, substantially as and for the purpose described.

"12. In apparatus for communicating electrical signals, the combination with an oscillation transformer at a transmitting station of an induction coil; an electric circuit containing the secondary of the said coil, a condenser and the primary coil of the oscillation transformer; a producer of electric waves of high frequency connected with the secondary of the induction coil; a signaling instrument in circuit with the primary of the induction coil; the secondary coil of the oscillation transformer electrically connected at one end to capacity and at the other end to a variable inductance, and an aerial conductor connected to the variable inductance, substantially as and for the purpose described."

Receiving-station claims:

"2. At a station employed in a wireless telegraph system, an oscillation-receiving conductor, a variable inductance connected with said conductor, a wave-responsive device electrically connected with said conductor and in circuit with a condenser, substantially as and for the purpose described."

"13. At a receiving station employed in a wireless-telegraph system, the combination of an oscillation transformer, an open circuit connected with one coil of said

transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a variable inductance being included in said circuit, a wave-responsive device electrically connected with the other winding of the oscillation transformer, and a condenser in circuit with the wave-responsive device, substantially as described.

"14. At a receiving station employed in a wireless-telegraph system, the combination of an oscillation transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a wave-responsive device electrically connected with the other winding of the oscillation transformer, and means for adjusting . . two transformer circuits in electrical resonance with each other, substantially as described."

"16. At a receiving station employed in a wireless-telegraph system, the combination of an oscillation transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, an adjustable condenser in a shunt connected with the open circuit and around said transformer coil, a wave-responsive device electrically connected with the other coil of the oscillation transformer, and means for adjusting the two transformer circuits in electrical resonance with each other, substantially as described.

[fol. 317] "17. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and means included in each of said transformer-circuits, for adjusting said circuits in electrical resonance with each other, substantially as described.

"18. At a receiving station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end, and capacity at the other end, a variable inductance being included in said open circuit, a wave-

responsive device electrically connected with the other winding of the oscillation-transformer, and a variable inductance included in circuit with the wave-responsi*be* device, substantially as described.

"19. In a system of wireless telegraphy, the combination at a receiving-station, of an oscillation-transformer; an open circuit comprising, in part, an aerial conductor connected with one end of the primary coil of the oscillation-transformer; a connection from the other end of said coil to capacity, a variable inductance in said open circuit, and electrical connections from the secondary coil of the oscillation-transformer to a receiving instrument, battery, condenser, wave-responsive device, and a variable inductance, substantially as and for the purpose described."

Claims covering both stations:

"10. A system of wireless telegraphy, in which the transmitting-station and the receiving-station each contains an oscillation transformer, one circuit of which is an open circuit and the other a closed circuit, the two circuits at each station being in electrical resonance with each other and in electrical resonance with the circuits at the other station, substantially as described."

"20. In a system of wireless telegraphy, a transmitting-station containing an oscillation-transformer, the primary of which is connected to a condenser-circuit discharging through a spark-gap which automatically causes electric waves of the desired frequency, the secondary of said transformer connected to an open circuit including a radiating-conductor, and with a capacity and a coil for charging the condenser aforesaid; a receiving-station containing an oscillation-transformer, the primary of which is connected with an oscillation-receiving conductor and with a capacity, a wave-responsive device connected with the secondary of said transformer, and a receiving instrument connected with the wave responsive device, all in combination with means for bringing the four transformer-circuits, two at each station, into electrical resonance with each other, substantially as described."

I have, I believe, already defined the technical terms employed in these claims, and explained the mode and operation of the apparatus described in the specification, and I

assume, therefore, that it will be unnecessary for me to explain the language of the claims in detail.

8. Question. You have used the term "tuning" and also the words "syntony" and "selectivity" with respect to each of the three patents considered in your last preceding [fol. 318] answer, and in respect to the last three patents you have also used the expressions "tuning" and "resonance." To avoid misunderstanding and make more clear the meaning of the several patents and the distinction between the apparatus which they describe, will you please point out the meaning of these terms as employed in connection with the Marconi reissue patent No. 11913, the Lodge patent No. 609154, and the Marconi tuning patent No. 763772?

Answer. In the terminology of the practical art these three patents have been commonly known, respectively, as "the plain antenna patent," referring to reissue patent No. 11913; the Lodge "loading coil patent," corresponding to No. 609154; and "tuning patent" or the "four-circuit tuning patent," corresponding to patent No. 763772. These designations very well illustrate the relation in which the patents stand.

The Marconi patent, No. 11913, disclosed to the world the idea of emitting electric waves from and receiving them by grounded antennae. The antennae consisted of elevated capacity areas having vertical wires connecting them to the transmitting and receiving apparatus, respectively, and thence to the earth. This first Marconi patent directs that the elevated plates or capacity areas are "preferably electrically tuned with each other," and on page 4, line 123, it appears that this preferable tuning is accomplished by making the elevated conductor at the receiving station similar to that of the transmitting station.

The idea of tuning as set forth in this reissue patent was therefore the idea of constructing the receiving station so that it should be identical with the transmitting station, to the end of localizing at the receiver the messages from this particular transmitter. There was involved here only the simple idea of a transmitting and a receiving station, each established to cooperate with the other, and the idea of constructing them to be similar to one another in their physical dimensions was to assist in localizing correspondence between them.

The apparatus of this first patent, while, of course, immensely useful, and particularly with respect to the grounded antenna construction, the foundation of all practical wireless telegraphy, was not particularly successful in respect of localizing messages. This was because the radiator radiated too rapidly to be sufficiently definite in its frequency, and the receiver absorbed too readily, and hence absorbed waves of different length and frequency from that which was intended.

The Lodge patent, No. 609154, employed the term "syntony" to designate this interstation tuning referred to in the Marconi reissue patent, and provided means of realizing more effectively Marconi's idea of localizing a particular message at the designated receiving station. He also introduced the idea of varying the frequency of oscillation or wave length characteristic of both a sending and receiving station in order that a plurality of stations might selectively operate one with another, thus making the system more flexible, so that a receiving station might receive from any one of a number of transmitting stations and a transmitting station to transmit to any one of a number of receiving stations.

This idea of selective syntony between stations has been designated in the art by the terms "syntony," "selectivity," and "interstation tuning," or, for short, simply "tuning."

[fol. 319] In the early Marconi patent and in the Lodge patent no other use of the idea of resonance is made. They relate exclusively to interstation communication by localizing messages at the desired station. This localizing involves two ideas—first, the idea of avoidance of interference, and, second, that of better reception, as I have already explained.

The Marconi patent No. 763772 also aims at the localization of messages at a selected receiving station, but in addition it introduces the idea of employing at each station both a radiating and a non-radiating circuit and effectively transferring energy by tuning these circuits to resonance. Marconi thereby enabled much more energy to be imparted to the radiator by coupling to the transmitting antenna a reservoir circuit. With such a circuit tuned to substantial resonance with the antenna circuit not only may much more energy be imparted to the radiator, but the radiated waves may be made still more prolonged and definite as

to frequency, and thus this intercircuit tuning becomes also a means of improving the quality of interstation tuning.

At the receiving station also the tuning to resonance of the absorbing antenna circuit and the nonabsorbing and nonradiating local circuit produces a more definite and less damped oscillation of the receiving antenna and a more effective accumulation of the energy from a distant station.

Thus this idea of resonance between local circuits in the Marconi second or tuning patent is an entirely different thing from the interstation tuning, referred to in the first Marconi patent and the Lodge patent, but it is a means which, while increasing the energy and the distance of signaling, possible with antennæ of given dimensions, also improves and facilitates interstation tuning.

In the first Marconi patent and in the Lodge patent there is one circuit at the transmitting station and one circuit at the receiving station tuned to agree with the transmitter. In the arrangement of the second Marconi patent there are two circuits tuned to resonance with one another at the transmitting station and two circuits tuned to one another at the receiving station, these circuits being also tuned to the wave length emitted by the transmitting station.

9. Question. Please compare the construction and mode of operation of the apparatus or elements of each of the radio systems, respectively described by Messrs. Weagant, Graham, and Langley in their depositions herein, and diagrammatically illustrated in plaintiff's Exhibits No. 79, "Drawing, Telefunken apparatus"; No. 87, "Drawing, Wireless Specialty Apparatus"; No. 87a, "Wireless Specialty Apparatus Co. instructions for I-P-76 set"; No. 88, "Drawing, Wireless Improvement Co. Apparatus"; No. 89, "Drawing, Simon apparatus"; No. 93, "Drawing, type of r-dio apparatus manufactured by Navy"; and No. 95, "Drawing, Wilbourne & Clark type of radio apparatus," referred to, respectively, by them in their depositions, with the construction and mode of operation of the radio system and apparatus of the inventions described in the Marconi patent No. 763772, and claimed in claims 1, 2, 3, 6, 8, 10, [fol. 320] 11, 12, 13, 14, 16, 17, 18, 19, and 20, pointing out, in your opinion, the similarities and differences between said systems and apparatus of said patent, as referred to in said claims, and the said systems and apparatus de-

scribed by Messrs. Graham, Langley and Weagant, and illustrated in said exhibits, giving your reasons for any opinion you may express. In making the comparison you may, if you desire, make any sketches or drawings you deem necessary and refer to any other exhibits introduced herein in support of any opinions you may express.

Answer. A comparison of the exhibits referred to in the question, namely, plaintiff's Exhibits Nos. 79, 87, 87a, 88, 89, 93, and 95, and Figures 1 and 2 of the second Marconi patent No. 763772 in suit and Figure C of Exhibit No. 99, which is a colored reproduction thereof, shows them to be substantially alike, the differences being all of minor and unimportant character. In each there is for each station shown a similar combination of similar elements; thus each transmitting station shown in these exhibits comprises a power circuit and operator's key, shown in yellow, a local closed nonradiating oscillatory circuit, consisting of a reservoir condenser *c*, an inductance *d*, and a spark gap G, and each of these closed reservoir circuits has some means, indicated by an arrowhead, for adjusting the time period of oscillation of the circuit. Each transmitting station also has an open radiating circuit, comprising an elevated capacity area *f*, a vertical wire *a*, connected through the transmitter to the earth at E, and each has an inductance coil *d'*, acting also as the secondary in the oscillation transformer. Some of these transmitters also have the separate inductance coil *d* and all have means, indicated by one or more arrowheads, for varying the time period of oscillation of the circuit.

It will perhaps be convenient to select one or two of these exhibits and consider the structure disclosed and then consider the others so far as they differ from the ones selected.

Comparison of apparatus of Marconi patent 763772 and Wireless Specialty Apparatus transmitter.—Referring to plaintiff's Exhibit No. 87, showing the apparatus of the Wireless Specialty Apparatus Co., and comparing the apparatus as described by Mr. Langley, and in several other exhibits pertaining thereto, as for example plaintiff's Exhibit No. 60, Navy contract No. 132, plaintiff's Exhibit No. 62, plaintiff's Exhibit No. 87*a*, the whole apparatus may be clearly understood.

Comparing it with plaintiff's Exhibit No. 99, Figure 6, which is a reproduction in colors of Figures 1 and 2 of

the Marconi patent No. 763772, it will be seen that the yellow, red, and black circuits at the transmitting stations are identical, in that each has a source of current *a*, a key *b*, and a transformer or induction coil *c*. in its yellow circuit. In its red circuit each has a condenser *e*, the primary *d*, of an oscillation transformer, a spark gap G. The sole difference between this red circuit of Exhibit No. 87 and that shown and described in the Marconi patent is that the inductance of the oscillation transformer primary *d* is variable and the condenser fixed, while in the Marconi description the reverse is true, as there the condenser is [fol. 321] variable and the inductance *g* is fixed. Since these are merely the means of adjusting the time period of the circuit in each case, it is clear that the circuits in substance are identical.

Similarly comparing the black circuits of the transmitting station, each has the following elements:

An elevated capacity area *f*, a vertical wire A, a variable inductance coil *g*, a secondary *d'* of an oscillation transformer, and earth connection E. The sole difference is that the number of turns of the oscillation transformer secondary *d'* in Exhibit No. 87 is indicated as variable, while it is not so described in this Marconi's patent, although oscillation transformers having different numbers of turns are described.

In elements, therefore, and in the presence of adjusting means, the transmitter of plaintiff's Exhibit No. 87 is identical with that of the Marconi patent No. 763772. That they are also identical in the adjustment of the two circuits to resonance, appears from plaintiff's Exhibit No. 60, for example, being Wireless Specialty Apparatus Co. Navy contract of September 21, 1912, in which I find the following:

"Wireless Specialty Apparatus Co. proposes to furnish apparatus as per the following details: * * * transmitting inductances will be supplied giving continuously variable wave lengths of 600 to 2,000 meters with no switches, exciting and radiating circuits, always in resonance and with maximum coupling."

Thus it appears that in addition to having the elements of this Marconi patent the circuits are particularly speci-

fied as being "always in resonance," as described in the specification of the Marconi patent. Again on the same point the witness Langley, in his reply to Q. 12, and referring to the transmitter of the Wireless Specialty Apparatus Co. says (MS. p. 190):

"The chief feature of the apparatus in question was this wave length changing switch and the means by which the proper tuning of the several wave lengths in the primary and secondary circuits could be accomplished."

Then in cross-examination, he was asked to state what he meant by tuning and stated in answer to X Q. 88 (MS. p. 221):

"The process of adjusting the closed circuit so that it will have the definite desired frequency and of adjusting the open or radiating circuit so that it will have independent of the closed circuit the same frequency."

Thus it is evident that this Wireless Specialty Apparatus transmitter of Exhibit No. 87 is subsequently identical with that of the Marconi patent, both in construction and mode of operation.

I may note that as regards the spark gap the contract, Exhibit No. 60, says:

"Quenched spark gap, new design, perfect cooling by special central draft. (We reserve right to furnish our new type tubular gap.) This latter having new feature of cooling and perfect sparking alignment with ease of dismantling)."

This emphasizes the cooling and hence the perfect operation of the spark gap indicating its ability to operate in the same manner as the apparatus described in Marconi patent whereby the efficiency of the apparatus is high and the amount of energy imparted to the radiator large.

[fol. 322] Comparing the receiving station type I-P-76 apparatus of Exhibit No. 87 with the colored diagram of Figure 2 of this Marconi patent, as found in Exhibit No. 99, each has an open oscillating antenna circuit, shown in black, a closed oscillating secondary circuit, shown in red, and a local indicating circuit shown in green. In each case, the open oscillating circuit has the following elements:

An elevated capacity area *f*, vertical wire A, a variable inductance coil *d'*, oscillation transformer primary *j'* and earth connections E. This Marconi patent also shows a condenser *h*, in the black circuit of Figure 2, which the Wireless Specialty Apparatus receiver does not have, it being in this respect like the antenna circuit set forth as to tunes 2 and 4 on page 4 of this Marconi patent. I have already called attention to the fact that the specification points out that the condenser *h* is not always used.

The secondary circuits of Exhibit No. 87 and Figure C of Exhibit No. 99 (Marconi patent, fig. 2) each contains the following elements:

Secondary j^2 of an oscillation transformer, variable condenser *h'*, detector T, "blocking" or "stopping" condenser j^3, and the green circuit connected around this condenser. The only difference between the two is that Figure 2 of this Marconi patent has the inductance of the circuit variable by the inclusion of variable inductance coils g^2, whereas in the receiver of Exhibit No. 87 the variable inductance is included in the secondary of the oscillation transformer j^2, as indicated at 7. This is a mere matter of detail, having to do with the mechanical method of associating the two circuits. If the two circuits *j'* and j^2 are made movable with respect to one another to vary the coupling in the circuits, then the same result exactly is obtained as though a fixed secondary were employed and exterior variable inductances g^2 used to vary the inductance.

The green circuits of the two receivers each contain local battery B and an indicating device R. This Marconi patent shows, in addition, in the green circuit choke coils c^1, c^2. These are not shown in Exhibit No. 87, it being customary to incorporate all of the choking effect necessary in the indicating device R itself. Exhibit No. 87 shows the variable resistance device P, often referred to as a "potentiometer." Its purpose is merely to give a more delicate adjustment to the amount of current flowing in the local circuit.

As to the adjustment of this receiver of Exhibit No. 87, it is evident that it has all of the adjusting means set forth in the Marconi patent for putting the two circuits in resonance. I find that the contract Exhibit No. 60 refers to

these receivers as "type I-P-76," and I find that Exhibit No. 87a is a pamphlet issued by the Wireless Specialty Apparatus Co. called "Instructions for I-P-76 set." On page 2 of this exhibit I find the following:

"The aerial, or antenna, is connected to A, and the circuit therefrom, after passing the variable inductance B and the transformer primary I J, is grounded at G. This circuit, which is called the primary circuit, is tuned or made resonant to any desired wave length by variation of either the loading inductance B, the primary I J, or by variations of both. The greater the number of turns of wire included in the primary circuit the greater is the inductance and hence the longer the wave length with which the circuit is in tune.

"Inductively coupled to the primary circuit is the secondary circuit H, including variable air condenser F. [fol. 323] This secondary circuit is tuned to the primary circuit either by variation in the length of the secondary winding or by variation of the capacity of condenser F. While it is possible to adjust the primary circuit by single turns, the secondary winding is made adjustable only by relatively large steps, so that for accurate tuning the condenser F must be used."

Again on page 10 it is stated:

"After the primary circuit has been tuned, the secondary circuit should be brought into resonance. This is accomplished by varying the number of turns in the secondary winding and the capacity of the variable air condenser F."

Other statements of like import might be quoted. Thus it is evident that this receiving apparatus has the two circuits tuned to resonance with one another by suitable adjustments of capacity and inductance.

Also it is evident from the quotations from this Exhibit No. 87a that the whole system consisting of two transmitting and two secondary circuits are in resonance with one another for the first of the above quotations particularly specifies tuning of the antenna circuit of the receiving station to the wave radiated by the transmitting station. Thus all four circuits are in tune, that is, in resonance, the circuits of the transmitting and receiving station respectively being likewise in resonance with one another.

I am personally very familiar with transmitters and receivers, such as are diagrammatically indicated in Exhibit No. 87 and have operated apparatus having identical elements arranged in the same manner, provided with the same adjustments and having circuits tuned to resonance in the same manner. I have also seen a transmitter manufactured by the Wireless Specialty Apparatus Co., although not one sold to the United States Government. I have seen and examined the Wireless Specialty Apparatus Co.'s I–P–76 receiver, which formed a part of the wireless telegraph apparatus exhibit by the Government at one of the electrical exhibitions in New York City and saw it operated by the operator in charge. I may say that I have owned and operated for a number of years transmitting and receiving apparatus, substantially identical with this Wireless Specialty Apparatus type shown in Exhibit No. 87.

From an examination of plaintiff's Exhibit No. 62, contract No. 170, dated April 14, 1912, and plaintiff's Exhibit No. 63, contract No. 19882, dated November 18, 1913, between the Navy Department and the Wireless Specialty Apparatus Co., as well as the exhibits heretofore mentioned, I understand that the apparatus called for in each of these contracts, is substantially the same in construction and mode of operation as already described above.

The details of the construction and mode of operation of this wireless telegraph apparatus of the Wireless Specialty Apparatus Co. are set forth in the deposition of Mr. Langley and as I have pointed out the elements and mode of adjustment and association of the several elements is substantially that specified in this Marconi patent.

Navy wireless specifications No. 16–T–5.—I however call attention in addition to plaintiff's Exhibit No 37, Navy wireless specification No. 16–T–5, which is referred to in plaintiff's Exhibit No. 60, contract No. 133, under this contract the apparatus of the Wireless Specialty Apparatus [fol. 324] Co was required to be in accordance with the specification except as modified in the contract. The specifications confirm the statements of the contract with respect to the resonance between the several circuits and confirm my opinion as to the essential likeness of the apparatus furnished under this contract with that of the Marconi patent, both in construction and mode of operation.

I call attention to the following quotations from this specification No. 16–T–5; from page 1:

"2. *Aerial* (furnished and installed by the Government.) —(*a*) The contractor shall specify in his bid such special requirements, if any, as to the constants and mechanical construction of the aerial, that it may insure the most efficient operation of the appliances under contract."

The term "aerial" is synonymous with antenna. This clause of the specification therefore shows that the Wireless Specialty Apparatus Co. was required to conform its apparatus to the antenna furnished by the Government and to furnish instructions to the Government as to the specific "constants" (i. e., capacity and inductance) and mechanical construction that it should have to go with the wireless telegraph apparatus to be furnished.

Page 2, under the heading "General design of the transmitter," paragraph 6 (*c*):

"(*c*) Constructions in which the exciting and radiating circuits can be simultaneously and rapidly altered in wave lengths over the entire available range for military purposes without alteration of syntony between the circuits or loss in power are preferred."

On page 3, paragraphs 7 (*h*, *i*, *j*), under the heading "The closed and open oscillating circuit of the transmitter, general":

"(*h*) The contractor shall furnish means by which the transmitting wave lengths can be quickly and easily changed, the apparatus to be permanently marked so that the transmitting wave lengths are known without recourse to diagrams or tables.

"(*i*) Facility for rapid changes is required for military purposes.

"(*j*) The apparatus shall be so constructed that the closed and open circuits of the transmitter can be easily adjusted to syntony for any wave length within the range of the apparatus."

On page 5, paragraph 12 (*a*, *f*), under the heading "Oscillation transformer and antenna helix":

"(*a*) The oscillation transformer shall consist of two inductively coupled coils with means for variation of coupling over a wide range. This range should include an indi-

cator and easily made adjustment for close coupling. The contract shall state the recommended normal degree of coupling and this shall be such as will give only one frequency in the antenna, the change of coupling to be made preferably by mechanical movement of one coil with relation to the other.

"(*f*) Preference will be given to designs embodying:

"(1) Means for continuous variation of inductance and consequent change of wave length by mechanical or other control at a distance, thereby eliminating the necessity for direct manual operation of the individual contact.

"(2) Means for variation of coupling by mechanical or other control at a distance."

[fol. 325] The oscillation transformer will be recognized as the part referred to in this Marconi patent and indicated in Figure 1 at *d*, *d'*. It is required in the above clauses to consist of two coils, just as in the Marconi patent. The preferred means of variation of the coupling or association between the primary and secondary coil is stated to be the mechanical movement of one relative to the other. I have explained in the foregoing answer that there are various modes of effecting a variation in coupling.

The "antenna helix," referred to above, is the Lodge coil, or loading coil, indicated at *g* of Figure 1 of this Marconi patent.

On page 5, paragraph 13 (*a*), under the heading "Spark gap":

"(*a*) The spark gap to be of approved design and to be adapted for reliable results in the frequent service incident to the work of the station."

Various forms of mechanical construction have been employed in making spark gaps, all aiming to get the best operation, namely, efficient transfer of the energy to the antenna circuit and then complete cessation of action. As briefly stating the facts in this regard I here quote from the Navy Manual of Wireless Telegraph of 1911, page 104, portions of paragraphs 152 and 153:

"152. A great deal of thought and ingenuity has been expended on improving the action of spark gaps. For instance, the use of magnetic blowouts induced and forced air

drafts across the gap; dividing them into a series of short gaps; placing gaps in parallel; inclosing them in compressed air and in nitrogen gas; making the points hollow and cooling them with air or water.

• • • • • • •

"The types of spark gaps now in use are shown in figures 52–61. The only types now supplied are figure 52, the synchronous rotating gap, and figure 57, quenched gap.

"153. The function of the spark gap in an oscillatory circuit is to allow the condenser to charge to the required potential and then to break down and permit the charge to surge back and forth until its energy is dissipated. The ideal spark gap would be one which would insulate perfectly while the condenser was charging and conduct perfectly while it was discharging, and the nearer these conditions can be fulfilled the more efficiently will the spark gap perform its duty. Either condition can be fulfilled alone, but the combination is somewhat difficult to obtain."

On page 9 of 16–T–5, paragraphs 21 (*b*, *c*), under the heading of "Wave lengths of transmitter":

"(*b*) The standard wave lengths shall be 425, 600, and 1,000 meters.

"(*c*) The radiation of each wave length to be practically equal."

This requirement that the radiation shall be equal no matter which wave length is used means that the circuits of the transmitter are to be in syntony or resonance with each other for each one of the required wave lengths, as is provided for in the quotations above rom pages 2, 3, and 5.

On page 9, paragraphs 25 (*a*, *b*, *c*, and *g*), under the heading "Receiver, general design":

"(*a*) The receiving system shall be of the inductive type with suitable provision for a wide range of variation in coupling.

[fol. 326] "(*b*) The range of adjustment for wave length shall be from 200 to 4,000 meters.

"(*c*) Means shall be provided for broadening the tuning of the receiver for the purpose of picking up signals over a wide range with minimum variation of the circuits and for

receiving strongly damped signals to best advantage. A method involving direct coupling will be considered in this connection.

"(*g*) Receiving system wherein the individual circuits may be placed in resonance as a unit with each other and with the incoming signals by the manual operation of a single mechanical element will be given preference."

This requirement for an "inductive type" receiver designates the particular type diagrammatically indicated in figure 2 of this Marconi patent, various forms thereof being indicated in figures 6, 7, and 8. The requirement for a "wide range for variation in coupling" implies some means of varying the association, as, for example, by the use of additional coils such as g^2, shown in figure 2, or by use of the construction, such as shown in figure 8, where the two coils are wound upon separate tubes, one slidable with reference to the other. The reference to "broadening the tuning" refers to the use of some means for permitting fairly efficient reception over a considerable range of wave length for which the receiver would be in approximate but not absolutely exact resonance. For example, the secondary circuit arrangement shown in Figure G of plaintiff's Exhibit No. 99, being the arrangement of tunes 1, 5, and 6 of the table on page 4 of this Marconi patent, is a circuit arrangement suited for this purpose, particularly when the receiving circuits are fairly closely coupled, as when the coils are of considerable size and in close association, as, for example, an arrangement such as figure 6 of the Marconi patent.

It will be noted both as to the transmitter and the receiver that the specification No. 16–T–5, particularly insists upon resonance between the two circuits and expresses a preference for a means whereby in changing from one wave length to another the circuits are automatically preserved in the resonance relation.

I find that the specifications attached to the contract, plaintiff's Exhibit No. 60, do not in any way modify these requirements; on the contrary, I have already quoted therefrom portions referring to the resonance of the circuits. The two are therefore in this respect in accord and cumulative.

The wireless-telegraph system of the Wireless Specialty Apparatus Co., as illustrated and described in the exhibits

referred to and in Mr. Langley's deposition, therefore substantially corresponds in elements, arrangement of circuits, and mode of operation to what is described in this Marconi patent and called for by the claims thereof recited in Q. 9. When installed and operated as the exhibits indicate was intended, this transmitting and receiving apparatus of the Wireless Specialty Apparatus Co. would derive its utility and operative efficiency in a large measure by reason of the constitution, arrangement, and adjustment of the two circuits at the transmitting station, and the two circuits at the receiving station, as set forth in the exhibits and testimony, which, as I have just noted, is the arrangement described and referred to in the claims in issue of this Marconi patent, [fols. 327-328] whereby the two circuits at each station are substantially tuned to resonance with one another—that is, to have the same time period—for, as previously stated, it is by virtue of this arrangement that more energy is imparted to the radiating antenna, that more prolonged and definite waves are radiated therefrom, and a more effective and selective accumulation of energy secured at the receiving station, and consequently a better transmission and reception of signals. The significance of the resonant or equal time period relation is fully recognized in the Government publications in evidence. For example, in the so-called Navy manual for 1913, plaintiff's Exhibit No. 78, on page 57, I find the following:

"89. In Figure 29a, A B and C D have been given some turns in common, forming an air core-auto-transformer, but, whether directly or inductively connected, these two circuits—the closed and open circuits—must have equal natural periods in order to produce and radiate electric waves efficiently."

Again, on pages 162 and 163, I find the following under the heading "Adjustments":

"This includes calibration and tuning. A station is tuned when both sending and receiving circuits are correctly calibrated, coupled, and adjusted to the standard damping and standard wave length.

• • • • • • •

"The closed sending circuit should be in resonance with the open circuit and the coupling and decrement of the

open circuit, such as to afford the necessary selectivity to the receiving circuit with the best efficiency of radiation.

"Receiving circuits to receive from such a sender should be in resonance with each other and with the sending circuits, and should have the same coupling as the sending circuits.

* * * * * * *

"Resonance is thus seen to be a vital quality in wireless-telegraph circuit. * * * (3) Resonance of closed oscillating circuit with open radiating circuit. (4) Resonance of coupled receiving circuits with each other and with coupled sending circuits."

Again, the Signal Corps book, "Radiotelegraphy," plaintiff's Exhibit No. 91, says on page 67:

"When the adjustments of a quenched spark transmitter have been correctly made—that is, the circuits are in resonance, the coupling is right, etc.—a simple experiment will show that the primary current is a minimum; that is, the spark has been quenched and the primary current has been stopped quickly, as at the point Q of Figure 53, and that at the same time the secondary current is a maximum; that is, it persists for a long time, as shown in Figure 56."

Again, at page 107:

"The tuning of the closed and open circuits to resonance and the determination of the correct coupling between them are the two most important adjustments in a quenched spark transmitter."

The expression, "decrement," used in some of the above quotations has reference to the rate of decay of the charge, and hence to the number of effective oscillations.

* * * * * * *

[fol. 329] *General operation of Wireless Specialty Apparatus.*—In using this Wireless Specialty Apparatus transmitter, the apparatus would be put in the desired position and the connections made as shown in the diagram. The first operation would be to make the necessary adjustments to insure the correct wave length and resonance between the two circuits in order to get an efficient transfer of energy. After starting and properly connecting the gen-

erator A the operator or installing engineer would press the key *b* by imparting a charge to the condenser *c* and setting up an oscillatory current in the red circuit by reason of the passage of a spark across the spark gap. By means of a suitable measuring instrument, he would then ascertain whether the product of capacity and inductance in the circuit was such as to give the desired time period or wave length and he would adjust the contact 3 until the correct time period was obtained. He would then proceed to adjust the black circuit, and the most convenient way of doing this is by means of a measuring instrument connected into the antenna circuit or otherwise associated with it, which will indicate the amount of current flowing in the circuit. By varying the contacts 1 and 2, it will be found that when the two circuits are in resonance a maximum current is flowing in the antenna circuit, this being an indication of a high efficiency resulting therefrom. In adjusting the contacts 1 and 2 the contact 2 would be so adjusted as to provide the proper coupling between the circuits and thereafter the contact 1 would be adjusted to give the correct wave length. In designing the antenna structure in the first instance this structure is designed with reference to the wave length or range of wave lengths for which it is to be used, and it is so designed as to require a suitable amount of inductance *g*, so as to give the desired number of waves for each charge imparted to the antanna. Thus this coil *g* is made to serve both the purposes of the Lodge coil, namely, to fix the wave length and establish a definite desired length of wave train. Once these adjustments are made, they need never be altered unless it is desired to transmit at some other wave length, and in this case the adjustments and operations are repeated for the new wave length.

It appears from the testimony of Mr. Langley that a wave-changing switch is provided with the apparatus whereby [fol. 330] by merely throwing this switch into one or another of several positions any one of several wave lengths may be used. In installing the apparatus, the installing engineer makes the adjustments as just described and permanently connects the ascertained points of contacts 1, 2, 3 to this switch, so that with the switch handle in a given position all of these contacts may be correctly made and the circuits will be in resonance. He then makes the ad-

justments in a similar manner for the second one of the desired wave lengths and connects the points 1, 2, 3 so ascertained to another set of contacts upon the switch. This is repeated for the several positions provided for in the specification No. 16-T-5, as for example 425, 600, and 1,000 meters. Thereafter all that the operator has to do is to actuate this switch to the position of the desired wave length and the circuits will be in resonance and the desired wave length secured with maximum efficiency. This is guaranteed in the contract, Exhibit No. 60, as already quoted.

The telegraph operator in using the apparatus therefore merely has to throw his switch to the desired wave length and press the key *b*. Thereupon a charge is imparted to the condenser, and when the condenser is fully charged a spark occurs at the spark gap, thereby setting the charge in oscillation. By virtue of the magnetic field thereby set up in the oscillation transformer energy is thereby transferred to the coil *d'* and a charge is thus imparted to the elevated conductor *f* of the antenna circuit, and because the circuits are in resonance this occurs in an efficient manner and a high voltage is developed in the antenna circuit. The charge thereupon oscillates between the elevated capacity area and the earth, setting up an oscillating electrostatic field and causing electric waves to be efficiently radiated. Because of the red or reservoir circuit a very much larger charge can be imparted than would otherwise be possible, and because of the resonant relation this charge is efficiently transferred and very intense electric waves are radiated. Thus all the benefits of the Marconi patent No. 763772 are secured. By the use of the Lodge loading coil *g* these waves are made more sustained and definite in frequency and exact determination of the wave length is effected, thus securing the benefits of the Lodge invention set forth in patent No. 609154. The antenna circuit is connected to earth, and thus the especially effective radiation of electric waves discovered by Marconi and set forth in his reissue patent No. 11913 result.

For the foregoing reasons I find combined in this Wireless Specialty Apparatus Co. transmitter the disclosures of the three patents just enumerated, the benefits of each being secured in full measure.

In using the Wireless Specialty Apparatus Co. receiver the connections to the antenna and earth constitute the only necessary acts of installation, as the receiver is com-

plete in itself. To receive a message the indicating device R, which in this instance is usually a telephone, is connected and the detector T suitably adjusted by manipulating the contact. The red circuit is then adjusted by moving the contact 7 and, if desired, also making use of the condenser h'. The mode of making the settings, or rather the position in which the adjustable devices are placed, are set forth in the instruction book, Exhibit No. 87a, with sufficient accuracy for a first approximation to any desired wave length [fol. 331] to be received. If it is desired that the operator should also be able to directly set the adjustments 4, 5, 6 of the antenna circuit to approximately the correct points for resonance, then it is necessary that the installing engineer should ascertain by means of a wave meter just what settings are required for a considerable number of wave lengths covering the range of the instrument when connected to that particular antenna and provide a table containing these ascertained adjustments for the use of the operator. The operator can then place the points 4, 5, and 6, as indicated by the table, for the desired wave length and proceed to listen for the desired signal. In doing this he will usually place the secondary coil j^2 of the oscillation transformer within or close to the primary coil j'. When he hears the signal he may alter the adjustments to suit his purpose, first, by getting more accurate adjustment to resonance between the two circuits, which will give him a louder signal; second, by selecting some other combination of adjustments, either for the purpose of getting a still louder signal or for the purpose of receiving with a higher degree of selectivity—that is, more effectively excluding other signals, should any others be heard. He may also adjust the coupling, as, for instance, by moving the secondary of the oscillation transformer, if he desires a still higher degree of selective reception.

As Exhibit No. 87a points out, various specific adjustments may be made to obtain any particular time period or wave length so that the operator may, for example, use a larger part of the winding j^2 and use little or none of the capacity of the condenser h' (the capacity of the coil itself being then relied upon), or he may use less of the winding of the secondary and more of the capacity of the condenser. The instruction book, Exhibit 87a, states on page 12:

"It will be seen from inspection of this table that most wave lengths can be tuned in by several different combinations of secondary windings and condenser capacity."

Examples are then given, and the instruction continues:

"In general the loudest signals are obtained with the longest possible secondary winding and the smallest condenser giving the desired wave length. The sharpest tuning, on the contrary, is usually obtained by using a shorter secondary and a larger capacity, for the reason that the detector circuit, which is practically the only source of energy for the secondary circuit, is connected in shunt therewith.

* * * * * * *

"For listening in, or receiving in the absence of interference, it is advisable to use the longest secondary and the smallest capacity that will give the desired tune, together with a fairly tight coupling; that is to say, the secondary should be well to the left and partly inside of the primary winding. In the event of interference, these conditions should be reversed, and a short secondary and a large capacity should be used, together with as loose a coupling as possible, the secondary being well outside the primary, to the right."

By such means the operator is enabled to suit the adjustment to his needs, obtaining the degree of loudness of signal and of sharpness of tuning or selectivity.

What happens in the receiver is that electric waves impinging upon the antena or black circuit of Exhibit No. 87 impart a charge thereto which oscillates between the elevated capacity area and the earth. This oscillation of the [fol. 332] charge produces an oscillating magnetic field by means of which the energy is transferred to the secondary or red circuit, creating an oscillating charge therein the characteristics of which depend upon how the adjustments have been made. If the two circuits are in resonance, as provided in the instruction book, Exhibit 87a, this transfer of energy will be very efficiently accomplished and the operator may determine the required degree of loudness of signal and selectivity to suit himself.

The oscillating charge causes a voltage or difference in potential to exist across the terminals of the condenser k' and the terminals of the coil, acting also as a condenser, and this voltage is impressed upon the parallel branch containing the detector T and stopping condenser j^3, the latter being so proportioned that the oscillating energy may freely pass through it. The detector T then functions, according to the particular method of the detector in use, the details of this action being, as I have said, not fully understood as to any detectors employed in practical wireless telegraphy. In the case of the crystal detectors, furnished under the contract, this action is understood to be such a variation of resistance as permits more current to flow in one direction than in the other. The effect of this is to stimulate a charge in the condenser j^3, thereby varying the current in the battery B through the indicating device R. As I have stated, the potentiometer P is merely a means of adjusting the battery current to the value at which the detector T is most sensitive or gives the best results for the purpose in hand.

Thus this receiver obtains all of the advantages of the Marconi patent No. 763772.

* * * * * * *

For the foregoing reasons I find combined in this apparatus of the Wireless Specialty Apparatus Co. the construction and mode of operation disclosed in these three patents and referred to in the claims in issue and the utilization of the benefits resulting therefrom.

Comparison of Telefunken apparatus with Marconi and Lodge patents in suit.—This apparatus is referred to in the testimony of Mr. Graham and shown in the diagram, plaintiff's Exhibit No. 79, produced by him. It is also a subject of plaintiff's Exhibit 46. I may say that I am personally familiar with Telefunken apparatus and have seen it used and used it myself. I understand the testimony and exhibits referring to it.

This Telefunken apparatus, as to the transmitter and as to the Type E^5 receiver in construction and mode of operation, is substantially identical with that of the Wireless [fol. 333] Specialty Apparatus Co. just fully considered. The only difference in the transmitter is in the particular form of oscillation transformer used and the only difference in the receiver E^5 is that it has in addition to the

elements of the Wireless Specialty Apparatus Co.'s receiver the primary condenser *h*, which is shown in Figure 2 of the Marconi patent No. 763772.

Referring to the transmitter, as shown in Exhibit No. 79, the elevated capacity area *f*, vertical wire A, inductance coil *g*, and earth connection E are all as shown in Figure 2 of the patent and as in the Wireless Apparatus Co. transmitter. The oscillation transformer *d*, *d'*, is different from that employed by the Wireless Specialty Apparatus Co. only in that it is of the single coil or "autotransformer" form. When such a transformer is employed the two circuits, red and black, are said to be "direct coupled" and when the two-coil transformer is employed they are said to be "inductively coupled." The only difference between the two transmitters, therefore, is that the Telefunken transmitter is direct coupled and the Wireless Specialty Apparatus Co. transmitter is inductively coupled.

These two forms of transformers are well-known equivalents and merely specifically different ways of associating windings for the transfer of energy. This is so clearly set forth in the U. S. Signal Corps book, Radiotelegraphy, plaintiff's Exhibit No. 91, that I quote the following from pages 42 and 43 and reproduce the Figures 36 and 37 referred to:

"Coupling: By means of the arrangement shown in Figure 36 a large charge may be stored in the condenser C, much larger than that which can be stored in the antenna of Figure 35, and the discharge of this condenser through the gap S and the inductance L will produce powerful oscillations in the closed oscillating or primary circuit. On account of its position and shape, however, this closed oscillating circuit is a poor radiator of electrical energy. There are two general ways in which the energy of this circuit can be transferred to the antenna or radiating circuit; or, as it is said, two ways of coupling the circuits. One is shown in Figure 37, where the ground and the antenna circuits are shown to be directly connected to the inductance coil of the closed circuit, and the circuits are said to be directly connected, directly coupled, or conductively coupled. The coil is often called the antenna coil or helix. The other is shown in Figure 36, where a number of turns in the coil L_2, connected between the antenna and ground, is brought near enough to a number of turns of the

coil L_1 in the closed oscillating circuit to have oscillations induced in the antenna coil and circuit, and the circuits are said to be inductively coupled or connected. The two coils L_1 and L_2 form an oscillation transformer, as it is usually called, the coil L_1 being the primary and coil L_2 the secondary. Hence the antenna circuit is sometimes called the secondary circuit. There is no essential difference in the operation or efficiency of the transfer of energy in the two types of coupling, but rather that each may have advantages in certain cases."

There is thus no difference in principle or operation between these forms of oscillation transformer, and hence the Telefunken transmitter is substantially identical with [fol. 334] that of the Wireless Specialty Apparatus Co., and what I have said may be taken as applying also to the Telefunken transmitter.

Referring to Exhibit No. 79, the red circuit is the reservoir circuit, and it contains the condenser *c*, spark gap G, and a portion of transformer turns, indicated by red lines between contacts 2 and 2^a. This winding, marked *d*, constitutes the primary of the oscillation transformer. The secondary of the oscillation transformer is comprised by the turns between the connection points 1^a and 2^a and is contained in the antenna or black circuit. The mode of operation is precisely as already described with reference to the Marconi patent Figure 1 and with reference to the Wireless Specialty Apparatus Co. transmitter.

In the drawing, plaintiff's Exhibit No. 79, a switch S is shown in the antenna circuit, so that when desired a condenser H may be included in the antenna. This is merely an additional wave length or time period adjusting device and is only used for the purpose of shortening the wave length below that which is natural to the antenna. Its effect is equivalent to reducing the size of the elevated capacity area. The international convention and the United States laws in conformity therewith require that it shall be possible for ships and land stations licensed for commercial use to send, when required, with a wave length as short as 300 meters. Some antennae are so large as to make this impossible without some means of effectively reducing their size, and this condenser H is supplied for this purpose. Whether it is used or not it in no way affects the mode of operation of the apparatus.

Referring to the Telefunken receiving apparatus, two arrangements of secondary circuits are shown in Exhibit No. 79. One of these marked E^3 is exactly like the wireless specialty apparatus receiver, except for the added condenser *h*, and is exactly like Figure 2 of the Marconi patent No. 763772 in suit, and the other marked E^4 is exactly like the arrangement of tune 3 of the table on page 4 of this Marconi patent, which is illustrated in Figure I of plaintiff's Exhibit 99. It differs from that of Marconi's Figure 2 and of the Telefunken E^3 receiver only in the omission of condenser *h'*. This means merely that capacity enough is provided in the coil itself, the coil referred to being the coil j^2 of the oscillation transformer. In the figure of exhibit No. 79 a variable condenser *h* is shown in dotted lines in the antenna circuit. This means that the condenser *h* is arranged with a switch so that it may be changed from the connection shown in solid lines to that shown in dotted lines. When the condenser is in one position it gives a longer wave length or time period and when in the position indicated by dotted lines, a shorter wave than that natural to the aerial. By this means resonance may be secured between the circuits for a very wide range of wave length.

It appears from the contract, Exhibit No. 46, that the detector supplied with the Telefunken receiver is "iron pyrites." This is another crystal detector, in which one contact is a crystal of iron pyrites and the other a fine pointed wire, adjusted to make a very light contact with the crystal surface. Its operation is supposed to be the same as those which I have considered in connection with the Wireless Apparatus Co. receiver. The indicating device R is a telephone.

[fol. 335] In operation the adjustments are made exactly as described with reference to the Marconi patent and the Wireless Specialty Apparatus Co. apparatus, both transmitting and receiving. In the type E^4 receiver there is no secondary condenser *h'*, and hence the entire adjustment is affected by the variation of the inductance contact 4 and by the variation of the detector T. I have personally used this received and have found that change in the adjustment of the detector changes the wave length, the detector acting to cause this result by virtue of its capacity. By the adjustment of these two elements substantial resonance between the primary and secondary circuits is secured.

I observe that the contract, Exhibit No. 46, states that the sets covered by the bid are not in accordance with specification No. 16-T-5. A drawing, however, accompanies the bid showing the transmitting apparatus in detail, and I find that this drawing is correctly indicated diagrammatically in plaintiff's Exhibit No. 79. I am also personally familiar with the Telefunken apparatus, both sending and receiving, and have tested the same and find that the circuits are substantially in exact resonance when adjusted for most efficient operation.

Since this apparatus is exactly like that of the Wireless Specialty Apparatus Co., with the exceptions noted, I will not repeat what I have said in describing that apparatus. In my opinion this Telefunken apparatus embodies the constructions and mode of operation and obtains the advantages set forth in the claims of the Marconi patent referred to in the question.

Comparison of Kilbourne & Clark apparatus with Marconi patent in suit.—The Kilbourne & Clark apparatus is diagrammatically illustrated in plaintiff's Exhibit No. 95, and described in the testimony of Mr. Weagant. It is also the subject of plaintiff's Exhibit No. 69, contract of January 31, 1914, from which it appears that it is in accord with Navy Department specifications No. 16-R-1, plaintiff's Exhibit No. 38, except as provided in the contract.

This apparatus is substantially identical with that of the Wireless Specialty Apparatus Co., the sole exceptions being as follows:

In the reservoir circuit of the transmitter there is in addition to the inductance coil *d*, constituting the primary of the oscillation transformer, a second variable inductance *d''*, thereby permitting variation of the time period of the primary circuit in two ways, namely, by moving the contact point 3 or by moving the contact point 4.

In the receiver the only difference is that the condenser *h* is provided, as shown in Figure 2 of the Marconi patent, and this is arranged by means of a switch so that it may be either connected as shown in solid lines in Exhibit No. 95 or as shown in dotted lines, so as to either afford means for lengthening or for shortening the wave length of the antenna.

Both these differences are merely additional means of tuning the circuits, giving greater flexibility. They do not alter the mode of operation in any way, and everything

which I have said in comparing the Wireless Specialty Ap- [fol. 336] paratus Co. transmitters and receivers and their operation with the Marconi and Lodge patents and claims thereof in suit applies equally to the Kilbourne & Clark apparatus, and I therefore will not repeat.

I observe that this apparatus was contracted for under specifications No. 16-R-1, instead of No. 16-T-5.

Navy wireless specifications No. 16-R-1.—These specifications require apparatus as specified under the several paragraph headings into which it is divided. These include, first, the power-supplying appliances, such as generators, power transformers, operating key, and all of the numerous details which go to a complete power outfit; second, they require that each transmitter shall be provided with two different sorts of spark gap for alternative use, with a primary condenser, an oscillation transformer, oscillation circuits therefor, and an antenna transfer switch, so that the antenna may be used either for transmitting or receiving; third, they require receivers, together with inductances, condensers, detectors, potentiometers, and telephone receivers therefor; fourth, they require measuring instruments, including a current-measuring instrument for measuring the energy transferred to the antenna and a wave meter for the measurement and adjustment of the several circuits; finally, they specify the drawings and instructions that shall accompany the apparatus, the sort of aerial to be used in testing it, and various provisions, such as workmanship, etc.

The specifications give the characteristics of the antenna with which the apparatus is to be used on page 26, paragraph 26, as follows:

"26. Dummy antenna for tests: (*a*) The dummy antenna used for tests of transmitters shall have a capacity of 0.001 mfd. for tests up to 2 kw. and a capacity of 0.002 mfd. for 5-kw. sets, and the resistances used at the different wave lengths shall be as follows:

	Ohms.
600 meters	8
750 meters	5
1,000 meters	3
2,000 meters	5
4,000 meters	8
7,000 meters	12

"For tests of receivers the capacity shall be 0.001 mfd. and the resistances as above.

"(*b*) Transmitters will be tested at full load on wave lengths of 600, 750, 1,000, and 2,000 meters, in accordance with the requirements of paragraphs 14 (A) (*f*) and 25. Receivers will be tested at wave lengths of 600, 750, 1,000, 2,000, and 4,000 meters, and in the case of long-wave receivers at 7,000 meters. A test of the transmitter at maximum power attainable will also be made at 300 meters."

The expression "dummy antenna" refers to a circuit employed in testing, which is arranged to have the same inductance and capacity as an actual antenna with which the apparatus is required to work, but has these arranged in the form of a closed circuit in order that no actual radiation may take place. The reason for this is that if, during the testing, electric waves were actually radiated, any commercial operation conducted by other stations in the neighborhood might be interfered with. In order, however, that the antenna may have the energy-dissipating qualities of an [fol. 337] actual antenna (without which an adequate test could be made) a resistance is included, which resistance corresponds both to the actual resistance of the intended working aerial and also to an amount of resistance sufficient to represent the energy dissipation due to radiation. The specifications require (page 26, paragraph 25b) that the energy radiated shall be 45 per cent of that supplied to the motors driving the power generator. The resistance is proportioned to the characteristics of an actual antenna, as determined by experience.

The abbreviation "kw." appearing in the designations "2 kw." and "5 kw." stands for the word "kilowatt," which is the electrical unit used in measuring considerable quantities of electric power. The fundamental practical unit of electric power is the watt, and 746 watts are equal to 1 horsepower. Electrical power in considerable quantity is measured in terms of a unit which is 1,000 times as great as the watt, and this is called 1 kilowatt. One kilowatt is therefore substantially equal to $1\frac{1}{3}$ horsepower. To convert the power expression "kilowatt" into the power expression "horsepower" it is therefore only necessary to multiply by one and one-third. Thus, 2 kw. equals $2\frac{2}{3}$ horsepower and 5 kw. equals $6\frac{2}{3}$ horsepower.

Another provision regarding the minimum capacity of the actual antenna with which the apparatus should be required to work is given on page 25, section 25 (*a*), as follows:

"(*a*) The transmitters of 5-kw. sets shall be designed so as to work satisfactorily on all wave lengths from 600 to 2,000 meters, with a minimum antenna capacity of 0.0012 mfd. The transmitters of 2 kw. sets shall comply with the above except that the minimum antenna capacity shall be 0.0007 mfd. The transmitters of both 5 kw. and 2 kw. sets shall work satisfactorily at wave lengths of from 300 to 600 meters with a suitable antenna."

Other portions to which I call attention are as follows: Page 17, paragraph 14 (*a*), as follows:

"14. Oscillation transformer: (*a*) The oscillation transformer to consist of two inductively coupled coils, with means for variation of coupling over a wide range. This range to include an indicated and easily made adjustment for close coupling over the entire range of wave lengths when used with an antenna, as specified in paragraph 25 (*a*). The change of coupling to be made preferably by mechanical movement of one coil with relation to the other."

Page 18, paragraph 14 (A) (*e*), as follows:

(*e*) The contractor shall furnish means by which the transmitting wave lengths can be quickly and easily changed and the apparatus marked so that the transmitting wave length is known without recourse to diagrams or tables. Facility for rapid changes is required for military purposes."

On page 19, paragraphs 16 (*a*, *j*, *k*, *l*, *n*), as follows:

"16. Receivers: (*a*) Two receiving sets will be furnished for each outfit, as follows:

"(1) One highly selective receiver of special design for receiving wave lengths from 300 meters up to 7,000 meters, to be provided with a variable condenser in primary circuit, with leads which can be operated by switches to put this condenser in series or in parallel with inductance, or to cut it out.

[fol. 338] "(2) One highly selective receiver with variable condenser for primary circuit as required for receiving waves from 200 to 4,000 meters."

"(*j*) Means shall be provided for broadening the tuning of the receiver for the purpose of picking up signals over a wide range with minimum variation of the circuits and for receiving strongly damped signals to best advantage. A method involving direct coupling will be considered in this connection.

"(*k*) Means shall be provided whereby the wave lengths of received signals may be directly indicated in the closed circuit, and a scale provided in the antenna circuit for entry of calculated values depending on the antenna used.

"(*l*) Receiving systems wherein the individual circuits may be placed in resonance as a unit with each other and with the incoming signals, by the manual operation of a single mechanical element, will be given preference."

"(*n*) The closed circuits of receivers shall be carefully adjusted and calibrated for all combinations provided for obtaining the various tunes, and the setting of the different parts of each for any tune shall be shown on a table provided in duplicate and installed for conveniently consulting it. This is in addition to the requirements of paragraph (*k*)."

On page 20, paragraph 16 (B) (*a*), as follows:

"(*a*) In all resonant circuits of the receiver the condensers must be of the variable air dielectric type."

One page 21, paragraph 16 (C) (*c*), as follows:

"(*c*) Rectifiers shall be furnished in two types in each receiver, one being relatively unaffected by static or powerful signals for ordinary use, and the other being highly sensitive for use on weak signals."

On page 22, paragraphs *a*, *b*, and *c*, as follows:

"(*a*) An approved type of wave meter with accessories to be supplied by the contractor.

"(*b*) The wave meter shall be adapted to measure—

"(1) Transmitter wave length by rectifier and telephone.

"(2) Transmitter wave damping by hot wire milliammeter or wattmeter.

"(3) Transmitter resonance curves by milliammeter or wattmeter.

"(4) Wave length of distant station by rectifier and telephone.

"(*c*) The wave meter shall be adapted for generation of waves for calibrating receiving apparatus and exciting antennae by approved buzzer excitation."

Page 24, paragraph 22 (*a*), as follows:

"(*a*) The contractor shall supply with the first delivery of the outfit, in addition to the blue prints, etc., furnished with his bid, a complete set of right-reading Vandykes and carbon-backed typed directions, showing over-all dimensions, location of terminals, details, diagrams of elementary and actual connections of the appliances, with values of resistance, inductance, and capacities entered, and *directions on all points necessary* and desirable in the installation, adjustment, and operation of motor generator, transmitter, spark gap, receiver, antenna, panels, and other [fol. 339] accessories, and for *maintaining resonance* under the various conditions of operating for wave lengths of from 300 to 2,000 meters." (Italics mine.)

Thus it appears from these specifications that the elements indicated as assembled in plaintiff's Exhibit No. 95 are, according to the specifications, to be provided with all of the necessary means for establishing resonance between the circuits in use, together with a wave meter for the purpose of assisting the tuning to resonance, and full directions for maintaining resonance of all the circuits under the various conditions of operating for wave lengths from 300 to 2,000 meters.

Examination of Exhibit No. 69, contract of January 31, 1914, shows that none of these requirements of specification No. 16-R-1 are modified by the special terms of the contract, and it is evident therefore that this Kilbourne & Clark apparatus contains the elements and adjusting devices arranged and in use adjusted so that there is at the transmitter a power circuit, shown in yellow in Exhibit No. 95, to charge the condenser *e* of a reservoir circuit, shown in red, which by virtue of resonance with the antenna circuit efficiently transfers energy there to cause effective radiation of elec-

tric waves, and that these are to be received at the receiving station by an antenna circuit, shown in black, tuned thereto and the energy then transferred to the conserving and utilization circuit, shown in red, by virtue of the resonant adjustment of this red circuit to the black circuit, there to be detected by the detector T and indicated by the indicator R in the green circuit.

The apparatus of Kilbourne & Clark therefore contains the elements arranged and operating, as set forth in the Marconi patent No. 763772 and recited in the claims to which my attention has been called.

It appears from the testimony of Mr. Weagant that the detector employed with this Kilbourne & Clark apparatus was similar to Exhibit No. 94, and hence a crystal detector, and what I have said as to the detector when considering the Wireless Specialty Apparatus Co. receiver, applies to this Kilbourne & Clark receiver.

Comparison of Marconi patent with apparatus manufactured by the Navy.—This apparatus is diagrammatically illustrated in plaintiff's Exhibit No. 93 and described in the testimony of Mr. Weagant. I have personally seen one of the transmitters manufactured by the Navy, but so far as I remember I have not seen a receiver. I saw the transmitter on a visit to the navy yard at Bremerton in the spring of 1916.

It is evident from an examination of Exhibit No. 93 that the transmitter there shown is identical with that of the Wireless Specialty Apparatus Co. and that it is provided with all of the adjusting means for placing the circuits in resonance to obtain the efficient transfer of energy from the red to the black circuit. What I have said as to the transmitter of the Wireless Specialty Apparatus Co. therefore applies to this transmitter of the Navy, as to the Marconi patent in suit and the claims thereof in issue, and I will not repeat.

[fol. 340] The receiving apparatus of Exhibit No. 93 made by the Navy is identical with that of the Telefunken type, already considered, save that the primary condenser *b* is indicated as in only one of the two positions shown in Exhibit No. 79. As I pointed out, this condenser is merely an additional adjusting means. In this receiver, as in that of the Telefunken type, the primary coil *j'* of the oscillation transformer performs the function of the coils *g'* and *j'* of the Wireless Specialty Apparatus Co. arrangement, it be-

ing immaterial in a receiver having variable coupling, whether these two windings are mechanically separate or mechanically joined together as one structure.

All that I have said with respect to the Telefunken receiver and, with the exceptions there noted, all that I have said with respect to the Wireless Specialty Apparatus Co. receiver apply to the receiver manufactured by the Navy, which, like those just referred to in my opinion, illustrates the combinations of elements and modes of operation set forth in the Marconi patent and particularly referred to in the claims thereof in issue.

Comparison of Marconi patent with Wireless Improvement Co. transmitter and Simon transmitter.—These two transmitters are shown, respectively, in plaintiff's Exhibits 88 and 89 and described in the testimony of Mr. Langley. The Wireless Improvement Co. transmitter is the subject of plaintiff's Exhibit No. 55, contract No. 415, from which it appears that the contract requires the apparatus to conform to specifications No. 16-R-1, already fully considered, except as modified in the contract itself, and it appears therefrom that there is no modification of the contract except as to the particular ranges of wave lengths desired.

The Simon apparatus is the subject of Exhibit No. 70, contract of September 2, 1915, and the specifications, being attached to the contract under Schedule 8121. These specifications relate only to the transmitter and do not differ materially from those which I have already considered, namely, No. 16-T-5 and No. 16-R-1.

These two transmitters are identical with that of the Wireless Specialty Apparatus Co. with one single exception in the Wireless Improvement Co. transmitter, namely, that the oscillation transformer secondary *d'* is not adjustable, so that there is in the circuit only one instead of two means of adjusting the time period.

Since these two transmitters are in all substantial respects identical with that of the Wireless Specialty Apparatus Co., which I have fully considered and compared, it seems unnecessary to repeat the explanations and comparisons, as they may be taken as though made directly with respect to each of these transmitters, namely, that of the Wireless Improvement Co. and that of Simon. Each, in my opinion, has the elements and mode of association and

operation disclosed in the Marconi patent No. 763772 and referred to in the transmitter claims thereof in issue.

* * * * * * *

[fol. 341] I may say that in the commercial use and in the use made by the Navy Department of its wireless apparatus it is inevitable that a receiver of one type should be used with transmitters of all the different types employed by the corresponding station and that, conversely, any transmitter will naturally transmit to all of the different receivers employed at the different stations with which it may have occasion to work. All of these receivers that I have considered are provided with means for making the adjustments to the range of wave lengths used by the Navy Department and in commercial practice (except for transoceanic communication), and hence it is quite immaterial whether a particular transmitter is used with a receiver of the same make or some other.

I note that in describing these two transmitters Mr. Langley calls attention to the fact that in the Simon transmitter the condenser *c* is connected across the power transformer directly, while the spark gap G is in series with the oscillation transformer primary *d*, whereas in the Simon transmitter it is the spark gap that is in shunt with the power transformer directly, while the condenser is in series with the oscillation transformer primary. I note that similar differences will be found in the other transmitters. Thus, the Kilbourne & Clark and the Telefunken transmitters have the spark gap directly across the power transformer, while the Wireless Specialty Apparatus and Navy type transmitters have the condenser across the power transformer. I have ignored this difference because, as Mr. Langley points out, it is universally recognized to be entirely immaterial, the actual connection being determined merely by considerations of convenience in assembling in each case. The reason why it is immaterial is that the charging current flowing to the condenser occurs at a low frequency, and for such low frequency the oscillation transformer amounts merely to a direct connection; hence, although there is an apparent difference in the diagram, there is no difference in fact.

I note that this Wireless Improvement Co. 5-kw. transmitter, referred to in the contract, Exhibit No. 55, and which according to the contract was to be delivered at "U. S.

Naval Radio Station, Radio, Va.," is apparently described in the article by Captain Bullard, contained in plaintiff's Exhibit No. 81, Bullard article in the Proceedings of the Institute of Radio Engineers, pages 431, 434; diagrams and photographs are shown on pages 432, 433, and 435.

10. Question. Please answer Q. 9 and make the comparison requested in that question but substituting for the defendant's wireless apparatus referred to in that question the defendant's apparatus contracted for in plaintiff's Exhibit No. 57, contract No. 14746, dated April 22, 1911, between Fritz Lowenstein and the United States Navy Department, which apparatus is described in the depositions, respectively, of Messrs. Graham and Weagant, and [fol. 342] the receiver of which Lowenstein apparatus is illustrated in plaintiff's Exhibit No. 96, drawing, Lowenstein type of receiver. In making this comparison you may refer to any other exhibits introduced herein and make any drawings or sketches you consider necessary.

Answer. *Comparison of Marconi patent with Lowenstein apparatus.*—Transmitter: It appears from the contract, Exhibit No. 57, that the Lowenstein apparatus contracted for under Navy specification No. 16-T-5. Additional specifications are attached to the contract, which is also accompanied by a drawing illustrating the apparatus diagrammatically. I produce herewith a simplified diagram, following the conventions and letters of reference which have heretofore been used, showing the Lowenstein transmitter, a photographic copy of which is inserted opposite this page. (Plaintiff's Exhibit No. 101.)

In this diagram, as in the others I have considered, the power supply arrangements are diagrammatically indicated in yellow and comprise a generator *a*, key *b*, and transformer *c*. The primary circuit of the transmitter is shown in red and comprises the condenser *e*, spark gap G, and a common portion *d* of an inductance, included between the arrows 4 and 5. The antenna circuit is shown in black and comprises the elevated capacity area *f*, vertical wire A, loading inductance coils *g*, adjustable by the arrows 1, 2, 3, and the common portion *d'* to other inductances at the lower end of which the connection passes to earth at E.

The Lowenstein transmitter is provided with a switch by means of which the operator has only to place the switch in one of several operative positions to select the desired one

of several wave lengths, and at the same time preserve the resonance between the circuits and the most advantageous coupling. The purpose of dividing up the inductance into three coils and similarly dividing up the oscillation transformer secondary *d'* into two coils is to enable this changing of wave lengths with preservation of resonance and coupling to be done. In other words, it is an incident of the particular mechanical construction employed by Lowenstein. In electrical effect the action is precisely the same as though the three coils *g* were formed as one and the two coils *d'* as one.

The adjustment of time period of the reservoir circuit is accomplished by the two contacts 4, 5, and the adjustment of both the time period and the coupling is effected by adjusting the contact 1, 2, 3, with particular reference to the adjustments already made of 4 and 5.

I note that the Navy manual for 1911, on page 95, gives a diagram, Figure 47, of this Lowenstein apparatus, which is substantially the same as that which I have just made from the drawing T 8 of contract. Regarding this Figure 47, the manual says, on page 96, as follows:

"Figure 47 indicates a method of connecting up sending sets so that the operator by moving a hand wheel or lever can change the wave length of the open and closed circuits the same amount without changing the coupling. This apparatus is just being introduced and should greatly facilitate the operator's control over his sending wave length."

[fol. 343] It will be seen that this Lowenstein transmitter has all the elements of the transmitter Figure 1 of the Marconi patent No. 763772, differing therefrom in electrical arrangement only in that the oscillation tranformer is of the autotransformer type instead of the inductive type. It is therefore substantially identical with the Telefunken transmitter of Exhibit No. 79, which I have already fully considered. As I have there fully explained the substantial identity and complete likeness of function between these two sorts of transformers, I will not here repeat.

This transmitter is identical with the Wireless Specialty Apparatus transmitter except as to this transformer, and what I have said, therefore, in comparing the Wireless Specialty Apparatus Co. transmitter with the Marconi patent may be taken without repetition here as applying to the Lowenstein transmitter.

That the circuits are in resonance is shown not only by the specification No. 16-T-5, but also by the additional specifications accompanying the contract; for example, items *j* and *k*, which read as follows:

"*j*. The closed and open circuits of the transmitter are automatically adjusted to syntony at the five wave lengths between 425 and 1,000 meters and easily syntonized for any wave length between these limits.

"*k*. The transmitter supplied is especially designed for resonance. No auxiliary apparatus is required to obtain resonance."

Paragraph 12 (*a*) states:

"The recommended normal percentage of coupling is 22 per cent to 25 per cent, which is automatically maintained constant at all the five available wave lengths. Provision of varying this coupling, if desired, is provided."

I also note that the resonance of the two circuits is indicated in the above quotation from the Navy manual of 1911.

It is therefore evident that transfer of energy from the reservoir circuit to the antenna circuit is affected by the tuning of the two circuits to resonance with one another, and I therefore find that this Lowenstein transmitter is such a transmitter as is set forth in the Marconi patent No. 763772 and referred to in the tranmitter claims in suit, both as to the elements and their mode of combination and operation.

* * * * * * *

Lowenstein receiver.—The Lowenstein receiver is shown in Exhibit No. 96, and is described by Mr. Weagant in his testimony. I find in the Lowenstein contract, Exhibit No. 57, two receivers marked, respectively, "Alternative receiver proposal No. 1" and "Alternative receiver proposal No. 2." It appears from the contract that alternative receiver proposal No. 1 was accepted by the Navy Department. Exhibit No. 96, produced by Mr. Weagant, is a diagrammatic illustration of the drawing R-8, at- [fol. 344] tached to Exhibit No. 57. It will be seen that this receiver is substantially identical with that of the Wireless Specialty Apparatus Co., shown in Exhibit No. 87. The

specific differences are that the antenna circuit has a condenser *h* connected therein, this being merely an additional adjusting means in the antenna circuit, and the secondary or red circuit has an additional inductance j^3 therein variable as indicated at 3, this being merely an additional means of adjustment for the secondary circuit. This coil j^3 corresponds to the coil a^2 of Figure 2 of the Marconi patent No. 763772. Everything that I have said in comparing the receiver of the Wireless Specialty Apparatus Co. with the Marconi patent No. 763772 applies to this Lowenstein receiver and I will not repeat.

* * * * * * *

11. Question. Please answer Q. 9 and make the comparison requested in that question but substituting for defendant's radio apparatus referred to therein the apparatus of the radio pack sets made by the United States Signal Corps and referred to by Mr. Weagant in his deposition, the defendant's radio pack sets made by the National Electric Supply Co. for the United States Signal Corps, also described by Mr. Weagant in his said deposition and referred to in plaintiff's Exhibit No. 51, contract of June 23, 1914, between said company and the United States Signal Corps, and also the defendant's portable field radio sets of the two-trunk type of the National Electric Supply Co., described by Mr. Graham in his deposition and illustrated in plaintiff's Exhibit No. 80. In making the comparison called for you may refer to any other exhibit introduced herein and make use of any drawings or sketches you deem necessary.

Answer. *Comparison of Marconi patent in suit with Army pack sets.*—Radio pack sets manufactured by United States Signal Corps: It appears from the testimony of Mr. Weagant that these pack sets manufactured by the United States Signal Corps are electrically substantially identical with those manufactured by the Navy and diagrammatically illustrated in plaintiff's Exhibit No. 93. He says also that their mode of operation is the same.

As I have already considered the transmitters and receivers manufactured by the Navy and diagrammatically indicated in Exhibit No. 93, I will ask that what I have there said be taken as applying also to this Signal Corps pack set.

National Electric Supply Co. portable field radio sets, two-trunk type, installed on U. S. S. *Georgia:* The trans-

mitter of this set, as shown in Exhibit No. 80, corresponds in the arrangement of its parts to Figure F of plaintiff's [fol. 345] Exhibit No. 99, Waterman drawing of Marconi and Lodge patents, to tune 6 of the table given on page 4 of the Marconi patent in suit No. 763772. It has the power supply circuit shown in yellow, comprising a generator *a*, key *b*, and transformer *c*; the reservoir circuit shown in red comprising the condenser *e*, spark gap G, and oscillation tranformer primary coil *d* and the antenna circuit shown in black comprising the capacity area *f*, wire A, oscillation transformer secondary *d'*, earth connection E. The antenna circuit has adjustable contacts 1 and 3 and the red circuit contacts 2 and 2^a. This transmitter is evidently arranged therefor to have the circuits tuned to resonance and to operate in an efficient and practicable manner, it would be necessary that the circuits should be so tuned. So connected and adjusted, the efficient transfer of energy referred to in the Marconi patent No. 763772 would be realized and this transmitter in my opinion contains the elements and combinations and would operate in a manner described in the patent and referred to in the transmitter claims thereof.

It does not have a separate inductance coil in the antenna circuit, but, as I have explained, it is not material that as a matter of mechanism or mechanical arrangement the loading coil *g* of Marconi, Figure 1, which is in fact the Lodge loading coil of Lodge patent No. 609154, should be separate from the secondary of the oscillation transformer, as the two may be combined. Where the coupling of the two circuits is variable the single coil *g'* is made to serve the purposes of both coils by the suitable adjustment of the coupling. According to Mr. Graham's testimony, the coupling of this transmitter is variable and hence I am of the opinion that there is embodied in this transmitter the variably acting inductance coil of the Lodge patent, giving the desired definiteness to the waves radiated and enabling the wave length to be adjusted.

The receiver of this set is practically identical with the type E-4 receiver of the Telefunken apparatus, shown in Exhibit No. 79, and what I have said with respect to that receiver applies fully to this National Electric Supply Co. receiver, and I will not repeat. It is my opinion that the apparatus of Exhibit No. 80, as described by Mr. Graham, embodies the construction and mode of operation of the

Marconi patent in suit, and particularly as recited in the claims thereof to which my attention has been called.

I may say that this apparatus differs from that of the Wireless Specialty Apparatus Co. only in details, such as the combination of the inductance coils *g*, *g'*, with the oscillation transformer coils *d'*, *f'*, and in the omission of the variable secondary condenser in the receiving station. These differences do not essentially alter or modify the mode of operation, and therefore what I have said as to the mode of operation of the Wireless Specialty Apparatus Co. system in comparing it with the Marconi patent in suit, applies to that of the National Electric Supply Co. field-pack set.

National Electric Supply Co. pack sets manufactured for the United States Signal Corps, model 1914: This apparatus is shown in drawing No. 988, forming part of Exhibit No. 51, National Electric Supply Co. contract. It is also described in the testimony of Mr. Weagant (MS. 249-250). I find the same drawing, reproduced on page 109 of the [fol. 346] Signal Corps book Radiotelegraphy, 1914, and the set is described on pages 101 to 114 thereof.

The drawing No. 988 when put in simpler diagrammatic form is identical with exhibit No. 80, National Electric Supply apparatus, with the single exception that the oscillation transformer is of the autotransformer or direct coupled type, instead of the inductive coupled type, shown in the drawing of this company's apparatus, Exhibit No. 80. As I have already explained, this does not alter the principle or mode of operation in any way and the drawing No. 988 shows that the coupling is capable of variation, so that the secondary of the oscillation transformer also performs the function of the Lodge loading coil.

Regarding the tuning of the transmitter, I quote as follows from pages 105 and 106:

"Tuning of sending set: The tuning of the closed and open circuits to resonance, and the determination of the correct coupling between them are the two most important adjustments in a quenched-spark transmitter. In the present type of directly coupled set with a flat spiral as the oscillation transformer, these adjustments can be made either with or without the help of a wave meter. If made without the meter, the adjustments should satisfy the following tests: (1) the number of turns in the closed circuit

should be chosen to give the desired wave length; (2) the antenna hot-wire ammeter should show the maximum reading; (3) the note should be clear and characteristic of 500 cycles. These adjustments are in general dependent on each other, an incorrect change in one seriously affecting all the others. As shown in the table, the position of the clips in the closed circuit determines the proper turns in the spiral to give the desired wave lengths.

"The number of turns in the open or radiating circuit necessary to bring it into resonance with the closed circuit must be found by trial, although the numbers shown in the table below are approximately correct and should be used in beginning to make the adjustments. * * *

"If the circuits are in resonance and the coupling is correct, the antenna hot-wire ammeter should read not less than 2.2 amperes, and may read as high as 3.0 amperes. If the ammeter reading is low, then either the coupling is too loose or the circuits are not in resonance, and one or both of the clips must be moved so as to get the highest possible reading consistent with a clear note. It is impossible to indicate which clip is to be moved or in which direction; but, if possible, the counterpoise clip should be kept on the outside turn."

The tuning of the receiving set is described on pages 110 and 111, from which I quote as follows:

"Tuning of the receiving set: First the detector must be adjusted to a sensitive point by means of the test buzzer, the note of which should be clearly heard in the receiving telephones when it is held near the antenna or counterpoise wires or the coil windings. When the wave length of the sending station is known the number of turns in the primary and secondary coils and the coupling should be set according to the values in the above table, which will be approximately correct for all sets using the standard antenna. When the wave length is unknown, then signals can be found only by repeated trials of different combina-[fol. 347] tions of turns and couplings, in which, however, consistent sets of values may be taken from the table. Whence once the signals have been heard such further adjustments of primary and secondary turns and coupling should be made as will give the maximum sound in the telephones. In general it will be found that when there

is interference or static troubles the sharpest tuning and the best protection from interference will be obtained when the loosest coupling is used; that is, when the secondary is pulled out as far as possible and still hear the desired station. * * *

"If the receiver is used with the standard antenna and signals are being received from an unknown station, the table of wave length can be used to determine approximately the wave length of the unknown station."

The description of the operation which I have given as to the Wireless Specialty Apparatus Co. system applies as to this system also and I will not repeat. In my opinion this pack set embodies the constructions and modes of operation of the Marconi patent in suit, particularly as recited in the claims thereof, to which my attention has been called.

12. Question. Beginning at page 81 of plaintiff's Exhibit No. 90, Radiotelegraphy, 1914, there is described certain "radio apparatus in use in the Signal Corps." On pages 91 to 101 there is described and illustrated certain field-wagon sets used by the United States Signal Corps and known as the "Telefunken two-wagon 2-kilowatt set." Have you read the description of these field-wagon sets and examined the illustrations referred to; and if so, do you understand same?

Answer. I have read the matter referred to and understand it.

13. Question. Please make the comparison called for in Q. 9, substituting, however, for the defendant's apparatus referred to in that question the defendant's Telefunken "two-wagon 2-kilowatt set," referred to in the last question and answer, and described and illustrated in plaintiff's Exhibit No. 90, pages 91-101.

Answer. The apparatus described in the portions of Exhibit No. 90, referred to, is in elements and arrangement and in mode of operation identical with that shown in plaintiff's Exhibit No. 79, drawing, Telefunken apparatus, the receiver of Exhibit No. 90, as shown on pages 94 and 98 thereof and described in the text, being identical with the E-4 receiver of Exhibit No. 79. The text describes the adjustments of the transmitter on pages 92 and 93 to 97, inclusive, and the adjustments of the receiver on page 92 and on pages 97 to 101, inclusive. It is evident from this descriptive matter that the circuits are adjusted to resonance,

both in the transmitter and in the receiver, in the same manner as I have described with reference to Exhibit No. 79, Telefunken apparatus, and also in similar manner to the description which I have given with reference to the Wireless Specialty Apparatus Co. transmitter and receiver of Exhibit No. 87. The text on page 99 calls attention to one means used in tuning to which I have not hitherto especially referred. It is stated on page 99 as follows:

"Operator then varies his condenser and also the coupling between the primary and secondary of the receiving transformer until he gets the best adjustment. Changing the coupling; that is, pulling the secondary away from or pushing it closer to the primary, changes the wave length, though not to as great an extent as does varying the con- [fol. 348] denser. Some stations can not be heard at all well unle the secondary coil is pulled some distance away from the primary."

The reason why the coupling affects the tuning is that it affects the capacity of the coils. Coils have, as I have stated, not only inductance but also capacity. This capacity is affected by the surroundings just as the inductance is also affected by the surroundings if there be iron in the neighborhood. Changing the capacity of course changes the time period or wave length. This is true not only of the Telefunken apparatus but is true in general of wireless telegraph receivers, being true also of the apparatus of the Marconi patent No. 763772 in suit.

I call attention to the fact that the descriptive matter on pages 96 to 101 describes and illustrates the calibration; that is to say, the ascertainment and tabulation of the tuning or resonance adjustments for various wave lengths.

In view of the substantial identity of this apparatus with that of Exhibits 79, Telefunken apparatus, and No. 87, Wireless Specialty Apparatus Co. apparatus, I will ask that the comparison of these which I have made with the subject matter of the Marconi patent in suit and the claims thereof in issue be understood as referring also to this Telefunken field-wagon apparatus.

14. Question. Have you examined plaintiff's Exhibit No. 53, contract No. 8503, dated June 27, 1910, between the Foote-Pierson & Co. and the United States Signal Corps, for the manufacture and delivery to it of eight wireless

pack sets under Signal Corps wireless specification 410, and have you examined said specification and plaintiff's Exhibit No. 98, Signal Corps drawing No. 741, field wireless pack set (two-trunk type), and do you understand the construction and mode of operation of such wireless sets, referred to in said exhibits?

Answer. I have examined Exhibits Nos. 53 and 98, referred to, and understand same.

15. Question. Please make the comparison called for in Q. 9, substituting, however, for defendant's apparatus, referred to in that question, the Foote-Pierson pack sets of plaintiff's Exhibits Nos. 53 and 98, mentioned in the last question. You may in answering the question refer to any other exhibit and make any drawings or sketches you deem necessary.

Answer. I have made a sketch, employing the same conventions as the other diagrammatic illustrations which I have been using, and illustrating this Foote-Pierson apparatus, as shown in Exhibit No. 98. (Sketch, plaintiff's Exhibit No. 102.) I understand that Exhibit No. 98, being drawing No. 741-1, is one of the drawings referred to in the specification No. 410 attached to the Foote-Pierson contract, Exhibit No. 53, and referred to therein. This Foote-Pierson apparatus does not differ in any important respect from the National Electric Supply Co., field radio pack set, as shown in plaintiff's Exhibit No. 80. By comparison of my sketch with Exhibit No. 80 it will be seen that the only difference is that the Foote-Pierson apparatus of specification No. 410 has both the transmitting and receiving [fol. 349] oscillation transformer of the direct coupled or autotransformer type.

As I have already explained, this change in the form of the oscillation transformer does not in any way alter the operative relation of the two circuits nor change the mode of operation of the apparatus. The mode of operation which I have set forth in considering the Wireless Specialty Apparatus Co.'s apparatus applies fully to this Foote-Pierson pack set. I note that the specification No. 410 appears to be devoted exclusively to the constructional features and does not deal with the operation. The elements and the adjustments provided, however, indicate clearly the adaptability of the apparatus for the tuning of the circuits to resonance, and this is their evident function. Regarding

the detector employed with this set the specification states, paragraph 11:

"Silicon detector: This shall be the standard silicon detector as made by the Wireless Specialty Co., 81 New Street, New York, and shall be furnished with nickel plated mounting, retaining chain for button and fittings complete for connection to the wireless receiving set."

This detector, here designated, is substantially like Exhibit No. 94, Wireless Specialty silicon detector, except that one of the contact points (the movable one) is a metal instead of a crystal contact. Its operation is the same and has already been described.

I also note that the spark gap in the transmitter appears to be a so-called open gap instead of the quenched spark gap of the National Electric Supply Co. set. It is common with the very small sets using small power to use this simpler form of gap. The operation of these gaps differs in regularity and perfection of result but the mode of operation of the apparatus is not altered.

Since the elements, mode of assemblage and operation is substantially the same as in the case of the National Electric Supply Co. type, shown in Exhibit No. 80, and differs only in minor details from the more elaborate apparatus of the Wireless Specialty Apparatus Co., illustrated in Exhibit No. 87, while the operation is the same in substance, I will not repeat the detailed comparison which I have made in considering these other types but will ask that they be understood as applying to this Foote-Pierson apparatus also.

Mr. Cosgrove: Plaintiff's counsel offers in evidence the following:

Navy manual for the year 1911, referred to by the witness in answer to Q. 10 and requests that the same be marked "Plaintiff's Exhibit 100, Navy manual of 1911."

Also the simplified diagram of Lowenstein transmitter produced by the witness in answer to Q. 10 and requests that the same be marked "Plaintiff's Exhibit 101, Waterman sketch, Lowenstein transmitter."

Also the simplified diagram produced of the Foote-Pierson pack set referred to by the witness in his answer to Q. 15, and requests that the same be marked "Plaintiff's Exhibit 102, Waterman sketch, Foote-Pierson pack set."

Also certified copy of Signal Corps Bulletin No. 17, "Instructions for operating field radio pack set, model of 1912," and requests that the same be marked "Plaintiff's Exhibit No. 103, Signal Corps Bulletin No. 17."

[fol. 350] 16. Question. Have you examined plaintiff's Exhibit No. 54, contract No. 445, dated October 24, 1910, between the North American Wireless Co. and the United States Signal Corps, and also plaintiff's Exhibit No. 42, Army wireless specification No. 547, referred to in the said contract? If so, please state whether you understand the same.

Answer. I have and do.

17. Question. Please compare the construction, arrangement, and mode of operation of the defendant's North American Wireless Co. wireless apparatus of plaintiff's Exhibits Nos. 42 and 54, referred to in the last question, with that of the inventions of the Marconi patent in suit, as recited in the claims in issue herein of those patents.

Answer. Exhibit No. 54 provides for a 2-kilowatt transmitter having a wave-length range from 300 to 2,000 meters, provided that the natural period of the antenna corresponds to a wave length of 250 meters or less and the electrostatic capacity of the antenna is approximately 0.0015 mf., and a receiver of the same wave length. This provision thus substantially fixes the characteristics of the antenna. It further appears from the specification No. 547, Exhibit No. 42, that the transmitter is to consist of two circuits adjusted to resonance, and the character of the primary condenser is specified. It is also required that the apparatus shall have means for rapidly changing to any desired wave length and that the wave length shall be permanently marked so that the adjustments may be made by reference to calibration curves or tables.

The particular construction of the oscillation transformer as to whether it is of the autotransformer or the inductive type does not appear from the contract or specification, but as I have pointed out, it makes no difference in the mode of operation or in the substantial organization of elements whether it is of one sort or the other. There is in either case substantially the same combination of elements as is found in the apparatus of the Wireless Specialty Apparatus Co., and it is immaterial whether the transformer for the high frequency energy has two mechanical distinct coils

d, *d'*, as does the Wireless Specialty Apparatus Co. transmitter, or whether these coils constitute a single structure as in the case of the Telefunken transmitter of Exhibit No. 79. The description which I have given of the arrangement and mode of operation of the transmitter of the Wireless Specialty Co. applies in either case.

With regard to the receiver, it appears that the same is to be provided with tuning condensers having air dielectric corresponding to the condensers *b*, *b'* of Figure 2 of the Marconi patent No. 763772, as I understand, and receiving inductances, and that the two circuits shall be in resonance with one another. It is also provided that the receiver shall have a capacity for adjusting to various wave lengths from 300 to 2,000 meters and also for broad tuning so as to receive signals over a wide range of wave length with a minimum of adjustment when required. The contract guarantees a high degree of selectivity, so that a variation of 3½ per cent from the wave length to which the circuits of the receiver are tuned will cut down the strength of an interfering signal to one-third of its strength before the variation of 3½ per cent was made.

[fol. 351] It is evident to me from this description that the receiver is substantially the same as that of the Wireless Specialty Apparatus Co., and the description which I have given and the comparison which I have made with respect to the appliances of that company apply as to the apparatus of the North American Wireless Co. and I will not repeat. It does not appear whether the oscillation transformer for the receiver is of the direct or the inductively coupled type, but, as I have pointed out, it is immaterial as far as the substantial features of combinations and operation is concerned which form is used.

I may note that the term "dielectric" used above designates the insulating material separating the plates of the condenser, which in the particular instance of the receiving condenser is required to be air. The reason for this is that air has practically no losses when employed as the dielectric of the condenser; thus the small amount of energy received will not be wasted in condenser losses.

The specification No. 547 requires that the detectors supplied with the receiver shall be equal in sensitiveness to those of the electrolytic type, but I do not find that the contract, Exhibit No. 54, specifically describes the construction of the detector.

In my opinion the apparatus to be furnished under the contract contains the elements, combinations, and mode of operation of the Marconi patent in suit and the claims thereof in issue and the comparison which I have made more specifically in considering the Wireless Specialty Apparatus Co. apparatus applies as to this apparatus.

18. Question. Have you read and examined the following contracts and wireless specifications, and do you understand the same: Plaintiff's Exhibit No. 47, contract 608, dated September 29, 1913, between the Atlantic Communication Co. and the United States Signal Corps for radio sets in accordance with Army wireless specification No. 506 (plaintiff's Exhibit No. 43); plaintiff's Exhibit No. 45, contract No. 14811, dated May 1, 1911, between the Garwood Electric Co. and the United States Navy for wireless telegraph sets under Navy wireless specification No. 16–T–5 (plaintiff's Exhibit No. 37); and plaintiff's Exhibit No. 71, contract No. 20437, dated March 5, 1914, between the Radio Telegraph & Telephone Co. and the United States Navy for radio sets under Navy specification No. 16–R–1 (plaintiff's Exhibit No. 38).

Answer. I have and do.

19. Question. Please compare the construction and mode of operation of defendant's Atlantic Communication Co. wireless apparatus of plaintiff's Exhibit No. 47 and plaintiff's Exhibit No. 43, referred to in the last question, with that of the inventions of the Marconi patent in suit, as claimed in the claims in issue herein of that patent.

Answer. Exhibit No. 43, specification No. 506, provides for a transmitter comprising a generator, transformer, condenser, spark gap, linking coil (oscillation transformer), and loading inductances, and expresses a preference for means for automatic, simultaneous tuning of the oscillating and radiating circuits of the transmitting sets and requires that the oscillating and radiating circuits shall be [fol. 352] provided with the necessary tuning inductances for preserving proper coupling for all radiating conditions.

The receiving set is required to have high selectivity and also to have provision for broad tuning. It is further required as follows:

"The antenna circuit shall be capable of tuning over a large range of wave length, which must be stated in the bid, including those below the fundamental of the antenna.

The secondary circuit shall be capable of broad as well as highly selective tuning, and proper means for this variation must be provided. Coupling between the antenna and the secondary circuit shall be variable.

"Mineral detectors are required, and no other type will be acceptable."

The necessary potentiometer and telephone receivers are also required. The contract, Exhibit No. 47, is accompanied by a diagrammatic drawing illustrating the transmitter and receiver. Photographs also are attached showing such portions of the apparatus. From this drawing it is evident that the transmitter is substantially identical with that of the Wireless Specialty Apparatus Co., plaintiff's Exhibit No. 87, which I have fully described, and that the receiver is identical with that of the Telefunken type, plaintiff's Exhibit No. 79, E-4. The only difference between the apparatus illustrated in the contract and that of the Telefunken transmitter is that the oscillation transformer is inductively coupled instead of direct coupled, this being, as I have already said, not substantially different.

It appears from the letter of August 28, 1913, which is a part of Exhibit No. 47, that the transmitter is the same as the Telefunken transmitter, which I have already considered, except that the apparatus is arranged for inductive coupling, but that direct coupling can also be used by change of connection. It also appears that the receiver is "the well-known Telefunken type E–4," and that two iron pyrites and one galena detector accompany the receiver.

In view of this substantial identity with the apparatus of the Telefunken type, plaintiff's Exhibit No. 79, and the Wireless Specialty Apparatus Co., plaintiff's Exhibit No. 87, the statements which I have made in comparing these with the Marconi patent in suit apply to this apparatus also. In my opinion the apparatus referred to in the Exhibits Nos. 43 and 47, inquired about, is such apparatus as is designated in the claims of the Marconi patent in issue.

20. Question. Please compare the constructions and mode of operation of defendant's Garwood Electric Co. transmitter of Plaintiff's Exhibit No. 45 and Navy wireless specification No. 16–T–5 with that of the inventions of the Marconi patent No. 763772, as recited in the transmitter claims thereof in issue.

Answer. I have already fully considered the specification No. 16–T–5, and have shown that it calls for a complete

transmitter, substantially as set forth in the Marconi patent No. 763772, having inductively coupled oscillation transformer, and that it provides for the tuning of the circuits to resonance and means for adjusting them for different time periods. The Garwood contract, Exhibit No. 45, does not modify nor alter any of these above requirements. It [fol. 353] specifies that the exciting and radiating circuits may be rapidly and simultaneously altered in wave length without alteration of the resonance between the circuits. It also gives data as to the constants of the circuits, the voltage that is employed to charge the condenser, and other details as to the construction. From this information it is evident that the transmitter is in substance the same as that of the Wireless Specialty Apparatus Co., shown in Exhibit No. 87, and I will ask that all the comparisons which I have made and the explanations which I have given with reference to this Wireless Specialty Apparatus transmitter be understood as applying also to the Garwood transmitter, without repetition.

21. Question. Please compare the construction and mode of operation of defendant's Radio Telephone & Telegraph Co. apparatus of plaintiff's Exhibit No. 71, as set forth in that exhibit and in Navy wireless specification No. 16-R-1, referred to in said exhibit, with that of the inventions of the Marconi patent No. 763772, as claimed in the claims in issue herein in that patent, giving your reasons for any opinion you may express as the result of such comparison.

Answer. The contract, Exhibit No. 71, is for two 5-kw radio sets complete, including receivers to be made in accordance with specifications No. 16-R-1, except as modified. The modifications do not affect the specifications, except as to mechanical features and as to the particular number of wave lengths obtainable by the movement of the single switch. Nine such specified wave lengths are required by the contract.

According to the specification No. 16-R-1 the transmitter is required to include a power generator of alternating current with a transformer and transmitting key, all corresponding to the yellow circuit of the Wireless Specialty Apparatus Co. transmitter of Exhibit No. 87. It is also required to furnish transmitter condenser, corresponding to *c*, a quenched spark gap, corresponding to G, and an inductively coupled oscillation transformer whose primary corresponds to the coil *d* of the red circuit of Exhibit No.

87. The secondary of this oscillation transformer corresponds to coil *d'* of the black circuit of Exhibit No. 87. Also the specification requires the "auxiliary antenna loading coil," corresponding to *g*, and provides for the aerial and earth connection, all as indicated by the black circuit of Exhibit No. 87. All of these elements will be found to be cited on pages 1 and 2 and specified more precisely in the succeeding pages. The specifications also require all of the necessary accompanying and coordinating parts, making a complete, operative wireless telegraph transmitter.

Further, the specifications require that there shall be means of adjusting the time period of these circuits (red and black) and these means are indicated diagrammatically at 1, 2, 3 of Exhibit No. 87. Further, it requires that these adjusting devices shall be quickly and readily changeable and that the apparatus shall be marked so that the transmitting wave lengths will be known from the markings placed thereon and the circuits can be set in resonance for the various wave lengths.

It is required that the apparatus shall be accompanied by necessary drawings and prints and directions on all points [fol. 354] necessary for maintaining resonance under the various conditions of operation for wave lengths from 300 to 2,000 meters and the specifications define the characteristics of the antenna, with which the transmitters are to be connected and adjusted.

As to the receivers, it is clear from the specification No. 16 R-1, that an inductively coupled receiver is required because highly selective tuning is required, together with means for broadening the tuning when desired and only in connection with this latter does the specification say that for this particular purpose direct coupling will be considered. The wave lengths provided for vary from 200 to 7,000 meters, one receiver covering the range from 300 up to 7,000 and the other the range from 200 to 4,000. Neither the specification nor the contract states specifically whether the inductances provided for this purpose shall include the separate loading inductance *d'* or whether the inductances may all be combined in the primary *j'* of the oscillation transformer, the letters of reference referring to the Marconi patent No. 763772, Figure 2, or to Exhibit No. 87, the Wireless Specialty Apparatus Co. receiver. As I have already pointed out it is immaterial which is the case whereas in the case of this specification a variable coupling is required.

In such an event it is merely a matter of mechanical convenience in construction and arrangement, whether the coils g' and f' are separate or united. I note that the contract Exhibit No. 71 makes alternative propositions in the third clause on the second page, where it says that receivers equal in convenience of manipulation and electrical efficiency to the I-P-76 type of the Wireless Specialty Apparatus Co., or, if preferred, the I-P-76 receiver could be furnished.

It is therefore evident that the receivers proposed are either identically that shown on Exhibit No. 87 or substantially the same.

The specification provides that there shall be means for broadening the tuning and prefers an arrangement wherein by the manipulation of a single mechanical element, both circuits may be simultaneously varied and kept continuously in resonance. It requires that all the adjustable parts shall be marked with wave length scales so that the operator may instantly set the two circuits to resonance for receiving any desired wave length and specifically requiring in addition thereto that the closed circuit shall be carefully adjusted and calibrated so that all the various combinations by which the wave lengths within its range may be obtained by the adjustment of the condenser h' and of the contact 7 (Exhibit No. 87) may be at once known from the table accompanying the instrument.

It is clear from the contract and the specification referred to in the question that the apparatus called for is substantially the same as that of the Wireless Specialty Apparatus Co., both as to the transmitter and the receiver, and I will therefore ask that the descriptions, comparisons, and opinions be taken without repetition as applying to this Radio Telephone & Telegraph Co. apparatus, so far as concerns the claims in issue the Marconi patent No. 763772.

22. Question. Have you read the description of the 1915 model pack set, set forth on pages 115 to 121 of plaintiff's Exhibit No. 91, Radiotelegraphy of 1915, on pages 118 to 127 of plaintiff's Exhibit No. 92, Radiotelegraphy of 1916, the description of the 1913 model pack set on pages 104-118 of the same exhibit, and the description of the tractor sets [fol. 555] on pages 121 and 127, respectively, of said exhibits, and do you understand same?

Answer. Yes.

23. Question. Please state, in your opinion, whether or not the 1913 and 1915 model pack sets and the tractor set described in said Exhibits Nos. 91 and 92 and referred to in the last question, if constructed, installed, and operated in substantial accordance with the description of said exhibits, would be substantially similar to any of the inventions of any of the claims in issue of the Marconi patent in suit; and if so, which claims, giving your reasons for any opinion you may express.

Answer. *United States Signal Corps pack set, model 1913.* I have already considered the 1914 pack set in a preceding answer, and in considering the National Electric Supply Co.'s pack sets. It appears from the 1916 Signal Corps book, Exhibit No. 92, that the 1913 model pack set is exactly the same in all substantial particulars, and what I have said in considering the National Electric Supply Co.'s set applies equally to this. I note that in considering that set I quoted the descriptive matter appertaining thereto so far as seemed pertinent from the Signal Corps book of 1914, Exhibit No. 90. The Signal Corps of 1916 substantially repeats that description somewhat amplified but not altered in any important particular. I therefore merely call attention to this description, particularly as found on pages 110 to 112, inclusive, of Exhibit No. 92, with reference to the transmitters, and pages 114 to 117, with reference to the receiver. The diagrams as given on page 109 of Exhibit No. 90 and 115 of Exhibit No. 92 are identical. The detector is said to be galena or other similar detector, hence it is a detector of the crystal variety. In my opinion, the apparatus if installed and operated as called for in the exhibits is as to its elements, combination, and mode of operation such an apparatus as referred to in the Marconi patent and the claims thereof in issue, for reasons more fully given in my consideration of the National Electric Supply Co. pack sets and the apparatus of the Wireless Specialty Apparatus Co. apparatus, to which the latter description makes reference.

United States Signal Corps pack set, model 1915.—The Signal Corps book for 1916, page 115, states that the 1915 model pack set is similar to the previous types, and that the same constructions apply, the only important differences calling for additional instructions being the construction of

the oscillation transformer and in the arrangement of the receiving set.

Transmitter: The transmitter differs from the models of 1913 and 1914, already considered, only in the use of a two-coil or inductively coupled, as distinguished from a one-coil or direct coupled, oscillation transformer. As I have explained, this is not a difference affecting the operation nor the substantial features of the construction and combination. I ask, therefore, that the comparison I have made as to these earlier transmitters be taken without repetition as applying to the 1915 transmitter.

Receiver: The following statement is made on page 118 of Exhibit No. 91 in differentiating the 1915 receiver. It will be seen that the primary difference set forth is in the method of associating or coupling the two circuits:

[fol. 356] "In the earlier sets, types A B, the two circuits were magnetically coupled; that is, the current in the primary (open or antenna) circuit induced currents in the secondary (closed or detector) circuit by means of magnetic lines which passed from the primary coil through the turns of the secondary coil. In the present set the two circuits are statically coupled; that is, the current in the primary circuit induces current in the secondary circuit by means of static lines in two coupling condensers connected in the leads between the circuits. The transfer of the energy for the operation of the detector and telephones from the primary to the secondary circuit is as efficient in this type of connection as in the other."

Substantially the same language is used in the 1916 book, Exhibit No. 92.

It will be seen from this statement that the difference which is set forth is in the coupling of the circuits, a third method of associating them being here referred to. These three methods are equivalent ways of transferring energy from the antenna circuit, in which it is received. The three methods are known, respectively, as the inductive or two-coil transformer coupling, the direct single coil or auto-transformer coupling, and the electrostatic or condenser coupling. All depend upon some one of the available ways of impressing an electromotive force upon the secondary circuit. In the inductive-coupled method, this is done through the instrumenta-ity of the electromagnetic field,

due to the flow of a current in the primary circuit, while in the other two methods it is due to the existence of an electromotive force in the primary which is directly connected to the secondary by the use of a common coil. In the case of the direct coupling, and transferred by electrostatic field, in the case of the static coupling. As the above quotation states, the transfer of energy is as efficient in the one case as in the other and the choice is dictated merely by considerations of convenience. The electrostatic coupling is considered convenient for these pack sets because, as the description states, the construction is more rugged and the coupling involves no moving parts.

Referring to the diagrams found, respectively, at page 119 of Exhibit No. 91, and page 125 of Exhibit 92, it will be noted that there are two such arrangements possible in this receiver, and the description says that the change from one to the other is effected by a switch provided for the purpose. According to the text, the upper one of these circuits is used for shorter wave lengths and the lower one for the longer wave lengths.

Short-wave receiver: In this receiver the antenna circuit consists of the elevated conductor marked "Antenna," the two inductance coils, each of which is marked "Primary," and the earth connection marked "Ground." The secondary circuit consists of the coil marked "Secondary," the detector so marked, the telephone condenser so marked, and the adjustable connection to the secondary coil. The utilization circuit is indicated by the "telephone." The coupling of these two circuits is indicated by two condensers marked "Fixed coupling condensers," this being, as I have stated, merely another way of transferring energy to the secondary circuit. Regarding the adjustment of this re- [fol. 357] ceiver, for the reception of signals, the following instructions for tuning are given on page 126 of Exhibit No. 92:

"When comparatively short-wave lengths are to be received, as from 300 to 700 meters, the double pole, double-throw switch on top of the set should be thrown to the position marked "Short." This makes no changes in the primary circuit, but connects into circuit (1) the secondary coil with the dial switch marked "Secondary" with contacts 0 to 24 for tuning to different wave lengths; (2) detector and telephones.

"Short-wave signals should be picked up by adjustments of the large primary and the secondary dials and fine adjustments made later on the small primary dial."

It appears from this description, that in use at this short connection, the primary and secondary circuits are tuned in exactly the usual manner to resonance with the received signal and with one another. The sole difference between this receiver and those of the other pack sets which I have considered lies in the mode of coupling, which, as I have stated, does not affect in any substantial way the operation.

For this reason, the statements which I have made in comparing the receivers of the other pack sets with the claims in issue of the * * * Marconi No. 763772 patent, apply also to this receiver when installed and operated, and I will not repeat.

Long-wave receiver: When the switch provided with the receiver is thrown into its other position, the circuit shown in the lower diagram is said to be produced. I have no personal knowledge of this arrangement and the description of its operation does not give sufficient information to enable me to make intelligent comparison, and in the absence of such information I am therefore unable to comply with the request in the question, as to this particular use of the receiver.

Tractor sets.—It appears from the description of these sets, that they differ from the 1915 pack sets only in size, being of larger energy capacity. What I have said as to the 1915 pack sets, therefore, applies equally to these tractor sets.

24. Question. I omitted to include in the last two questions the description of the field radio pack sets, model 1912, of plaintiff's Exhibit No. 103, Signal Corps Bulletin No. 17. If you have read and understand the description of this pack set in this exhibit, will you please answer the last question, Q. 23, substituting for the 1915 model pack set and the tractor sets, therein mentioned, the field radio pack sets, model 1912, of Signal Corps Bulletin No. 17?

Answer. This 1912 pack set described in Signal Corps Bulletin No. 17 and illustrated in the diagrams accompanying it, marked 1911 *a*, and *b*, respectively, is substantially identical with the 1914 and 1915 pack sets, which I have

already considered, the differences appearing to be merely differences in capacity of the generator and details of construction. The comparisons which I have already made, therefore, applies equally to this 1912 pack set.

25. Question. Have you read the following specifications and instructions for radio apparatus, and the drawings annexed thereto, and do you understand the same?

[fol. 358] Plaintiff's Exhibit No. 39, Navy wireless specification No. 16-R-1a.

Plaintiff's Exhibit No. 40, Navy wireless specification No. 16-R-2 (receivers).

Plaintiff's Exhibit No. 41, Navy specification for portable wireless sets.

Plaintiff's Exhibit No. 44, Signal Corps specification, radio field wagon sets (dated February 19, 1916).

Answer. Yes.

26. Question. Please state in your opinion whether or not the radio apparatus described in plaintiff's Exhibits, wireless specifications and instructions, Nos. 39, 40, 41, and 44, respectively, and specified in the last question, if constructed, installed, and operated in substantial accordance with the requirements of said exhibits respectively would be substantially similar to any of the inventions of any of the claims in issue of the * * * Marconi * * * patent in suit, and, if so, which claims, giving your reasons for any opinion you may express.

Answer. *Navy specifications Nos. 16-R-1a and 16-R-2.*—These two specifications comprise in substance a revision and rearrangement of the subject matter of 16-R-1, which I have already fully considered. Specification No. 16-R-1a is devoted to transmitters and No. 16-R-2 to receivers.

Specification No. 16-R-1a: This specification requires a complete transmitter having the power circuit, including a generator, transformer, and operating key, as indicated for example in plaintiff's Exhibit No. 87 in the yellow circuit of the diagram of Wireless Specialty Apparatus Co.'s transmitter. It also requires, of course, all of the auxiliary parts for practical use, adjustment, and control. It also requires all the elements of the red circuit of Exhibit No. 87, namely, a condenser *c*, spark gap G, an inductively coupled oscillation transformer, having primary coil *d*. It further requires all the elements of the black circuit, including the secondary *d'* of the oscillation transformer, and

loading coil g, and says that the antenna and various connections will be provided by the Government, but it specifies the characteristics of the antenna with which the transmitter must operate, the capacity given being the minimum, since this minimum determines the maximum size of the necessary inductances.

Means of adjusting the circuits are required, and it is further insisted upon that the contractors shall supply "directions on all points necessary and desirable * * * for maintaining resonance under the various conditions of operating for wave lengths of from 300 to 2,000 meters," and this is one of the provisions which the specifications says is not subject to modification, but must be strictly complied with.

In my opinion, the transmitters furnished in accordance with this specification would unquestionably embody the invention set forth * * * in the specification of Marconi patent No. 763,772, and referred to in the transmitter claims thereof. * * *

[fol. 359] Specification No. 16-R-2: This specification relates to receivers of four different ranges, designated respectively as portable receivers, having a wave length from 75 to 1,200 meters; short-wave receivers, with a range of from 300 to 6,500; long-wave receivers, having a range of from 1,000 to 10,000 meters; and special receivers, whose range is from 5,000 to 18,000 meters. The minimum antenna capacity for which each must be constructed is specified.

As to all of these, the specifications provide for the elements shown in the black circuit of Exhibit No. 87, Wireless Specialty Apparatus Co. receiver, and for all of the elements of the red and green circuits thereof, save in the case of the portable receiver, which is not required to have the condenser h'. Other receivers are required to have this condenser, but are to be provided with switches so that it may be used or not, as desired. As I have pointed out, this condenser h' is merely an added means of adjusting the secondary circuit, particularly useful for giving refined adjustments and for increasing the flexibility by making it possible for the operator to suit the adjustment to his special need, according as greatest loudness or greatest selectivity, or some compromise between the two, best suits the purpose at hand. I note also that the specifications require that means shall be provided for the

insertion of an additional secondary inductance coil, corresponding to the coils g^2 of Figare 2 of the Marconi patent No. 763772, this being an additional tuning means. For all of the receivers except the portable receiver, a very high degree of selectivity, which implies a very high degree of accuracy in tuning to resonance between the circuits, is required, and in all of these latter receivers it is required that the secondary circuit shall be marked with the wave length resulting from given adjustments so as to facilitate this accuracy of tuning.

In view of this substantial identity of the receivers with the receiver of the Wireless Specialty Apparatus Co., diagrammed in Exhibit No. 87, it is my opinion that these receivers comply with the description of * * * the specification of the Marconi patent No. 763772, particularly recited in the receiver claims thereof.

I note this specification refers to the portable receivers in the following language (page 2):

"(c) Portable receivers shall be provided with the so-called 'untuned' secondary system; no secondary tuning condenser to be provided."

This does not mean that the circuits are not in resonance for such circuits are provided with adjustments for the purpose of putting them in resonance. It merely is a way of designating the fact that there is no secondary condenser, such as h', which the Marconi patent No. 763772 says is sometimes included in a shunt around the detector. The two forms of circuits designated by the expressions "tuned" and "untuned" are simply the circuits of the Marconi table on page 4 for tunes 2 and 1, for example, shown respectively in Figures H and G of Exhibit No. 99. In the absence of the condenser h', the coil itself is given a proper capacity so that the circuit is able to oscillate and will have a substantially correct resonant time period for a certain limited range of wave lengths corresponding [fol. 360] to each adjustment of a number of turns in the secondary coil. This matter is very well explained in the Signal Corps manual, and I quote for example from the manual of 1916, being plaintiff's Exhibit No. 92, pages 73 to 74, as follows * * *:

"The closed or secondary circuits are of two general types, called untuned and tuned, as shown respectively in Figures 61 and 62.

"In the untuned circuit there is no secondary tuning condenser, the only adjustment being in the number of turns in L_2, which is generally in steps of many turns. In the adjustment of such a set to get signals of maximum loudness, the circuits must be adjusted to resonance, and the proper coupling between them must be used. The primary circuit will be sharply tuned, but the secondary only very broadly tuned, if at all. If a close coupling is used between the circuits the tuning of both will be broad, and hence the set will have the disadvantage of being liable to severe interference. Under certain conditions, however, as in searching for an unknown station, it may be of advantage to use this coupling at first and then when the station has been picked up to loosen the coupling and to make such changes in both circuits as will give the sharpest tuning and the loudest signals. In many receiver sets of this type the so-called untuned secondary circuit is really a broadly-tuned one in which the inductance of the coil and its distributed capacity form the tuning elements. The range of wave lengths to which each step is thus broadly tuned is generally marked for each contact, thus 400 to 500 meters, 600 to 1,000 meters, etc.

"In the tuned circuit there is a variable tuning condenser, as C' in Figure 62, the adjustment of which is necessary to secure the maximum loudness of signals. The secondary inductance is sometimes variable by steps and in a few cases by single turns."

In my opinion, such portable receivers would undoubtedly be tuned receivers having the two circuits in resonance by the adjustment of the inductance and of the detector, as I have already explained, and hence, would be in accordance with the receiver claims of the Marconi patent No. 763772. • • •

Specification for portable wireless set, Exhibit No. 11. This specification is accompanied by drawings marked "1815 L, sheet 1 and sheet 2, 9-22-10." Sheet 1 indicates the suggested mechanical arrangement and sheet 2 diagrammatically indicates the circuit arrangement. This circuit arrangement is identical with that of the Wireless Specialty Apparatus Co. apparatus as shown in Exhibit No. 87, except that there are no separate loading coils a, a', but since the coupling in both transmitter and receiver is variable this is immaterial to the result.

In page 1, paragraph *j*, the antennae for which the apparatus is to be adapted is defined, and in paragraph 10, page 5, referred to in paragraph *j*, it is specified that the wave lengths shall be 90, 130, 170, and 210 meters. A power circuit corresponding to the yellow circuit of Exhibit No. 87, including a generator, transmitting key, and transformer, is specified. A primary oscillatory circuit, includ-
[fol. 361] ing a condenser *c*, spark gap G, and coil *d'*, constituting the primary of an oscillation transformer, with four connections brought out for changes in the number of turns, is also required, and both the condenser *c* and the primary *d* are variable for changes in wave length. The oscillation transformer is required to be inductively coupled, the secondary to slide inside of the primary to permit of variation in the coupling. The secondary is required to have its inductance variable continuously from zero to maximum and connections are provided for attachment to the elevated conductor and earth wire.

The receiver is required to include an inductively coupled oscillation transformer, the secondary to be designed so as to be as highly selective—that is, as sharply tuned and as accurately in resonance—as possible. The primary coil is required to be variable, one turn of wire at a time by means of two dial switches, one controlling 10 turns, 1 at a time, and the other controlling the balance of the turns, 10 at a time. This is the commonest arrangement in commercial wireless-telegraph receiving apparatus. The secondary coil consists of a fixed number of turns, but has the condenser marked D in sheet 2 accompanying the specification and marked *h'* in Figure 2 of the Marconi patent and in Exhibit 87, illustrating the Wireless Specialty Apparatus Co.'s receiver. It is by variation of this condenser that the highly selective tuning required is to be obtained. The detector is not specified but is required to be robust and capable of operation without loss of sensitiveness. A potentiometer and detector battery is also required, and these requirements at that date could, so far as I know, only have been satisfied by the crystal detector.

Telephones are specified as indicating instruments.

The word "resonance" does not happen to be used in this specification, but since both circuits of the transmitter and both circuits of the receiver are required to be varied in time period for a change in wave length and high selectivity is required, it is clear to one skilled in the art that

the purpose of the adjustment was to put the two transmitter circuits in resonance and to put the two receiver circuits in resonance, and when these constitute an intercommunicating system all four circuits would thus be in resonance. In referring to these circuits I of course refer to the oscillatory circuits and not to the power and indicating circuits.

It is my opinion, from this description, that the comparisons and conclusions which I have made with respect to the Wireless Specialty Apparatus Co.'s transmitter and receiver apply equally to any transmitters made under this specification, Exhibit No. 41, bearing in mind the fact that separate loading coils are not called for but are effectively combined with the oscillation transformer. In my opinion apparatus complying with the specification would necessarily embody the construction, combination, and mode of operation set forth in the Marconi patent and referred to in the claims thereof in issue.

United States Signal Corps specification, Exhibit No. 44 (dated February 19, 1916), radio field wagon set.—This specification provides for a power circuit consisting of a generator, transformer, and operating key, as shown in the yellow circuit of Exhibit No. 87, showing the Wireless Specialty Apparatus Co.'s transmitter and receiver, and also requires a primary oscillatory circuit, including spark gap, condenser, oscillation transformer primary, as shown in [fol. 3672] the red circuit of Exhibit No. 87, and for a secondary circuit having the secondary of the oscillation transformer of such dimensions as will give a range of wave length from 600 to 2,000 meters when used with antennae, as specified in the specification. It is also required that the inductances shall be variable so that the transmitter shall be capable of being correctly tuned and coupled at all of these wave lengths. It is stated in the specification that the spark gap, transmitter, condenser, and key shall be furnished by the Signal Corps and that information regarding these will be furnished to the contractor. It does not provide for or require separate loading coils, such as *a*, *a'*, of Exhibit No. 87, but does provide that this shall be effectively included in the oscillation transformer. It is clear therefore that the transmitter built under these specifications would be substantially such a transmitter as that that I have fully considered and compared in considering the transmitter of the Wireless Specialty Apparatus Co.,

and, in my opinion, with such a transmitter as is described in the Marconi patent No. 763772 and referred to in the transmitter claims thereof.

The specifications state regarding the receiver that two receiver sets are intended to be furnished by the Signal Corps, but that the bidder's design will be considered. Each wagon set is to be provided with two receivers, one of simple rugged construction, to cover a range of from 300 to 2,500 meters and the other of larger size and greater sensibility and selectivity from 300 to 5,000 meters range. The sort of detector to be used is not specified. This information regarding the receiver is hardly sufficient to enable me to make a comparison.

27. Question. Have you read and do you understand that part of the article by Captain Bullard contained in plaintiff's Exhibit No. 81, Proceedings of the Institute of Radio Engineers, relating to the 100-kw. arc set of the Federal Telegraph Co., installed at the Arlington Radio Station; the evidence relating to this set given by Mr. Graham in his deposition herein; the description and illustration of said Federal Telegraph Co. receiving circuits contained in article 200, page 134, of plaintiff's Exhibit No. 78, Navy Manual for 1913 and 1915; plaintiff's Exhibit No. 65, contract No. 1948, dated June 30, 1913, between the said Federal Telegraph Co. and the United States for the installation of a radio station at San Pablo site, Canal Zone, and the wireless specification forming part thereof; and plaintiff's Exhibit No. 66, contract dated June 11, 1914, for furnishing certain radio equipment for said Canal Zone station, and supplemental to said contract, plaintiff's Exhibit No. 65; also plaintiff's Exhibit No. 67, contract No. 269, dated April 6, 1914; and plaintiff's Exhibit No. 68, contract No. 421, dated May 6, 1915, between the same parties for radio sets?

Answer. I have read the exhibits referred to and understand them so far as they go, but they do not in all cases make the construction contemplated clear to me.

28. Question. Please consider and explain the evidence referred to in the last question relating to these are transmitters and the receivers of the Federal Wireless Telegraph Co., and where such evidence forms a sufficient basis [fol. 363] for comparison of such transmitters and receivers, or either of them, with those of the invention of the claims in issue of the Marconi patent, please make the

comparison and give your reasons for any opinion you may express, and where the evidence does not form sufficient basis for such comparison will you please point it out and state why you can not make the comparison or express any opinion.

Answer. *Federal Telegraph Co.'s Arlington arc transmitter.*—The Arlington arc transmitter, as described by Captain Bullard and diagrammatically indicated in Figure 14, is more simply illustrated in the diagram which I have made, using the same letters of reference as were placed by Mr. Graham upon Exhibit No. 81. It comprises an elevated conductor *f*, loading coil *g*, spark gap (not lettered), and earth connection E. Across the gap is connected a condenser *c* and a power circuit, comprising a generator *a*, protective reaction coils *y*, adjusting resistance W, and magnetic blast X. The usual measuring instruments and switches are provided, but I have omitted them from my diagram. The telegraph key *b* is connected to the inductance coil *g* and operates by changing the wave length, instead of by connecting and disconnecting the power.

In the transmitters which I have heretofore considered a charge is imparted to the antenna or a condenser and is set in oscillation by the passage of a spark across the gap, and the oscillation of current thereby set up in the antenna continues until the energy is dissipated. Thereafter another charge is imparted and the operation repeated, this taking place with a frequency depending upon the character of the source of supply, being at the present time commonly one thousand times per second. In the arc transmitter the energy is not intermittently supplied, but a generator of direct current is employed which generates the same, or substantially the same, electrical pressure at all times, and energy is therefore more or less continuously supplied to the antenna, the idea being that the waves shall not be permitted to die out, and such a transmitter is often referred to as a continuous or undamped oscillation transmitter. It is also called an arc transmitter, because the discharge across the gap appears to be continuous, as in the case of the ordinary electric arc, and it was in fact originally developed, as I understand, from such an arc. When the circuit of a suitable source is closed through a pair of electrodes and a resistance in series and then the

electrodes slightly separated, a flame or arc passes between the electrodes, and from this phenomena the familiar arc lights result. The arc is a very erratic phenomena, and although the flame appears to conduct the current it is a conductor of unusual characteristics. One of these is that its resistance is less the greater the current and greater the less the current. To utilize this phenomena for wireless telegraphy it is necessary to exaggerate these peculiarities of the arc by causing it to take place in an atmosphere of hydrogen or hydrocarbon gas. It is also found desirable to apply a blast magnet. When an arc is properly exposed to the action of a magnet, it will act as though a strong blast of air were directed upon it and may be extinguished just as one blows out a candle. Such a magnet is used in connection with the Arlington arc generator.

Precisely what the action going on within the arc is, has been, and still is—the subject of a good deal of difference of [fol. 364] opinion, and the general opinion is that various things may happen, depending upon how the operation is carried on. According to the views of some authorities, the operation of the arc transmitter is precisely the same as the spark transmitter, except that the charging of the antenna occurs very much more often, being many thousand times a second instead of only about 1,000 or less. Another view is that the oscillations are continuous, but somewhat modified, in that there are brief periods during which current is not changing and hence perfect continuity of the electric waves is broken.

In shunt with the arc of the Arlington transmitter there is a condenser c, and it is possible that the closed circuit containing the spark gap and the condenser is a tuned resonant circuit. Such circuits are sometimes employed with arc transmitters—in fact, always, I believe, where used for wireless telephony—and it is possible to so constitute the condenser c and the length of its connecting wires as to cause this to be a direct coupled tuned transformer type of transmitter of the Marconi patent No. 763772. Whether or not it is in fact such a transmitter I am unable to say, because the exhibits referred to do not inform me, and I have never personally tested this transmitter. I am therefore unable to compare it with the Marconi patent No. 763772.

* * * * * * *

Federal arc transmitters of plaintiff's Exhibits 65, 66, 67, and 68.—The transmitters of these contracts are not illustrated by drawings, nor are they fully described. It is evident that an inductance coil is to be provided for an antenna circuit to vary the wave length through wide range. I am unable to make any comparison, because the circuit arrangements are not described. I note that Exhibits Nos. 65 and 66 state:

"If it be necessary to use coupled circuits to give maximum antenna input, necessary condensers and inductances will be supplied."

This evidently refers to and contemplates the use of a closed oscillatory circuit, coupled to the antenna circuit, as set forth in the Marconi patent 763772, but whether such apparatus was furnished or not does not appear from the contract.

Exhibit No. 65 also provides that the transmitting apparatus shall be so designed that by the operation of a single switch the energy radiated may be emitted either in wave trains or continuously, as desired. The means by which this was to be effected is not described. The effect would be to enable the transmitter to send signals like a spark transmitter or like an arc transmitter at will.

How the coupled circuits referred to in the above quotation might and presumably would be used is shown in Figure 29d, on page 58, of plaintiff's Exhibit No. 78, Navy Manual of 1913, and very briefly alluded to in the text of paragraph 94, and also in Figure 62, on page 118, and [fol. 365] somewhat more fully described in paragraph 182. In this instance the transmitter is shown as provided with telephone mouth-piece instead of the telegraph key, but this does not in any way alter the general mode of operation. In my opinion, this circuit, if supplied under the contracts mentioned in question, would necessarily be adjusted to have its circuits in substantial resonance and would be such a combination as is set forth in the Marconi patent 763772 referred to in the transmitter claims thereof. Whether there is specifically a difference between the power supply or circuit-charging mechanism, the result is to furnish charges to the condenser and cause their oscillation by a discharge across the gap; and if this is done more often or more continuously, it is not a lesser but rather a greater use of the disclosures of the Marconi patent.

Federal Telegraph Co. receivers.—The specifications regarding the receiver contained in Exhibits 65 to 67 call for receiving sets, and in 65 and 66 ticker detectors are also specified. The ticker detector is a vibrating device which interrupts or varies the resistance of the indicator circuit so as to permit an indicator to respond.

The specifications of the contract are not at all descriptive of the details of the receiver, leaving it to be assumed that the receiver be furnished is the regular Poulsen receiver such as is shown, for example, in the Navy manual for 1913, plaintiff's Exhibit No. 78, in Figure 89, found on page 134 thereof and described in section 200. I here quote the description as follows:

"200. Figure 89 represents receiving circuits for continuous oscillations; it shows the receiving telephone connected across the terminals of a fixed condenser in series with the detector.

"In using undamped oscillations for wireless telegraphic purposes it must be remembered that the frequency of the oscillations themselves is too high to be heard in the telephone connected with the ordinary receiving circuit, and when the circuit at the sending station is closed all that would be heard is a slight click, so that there is no way of telling a dot from a dash. This makes it necessary to place a rapidly rotating circuit breaker in the sending or receiving circuit for the purpose of creating a buzz in the telephone at the receiving station when the circuit is closed. This circuit breaker may be placed in the sending aerial, while the sending key is placed either in the aerial or shunted around a few turns of the aerial inductance, in which case it serves merely to throw the aerial in and out of tune with the closed circuit. (Art. 164.)

"If no interrupter is used in the sending apparatus, no signals can be read at a receiving station unless the wave trains are there broken up so as to produce a buzz in the telephone. For this purpose the Poulsen ticker is sometimes used, which at the same time does away with the need of any special receiver. It consists essentially of a circuit breaker actuated by a small magnetic vibrator, kept in action by a dry cell. In this receiver the closed circuit is coupled very loosely to the aerial, and this circuit is intermittently [fol. 366] connected to a large condenser, of the order of a

microfarad, by the ticker or a slipping contact detector. (Art. 210.)

"During the time of contact the condenser becomes charged, and when the contact is broken it discharges itself through the telephone, producing a note corresponding in tone to the frequency of the ticker."

The motor-driven form of the ticker is that referred to in paragraph 210, to which cross reference is made in the above quotation. In that paragraph it is referred to as a "slipping contact detector."

"210. Slipping contact detector: In its present form this consists of a small bundle of fine wires, or a single wire resting lightly on the rim of a wheel of conducting material, which is revolved at high speed by a small motor. It is not, in general, as satisfactory as crystal detectors, but is suitable for receiving undamped oscillations (fig. 89)."

Comparing with the Marconi patent No. 763772, it will be seen that the Federal company receiver, as shown in Figure 89 of Exhibit No. 78, is identical with tune 2 of page 4 of the Marconi patent, except that it has a condenser in the antenna circuit as an additional means of tuning. Figure H of Exhibit No. 99 shows the arrangement of tune 2. The adjustable elements in the antenna circuit are the loading inductance coil, this fact being indicated by an arrow across the coil and a condenser whose variable character is similarly indicated. A fixed condenser is arranged with a switch so that it may be employed if desired. The purpose of this is to shorten the wave length of the antenna and so enable waves shorter than the natural wave length to be received while still employing the inductance coil as a tuning means. The secondary coil of the oscillation transformer is shown as nonadjustable and the secondary circuit is tuned by means of the variable condenser shunted across the coil. The detector is indicated as a ticker and the indicator is a telephone. By this means the so-called continuous or undamped oscillations produced by the Federal company's arc transmitter are received. The Navy manual does not explicitly say that the circuits are tuned to resonance with one another, but they are provided with the means for tuning and are capable of being put in resonance therefore, and the results of so doing are so superior as to make it certain that no other mode of use would be acceptable to the Government. Assuming that they are so used, the description and comparison which I have made in considering the ap-

paratus of the Wireless Specialty Apparatus Co., Exhibit 87, apply, and I will not repeat. In my opinion this Federal receiver is such a receiver as is referred to in the receiver claims of the Marconi patent No. 763772. • • •

[fol. 367] Mr. Cosgrove. Plaintiff's counsel offers in evidence the diagram of the Federal arc transmitter, produced by the witness in answer to question 28, and requests that the same be marked "Plaintiff's Exhibit No. 104, Waterman diagram, Arlington Federal arc transmitter."

29. Question. Please state whether you are familiar with the construction and mode of operation of the wireless-telegraph apparatus of the National Electric Signaling Co., which was held to be an infringement of the claims in issue herein of the Marconi patent No. 763772 in suit in the suit of this plaintiff against said National Electric Signaling Co., United States District Court, Eastern District of New York; and if so, how you became familiar with said apparatus.

Answer. I am familiar with the apparatus involved in the litigation referred to. I became familiar with it in connection with that litigation, wherein I testified on behalf of the plantiff.

30. Question. Will you please briefly describe the construction and mode of operation of the wireless apparatus of the National Electric Signaling Co., referred to in the last question, referring to any sketch or drawing you may have of the same, and state how such construction and mode of operation compare with the construction and mode of operation of the apparatus of the defendant herein, which you have considered and testified about, using as a specimen of said apparatus that illustrated in plaintiff's Exhibit No. 87, drawing of Wireless Specialty Co. apparatus, or plaintiff's Exhibit No. 95, drawing, Kilbourne & Clark type of apparatus, or any of the defendant's apparatus you have testified to?

Answer. The National Electric Signaling Co.'s transmitter and receiver are shown in the diagram which I produce, marked "National Electric Signaling system," in which the same conventions are employed and the same color scheme used as in the other drawings, showing circuit arrangements.

Thus the National Electric Signaling Co.'s transmitter has the power circuit shown in yellow, including a generator

a, key *b*, transformer *c*, arranged to furnish the power for the wireless waves by supplying electric charges. It has a red circuit, comprising a condenser X, spark gap G, oscillation transformer primary *d*, adjustable at 2. Three different forms of spark gap were employed in the different installations, one an open gap type, one the so-called quenched gap type, and the third a rotary spark gap. These are indicated on the diagram which I produce by repeating three times the primary or red circuit, using different specific conventions to denote the spark gap.

The transmitter also has the antenna circuit shown in black, comprising an elevated conductor *f*, *A*, inductance coil *g*, adjustable at 1, inductance coil *d'*, adjustable at 1', and constituting the secondary of the oscillation transformer, and an earth connection at E.

The receiver comprises an antenna circuit for receiving the waves, having an elevated conductor system *f*, A, and variable inductance coil *d'*, variable at 3, the primary of an [fol. 368] oscillation transformer, *f'*, variable at 3', and earth connection E. It also has a condenser *h*, which may or may not be included in the antenna, according as the switch *s* is open or closed. The receiver also has a closed conserving and detecting circuit shown in red, and comprising the oscillation transformer secondary winding *f'*, adjustable at 4, a detector T, and condensor *f*³. Across this circuit there may be connected a condenser *h'*, if the switch shown just below it is closed, this furnishing an additional adjusting means. The receiver also has an indicating circuit, shown in green, comprising an indicator R, battery B, potentiometer *u*, for adjusting the battery.

This National Electric Signaling apparatus might as a matter of fact be compared with any of the sufficiently disclosed apparatus of the defendant. As I have pointed out in my preceding answers, all of the defendant's apparatus is essentially that shown in Figures C to J of Exhibit No. 99, being the several forms or arrangements shown and indicated in the Marconi patent No. 763772, in suit.

Specifically for the sake of illustration, I compare this National Electric Signaling apparatus with that of the Wireless Specialty Apparatus Co. It will be seen that the transmitters are identical in elements and their relation to one another, except that the National Electric Signaling Co. employed in its various installations sometimes the quenched spark gap, and in other cases the rotary spark

gap, or the plain open spark gap. This being merely a matter of an improved form of spark gap, it is an immaterial detail, the transmitter having, as I am advised, been held by the court to be the transmitter as disclosed in the Marconi patent, without particular regard to the construction of the spark gap.

The receiver of the National Electric Signaling Co. is identical with that of the Wireless Specialty Apparatus Co. shown in Exhibit No. 87, save that it has the additional condenser *h* controlled by a switch so that it may or may not be employed as an additional adjusting means, and that condenser *h'* also has a switch that it may or may not employ.

The same comparison might be made as to the Kilbourne & Clark apparatus shown in Exhibit No. 95, the only additional items to be mentioned being the fact that the Kilbourne & Clark transmitter has an added means of adjustment in the red circuit of the transmitter, namely, the coil *i''*, adjustable at 3. This is merely for greater flexibility of adjustment. The only difference as to the receivers is that the condenser *h* of the Kilbourne & Clark apparatus may be placed either in the antenna directly or in parallel to a portion of it, as shown in Figure 2 of the Marconi patent, and that the condenser *h'* is permanently connected across the secondary instead of by means of a switch. These are, of course, merely matters of detail.

As in the case of the Government apparatus, in the various forms which I have discussed, the two circuits of the transmitter and the two circuits of the receiver (red and black) were in resonance with one another and transferred energy, therefore, in the same manner. The detector employed by the National Electric Signaling Co. was a crystal detector or an electrolytic detector.

Mr. Cosgrove. Plaintiff's counsel offers in evidence the diagram produced by the witness in answer to Q. 28, and [fol. 369] requests that the same be marked "Plaintiff's Exhibit No. 105, Waterman diagram, National Electric Signaling Co.'s system."

30. Question. Your attention is called to plaintiff's Exhibit No. 34, certified copy of the Marconi British patent No. 7777 of 1900. Please state how the disclosure of that patent compares scientifically with the disclosure of the Marconi patent in suit No. 763772 in respect to the inventions of the claims in issue thereof.

Answer. The provisional specification of British patent No. 7777 of 1900 is in substance an abstract of the subject matter of United States patent No. 763772. It discloses the use of two circuits at the transmitter and two circuits at the receiver, means for adjusting these circuits, and the greatly increased energy which results in the transmitter and improved selectivity in the receiver from the tuning of the two circuits together to resonance.

The complete specification is similar to the specification of United States patent, the principal difference being the inclusion therein of a larger number of illustrative examples and more drawings illustrating them.

I notice one use of terms which is contrary to American usage, namely, the employment of the term "induction coil" to designate the oscillation transformers described. The drawing and descriptive matter, however, make it clear what the meaning it.

31. Question. Please explain the nature of the inventions set forth in the Fleming patent in suit, No. 803684, as claimed in claims 1 and 37 thereof, and the way the elements and devices of said inventions function or operate, defining and explaining such technical terms, phrases, and ideas found in the patent which you have not already explained and which you may consider necessary to a full understanding of such inventions, and incorporating in your answer any drawings or sketches which may simplify your explanation of technical matters.

Answer. *Fleming patent in suit, No. 803684.*—The Fleming patent relates to what is now often known as the incandescent-lamp detector and discloses the possibility of using such a lamp by the insertion within it of another electrode other than the filament, by means of which the wireless-telegraph receiver may be connected to the interior and the indicator also connected thereto to respond to any changes produced therein. Referring to Figure 1, there is shown an incandescent-lamp bulb *a*, within which is mounted in the customary manner a filament *b*, having terminal wires *f*, *e*, led therefrom to a suitable source of current, indicated as a battery *h*. There is also within the globe a metal cylinder *c*, held in place in a suitable manner, as by wires *d*, sealed into the glass, and one of these wires is brought through the glass for connection to the wireless-telegraph receiver. The antenna of the wireless-telegraph receiver is shown at *n* and is connected

to one coil *m* of an oscillation transformer, the other end of which is connected to the earth at *o*. The secondary coil *k* of the oscillation transformer has its terminals connected by wires *j* respectively to the cylinder *c* by way of wire *d*, and to the negative terminal of the battery *h* through an indicating instrument *l*. Figure 2 shows a [fol. 370] modified circuit arrangement employing two bulbs, and Figure 3 an arrangement wherein several may be used, three being shown. These two latter figures do not show the antenna, but only the secondary coil *k* of the oscillation transformer, the primary and antenna being understood. This arrangement constitutes a very sensitive and reliable detector.

The Fleming patent, in introducing the specification, states as follows, page 1, lines 11 to 37 and 53 to 76:

"This invention relates to certain new and useful devices for converting alternating circuit currents, and especially high-frequency alternating electric currents or electric oscillations, into continuous electric currents for the purpose of making them detectable by and measurable with ordinary direct-current instruments, such as a 'mirror galvanometer' of the usual type or any ordinary direct-current ammeter. Such instruments as the latter are not affected by alternating electric currents either of high or low frequency, which can only be measured and detected by instruments called 'alternating-current' instruments of special design. It is, however, of great practical importance to be able to detect feeble electric oscillations such as are employed in Hertzian wave telegraphy by an ordinary movable coil or movable needle mirror galvanometer. This can be done if the alternating current can be 'rectified'—that is, either suppressing all the constituent electric currents in one direction and preserving the others, or else by changing the direction of one of the sets of current which compose the alternating current so that the whole movement of electricity is in one direction. * * *

"I have discovered that if two conductors are inclosed in a vessel in which a good vacuum is made, one being heated to a high temperature, the space between the hot and cold conductors possesses a unilateral electric conductivity, and negative electricity can pass from the hot conductor to the cold conductor, but not in the reverse direction. As the hot conductor should be heated to a very high

temperature—say, near to the melting point of platinum (1,700° centigrade)—it should be of carbon, preferably in the form of a filament such as is used in any ordinary incandescent electric lamp. The cold conductor may be of many materials; but I prefer a bright metal, such as platinum or aluminum or else carbon. The two conductors are inclosed in a glass bulb similar to that of an incandescent lamp, and I generally heat the carbon filament to a high state of incandescence by a continuous electric current, the electrical connection to the filament and the cold conductors being made by platinum wires sealed air-tight through the glass."

Regarding the construction of the bulb, the specification says, as follows, quoting from page 1, line 84, to page 2, line 4:

"In figure 1 *a* is a glass bulb, and *b* is a carbon filament of an incandescent lamp suitable, say, for taking a current of six to eight volts and two to four amperes. *c* is a cylinder of aluminum, open at the top and bottom, which surrounds but does not touch the filament. The cylinder *c* is suspended and steadied by platinum wires *d*, and the ends of the filament *b* are connected to platinum wires connected to the leads *e* and *f*. The platinum wires are sealed through the glass in the ordinary manner.

[fol. 371] "As a very high vacuum should be obtained in the bulb *a* and as a considerable quantity of air is occluded in the conductors, these should be heated when the bulb is being exhausted. The filament *b* can be conveniently heated by passing a current through it, while the cylinder *c* can be heated by surrounding the bulb *a* with a resistance coil through which a current is passed, the whole being inclosed in a box lined with asbestos or the like. When, as hereinafter described, the cylinder *c* is replaced by any form of conductor which can be heated by passing a current through it this method is usually more convenient than that just described."

Modifications of the construction are referred to as, for example, the cylinder may be replaced by a loop, or a number of filaments may be employed to constitute the several elements or a gridlike structure may be used. This is set forth on page 2, line 73 to line 86, as follows:

"In place of using a metal cylinder surrounding a carbon-loop filament I sometimes use a number of carbon filaments. Some of these are heated by means of an electric current and become the hot conductor of the oscillation valve and the other remains cold and form the cold conductor, or the metal cylinder may be replaced by a cylinder of meerschaum or the like having wound helically upon it a narrow ribbon of metallic foil. In those cases in which a larger alternating current has to be dealt with the hot conductor may be a rod of soft graphitic carbon held in suitable supports."

Regarding the mode of use, the specification says, page 2, lines 5 to 14, as follows:

"The carbon filament is made highly incandescent in the usual way by a continuous electric current produced by the battery *h*, the negative pole of which is connected to the wire *e* and the positive to the wire *f*. The wires *d* and *e* are connected together by a wire *j*, which completes the circuit through the secondary winding *k* of an induction coil (such as is ordinarily used in wireless telegraphy) and a galvanometer *l*."

I note in this last quotation the use of the expression "induction coil," as meaning an oscillation transformer. This should not be confused with the same term as used to designate a source of high-tension current for the transmitter.

The circuit described in the above quotation and shown in figure 1 is a well-known wireless-telegraph circuit, and this and others are used in the practical application of the Fleming invention. It will be observed that it serves two purposes in the practical use of the device: First, through the intervention of the oscillation transformer *k* it impresses upon the space between the element *c* and the filament *b* the effect of the received electric waves; second, it connects the two elements *b* and *c* with a conducting path containing an indicator *l*, and thus indicates that the effect of the electric waves has been impressed on the space, and thus the indicator is caused to indicate the receipt of the signals and it becomes possible to read them. Regarding the operation, the specification states as follows on page 2, lines 18 to 27:

"The arrangement described above operates as an electric valve and permits negative electricity to flow from the hot carbon *b* to the metal cylinder *c*, but not in the reverse [fol. 372] direction, so that the alternations induced in the coil *k* by the Hertzian waves received by the aerial wire *a* are rectified or transformed into a more or less continuous current capable of actuating the galvanometer *l* by which the signals can be read."

Why the device operates in the manner set forth in the patent or what the particular natural mechanism of the space within the bulb may be which secures the result is not certainly or clearly understood, but Fleming sets forth the construction and the apparent functioning of the apparatus in the above statement.

As to the means of indicating, associated with the devices, the specification says as follows on page 2, lines 118 to 123:

"When I specify in my claims 'means for detecting a continuous current,' I intend to include any instrument for detecting such a single unidirectional pulsating current or two such unidirectional pulsating currents flowing in opposite directions."

I note that the term "continuous current" here employed meant at that time simply a current flowing in one direction, whether constant in strength or not. Recently by a convention the term has been reserved to apply to a current flowing always in one direction and substantially constant in strength, while the term "direct current" designates a current in one direction, whether constant or pulsing or otherwise variable.

Claims 1 and 37, to which my attention is called, read as follows:

"1. The combination of a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for heating one of the conductors, and a circuit outside the vessel connecting the two conductors."

"37. At a receiving station in a system of wireless telegraphy employing electrical oscillations of high frequency a detector comprising a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for heating one of the conductors, a circuit outside of the

vessel connecting the two conductors, means for detecting a continuous current in the circuit, and means for impressing upon the circuit the received oscillations."

32. Question. Are you familiar with the operation of and have you used detectors as described in the Fleming patent in suit? And if so, what was the structure of these detectors and from whom did you obtain them?

Answer. I am familiar with the use of these detectors of the Fleming patent and have personally used large numbers of them. In structure these have differed from one another in various particulars, such as the shape and position of the cold element and the shape, position, and material of the hot element. I have used considerable numbers, substantially identical with the construction shown in the Fleming patent and others, in which the cold element took the form of one or two plates, parallel to the filament or facing it and at right angles to it. I believe that all that I have used have been obtained from the plaintiff Marconi company. I have used them, both for the receipt of messages and also for the various tests and experiments I have made with them. I have found them both sensitive and reliable in practical use.

33. Question. Have you used and are you familiar with the detectors of the type known as the PX audion referred [fol. 373] to in plaintiff's Exhibit No. 71, contract with the Radio T. & T. Co., of March 5, 1914; also the DeForest PX audion, used by the Navy, of plaintiff's Exhibit No. 82, and the diagrams and connections of such exhibit as illustrated in plaintiff's Exhibit No. 83; the "ultra audion" of the type called for by plaintiff's Exhibit No. 74, contract between the Radio T. & T. Co. and the Navy as illustrated in plaintiff's Exhibit No. 84, official instructions for use of "ultra-audion," and the amplifiers illustrated in plaintiff's Exhibit No. 85, drawing of audion amplifier used by the Navy, and referred to in plaintiff's Exhibit No. 72, contract of Radio T. & T. Co.? And if so, will you please state when and under what circumstances you became familiar with those types of detectors and used the same?

Answer. The several trade names used in the question, such as PX audion, ultra-audion, and audion amplifier, all refer to the same thing, namely, an incandescent-lamp detector used with various adjustments and circuits. I do

not remember when I first became familiar with these, but I have owned one of the PN audions, substantially like plaintiff's Exhibit No. 82, for some years and have made much use of it and I have used it in all of the ways indicated by the several trade names of the question and various others as well. I have owned numerous bulbs, known as audions, and have used them with various other apparatus than the particular PN audion box to which I have just referred.

I also became familiar with the several types of audion referred to in the question in the suit of Marconi Wireless Telegraph Co. *v.* the DeForest Radio Telephone & Telegraph Co. in the United States District Court for the Southern District of New York, brought for the infringement of this Fleming patent. I testified on behalf of the plaintiff in this case, and I am advised that these types of audions referred to in the question were held to infringe claims 1 and 37 of the Fleming patent in suit. I recognize Exhibit No. 82 as the sample which was in evidence in that case as plaintiff's Exhibit No. 2 therein, and also the bulbs as similar to the bulbs which were in evidence in that case, one apparently being the same one as was there in evidence.

34. Question. Please compare the construction and operation of the invention of the Fleming patent in suit, as described in claims 1 and 37 thereof, with the construction and operation and use of (1) the De Forest PN audion detector, (2) the "ultra-audion" detector, and (3) the audion amplifier used by the Navy as set forth in Mr. Graham's deposition and illustrated in plaintiff's Exhibits No. 83, drawing, PN audion, No. 84, official instructions for use of ultraaudion, No. 85, drawing of audion amplifier, and as exhibited in plaintiff's Exhibits No. 82, De Forest PN audion, and also as referred to in plaintiff's Exhibits Nos. 71, 72, and 74, contracts between the radio T. & T. Co., and the United States Navy. In answering this question, you may make use of any other exhibits and drawings you deem necessary?

Answer. Exhibit No. 82, defendant's PN detector, is simply a box fitted with suitable mountings for two incandescent lamp detectors, sold under the trade name "audion" and provided with suitable connections and binding posts, switches, and the like for using either one of the bulbs at will after the manner indicated in the diagram, plaintiff's Exhibit No. 83, or otherwise as desired.

[fol. 374] The incandescent lamp detectors which form part of this Exhibit No. 82 are simply small incandescent lamps, each of which is provided with two filaments and two additional elements, one of which is a bit of wire bent back and forth to form a sort of grid, placed parallel with the plain filaments and about one-sixteenth of an inch away from it, and the other of which is a small metal plate, placed parallel with the grid and about one-sixteenth of an inch away from it. The two filaments are provided so that if one burns out the other may be used and the spare filament is not normally connected. One of the bulbs, namely, that one which has upon it a tag marked "De Forest standard audion bulb" and initials "W. C. B., Oct. 13, 14," is a so-called standard audion bulb, having a tantalum filament, while the other, having an additional tag marked "dup-A-4," is identical with the other, except that the filament is the so-called Hudson filament, being, as I understand, a tungsten filament with a little particle of tantalum in the center. The circuits of the box, Exhibit No. 82, are shown in the diagram marked "Simplified circuit of PN detector." The upper figure shows the circuit arrangement of the box itself and the several letters thereon such as "R A" and "R E" are the markings found on the box itself. The lower diagram shows the complete wireless telegraph circuit of the box when one bulb is in use. The heavy, black line incloses so much of the circuit arrangement as belongs to the box. This lower diagram is substantially identical with Exhibit No. 83, introduced by Mr. Graham.

Comparing the PN audion as connected for use, namely, as shown in plaintiff's Exhibit No. 83, copy of which is inserted opposite, with the Fleming patent, it will be seen that there is in each case an incandescent lamp detector, connected to a wireless telegraph circuit. The particular details of the wireless telegraph circuit itself I assume are immaterial and it is sufficient to note that in each secondary of the oscillation transformer (marked f^2 in Exhibit 83 and k in the Fleming patent), has one end connected to the wire leading to one terminal of the incandescent filament and the other leading to a cold element within the bulb, whereby the oscillations produced by the receipt of the electric waves are impressed upon the space between the cold element and the filament. In each, also, the effect of the receipt of these oscillations is indicated by an indicator marked R in Exhibit 83 and l in the Fleming patent. In the

particular circuit which Fleming has chosen, the two functions of impressing the oscillations on the space and conducting the indicating current to the indicator, are performed in a single circuit by means of a single cold element. In the case of the lamp called the audion, these two functions are divided and the cold element is divided into two to one of which, marked G in Exhibit No. 83, is assigned the function of impressing the oscillations upon the space, and to the other of which, marked P, is assigned the function of completing the circuit of the indicator and indicating the result of the oscillations. These two forms of circuit I may say are very well-known equivalent forms. It will also be noted that in the arrangement of Exhibit No. 83 there is a local battery B^2, in circuit with the indicator and there is a condenser 3 in the wire leading to the oscillation transformer.

[fol. 375] For greater ease in comparing these and showing exactly what the differences are I produce a diagram marked "Fleming and De Forest compared." The left-hand one of these figures substantially reproduces Figure 2 of the Fleming patent in slightly more conventionalized manner and the right-hand figure similarly represents Exhibit No. 83, somewhat more conventionalized. The splitting up of the cold element and the combined detecting and indicating functions of Fleming's arrangement into two cold elements and circuits in the PN audion arrangement is here clearly shown.

In the Fleming patent no local battery is employed in the indicating circuit, the only battery being the heating battery. In the PN circuit, a battery B is shown. Such a battery may also be used in the Fleming valve circuit, or the Fleming valve may be used in the PN circuit. My practical use of these valves of the Fleming patent shows that some of them are very much improved by the use of a battery and that others are not.

It will be seen that the audion is, like the Fleming valve, an incandescent lamp detector having an incandescent lamp filament, mounted in a highly evacuated glass globe, that there is mounted therein in addition to the filament, a plate and a wire grid with terminals brought out for connection to the exterior circuit. The separation of Fleming's cold conductor into two does not in any way alter the valvelike action, which permits the flow of negative electricity from a hot filament to the cold element but not in the

reverse direction, as described by Fleming, and the device acts in similar manner to detect the receipt of wireless signals. Of course, when the valve of the Fleming patent is used without a battery, in circuit with the indicating instrument the effect of the received signal is to produce a current in the indicator to which the latter can respond. If a battery is used, the effect is to produce a variation in the battery current flowing. Similarly in the PX audion arrangement, wherein the local battery is employed the effect of the receipt of a signal is to produce a change in the current flowing to the indicator, which is observed by the operator either orally or visually.

In my opinion, the De Forest PX audion is such an incandescent lamp detector as is disclosed in the Fleming patent, being substantially such a structure and being associated with the wireless telegraph circuit, substantially as shown in the patent and referred to in claims 1 and 37 thereof.

Exhibit No. 71, referred to in the question, I have already considered in connection with the Marconi patent. I note that in item 5 the letter attached to the contract in this exhibit, states that the audion, PX type, will be furnished if desired by the bureau. I understand that the box and bulbs as illustrated in Exhibit No. 82 are there referred to.

Mr. Cosgrove. Plaintiff's counsel offers in evidence the diagrams and drawings referred to by the witness in this answer to Q. — and requests that the same be marked "Plaintiff's Exhibit No. 106, drawing, simplified circuits of PX detector," and "Plaintiff's Exhibit No. 107, drawing, Fleming and De Forest compared."

[fol. 376] Witness (continues). I produce a leaflet which purports to give instructions for the type RJ4 audion detector, this being the same sheet which was in evidence in the case of this plaintiff against the DeForest Radio Telephone & Telegraph Co., above referred to, and was accepted as instructions in the operation of the exhibit PX audion detector, which was in evidence and which is here in evidence as Exhibit No. 82. My understanding is that it was issued as such by the Radio Telephone & Telegraph Co. upon the original purchase of Exhibit No. 82. It gives the circuit diagram and instructions for connecting and operating. These instructions caution against using too much local battery and say that when enough local battery is used

to produce a blue glow the bulb loses its sensitiveness. This means that the vacuum in the audion bulb is high and that the bulb must not be used at any local battery voltage which is great enough to excite or ionize any residual gas contained therein, as to do so would mean to lose the sensitiveness of the bulb.

Mr. Cosgrove. Plaintiff's counsel offers in evidence the instructions referred to and requests that the same be marked "Plaintiff's Exhibit No. 108, audion instructions."

Defendant's "ultra-audion."—The so-called ultra-audion is simply the audion with its circuits slightly modified. That this is so is clearly stated in plaintiff's Exhibit No. 78, Navy manual for 1915, page 144:

"When connected for receiving continuous oscillations it is called the 'ultra-audion.'"

This circuit enables undamped oscillations to be more easily received and also more easily permits the audion to oscillate and therefore increases its sensitiveness.

Exhibit No. 84, official instructions for use of ultra-audion, describes and illustrates how the audion box, such as the PN detector box in evidence, is to be connected in order to have the ultra-audion connection, and it shows that the receiving tuner is simply to be connected to one of the binding posts marked G, through a variable condenser and to one of the binding posts marked R, instead of to the post marked R A and R E. I produce a diagram, which shows in simplified form this Fig. — of Exhibit 84. It will be seen that it differs only in that a variable condenser is substituted for the fixed condenser of Exhibit No. 83 and that the other end of the oscillation transformer connects to the plate end of the telephone circuit. There is also a condenser around the local battery and telephone. The mode of operation of the bulb in this connection is not different from that in the other or PN connection, but it is easier in this circuit to bring about the so-called oscillating condition. In this condition the current in the indicator circuit becomes oscillating in character, and this condition will be continuously maintained if the adjustment is correct. The flow of this oscillating current increases the sensitiveness of the bulb as a detector and also enables it to effectively alter the received frequency of undamped oscillations, which are then detected in the regular way. The precise details of

the operation of these vacuum valves are not fully understood, and my statements are therefore to be regarded as [fol. 377] merely a general indication of what happens, rather than a precise definition of the way it happens.

Contract, Exhibit No. 74, refers to ultra-audion detectors and bulbs therefor, also receiving cabinets therefor. The bulbs called for are two sizes, namely, 6-volt bulbs, which means that the incandescent filaments can be properly heated from this 6-volt battery, and 12-volt bulbs, which means that a battery of 12 volts is required for the heating.

In my opinion, these ultra-audion detectors called for in this contract are such detectors as are disclosed in the Fleming patent and operating in substantially the same manner. They are also used in such combinations as are referred to in claims 1 and 37.

I may note that the so-called oscillating state is not a peculiarity of incandescent lamp detectors, although they are particularly convenient for this work. Any detector which is also able to control the local battery current so as to amplify the received energy is capable of being put in the oscillating condition, this being done by transferring part of the energy of the battery circuit back to the controlling circuit to keep the latter continuously excited. In other words, the continuous repetition of the detecting function is the so-called oscillating state, and a detector in the oscillating state may be said to be continuously detecting, the fact that it is detecting.

Mr. Cosgrove: Plaintiff's counsel offers in evidence the diagram referred to above and produced by the witness and requests that the same be marked "Plaintiff's Exhibit No. 109, Waterman diagram, defendant's 'ultra-audion.'"

Defendant's audion amplifier.—The arrangement of the audion, which is called the amplifier, is shown in Mr. Graham's drawing, Exhibit No. 85, inserted opposite. This drawing shows the so-called three step amplifier, being three bulbs arranged tandem, each one to receive and amplify the signals produced by the one in advance. If the right-hand bulb and its circuit connections were simply omitted, the remaining portion of the diagram would show the so-called two-step amplifier, and if the two at the right were omitted a one-step amplifier would remain. In the actual instruments, as I am familiar with them and as indicated by Mr. Graham in Exhibit No. 85, either one, two,

or three steps may be employed by connecting the indicator R at R^2 for a two-step amplifier or R^1 for a one-step amplifier. I note that Mr. Graham's diagram does not show the complete circuit arrangement. A complete diagram, however, is given on page 143 of plaintiff's Exhibit No. 78, Navy manual for 1915.

This diagram I produce, attaching to it letters of reference. In this diagram A is the vertical wire, j^1 the primary of the oscillation transformer, j^2 the secondary thereof, and h the tuning condenser. Three detector bulbs T, T^2, T^3, together constitute the detector, R being the telephone indicator. In this particular figure the first bulb T^1 receives the signal in the ordinary way, which I have considered in considering the PN audion, and which is shown in Exhibit No. 83. The signal so received may be too faint to be readable, and in that case the telephone or indicator of Exhibit No. 83 is replaced by a transformer 1, to which [fol. 378] is connected a second bulb, as shown in the sketch opposite. If the signal is still too weak, a second transformer 2 is inserted, to which another bulb T^3 is attached in the local circuit of which the telephone R is placed, or, if need be, still another bulb may be added until the resulting sensitiveness of the group is sufficient to give the desired loudness of signal. Referring again to Mr. Graham's diagram, Exhibit No. 85, the two left-hand terminals X Y correspond to X Y on the diagram just reproduced, being the two terminals which would be connected to the receiver in place of the telephone of Exhibit No. 83.

I note that Exhibits 72 and 73 are contracts for the supply of amplifiers of this audion-detector type. I also note that Exhibit No. 86 is a bulletin of the Radio Telephone & Telegraph Co., illustrating on page 190 the PN type of audion detector and on page 192 the audion amplifier detector, having three bulbs corresponding to Mr. Graham's diagram, Exhibit No. 85. I may say that in the case of this plaintiff against the DeForest Radio Telephone & Telegraph Co. a combined ultra-audion and amplifier instrument, in appearance exactly like the cut on page 192 of Exhibit No. 86, was before the court, the first or lower bulb being provided with circuit connections, so that all three bulbs were arranged exactly as shown in Figure 88[a] of Exhibit No. 78, which I have just produced, or the first bulb could be connected in the so-called ultra-audion manner, the other bulbs being connected as shown in the last-

mentioned diagram. All of these arrangements, namely, the PM detector, the ultra-audion detector, and the audion amplifier detector, were before the court in that case, and, as I understand, were held to be infringements of the Fleming patent No. 803684 in suit.

The operation of a tandem series of bulbs is the same substantially as that of a single bulb, that is to say each successive bulb repeats the action of the one before it. Thus, the first bulb T^1 (referring to fig. 88*a*), detects the receipt of an electric wave with the result that a variation of current is produced in the circuit of its local battery B^2. This variation of current will consist of a variation of the normal current flowing through the battery, both at the same rate as the variation of the received signal, and also at the lower rate corresponding to the group frequency or spark frequency of the signal. These variations pass through the transformer I and are handed on to the next bulb, which does exactly the same thing, but if it is a bulb capable of amplifying, the variations produced in its local battery circuit will be larger. These larger variations are passed on to the next bulb, which in turn will amplify and thus by successive repetitions variations great enough to be easily audible in the telephone or to be loud enough for the purpose desired may be secured. It is, of course, the fact that a local battery is used that enables these repetitions to be made successively stronger.

It should be understood that, as a matter of fact, not all bulbs, whether they have one cold element as shown in defendant's patent, or two, as in the so-called audion, are able to work efficiently enough to produce an amplification. The bulbs which will amplify have to be selected by trial.

In my opinion, these audion detectors, referred to in the several exhibits, are incandescent lamp detectors, as set [fol. 379] forth in the Fleming patent and referred to in the claims thereof and the particular uses or modes of connection merely illustrate ways of using them to receive wireless-telegraph signals, as set forth in the Fleming patent.

34½. Question. In your last answer you have referred to and quoted from paragraph 208, page 143, of plaintiff's Exhibit No. 78, Navy manual for 1915. What is your opinion as to the so-called differences between the audion and Fleming valve and the alleged additional advantages attributed to the former, as set forth in that paragraph?

Answer. The paragraph 208 of Exhibit No. 78 inquired about is merely comparing the use of the incandescent lamp detector used without a local battery with its use with a local battery. The great drawback to the use of a local battery is that the batteries deteriorate and give a very large amount of trouble. The Fleming valve literally as shown in the Fleming patent is an excellent detector used with or without a local battery and when used without a local battery it avoids the nuisance of maintaining and adjusting these batteries. Further, until the last few years, there have not been available small dry batteries convenient for the purpose. The incandescent lamp detectors have been used both with and without the local batteries. Either the two element bulbs shown in the Fleming patent or the three element bulbs may be used without a battery or either may be used with a battery. Paragraph 208, under consideration, merely compares the "Fleming valve" as used without a battery with the audion as used with a battery. Of course, no detector used without a battery can amplify, because there must be a local source of energy to give the increased signals, but either the two- or the three-element bulb can be used to amplify when used with a local battery. When, therefore, paragraph 208 states "The audion has the further advantage over the valve, in that the telephone can be replaced by the primary of a transformer, the secondary of which is connected to another audion, with the result of amplifying the signals produced (see fig. 88*a*)" it is referring to a result obtained by the use of the incandescent lamp detector with a battery.

I may note that individual bulbs, whether two element or three element, are found to differ greatly in sensitiveness even though apparently of the same construction. The reason for this variation is not known, but it is true of either form and is not the result of definable differences in construction.

Mr. Cosgrove: Plaintiff's counsel offers in evidence the Figure 88a from the Navy manual of 1915, referred to in the answer to Q. 33, and requests that the same be marked "Plaintiff's Exhibit No. 110, Figure 88a, amplifying audion."

35. Question. Have you examined and do you understand the construction, arrangement of circuits, and operation of

plaintiff's Exhibit No. 28, Fleming valve receiver, and plaintiff's Exhibit No. 29, Fleming valve or bulb forming part of said receiver?

Answer. Yes; I examined the exhibits referred to on April 16 of this year and traced the circuits of Exhibit No. 28.

36. Question. What relation does the construction, arrangement of circuits, and operation of plaintiff's Exhibits Nos. 28 and 29, referred to in the last question, bear to the invention of the Fleming patent, as described in the specification thereof and recited in claims 1 and 37 thereof?

[fol. 380] Answer. Exhibit No. 28, together with the bulb 29, constitutes an incandescent-lamp detector and wireless-telegraph receiver, such as shown in the Fleming patent, substantially as shown in Figure 1. I have made a diagram, * * * illustrating the apparatus arranged for use, and I have inclosed in dotted lines that portion, which is contained within the exhibit itself. In the diagram as I have drawn it, f A is an elevated conductor, connected to the primary j' of an oscillation transformer, the other end of which is connected to earth. The two binding posts for connection to antenna and earth are found on the sides of the box, marked respectively "aerial" and "earth." The secondary circuit consists of a secondary coil j^2, for the oscillation transformer, a variable condenser h, which is at the left of the front of the instrument and comprises two slidably mounted brass tubes, by which it may be recognized. It also includes a connection leading to the binding post mounted on a rubber pillar on the front of the box to which the wires connected with the cold elements of the bulb are to be attached and it has sockets for the mounting of the two bulbs and a switch, which I have indicated at S, for determining which one of the bulbs shall be used. The other terminal of the secondary circuit is connected through two condensers j^3, j^4, to the negative terminal of the battery B^1. The indicator R is connected around the condenser j^4. It will be seen by comparing with Figure 1 of the Fleming patent that the circuit arrangement, when bulb is in use, is identical with that shown in the Fleming patent, except for the addition of the adjustable condenser h, which is a means of tuning and the insertion of the fixed condenser j^3 and j^4, which are merely variations of the details of the circuit evidently found useful.

Mr. Cosgrove: Plaintiff's counsel offers in evidence the sketch produced by the witness in answer to the last question and requests that the same be marked "Plaintiff's Exhibit No. 111, Waterman sketch, circuit of Exhibit 28, Fleming valve receiver."

37. Question. Your attention is called to plaintiff's Exhibit No. 77, certified copy of Fleming British patent No. 24850, of November 16, 1904. Please state how the apparatus disclosed in the provisional specification of that patent and its operation compare with the disclosure of the Fleming patent in suit No. 803684, as claimed in claims 1 and 37 thereof.

Answer. The provisional specification of the patent referred to makes practically the same disclosure as the Fleming patent in suit, No. 803684, as I understand the same.

38. Question. Please compare and point out the relation, if any, in your opinion, between the construction, arrangement, and operation of the wireless-telegraph receiving circuits of the "N audion, "ultra-audion," and audion amplifiers, used by the Navy, and which you have considered in Q. 33, and the construction and operation of the inventions of Marconi patent No. 763772, as recited in the receiver claims thereof in issue herein, referring to any exhibits already introduced herein and giving your reasons for any opinion you may express.

Answer. The only information which I have as to the wireless telegraph circuits employed when the audion is [fol. 381] used by the Navy as the detector, whatever the specific mode of use may be, is that found in Exhibits 83 and 84, and that indicated by the diagram on page 143 of Exhibit No. 78, Navy manual of 1915. Exhibit No. 83 shows specifically the circuit arrangement of the Wireless Specialty Apparatus Co. I-P-76 receiver, and Exhibit No. 84 appears to state that it is the I-P-76 receiver, which is used with the ultra-audion detector. As to both of these, therefore, I have already made the comparison and have pointed out that this I-P-76 receiver is such a receiver as is referred to in the Marconi patent No. 763772, and particularly as recited in the receiver claims thereof. The diagram on page 143 of Exhibit No. 78 seems also to be intended to illustrate an antenna circuit, including one coil of an oscillation transformer and a secondary circuit, whose induc-

tance and capacity are both variable for the purpose of tuning the two circuits to resonance with one another and with the received signals. So, understanding the circuit, it evidently is also such a receiver as is referred to in this Marconi patent and particularly pointed out in the receiver claims thereof.

Mr. COSGROVE. Plaintiff's counsel gives notice that on the issues herein of validity and infringement or unlawful use of the inventions of the claims in issue of the patents in suit, plaintiff relies upon the defendant's wireless apparatus, considered in the foregoing deposition of Mr. Waterman, as samples or specimens of said infringement or unlawful use without, however, waiving or prejudicing the plaintiff's right to recover on the issue of compensation for infringement or unlawful use, damages, and profits, or compensation not only on such sample apparatus, but on all wireless apparatus of substantially the same type or character made and used or installed and used by the defendant since June, 1910, including the wireless apparatus called for in all of the exhibit contracts offered in evidence herein.

(Direct examination closed.)

Deposition of Geo. H. Clark, for claimant, taken at New York, N. Y., on the 11th day of December, A. D. 1922, and subsequent dates.

* * * * * * *

Direct examination.

By Mr. Peters:

GEORGE H. CLARK deposed and said that his name is George H. Clark; that his occupation is that of radio engineer; that he is 41 years of age; that his place of residence is 38 Washington Square; that he has no interest, direct or indirect, in the claim which is the subject of inquiry in said cause; and that he is not related to the claimant.

And thereupon the said George H. Clark was examined by the counsel for the claimant, and in answer to interrogatories testified as follows:

1. Question. What practical experience have you had in radio work?

Answer. I am a graduate of the Massachusetts Institute of Technology in electrical engineering, graduating in 1903, [fol. 382] and have been continuously engaged as a radio engineer from that time until now. From 1903 to 1908 I was with the Stone Telegraph & Telephone Co., a radio company in Boston, Mass., engaged in design and research work. From 1908 until 1919 I was radio engineer with the United States Navy, stationed at Washington, D. C. I was first designated as Government inspector of wireless-telegraph stations and later as expert radio aid. From the very first of my work in Washington I was adviser in technical radio matters to the officer in charge of the radio division of the Bureau of Steam Engineering, Navy Department, Washington. My work took me to practically every station of the Navy system and to very many ships. One duty which I performed exclusively up to 1917 and continued in with assistance thereafter was the preparation of the specifications for all radio apparatus which the Navy purchased. I am familiar with every type of set, both transmitting and receiving, that the Navy obtained between the dates 1908 and 1919. I was also in close touch with the Signal Corps headquarters at Washington, and have some knowledge of the Signal Corps radio apparatus. In June, 1919, I resigned from the Navy and went with the Marconi Wireless Telegraph Co. of America, and am now engaged with the Radio Corporation of America.

2. Question. Please enumerate the different types of radio apparatus which the Government had manufactured for it during the period from July 1910 to 1919, when you left the service, and in this connection state approximately when the different types were purchased and used and how they operated.

* * * * * * *

Answer. All the radio apparatus which the Navy Department had made for it or which it made itself during the period referred to was made according to specifica-

tions which I drew up. These specifications were the result of conferences with all manufacturers, modified to meet military requirements. I was officially ordered to the various manufacturing plants to observe the progress of manufacture, and such apparatus as was delivered at the Washington Navy Yard was directly under my observation while it was being tested for acceptance.

In addition to this I myself have used every type of apparatus that the Navy purchased, with the exception of airplane transmitters in service use. As a result of this close contact with the Navy apparatus I divide the Navy radio apparatus purchased during the period referred to into three general classes—transmitters, receivers, and auxiliary apparatus. In subdividing the various classes into their chief subclass I will follow the terminology which is used in a publication by the Government Printing Office, Washington, D. C., entitled "Hearings before the Committee on Military Affairs, House of Representatives, Sixty-seventh Congress, first session, Monday, May 23, 1921," the subject of the hearing being stated as "Radio patents, settlement of claims against Government for use of radio patents during the World War." I shall refer to this as the "Patent board's report" in further reference.

[fol. 383] The division of apparatus given on pages 27, 28, and 29 of this report is excellent, and I will therefore follow it. Transmitters are divided into spark, arc, alternator, and vacuum-tube types. The spark type consists of a number of forms, the oldest of which is the "open-gap" type.

One. Open-gap transmitters have spark gaps of various types, the earliest forms consisting of two fixed electrodes. A number of the sets in use in 1910 were of this type, but I do not think that any were purchased after that time. Around 1910 an open-gap of the rotary type, mounted on the alternator shaft and designed so that the spark gap moved synchronously with the alternator, were purchased. These were from the National Electrical Signaling Co. In 1911 or 1912 purchases of sets with nonsynchronous rotary gap, supplied as auxiliaries to the quenched gap, to be described later, were made. Every quenched gap set, practically, had an auxiliary rotary gap. Whereas this rotary gap was originally intended for breakdown use, during the World War it was found necessary to use the rotary gap

entirely. The purchase of these sets with open gap of the nonsynchronous type continued down to the date when I left the Navy in 1919. I have prepared a drawing, which is headed "Typical transmitter with rotating gap." This drawing was made from an original sketch of mine, and I have checked it as being correct. The lettering of the parts of this sketch corresponds with the lettering, for example, in claimant's Exhibit No. 87, which shows a Wireless Specialty Apparatus Co. transmitter. The only difference is that the quenched gap G in Exhibit No. 87 is replaced by a nonsynchronous rotary gap in my sketch, here offered. The operation of the transmitter and the function of the various parts, as well as the adjustment to any wave length, is the same as that which has been previously referred to by one of the witnesses in this case, Langley, whose testimony I have read, and the only difference in adjustment is one of degree of coupling. Langley's description of the adjustment of a quenched-gap set is correct and applies equally to the rotating-gap set which I am here describing.

Two. The second type of spark transmitter is the quenched gap. These sets were manufactured for the Navy and came into use around 1911 and have been used continuously up to 1919. These sets have been described by previous witnesses, namely, Langley, Weagant, and Graham. I am familiar with all the types of apparatus which they have described, and in some cases have seen the identical apparatus to which they refer. The Wireless Special Apparatus quenched-gap transmitter is correctly shown in schematic diagram in plaintiff's Exhibit No. 87, and the description of the parts and of the method of adjustment and operation by Langley, whose deposition I have read, is correct. I have also examined the schematic diagrams and read the testimony regarding the Wireless Improvement Co., Simon, Lowenstein, National Electrical Supply Co., and Kilbourne & Clark, and I find them all correct.

Quenched-gap apparatus was supplied to the Navy by other companies than those referred to, but the schematic diagram of circuits and the operation is the same as that described.

Three. Transmitters with pure impulse excitation were supplied to the Navy by a number of companies, including Cutting and Washington and others, and I have seen and used this apparatus.

[fol. 384] Four. Spark sets with vacuum-tube excitation are sets originally designed for spark work and modified afterwards so as to be used with vacuum tubes. A few of these sets were changed over prior to my leaving the Navy in 1919.

The next great division of Navy radio apparatus is receivers.

Five. A large number of the receivers purchased by or made by the United States Navy were arranged with terminals so that any form of detectors could be used. Some of these have the crystal detector mounted on the panel, and have binding posts for other detectors which could be substituted externally. Other types had no detector at all with the set. All these receivers were fitted with feed-back coil. I have prepared a drawing which is marked "Receiver arranged with terminals for any form of detector." This drawing was made from a sketch of mine, and I have checked it as being correct. It shows a receiver with two-coupled circuits, inductively coupled, which was the standard type adopted by the Navy. The primary circuit consists of a primary coil j^1, with a contact arm 3, whereby the inductance could be varied. In series with this is a variable condenser h^1, shown schematically in the series connection only, although in many receivers switching mechanism was provided for putting this condenser in parallel with the primary coil j^1. The primary circuit is fed from an antenna f with down lead A, and on its other side connected to ground E. The secondary circuit consist of a coil j^2, inductively related with the coil j^1, and a variable condenser h^2. In practice loading inductances for use in both circuits were used, but are here omitted in order to simplify the drawing. The primary circuit f-A-h^1-j^1-3-E is in service use adjusted so as to be in resonance with the incoming wave, and the circuit j^2-h^2 with such additional capacity as may be offered by external detector and other apparatus is adjusted to be in resonance with the incoming waves. Hence the two circuits are tuned to the same period. From the terminals of the secondary condenser h^2 wires are led to two external binding posts, shown on the drawing as RA and RE, these being the actual letters employed on many of the receivers. From these terminals connection could be made by standard circuit to a crystal detector system, a vacuum tube, a ticker, or any other detector. A coil shown

as j^3 is in inductive relation with the secondary coil j^2, the coupling being adjustable. This coil is brought out to two external binding posts marked "Tickler." This coil is used in the plate circuit of a vacuum-tube detector when regeneration or oscillation of the detector are required. These receivers were bought by or manufactured by the Navy, being approximately the first of 1915, and receivers of this type were obtained up to 1919.

Six. The next type of receiver is the type in which the vacuum tubes were located in the receiver itself. The first type of this receiver was that obtained by the Navy from De Forest in the middle of 1914. These De Forest receivers were of the "ultra-audion" type, and were used constantly in the oscillating state. Under working conditions the vacuum tube was always oscillating. Not very many of these sets were obtained. The schematic diagram showing the circuit for this type of receiver is shown in plaintiff's Exhibit No. 109, which I have examined and find correct. I have operated these receivers personally and am familiar with the diagram. This is the receiver which the patent board's report refers to as "Receivers having built-in ac-
[fol. 385] commodations for vacuum tube, arranged for oscillations only."

Seven. Receivers having the vacuum tube built into the set were also purchased in which provision was made for both oscillations and regenerations. This means that by suitable adjustments, particularly of the tickler coupling, it was possible to use a vacuum tube in the regenerative state, obtaining thereby regenerative amplification without the tube passing into oscillation. By further adjustment, such as the tickler coupling, the tube could be made to oscillate if desired. Large numbers of these receivers were purchased and made by the Navy, and since Washington Navy Yard was the yard to which all receivers and detectors were assigned I was particularly well acquainted with these types. I have prepared a drawing headed "Vacuum-tube receiver, arranged for both oscillations and regeneration," which shows schematically the wiring of this type of receiver. This sketch was made from my original pencil sketch and I checked it as being correct. The primary and secondary tuned circuits, the antenna and ground, and the tickler coil serve the same function as, and are similarly lettered to, the receiver shown in my drawing

headed "Receiver arranged with terminal for any form of detector." Continuing with the drawing here produced a vacuum tube P is shown, with its three elements P for plate, G for grid, and F for filament. This tube is mounted in an appropriate socket in the receiver. One terminal of the secondary resonant system passes through a grid condenser h^3, with a grid leak L around it, and thence to the grid G of the vacuum tube. The other side of the secondary resonant system connects to one terminal of the filament F. The plate P connects through the tickler j^3 to a receiver R, which may be an ordinary telephone receiver, and which is ordinarily shunted by a fixed condenser, thence to the positive side of a high-voltage battery marked B^2, the negative side of which goes to the common filament terminal. The filament is fed by a battery B^1. The battery B^1 and the battery B^2 and the receiver R are usually external to the receiver. In operating this set the adjustment of the two coupled resonant circuits to the incoming wave length is the same as that described by me in referring to the sketch headed "Receiver arranged with terminals for any form of detector." The coupling between coils j^1 and j^2 may be varied to any degree required for selectivity and strength of signal. The filament F of the vacuum tube is brought to a suitable degree of incandescence by the battery B^1 and suitable controlling means not shown in the schematic drawing. The grid condenser h^3 is adjusted to the value required for the particular use of the valve, whether for regeneration or oscillation. To receive signals with the regenerative feature of the valve, the coupling between the tickler coil j^3 and the secondary coil j^2 is made small. In practice this coupling is brought up from its minimum value to a value where maximum regenerative amplification is obtained just below the oscillation point. If it is desired to have the vacuum tube oscillating the chief factor in determining this is an increase in the coupling between the coils j^2 and j^3.

This receiver is the one referred to in the patent board's report as "Receiver having built-in accommodations for [fol. 386] vacuum tube, arranged both for oscillation and regeneration." These receivers were purchased by and made by the Navy from about the middle of 1915 until I left the Navy in 1919.

Eight. The Navy purchased a large number of arc transmitters, both high power and low power. The first of these was obtained from the Federal Telegraph Co., and was in-

stalled at the Arlington Radio Station. I worked with this set for many months. I also worked with a great many other of the arcs, installing them as well as operating them.

The first installation—the Arlington one—was made in 1914, and others followed soon thereafter. I have read the testimony of Graham as to the component parts and operation of this set and I find it correct. I have examined plaintiff's Exhibit 104, Waterman diagram of Arlington Federal arc transmitter, and it is schematically correct. These transmitters all were characterized by large loading inductances in the antenna, since they were used for long-wave lengths.

Nine. The Navy purchased many thousands of vacuum tubes, both for transmitting and receiving, in the period from May, 1914, to the middle of 1919. A few vacuum tubes were purchased prior to May, 1914. The receiving vacuum tubes were used as detectors, as amplifiers, and as oscillators. The transmitting vacuum tubes were used as oscillator, modulator, and amplifier. The chief value of these tubes lay in their amplifier characteristics, as there is no other practical way known for obtaining amplification. Their use enabled long-distance communication to become an assured fact. A second very valuable feature was the ability to oscillate, particularly in receiving, as the oscillating vacuum tube was the only practical way for receiving continuous wave-telegraph signals.

I have read the testimony of Mr. Graham relative to the audion and find it to be correct. The schematic drawing of plaintiff's Exhibit 83 correctly represents schematically the three elements essential to an audion (or vacuum tube or valve by which name it is frequently known), as well as the necessary auxiliary devices.

The Navy Department had large quantities of these vacuum tubes in store when I left in 1919, and subsequently sold a number of these to commercial concerns. I have seen these tubes in stores of various dealers and know of the circumstances surrounding the sale.

Ten. Direction finder: The Navy bought and installed a large number of direction finder outfits before and during the war. The first installation was 1915 or 1916. Practically every vessel had a direction finder on board and a large number of shore direction finders stations were erected. I was frequently detailed to watch the experimental development of these devices at the Philadelphia

Navy Yard and their installation at various locations on shore and ship.

The direction finder consists essentially of a rotatable coil of wire which is used in place of an ordinary vertical antenna to pick up radio signals, the strength of these signals varying from a maximum to a minimum, depending on the angle made by the plane of the coil with the axis of incoming signals. This loop aerial, as the rotating coil is called, is connected to an ordinary receiver, which has a special feature in that the primary circuit is in two parts, one connecting the loop aerial referred to and the other to a vertical antenna. Both these primaries are coupled to a [fol. 387] single secondary resonant circuit. In operation, the loop antenna system is tuned to resonance with the incoming signal, and so is the circuit including the vertical antenna. The secondary circuit is tuned to be in resonance with the incoming signal, and hence with both of the primary circuits coupled to it. Most of the receivers supplied for this work have vacuum tubes built into them, and were arranged for regeneration and oscillation.

I have prepared a drawing, which I have here, marked "Direction finder." This drawing was made from my original sketch and I have checked it as being correct. The secondary resonant circuit consists of two coils, j^2 and j^4, usually arranged so as not to be in inductive relation with each other. These two inductances together with the variable condenser h^2, form the secondary resonant circuit which in use is tuned to the incoming signal. The arrangement of a vacuum tube, and the coupling of the feed-back coil (or tickler coil, as it is sometimes called), with the secondary inductance system, is the same as has been described by me in connection with the drawing headed "Vacuum-tube receiver arranged for both oscillations and regeneration." The loop antenna, shown as LA, connects to a primary coil j^5, which has an adjustable arm 3A, and in series with these two inductances, namely, the loop aerial and its primary, is a variable condenser h^3. The condenser h^3 and the coil j^5 are a part of the receiver. The coupling between j^5 and j^2 is variable. The vertical antenna F with its lead in A, passes through a series variable condenser h^1 and thence to a primary coil j^1, with its associated variable contact arm 3, and thence to ground E. The coupling between primary coil j^1 and the coil j^4 of the secondary inductance system is variable. The cir-

cuit F-A-h^1-j^1-3-E is tuned to the incoming signals, as is the secondary circuit, and the two form a coupled system in which both elements are in resonance with each other and with the incoming wave lengths.

Most of the receivers used with the direction finder were of this special type, but a few were used with a loop aerial only and without the vertical antenna. All these receivers for use with the direction finder have vacuum tubes or were arranged for use with vacuum tubes.

Eleven. The Navy purchased or manufactured a great number of audion detector and control boxes. The first of these were obtained in May, 1914, from DeForest and were known as type PN. I used these detectors personally. Later a modified design of audion-control box was made at the Washington yard by me, and this was the type most used in service thereafter. Plaintiff's Exhibit No. 83, drawing, PN audion, correctly represents schematically the wiring of this PN type of audion-control box. I have read the testimony of Graham as to the audion-control boxes in general, and the PN detector in particular, and I agree with him.

Twelve. A large number of vacuum-tube amplifiers were purchased and made by the Navy, beginning with about May, 1914, and continuing until I left the Navy in 1919. These amplifiers were audion amplifiers and made use of the vacuum tube.

Plaintiff's Exhibit 85, drawing, audion amplifier used by Navy, correctly shows the wiring of the first audion amplifier purchased by the Navy; this was from the DeForest company in 1914. This was a three-stage audion amplifier. The wiring diagram for a subsequent type differs in detail from that shown in Exhibit 85, par- [fol. 388] ticularly in that the secondary circuit of the interstage transformers was physically connected in some part of the circuit in later design, whereas in Exhibit 85 it is left open circuited. The operation is the same, however. In plaintiff's Exhibit 85 illustration, DeForest audion amplifier used by Navy, this is a copy of the DeForest bulletin illustrating the three-step audion amplifier, and the page stamped 192 correctly shows the device with which I worked in 1914. I have read the testimony of Graham as to the description and operation of the audion amplifier and find it correct. Plaintiff's Exhibit No. 84, official instructions for use of ultra-audion, is identified by me as

being a multigraph copy of the pamphlet gotten up by the Navy in Doctor Austin's laboratory, and copies of which were sent to all naval ships and shore stations. I was present at the Bureau of Standards when this pamphlet was being prepared and am familiar with its contents. This was sent out in the winter of 1914-1915.

Thirteen. Some receiving tuners were obtained by the Navy from time to time, the term "receiving tuner" referring to a receiver which does not have any detector apparatus associated with it. The receivers which I have previously referred to as "receivers arranged with terminals for any form of detector," fall under the class of receiving tuner as long as no crystal detector is mounted on the panel. Receiving tuners also comprise those receivers which were originally designed for one type of detector only, although in practice any such receiver can actually be used with other forms of detector. An example of this is shown in plaintiff's Exhibit No. 84, where instructions are given for using the I-P-76 receiver (originally designed for crystal detector work only), with an oscillating vacuum tube.

Receiving tuners were purchased by the Navy in the earlier days, and I think that very few were called for after about 1915.

Fourteen. Under the heading "Transmitters," strictly speaking one should consider radiotelephone sets, but since they are separately classed in the patent board's report they will be referred to separately there. The Navy bought a great many vacuum-tube type of wireless-telephone sets from 1916-1917 on to the middle of 1919, when I left the Navy. These were, in general, for use with sub-chasers, submarines, airplanes, and a few for battleship and shore-station work.

The complete report of all the radiotelephone sets purchased by the Navy is found in two publications, both of which were compiled by T. Johnson, jr., formerly radio aid, Navy Department, Washington, D. C. Early in 1919 the Navy wished to have a complete record of its activities in wireless telephone lines, and Mr. Johnson was detailed by the head of the radio division Bureau of Engineering, Navy Department, to compile such a report. This report was for the purpose of publication in the Proceedings of the Institute of Radio Engineers, in order to put before

the public the record of the Navy in this line. Similar reports were prepared by the Signal Corps. In my capacity as technical adviser to the head of the radio division, I passed on both these papers of Mr. Johnson and assisted in preparing them. I am familiar with all the apparatus described therein. The first paper was presented before the Institute of Radio Engineers by Mr. Johnson on June 4, 1919, and a reprint was issued by the Navy Department by the Government Printing Office, Washington, 1920, under the heading "Naval aircraft radio." The second [fol. 389] paper was presented by Mr. Johnson before the Institute of Radio Engineers on January 5, 1921, and was headed "Naval radio tube transmitters." I shall refer to both of these in describing the various transmitters and for brevity will refer to the Navy Department reprint, by the letters "SE," for Steam Engineering, and the Institute of Radio Engineers' booklet which contains the lecture of January 5, 1921, by the letters "IRE," standing for Institute of Radio Engineers.

From these sources I have prepared a list of the various types of tube transmitters which the Navy purchased. Photographs of these and wiring diagram thereof are to be found in either of the two books SE or IRE. The extremely simplified schematic drawings, showing only the essential elements used to create oscillations in the antenna, have been prepared by me and are four in number. These were prepared on two sheets from pencil sketches of mine, and I have checked them as being correct.

The schematic diagrams fall broadly into four classes, which are designated in these drawings as DeForest, General Electric No. 1, General Electric No. 2, and Western Electric, respectively abbreviated in further reference as DF, GE No. 1, GE No. 2, and WE.

In each of the four schematic drawings *f* represents the antenna, A the antenna down lead, *g* the antenna inductance coil, I the variable contact arm where such arm is present, and E the earth connection. In each of the four sketches T represents a vacuum tube, with its element, the plate, P, the grid, G, and the filament, F. B^1 represents the source of supply for rendering incandescent the filament. The supply source may be direct or alternating. B^2 represents the supply source for the plate voltage and this may be a generator or a battery. L represents a grid leak resistance where such is used.

In diagram WE, c^1 represents a series antenna condenser, which is variable, and in diagram DF, c^1 represents a series antenna condenser, which is fixed.

Referring now to each individual drawing, in diagram DF, the coil d^2 is a grid coupling coil and is inductively related with the antenna coil g. Coil d^2 is paralleled by a variable condenser cc^3. c^2 is a series grid condenser shunted by a grid leak L. The grid and plate circuit are completed to earth through the small capacity formed by the capacity of the various elements of the apparatus to ground, no direct earth connection being supplied.

In diagram GE No. 1, d^2 is a plate coupling coil, variable, by variable arm 2. d^3 is a grid coupling coil, variable by arm 3. c^1 is the series grid condenser shunted by the grid leak L. The plate and grid coupling coil d^2 and d^3, are in inductive relation with each other and with the antenna coil g.

In diagram GE No. 2, a second coil d^1, varied by the arm 2, is in series with the antenna coil g, the two together forming the total antenna inductance system. Coil d^2, variable by arm 3 is in series with a condenser c^2 and these two elements connect the plate to the filament circuit. c^1 is a series grid condenser.

In the diagram WE, condenser c^1 is the grid condenser, shunted by the leak L. Condensers c^2 and c^3 serve to couple the valve elements in such a way as to give regeneration.

The following is a list, with very approximate figures as to the number of purchase of the chief wireless-telephone [fol. 390] outfits purchased by the Navy between 1916 and the middle of 1919. The first column is the name of the manufacturer, this column being headed "Company." The second column, headed "Type of set," gives the Navy type number or model number which identifies the apparatus. The third column, headed "Photo," refers to the figure in either the Navy publication headed "Naval aircraft radio," before designated by the letters SE, or in the publication of the Institute of Radio Engineers, previously referred to and designated by the letters IRE. The fourth column, headed "Wiring diagram," similarly refers to the figure in the book SE or IRE, where the actual wiring diagram of the set can be found. The fifth column, headed "Schem. Diag.," or schematic diagram, refers to the very simplified

schematic drawing, which represents the oscillation system, which applies to each set, as shown by the appropriate one of the four schematic drawings previously referred to by me as DF, GE No. 1, GE No. 2, or WE. The sixth column, headed "Approx. No.," tells to the best of my recollection the number of sets which the Navy purchased. The last column tells what the general use of the set was—that is, the location for which the sets were purchased.

The sets were supplied by four manufacturers, DeForest, General Radio, Western Electric, and General Electric. The list giving the detail types of apparatus here follows:

Tube transmitters purchased by the United States Government

Company	Type of set	Photo	Wiring	Diag.	Schem. diag.	Approx. No.	Used in—
DeForest	Dirigible	None	Sim. to BK. SE	Fig. 10	DF	10	Dirigibles.
Genl. Radio	CAG No. 1295	Fig. 67, BK. SE	Sim. to	Fig. 66, BK. SE	GE No. 1	100	Airplane.
Western Elec.	CW No. 1058				WE	100	Airplane.
	Similar to Army type SCR68						
Western Elec.	CW936	Fig. 10A, BK. IRE			WE	700	Sub. chasers.
Western Elec.	Model TB					20	Battleships.
Genl. Elec	3E1380	Fig. 72, BK. SE	Fig. 74, BK. SE	GE No. 1	GE No. 1	10	Flying boats.
Genl. Elec	SE1340	Fig. 62, BK. SE	Fig. 63, BK. SE	GE	GE No. 1	200	Flying boats.
Genl. Elec	SE1370	Fig. 68, BK. SE	Fig. 70, BK. SE		GE No. 31	200	Flying boats.
Genl. Elec	SE1345	Fig. 57, BK. SE	Fig. 59, BK. SE		GE No. 1	100	Airplane.
Genl. Elec	SE1390	Fig. 80, BK. SE	Fig. 81, BK. SE		GE No. 1	20	Flying boats.
Genl. Elec	Model TC	Fig. 14, BK. IRE	Fig. 16, BK. IRE		GE No. 1	20	Battleship.
Genl. Elec	Model TD	Fig. 33, BK. IRE	Fig. 32, BK. IRE		GE No. 1	55	Base station.
Genl. Elec	Model TE	Fig. 25, BK. IRE	Fig. 26, BK. IRE		GE No. 2	60	Submarine.

Some of these sets were supplied as transmitters only, without receivers. Some were supplied with external receivers, and a few, particularly the Western Electric CW936, sub.-chaser set, have the receiver built in. When the receivers were built in to the set they corresponded to the class designated by the patent board report as receivers having built-in accommodations for vacuum tubes and arranged both for oscillations and regeneration. The West- [fol. 391] ern Electric receiver circuit is shown on the left-hand side of Figure 9, book IRE, and this shows two resonant tuned circuits coupled. A vacuum tube detector and two stages of audio amplification were included. These receivers were designed so that they could receive any kind of signal, from another continuous-wave telephone set or from a spark set. I have used these many times myself for receiving from all classes of Navy vessels, whether fitted with tube transmitters or the standard inductively coupled spark transmitter.

In cases where receivers were purchased with the transmitters, these receivers being separate articles, the chief reason why we purchased the receivers at the same time as the transmitters was because it made it easier to obtain both these articles in one requisition. In other cases we took receivers from stock and added them to transmitters which we bought separately. In practically every case the receivers used were the standard Navy two-circuit receiver, with two tuned circuits, and in the majority of cases with vacuum tubes built in and with provision for regeneration and oscillation. A few airplane sets were purchased where the receivers did not have a primary and a secondary circuit, each resonant to the incoming wave lengths, as such, but have the vacuum tube connected directly to the antenna inductance. These receivers were fitted with tickler coil in the plate circuit, inductively coupled with the antenna.

Fifteen. Referring to wave changers, another subclass in the patent board report, these devices essentially consisted of switching means attached to already existing loading and coupling inductances in transmitter circuit, or containing built-in loading and coupling inductances which replaced others formerly present in the set.

Sixteen. Referring to the item "Variometers," which appears in the patent board report, a number of the Telefunken transmitting sets which were purchased around 1912 or shortly thereafter, contained variometers in their cir-

cuits. Variometers were also used in receiving sets built by the Navy in or about 1918, and I think that some of these were purchased with these features in them. A variometer is in general merely a variable inductance forming a part or all of the tuning inductance in the circuit, and being variable by a particular way—that is, by variation of the mutual inductance between two of its parts.

3. Question. Please describe briefly the sets which you refer to as "spark sets for vacuum excitations."

Answer. These sets are of the type referred to in the patent board report as "Transmitters with (four) vacuum tubes excitation." These sets were originally coupled spark transmitters, which were modified so as to be capable of excitation by vacuum tubes. Part of the spark apparatus was retained, for example, the motor generator and transformers, and other apparatus was added, such as vacuum tubes, rectifying tubes, and various parts of the coupling circuits. The set when completed became practically equivalent to a continuous-wave radio telegraph transmitter, and any one of the circuits shown schematically in my drawings DF, GE No. 1, GE No. 2, or WE, could have been used.

[fol. 392] 4. Question. You stated that the vacuum tubes purchased were used either as detectors, amplifiers, oscillators, modulators. Can you refer to the circuits in which they were used?

Answer. In receiving work a typical circuit showing the use of the valve or audion as a detector is found in plaintiff's Exhibit 83; its use as an amplifier and the circuit in which it would be so used is correctly shown in plaintiff's Exhibit 85. Its use as an oscillator is shown as to one type in plaintiff's Exhibit 109, as well as in the drawing which I have produced headed "Vacuum-tube receiver arranged for both oscillations and regenerations."

The use of the vacuum tube as a transmitting oscillator is exemplified most clearly in my schematic drawing GE No. 1 and another more complete wiring diagram showing this is found in Figure 32 of the book IRE, where the three vacuum tubes on the left are always used as oscillators to generate oscillations. The use of a transmitting vacuum tube as a modulator to modify the output of some other oscillator tube is shown in this same Figure 32, where the fourth, fifth, and sixth tubes in the diagram, reading from left to right, were used as modulators when the set was operated as a wireless telephone set. The use of the trans-

mitting vacuum tube as an amplifier is again shown in Figure 32, where the extreme right hand tube is a 5-watt transmitting tube used to amplify the speech output of the microphone before impressing it upon the modulator tube.

5. Question. During the years 1912 to 1915, inclusive, to what extent were loading coils, such for example as those shown at G and G' in Exhibit No. 87, employed in the radio receivers and transmitters used by the Navy and what advantages, if any, were derived from their use?

Answer. Loading coils such as transmitter load coils G and receiver load coil G' formed a part of practically every transmitter and receiver bought by the Navy during the years 1912 to 1915. These coils were an integral part of both transmitter and receiver, rendering it possible to operate these pieces of apparatus over a wider range of wave length and particularly to enable long wave lengths to be reached.

6. Question. To what extent were transmitters and receivers, each having coupled tuned circuits of the kind shown, for example, in plaintiff's Exhibit No. 87, employed by the Navy Department during the period beginning March, 1912, and ending in 1919?

Answer. By far the greater number of spark transmitters purchased by the Navy during the above period were transmitters embodying coupled tuned circuits. All the quenched gap sets which formed the bulk of spark transmitters in the Navy were of this type. The receivers were almost exclusively of this type, mainly, having two coupled circuits, each tunable to the desired wave length. With the exception of the airplane receivers referred to in a previous answer, which did not per se contain the tuned secondary circuit with variable condenser, I do not recall that receivers of any other type were in use or purchased during that period.

7. Question. What improvement, if any, in the Navy radio service resulted from the introduction and use of vacuum tube receivers and transmitters of the several kinds you have testified about?

Answer. They were both an indispensable part of naval radio. In receiving the vacuum tube amplifier made long-[fol. 393] distance work possible for the first time, and the use of the tube as an oscillator in the receiving circuit is the only practical way to receive continuous-waves telegraph signals. This is especially positively stated when

I recall the difficulties experienced in trying to receive the early arc stations before the oscillating audions became available. In transmitting, the vacuum tube, for one thing, made naval air craft radio possible, particularly as to radio telephony, and the use of the vacuum-tube transmitter in other locations provides the simplest and most practical form of excitation for continuous-wave work. In telephony its necessity is essential. Without it radio telephony would not be to-day possible for the everyday ship and shore stations.

By Mr. Peters: I offer in evidence the following drawings used and referred to by the witness in his testimony:

Drawing marked "Typical transmitter with rotating gap," plaintiff's Exhibit No. 112.

Drawing marked "Receiver arranged with terminals for any form of detector," plaintiff's Exhibit No. 113.

Drawing marked "Vacuum-tube receiver arranged for both oscillations and regeneration," plaintiff's Exhibit No. 114.

Drawing marked "Direction finder," plaintiff's Exhibit No. 115.

Drawing comprising two sheets, marked "Vacuum-tube transmitters for radiotelephony," plaintiff's Exhibit No. 116.

Publication entitled "Naval Aircraft Radio," issued by Navy Department, Bureau of Steam Engineering, Washington, D. C., June, 1919, plaintiff's Exhibit No. 117.

Also article in proceedings of Radio Institute of Engineers, October, 1921, by T. Johnson, jr., comprised between pages 381 and 433, entitled "Naval radio tube transmitters," plaintiff's Exhibit No. 118.

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8. Question. During the time the United States was engaged in the World War did the Navy Department assume any, and if what, responsibility as to infringement of radio apparatus purchased by it? State your own knowledge and refer to any Government document known to you.

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Answer. In my position as adviser to the head of the radio division the matter of the liability of companies for damages due to patent infringement was often discussed.

Prior to the war all companies had signed a contract in which they guaranteed to save the Government harmless in case of prosecution on infringement of patents. When the Western Electric Co. was given the first big order for war material it brought the point that it could not proceed with the contract unless the Government would agree to withdraw this requirement. It was recognized that in times of emergency the only thing that counted was getting the material out, so the Navy Department agreed to remove the clause and allow the Western Electric Co. to supply the apparatus without any question of guarantee against pat- [fol. 394] ent suits. This was done also for other companies of which I personally know.

On pages 20 to 21 of the patent board report appears a detailed statement with reference to this fact. This statement is contained in the last two lines of page 20 and the first 44 lines of page 21.

The statement is as follows:

"In January and February, 1918, the Western Electric Co. prior to final decision by the Supreme Court in the Cramp and Simon cases, below mentioned, had insisted, as to its contracts with the Government, that it (Western Electric Co.) be held harmless in any patent litigation. In one such contract, for example, relating to a radio apparatus designated as an audio frequency amplifier the supply officer at the navy yard in New York was instructed to award the contract to the Western Electric Co. subject to the following condition:

" 'The apparatus mentioned herein being required without delay by the United States Government, said apparatus is furnished in this emergency without investigation of outstanding patents, upon the condition (to which the United States in placing its order agrees) that the United States will save the Western Electric Co. (Inc.) harmless from all claims for infringement of patents on account of the apparatus so furnished, the Government assuming with the patentees direct all responsibility for said patent infringement.'

"On March 4, 1918, the United States Supreme Court, in the cases of William Cramp & Sons Ship & Engine Building Co. *v.* International Curtis Marine Turbine Co. (246 U. S. 28) and Marconi Wireless Telegraph Co. *v.* Simon,

(246 U. S. 46), having rendered the opinion that in certain cases contractors with the Government were not protected by the act of 1910 from independent liability, it was represented to the Government, and particularly to the War and Navy Departments, that contractors could no longer safely undertake the warranty against infringement. See in this connection the letter from DeForest Co., dated March 14, 1918. Similar letters were received from the National Electrical Supply Co., the Wireless Improvement Co., Emil J. Simon, the Wireless Specialty Apparatus Co., Kilbourne & Clark Manufacturing Co., and the Sperry Gyroscope Co.

"The contracts with the Western Electric Co. referred to in said letter had been made prior to the rendering of the decisions in the Cramp and Simon cases, the Western Electric Co. having (as already stated) made their bids in certain cases only on condition that such warranty be given. At this time there had been called to the attention of the Government claims of various companies owning patents for radio apparatus, particular stress being laid upon claims arising under adjudicated patents of the Marconi Wireless Telegraph Co. of America, the International Radio Telegraph Co., and the DeForest Radio Telephone & Telegraph Co.

"On March 29, 1918, the Acting Secretary of the Navy caused to be addressed to the DeForest Radio Telephone & Telegraph Co. a communication accepting certain responsibility on the part of the Government for the protection of contractors against patent claims, and, by direction of the Secretary, the Bureau of Supplies and Accounts, Navy Department, was, on April 3, 1918, notified that letters of similar purport to that sent to the DeForest Co. [fol. 395] would be sent by the department from time to time to other contractors where it appeared that such action was necessary, in addition to those mentioned in the first indorsement of the Solicitor for the Navy Department on April 3, 1918.

"The Secretary of War issued similar orders, and the Secretary of the Navy did likewise in several additional instances."

* * * * * * *

9. Question. The report of the patent board to which you refer is published where?

* * * * * * * .

Answer. The quotation given is from a publication entitled "Hearings before the Committee on Military Affairs, House of Representatives, Sixty-seventh Congress, first session, Monday, May 23, 1921," the subject being further given as "Radio patents, settlement of claims against Government for use of radio patents during the World War." The publication is marked with the data "Washington, Government Printing Office, 1921."

(Direct examination closed.)

The said witness was then cross-examined by the counsel for the defendant, and, in answer to interrogatories, testified as follows:

10. Cross-question. You testified as a witness for the plaintiff in the case of Marconi Wireless Telegraph Co. of America against the DeForest Radio Telephone & Telegraph Co. and Lee DeForest in the United States District Court for the Southern District of New York, did you not?

Answer. Yes.

11. Cross-question. The "audion apparatus" to which you there refer in your testimony was the same three-element vacuum bulb concerning which you have testified in this case, was it not?

Answer. Yes; the same audion.

12. Cross-question. Testifying with reference to that apparatus, did you not there testify as follows:

"Q. Please compare the value and utility of this audion apparatus involved in these accounts with other types of apparatus available for use for the same general purposes at the time the audion apparatus was purchased.

"A. The apparatus referred to in the list which I saw consists in general of the two general classes of the audion as a detector or oscillator and the audion as an amplifier, using the term 'audion' to include the particular control system and bulb, which is the apparatus which we purchased. Taking the first part, the oscillating audion, prior to the purchase by the Navy of the DeForest apparatus there were three general types of apparatus which were used for this purpose—first, the ticker; second, the tone wheel; third, the arc form of heterodyne of the National Electric Signaling Co. These were all devices which would enable signals to be detected from continuous-wave transmitters such as the arc or alternator. Considering these

one by one, the ticker was the only device which was at all useful, and it was far below the standard of the DeForest [fol. 396] oscillating audion or ultraaudion, as it was termed at that time. The chief faults of the ticker were, first, its lack of sensitiveness, and, second, the grave fault, that it was difficult to distinguish signals and atmospheric disturbances, in that both had very much the same sound. When the DeForest apparatus was used it was possible to distinguish between the atmospheric disturbances and the signal very much more efficiently, first, on account of the increased sensitiveness of the DeForest apparatus, which enabled the full advantages of loose coupling in the receiver to be made use of, and, second, because with the DeForest apparatus it was possible to obtain a clear musical note from the signal, whereas the static note remained rather unmusical and very much different in quality.

"The tone wheel was never purchased by the Navy Department, and I recall only one case where it was even seen by any member of the naval forces. That was at the high-power station at Tuckerton, where one of these instruments was available. I tested this apparatus for a long time and found it absolutely unreliable and not satisfactory for a radio-receiving device.

"The third apparatus, the arc form of heterodyne, was purchased by the Navy to a very small extent, in that three sets of this apparatus were obtained as an adjunct or part of a high-power transmitting system which was purchased by the Navy. The arc heterodyne was tested by me on the voyage of the U. S. S. *Salem* to Gibraltar and back, and my notes of the voyage and my present memory show that it was — very reliable. The arc was constantly getting out of adjustment, and the apparatus required a very skilled operator to keep it in shape, but the chief disadvantage was that noises from the arc, such as hissing and sputtering, were constantly present and interfered very greatly with the intended function of the apparatus. No further sets of this type were obtained by the Navy, and the use of the heterodyne method of receiving was not taken advantage of until the demonstration by Dr. DeForest of his apparatus.

"Referring now to the second general classification, the amplifier, prior to the DeForest amplifier the only types of apparatus known to the Navy for this apparatus were of the carbon microphone class, and all of these devices in-

troduced so much noise, due to frying of the carbon and other causes, as to defeat entirely the aim of the apparatus, where, as the signals were amplified, so many additional noises were brought in that the actual readability of the signal was lessened. Some of these instruments were purchased, but none were ever put into actual use for this reason. In March, 1914, I witnessed a demonstration by Dr. DeForest of his oscillating audion at the Bureau of Standards in Washington, and I considered that this was a wonderful piece of apparatus. I recommended to the Navy that we purchase a number of these instruments. A requisition was very quickly made for a number of pieces of apparatus, and they were delivered and used in a very short time. From that time on we have continued the use of this general form of device without exception. I consider that the oscillating audion marked a distinct step in the art of radio communication. I considered at the time that I first saw it that it was a very wonderful advance, and I have never changed my point of view. Just at that time the Navy was introducing high-power arc transmitters in the endeavor to obtain long-range communication. That [fol. 397] long-range communication would not have been possible with any of the known detectors at the time, nor would it have been possible without amplification, and therefore I consider that the use of the DeForest wireless device, the oscillating audion, and the amplifier are absolutely indispensable in maintaining long-distance communication in the Navy, which has been of the greatest military value. I think I can put the thing more clearly and simply by saying that my general idea is that the oscillating audion and the amplifier are of inestimable value in the art of radio communication."

Answer. Yes; I recall that testimony.

13. Cross-question. In the same case did you also give the following testimony?

"Q. The electrolytic detector—does that amplify?—A. It is a detector pure and simple, and in the sense that I stated before it falls in the same category as the crystal detector. I have never seen it used other than as the original detector of signals.

"Q. But if you had to depend upon the electrolytic device and added a battery to that, then the limit of amplification would be about the same as that of the crystal detector?—A. I don't accept the use of the word 'ampli-

fication' at all there. Neither of these devices was in any sense an amplifier. They were merely detectors.

"Q. That is, even if you here added a battery circuit to the crystal detector or the electrolytic detector that would not be what you understand to be an amplifier?—A. That would be what I understand as an increase in the sensitiveness of the detector. That in a sense is an amplification, but we have never called it such.

"Q. In order to straighten this out will you try to give us a little clearer idea of the disfinction that you draw between increase of sensitiveness by adding a battery and what you call amplification or real amplification?—A. The general understanding that the Navy has as reflected in its purchases and its general policies with which I am acquainted is as follows: A device for indicating the presence of radio frequency energy is a detector. The sensitiveness of that detector is a variable quantity, depending on a number of factors. In the case of the crystal detector is depends on finding sensitive points of the crystal; it depends on the presence or absence of the battery and the correct adjustment of said battery. In the case of the electrolytic it depends on the diameter of the wire, the immersion of the wire in the liquid, the presence of a battery, and the correct adjustment of that battery. Now, having obtained a signal from said primary detector we may make use of other apparatus which is entirely separate in form for increasing its energy. Of these amplifiers the carbon microphone, which I mentioned, is one. The DeForest audion amplifier is another. But I have always used and the Navy has always used the term amplifier to mean a piece of apparatus used as the second step in the reception of a radio signal."

Answer. Yes; I recall that testimony.

14. Cross-question. In the same case did you also give the following testimony?

"Q. Did you ever try or use any of the incandescent lamp bulbs in which there was only a plate and a filament?—A. Yes; I have.

"Q. To what extent?—A. In one set of apparatus only, furnished by the Marconi company, and which I used to a very limited extent, and only as incidental to certain experiments with direction finders."

[fol. 398] Answer. Yes; I recall that testimony.

15. Cross-question. In the same case did you also give the following testimony?

"Would you say that it would amplify to any greater extent than the crystal detector or the electrolytic detector?—A. Not having made the exact test, I don't wish to give testimony.

"Q. But you did express the opinion that these results would be impossible without the DeForest device over and above anything that was known at that time?—A. This device which I used from the Marconi company was not an amplifier in the naval sense of the term. It was a detector, and a detector of damped signals pure and simple. As such we did not even think of it as being a possible amplifier; and I am referring, as I said, to apparatus which we used. It was submitted as a detector, to be used as an alternative to the crystal detector in the same set."

Answer. Yes; I recall that testimony.

16. Cross-question. In the same case did you also give the following testimony?

"Q. Were any of these amplifying devices used by being connected to a crystal detector?—A. Yes. Probably as many as were used with an audion as the original detector. Probably more. Possibly more.

"Q. In that case the impulses would be detected by the crystal detector, and the audio frequency from the crystal detector would be amplified in the audion bulb or bulbs?—A. That is the commonly accepted idea."

Answer. Yes; I recall that testimony.

17. Cross-question. In the same case, did you also give the following testimony?

"Q. Generally it is true, is it not, that the potential on the grid ought to be very much below that on the plate?—A. Yes; that should be.

"Q. And that if the grid voltage should be the same as the plate voltage, then you would not get the amplification?—A. That is true.

"Q. That is, if the grid were connected to the plate, either on a wire or so that you would have the same voltage, then you would not get the amplification or the oscillation of the device? Am I right?—A. I never tried

that experiment. Again, that is in the realm of theory. I don't know.

"Q. But you do know that in practice the potential on the grid is very much below that of the plate, do you not?—A. As the apparatus was supplied us; yes. Whether or not you could make it work by redesigning it for that particular use, I don't know, not having tried it.

"Q. So far as you know, it was always used with the lower grid potential, was it not?—A. I am speaking now just from elementary theory; yes; but there was no specific means provided from which you could specifically say that this was lower voltage. For instance, in any of the apparatus we got from the DeForest Co. there was no additional battery supplied for deliberately changing the voltage of the grid electrode.

"Q. But there was a connection from the grid to the filament in the bulb, was there not; in the device itself? [fol. 399] It contained a connection from the filament to the grid?—A. Not a direct wire connection; no; but there was a connection—yes—an electrical circuit.

"Q. That would be the receiving circuit?—A. Yes.

"Q. And the result of that would be that the potential of the grid would be approximately that of the filament normally, would it not?—A. Other than for the presence of the stopping condenser or grid condenser, which was present in all the sets.

"Q. And how would that affect it?—A. That I don't wish to answer. It would mean that there would not be direct current potential from the plate battery impressed on the grid, and therefore it puts the actual determination of the voltage into the realm of the theoretical, on which I do not wish to estimate.

"Q. That would mean, in effect, would it not, that the voltage on the grid would depend entirely on the current in the receiving circuit rather than in the battery *current in the receiving circuit rather than in the battery* circuit, would it not?—A. Would depend entirely; yes.

"Q. Of course, as I understand you, if that grid were connected to the plate, then that would not necessarily be true, would it?—A. I would not necessarily say so without having done it."

Answer. Yes; I recall that testimony.

18. Cross-question. In the same case, did you also give the following testimony?

"Q. Were any of these amplifying devices used by being connected to a crystal detector?—A. Yes. Probably as many as were used with an audion as the original detector. Probably more. Possibly more.

"Q. In that case the impulses would be detected by the crystal detector, and the audio frequency from the crystal detector would be amplified in the audion bulb or bulbs?—A. That is the commonly accepted idea."

Answer. Yes; I recall that testimony.

19. Cross-question. All of the vacuum tubes purchased by the Navy, from May, 1914, to the middle of 1919, for the period covered by your testimony, and concerning which you have testified, were of the three-electrode type, were they not?

Answer. Yes.

20. Cross-question. And the bulbs referred to under subdivisions nine, ten, eleven, twelve, thirteen, and fourteen of your answer to Q. 2, referred to these same three-electrode vacuum tubes. Is that correct?

Answer. There were probably some two-electrode tubes purchased prior to the middle of 1919, known as kenetrons, but my testimony was entirely concerned with the three-electrode tubes used in the purely radio part of the circuit. The kenetrons, if supplied prior to that date, were used for rectification of the A. C. power supply.

21. Cross-question. Were all of the tubes concerning which you have testified of the hard vacuum type?

Answer. By far the greater majority were. A few of the earlier ones were not.

22. Cross-question. Generally speaking, the ones which were not were those made by the DeForest company, were they not?

Answer. Yes.

23. Cross-question. And generally speaking, the other types were of the hard vacuum type, were they not?

[fol. 400] Answer. Relatively hard, compared with the strictly soft tubes. I do not recall whether the degree of exhaustion in all of the tubes was carried to the ultimate degree possible or not, but they would all be known in the trade as hard rather than soft tubes.

24. Cross-question. What is the difference in performance characteristics between the hard vacuum tube and the soft tubes, such, for example, as the DeForest tubes?

Answer. Testifying entirely as to the period covered by my Navy experience, the chief difference known at that time was that the hard tubes were more uniform in operating functions, whereas the soft tubes varied greatly in sensitiveness. Some of the soft tubes would be very much more sensitive as detectors than the standards for the hard tubes, and others would be very much less sensitive, as used in the period referred to. Another characteristic noted was much greater plate voltage could be used with the hard tube. With the soft tube there was very great possibility of causing what is known as a blue glow in the tubes if the voltage were above a certain value.

25. Cross-question. Can you say what caused the uncertain performance of the soft vacuum tubes?

Answer. That is a matter of theory and not of practical engineering, and I wish to testify as to what I actually know through performance rather than theory.

26. Cross-question. Referring to the amplifiers referred to by you under subdivision twelve, were these adapted to amplify currents of radio frequency or currents of audio frequency?

Answer. They were purchased and used as audio amplifiers.

27. Cross-question. Referring to the plaintiff's Exhibit No. 85, this could be used by connecting the terminals XY to an ordinary telephone circuit, could it not?

Answer. Yes.

28. Cross-question. Was it such a device as this, for example, as was used in transmitting telephone signals from the flying boat to the office of the Secretary of the Navy described on pages 101 and 102 of the plaintiff's Exhibit No. 117?

Answer. By "transmitting telephone signals from the flying boat" I presume that you mean relaying the received signals received at the navy yard, Washington, from the flying boat and thence relayed to the Secretary's office. I did not witness this test and can not specifically answer your question. In general, the circuit referred to is the type of audio amplifier, with minor modifications, that was used in the service up to the time I left. The publication from which you quote, which is the official report of this test, states that two stages of audio frequency were used, and therefore the circuits used in the test were of the same

general nature as those shown in Exhibit No. 85, with minor modifications as the art progressed.

29. Cross-question. Where the amplifier was used in work similar to the example given in the publication referred to, I take it the signals were transmitted from the transmitting station at radio frequency to a receiving station—for example, the Washington Navy Yard—and there in some manner changed to audio frequency, and these audio frequencies were amplified in the amplifier device of which Exhibit No. 85 is the diagram, and the amplified audio frequencies transmitted over a telephone wire. Am I right in understanding that was one of the uses of these amplifiers?

[fol. 401] Answer. Yes.

30. Cross-question. So far as the change from radio frequency to audio frequency was concerned, this might be accomplished by a vacuum tube or a crystal detector or any other suitable device, could it not?

Answer. Yes.

31. Cross-question. Were crystal detectors used for this purpose by the Navy?

Answer. When the first vacuum tube purchases were made in 1914 and tried out in service a conference was held at Washington, in which it was definitely decided to equip all ships and stations in time with the vacuum-tube detector and with amplifiers of this type. On account of the fact that not enough money was available to do this at once, it was decided to begin with the more important stations and ships, fitting these with vacuum-tube detectors and with amplifiers. Stations and ships of next importance were supplied with amplifiers only to be used with the crystal detectors which they had. Stations of still lesser importance were for the time left as they were. Instructions were given that the stations having complete vacuum-tube outfits would use them for long-distance work only and use the crystal for short-distance work to save replacement cost. As fast as money became available every station under the Navy Department obtained vacuum-tube detectors and amplifiers. The policy was clearly determined long in advance of the money being available.

32. Cross-question. When you say stations of lesser importance were left as they were does that mean that they were left with the crystal detectors for detecting purposes?

Answer. Yes.

33. Cross-question. Were they supplied with amplifiers to use in connection with these crystal detectors?

Answer. As stated in my previous answer, not at first. The line of progress was very clearly marked, in that the lesser stations were first left alone with the crystal detectors they had, then later obtained amplifiers as the money became available, and still later obtained regenerative receivers with the vacuum-tube detector in use.

34. Cross-question. You say the stations with crystal detectors were not at first supplied with the amplifiers. Were they supplied with amplifiers later?

Answer. Yes, sir; I have so testified.

35. Cross-question. Then the process of transformation, as I understand, would be substantially as follows: A station with a crystal detector would be supplied with an amplifier, then later a tube would be supplied to take the place of the detector. Am I right in that understanding?

Answer. In order to make this clear, I will repeat my previous testimony. You are correct, as I stated before, only in the case of stations whose importance was such that they did not warrant getting the first supply of vacuum tube equipment which could be purchased with the limited funds available when the vacuum tube detector and amplifier became available. A number of stations, shore as well as ship, were immediately equipped with vacuum tube detector and amplifier throughout, retaining their crystal [fol. 402] equipment for short-range work. Another group were fitted out then or shortly thereafter with the amplifier only for to equip them for taking full advantage of the vacuum tube detector would have meant replacing their nonregenerative receivers with regenerative receivers. Your supposition is correct only for the stations of least importance.

36. Cross-question. And in the stations of greater importance, the crystal detector was still retained for short-range work, was it not?

Answer. Yes.

Redirect examination.

By Mr. Peters:

Mr. Peters: I request that the pamphlet containing the hearings on the Committee on Military Affairs, referred to

the testimony by the witness during the course of his examination be marked for identification.

* * * * * * *

37. Redirect question. Did you ever have occasion to compare the sensitiveness of the two-element vacuum tube detector and the crystal detector?

Answer. Yes. I made a number of such tests in 1910 or 1911, in connection with a Bellani-Tosi direction finder, which the Navy purchased. This has two-element valves, and in testing it I compared these valves with a crystal a number of times.

38. Redirect question. What was the result of the comparison?

Answer. The two-element valve was of the same general order of sensitiveness as the crystal. By this I mean that the difference in sensitiveness was not, say, ten to one, but of a much less value. I recall that the valve was, of the two, the more sensitive. Possibly it was twice as sensitive.

39. Redirect question. Were the amplifiers purchased by the Navy Department, such as that shown in Exhibit No. 85, used in any other way than in connection with a separate detector?

Answer. Yes. The first amplifier, the DeForest, one whose circuit is shown in Exhibit No. 85, were sometimes used with the first valve, as a detector, and the second and third as amplifiers. To do this, of course, the circuit connections were not those shown in Exhibit No. 85, in that the receiver, instead of being connected to binding posts XY, were connected to the grid and filament of the first valve. I remember writing instructions for the service directing how this was to be done. The valves at that time were provided with flexible wires for the grid and plate, with different colored coverings, and I remember especially that the instructions referred to connecting the grid side of the receiving circuit to the green or grid wire of the valve and the other side of the receiving circuit to one of the common filament connections.

40. Redirect question. You have drawn a distinction between detecting and amplifying. Will you please state just what you mean by detecting and what you mean by amplifying? Define these terms as you understand them.

[fol. 403] Answer. This is a matter of nomenclature, in which I have always been very interested. While in the

naval service I, got up the first system of nomenclature, or standard names, for apparatus and their functions, which was ever prepared for this service, and after coming with the Radio Corporation I got up a much revised and more complete standard nomenclature list, which it and the General Electric Co. have adopted. I have also worked with the nomenclature committee of the Institute of Radio Engineers. The question of defining detection and amplification has always been one on which there were two points of view. Take, for example, the case of a vacuum tube, connected to a receiving set, with every precaution taken to avoid to the utmost any question of regeneration or oscillation. My definition of such a valve would be that it was a detector, in that the function which it chiefly performs, that of rectification, was the same as the function performed by the crystal detector. On closer examination, this is a narrow view to take, because it really defines the valve in terms of one particular other type of device, namely, the crystal detector, and not as to the general function which the valve is performing. It was in this narrow sense that I have referred in my Navy work and in some previous testimony to the valve as a detector.

Now, consider what happens if the valve is connected in the ultra-audion connection, or with a variable feed-back. In the latter case, as the coupling of the feed-back is increased, what you hear in the telephone, namely, the signal, is increased in strength. According to one viewpoint, it might be said that we were aiding to the rectifying feature of the valve—another quality which was similarly inherent in the valve, namely, its amplification ability. In my Navy work I looked upon the functions of the valve in this case as two simultaneous ones, namely, detection and amplification. My later view, which is in accordance with the standard definitions which the Institute of Radio Engineers has published, is that this vacuum tube and its associated local control forms a device which is interposed between the radio frequency receiver circuit and some sense of the receiving operator, such as -is hearing, and that this whole device, which makes the inaudible radio signal audible, or noticeable in some other way, is called the detector system.

41. Redirect question. With what type of transmitters were the wave changers about which you have testified used?

Answer. Almost all of them were used with quenched gap-spark transmitters, such as the Wireless Specialty set,

whose schematic drawing is shown in the left-hand side of Plaintiff's Exhibit No. 87; also in the Lowenstein transmitters and many others.

42. Redirect question. When were these wave changers purchased by the Navy Department?

Answer. From some time in 1913 until the middle of 1919, when I left the Government service.

43. Redirect question. To what extent were the amplifying arrangements purchased by the Navy Department used in the way described in your 28th answer?

Answer. During the period from May, 1914, until the middle of 1919, I used such amplifiers in the way described, one only, for transferring received signals at the Washington yard to an official in the Navy Department.

[fol. 404] Every one of these amplifiers for the specifications of which during the entire time I was in the service were prepared by me called for a design suitable for use with a radio receiver in transferring signals from the detector thereof to an operator's telephone and amplifying them in this transfer. The use of such amplifiers in the method referred to in my answer to question 28 was occasional only, and possibly a few amplifiers out of every thousand were so used.

44. Redirect question. Please state in a general way how the radio apparatus used by the Signal Corps compared with that which you have described in detail as having been used by the Navy.

Answer. Much of the apparatus was absolutely identical. The Signal Corps obtained a great many receivers, for example, from the Navy. The apparatus which I saw in the Signal Corps from time to time was electrically exactly the same as the Navy apparatus; the engineering designs and circuits were the same. Such differences as existed were mechanical. For instance, the Signal Corps had to provide against rough transportation in the field, whereas the chief features that the Navy apparatus had to be designed to meet were salt spray and shock due to gunfire.

Recross-examination.

By Mr. Edwards:

45. Recross-question. Were the tests referred to in your answer to redirect question 37 the same ones to which refer-

ence was made in your testimony in the De Forest case, quoted in cross-question 14 of this deposition?

Answer. Yes.

46. Recross-question. Your test on this occasion was not directly for the purpose of comparing the sensitiveness of the valve and the crystal, was it?

Answer. Yes; just that.

47. Recross-question. In your testimony in the De Forest case you referred to this test as being only incidental to certain experiments with direction finders. What was the direct experiment or test made at this time?

Answer. Obviously any test consists of a large number of subsidiary or auxiliary tests any one of which is complete in itself as to its local conclusions. My main object in testing the Bellani-Tosi detector was to determine its efficiency for naval use, and this included an investigation into any possible way of improving it. One test I made was to determine whether the indication of the direction finder gave a line of bearing only or an absolute direction, and I found the former to be the case. Further tests then went on along this line until I found an improvement which would give absolute direction. A second subsidiary test was to try the efficiency of the detector supplied with the direction finder, namely, the two-element valve with the standard detector in the Navy at that time, and that test, while related to the main test, was also a separate and complete test of its own. It gave the results of the effect produced in receiving telephones on incoming wave signals, using a receiving circuit of the general type then standard, when first one and then the other detector was put in place.

48. Recross-question. Was the two-element valve furnished as a part of the Bellani-Tosi direction finder?

[fol. 405] Answer. Yes; it was.

49. Recross-question. Who furnished this device to the Navy?

Answer. I do not recall whether this was purchased in the usual way or was obtained by one of our naval attachés abroad. It was sent to Washington yard, I remember, in a way which was not according to Navy routine, and my recollection is that this may have been a special piece of apparatus that was being tried out and that may have been obtained as a loan or in some other way.

50. Recross-question. It was furnished by the Marconi company, was it not?

Answer. I am not sure now. We got some later from that company but I am not sure about this original set.

51. Recross-question. How many of these Bellani-Tosi direction finders were purchased or acquired or used by the Navy as far as you know?

Answer. I remember two of the type I described and possibly two or three of the subsequent type.

52. Recross-question. Were all of these furnished with two-element bulbs?

Answer. No; the subsequent sets which were gotten from the Marconi company had three-electrode valves.

53. Recross-question. In your testimony in the DeForest case, concerning the apparatus used in these tests, you referred to it as furnished by the Marconi company. Have you any reason to believe that that testimony is incorrect?

Answer. No; it probably is a fact that the Marconi company furnished the sets. Whether by purchase of the Navy Department or by an attaché abroad or as a loan I do not recall at the present time. I undoubtedly can find data to this effect in my files, but I have not thought of this matter for many years.

54. Recross-question. Then, so far as you recollect, the only time a two-element bulb was tested by the Navy was the test which you made on the one Bellani-Tosi direction finder set furnished by the Marconi company, which set included the two-element bulb; am I right?

Answer. That is the only test I made of the two-element valve during my association with the Navy Department.

55. Recross-question. How many two-element bulbs were furnished with this Bellani-Tosi direction finder set?

Answer. Few; possibly half a dozen.

56. Recross-question. Did you use all of them?

Answer. I remember that one was burned out from previous use when I got the set, but I tried all the others. That would be the only way in which such a test would be made to obtain the average of all available units.

57. Recross-question. Were any of the bulbs burned out during or as a result of the test?

Answer. You mean the test I made?

58. Recross-question. Yes.

Answer. No; I do not recall any.

59. Recross-question. In your testimony in the DeForest case, quoted in X Q. 15 of this case, you were referring to

the same two-element bulb as was tested with the Bellani-Tosi direction finder set, were you not?

[fol. 406] Answer. Yes.

60. Recross-question. It is true, is it not, that in all of the DeForest apparatus purchased by the Navy from the DeForest company the audio-frequency amplification was used exclusively?

Answer. The devices in which these DeForest valves were used were the types known as audio-frequency amplifiers, and their practical function was to make louder in the receiving telephones any signal which ordinarily would be heard with less intensity if the receiving telephones were in the detector circuit only.

61. Recross-question. In the DeForest case you testified as follows, did you not?

"Q. Would this amplification depend upon whether the bulb is receiving radiofrequency from the antennae, or audio frequency from a detector device, or will it amplify equally well in either case?—A. The audion amplifier will amplify equally well, speaking generally, whether or not the radiofrequency energy is being amplified or whether the audio-frequency signal from a detector is being amplified. In all the DeForest apparatus which we purchased from the DeForest company the audio-frequency amplification was used exclusively, the reason being that radio technic had not advanced to the point of using radiofrequency amplification. To-day the tendency is entirely in the other direction."

Answer. Yes; my testimony, I wish to make very clear at this point, was entirely with reference to practical use of actual apparatus, and with no reference to the theoretical. In referring to audi-frequency amplifiers and radiofrequency amplifiers I was referring then and am referring now to the specific pieces of apparatus whose trade names are audio amplifier and radio amplifier.

62. Recross-question. Can you produce any adopted or authorized system of nomenclature or standard names adopted while you were in the naval service, or the later one adopted by the Radio Corporation?

Answer. Yes; I have these in my files. I have not these with me, but can produce them from my files. The Radio Corporation list is a standard nomenclature list, giving the standard names for various units which are often incor-

rectly named, and I am not sure whether any definitions are given or not. I can produce copy of definitions which I got up for the Navy and those which I worked on with the I. R. E. standardization committee.

63. Recross-question. Can you state at this time the substance the definitions which you got up for the Navy for the words "detector" and "amplifier"?

Answer. There were a number of different papers of the Navy Department where definitions were given, ranging from early days to later days, and I will be giving more accurate information if I quote from all of these which I can find.

64. Recross-question. Can you state the substance of the first definition of detector which you got up for the Navy?

Answer. I prefer to quote from actual data which I can obtain. The first definition of detector, I recall for one thing, was "tied up" with the idea of crystal detector only, as that was the only detector in standard use at that time. I think this was somewhere around 1912.

[fol. 407] 65. Recross-question. According to the copy of the record in the DeForest case, you gave your testimony in January, 1920. Does that coincide with your recollection of the approximate time when that testimony was given?

Answer. Yes, it was shortly after I came with the Marconi company in June, 1919.

66. Recross-question. Up to that time you used the term detector in the limited sense of meaning a rectifying device did you not?

Answer. The term was loosely used by a great many engineers including myself, as sometimes meaning rectifier and sometimes meaning detector system complete. I remember that in 1921, in conferences on the standardized terms with former members of the Navy Department and with the General Electric, this question came up in connection with the definition of "system" as opposed to unit. I think that prior to that time I used the term very loosely.

67. Recross-question. Can you not answer my question directly?

Answer. Where I was referring to any comparison with some other device, it was a rectifier only—yes. Where I was referring to a complete system, I may have and probably did use the term in the other sense.

68. Recross-question. And in the De Forest case and in this case where you have referred to apparatus as detectors, you have used the term "detector" in the sense of meaning a rectifying device, have you not?

Answer. In referring to the actions which went on in the valve, my testimony at any time up to 1921, would have referred to the rectifying characteristics of the two only. One rule I always tried to keep in mind was to keep one thing in mind in making a comparison between any two things. This led me to distinguish between the detector action, or rectification of a tube and its possible amplification quality, in that the first was the thing which could be directly compared with some other device wholly a rectifier, in my opinion, such as a crystal. But where I referred to a piece of apparatus as a detector, this meant the physical apparatus with whatever total functions it might possess.

69. Recross-question. Can you state the substance of your definition of the term "amplifier" as adopted by you for the Navy?

Answer. Since I can produce the actual definition, I prefer to be accurate by quoting from it. The substance as I recall it now would be a device which, placed between the device which changes radio signals into audio signals would make these audio signals louder and make their effect on some visible or audible instrument greater. This definition referred to physical apparatus, namely, an amplifier as a device which the Navy would purchase or issue from stock, whereas a vacuum tube alone might be termed an amplifier, my definition was entirely as to apparatus which we would purchase, or the operators would use in service.

70. Recross-question. And is that the sense in which you used the term "amplifier" or "amplification" in your testimony in the De Forest case and in this case?

Answer. Not necessarily—where I was referring to apparatus, referring to an amplifier as a physical complete piece of apparatus, that would be the sense. Undoubtedly, [fol. 408] in all my testimony I have occasionally referred to a vacuum tube itself as being capable of use for amplification and hence being in one sense an amplifier. Those were definitions of apparatus.

71. Recross-question. Did you not in the De Forest case and in this case use the term amplification in the sense of meaning to make louder a signal which already exists from some detecting source?

Answer. Except where I referred to radio amplification; yes.

72. Recross-question. In the De Forest case you testified as follows, did you not?

"Q. The crystal detector is still in use?—A. The crystal detector is still in use, greatly in use.

"Q. What is the limit of its use, generally?—A. The crystal detector is used exclusively for reception of spark signals, and to some extent for radiotelephony.

"Q. Is it of any use for amplification purposes?—A. No; it is not.

"Q. Is it capable of amplifying at all?—A. Your question can be answered only in general terms. We use the word amplification in the naval service in the purely practical sense of making louder a signal which already exists from some detecting source. Taking that meaning, the crystal detector is not capable of being used as an amplifier."

Answer. Yes.

73. Recross-question. If the tubes which you have testified were used by the Navy had not possessed the ability to amplify in the sense in which you have used the term amplification, would they have been capable of use for regenerative purposes or for sending purposes?

Answer. That is a question calling for theoretical and expert reply, and I therefore do not wish to answer it. I am desirous of giving full information as to the actual apparatus used by the Navy Department, for which I prepared a great majority of the specifications, and the use of such apparatus which I, as a qualified operator, used or many of the operating instructions for which I prepared. My work in the Navy did not extend to theoretical matters.

74. Recross-question. In your direct examination in answer to Q. 7, you seemed to have no difficulty in giving your opinion that vacuum tube receivers and transmitters were an indispensable part of the naval service. Will you state the facts on which you based your opinion?

Answer. My opinion is based upon actual observation and participation in the field of radio communication before and after the introduction of the various functions of the vacuum tube, and upon my knowledge, based on instructions from my superior officer, and on my own use in the service of the needs of the Navy communication system. My testimony was further based on the actual performance

of the different types of valves in the use for which they were purchased. It does not extend to theoretical consideration of what other things might have been done with the tubes.

75. Recross-question. Could you not have accomplished with crystal detectors, for example, all that was accomplished by the vacuum tubes?

Answer. No, sir; because never, to my knowledge, was the crystal detector capable of use in an amplifier or as an oscillator. I did know a vacuum tube which would perform these functions, used them, and made recommenda- [fol. 409] tions to the bureau as to their suitability in the service.

76. Recross-question. Since you say that the crystal detector could not have accomplished what the vacuum tubes did, because the crystal detectors were not capable of use in an amplifier or as an oscillator, does it not follow that if the vacuum tubes had not been capable of use as amplifiers or as oscillators they would have failed to accomplish the results which you say in answer to Q. 7 they did accomplish?

Answer. That again is a matter of definition. For example, if a vacuum tube, a single tube, is placed in a detector circuit and the device is used in connection with a variable feed-back circuit we get very remarkable effects. For example, we get very much louder signals than if a crystal-detector system were used. According to the I. R. E. definition, and the definition which I now adhere to, this entire device is a detector system, in that it is a single device which makes the radio signals in the receiver audible to the operator. From this viewpoint vacuum tubes as used in a detector system are very valuable features in radio communication, and such a device as I have outlined is one of the great advances in the radio art since the days of the crystal detector.

77. Recross-question. Now, can you answer my question?

Answer. No; your deduction is not correct.

78. Recross-question. Wherein is it incorrect?

Answer. In that there are three major ways in which vacuum tubes are capable of use—in a detector system, in an amplifier, or in an oscillator. You refer to the latter two only. The first is, in general, of equal importance, and had tubes been used for this purpose only they would have accomplished part of the results which I state in question 7.

The amplifier made long-distance work possible, but the type of detector which I have outlined is also very suitable for this work and render- very much greater distances possible than in the preceding art. It is a question of degree. The amplifiers made extreme long distance possible. The detector system I have outlined makes great improvement over the prior art, though it does not go as far as the amplifier. As far as the part of my answer to Q. 7, which refers to oscillators, is concerned, then that part of your question 76 is correct.

79. Recross-question. Is it not true that unless the vacuum tube would amplify or oscillate it would have failed to accomplish substantially more than was accomplished or could be accomplished by the crystal detector?

Answer. As an oscillator, yes; but if it had not been used at all in any amplifier apparatus but only in a detector system, as I have previously outlined, it would have represented a very considerable advance over the crystal art.

80. Recross-question. And even in the detector system, to which you have referred, you have assumed the use of a tube which is capable of amplifying, have you not?

Answer. I am referring to a tube which was bought by the Navy and issued by the Navy for use in a detector system, and so termed. I am not going into the theoretical discussion of the term amplification and am merely referring to the fact that when the Navy sent out amplifiers it sent amplifier tubes to work with them, and when it issued [fol. 410] detector systems the bulb used in this was a detector bulb, and was so called. Such a system, as I said before, is capable of giving much better results than the prior art.

81. Recross-question. Is it not true that the so-called detector tube to which you are referring is a tube which amplifies.

Answer. It is a tube which is in general capable of being used in an amplifier, with greater or less efficiency, depending on characteristics and the purpose for which it was bought.

82. Recross-question. Will you state the type designation of the tube, so that we can identify it?

Answer. One name was the type of a vacuum tube supplied by the De Forest company in 1914 and termed by them the "audion."

83. Recross-question. That was a three-element tube?

Answer. Yes, sir.

84. Recross-question. Is it not a fact that you, in your advisory capacity, would never have recommended or urged the use of these vacuum tubes by the Navy unless you had been satisfied that they would amplify?

Answer. That general statement is not correct. I recommended the use of the audion as an oscillating device because it gave us a good way of receiving continuous wave signals. A little later, possibly the same time, I recommended the use of the amplifier, because it enabled us to get louder signals than before. Later I recommended the use of the detector system, which I have just testified about, for the definite reason that it worked as a better detector and that we could get louder signals with one bulb than we could get with two or possibly three in an amplifier alone. I recommended the use of the vacuum tube at three different times, the first two being almost coincident, on account of the three different functions which it carried out.

85. Recross-question. You know, do you not, that the tube would neither oscillate nor give louder signals unless it did amplify?

Answer. It would not give louder signals unless it did amplify. The question of the amplifier being essential for oscillation is one for an expert to testify on. This matter did not enter at all into my recommendations for use of the device in the Navy. I prefer not to express a technical opinion on this matter.

Re-redirect examination:

86. Redirect question. When you stated that the audio-frequency amplifiers were used to increase the strength of signals which had already been detected and which already existed, did you mean that they had already been put in such condition that they could be copied and read by the operators before passing through the amplifiers?

Answer. Not necessarily so; where the initial signal delivered by the detector system was too weak to copy this would not be the case. In general, however, the effect of amplification was to make it easier for the operator to copy. My experience is that with concentration in almost every case you could read the original signal, and read it better after amplification.

87. Re-redirect question. Imperfection detection might have been had without the amplifiers?

Answer. Yes.

[fol. 411] The examination by counsel being concluded, the witness in compliance with the rule of the court requiring him to state whether he knows of any other matter relative to the claim in question, and if he does to state it, says he does not.

Deposition of Frank N. Waterman (recalled), for claimant, taken at New York, N. Y., on the 15th day of December, A. D. 1922, and subsequent dates.

Mr. Waterman, in response to interrogatories by counsel for plaintiff, testified as follows:

1. Question. Have you read the testimony of George H. Clark herein?

Answer. I have.

2. Question. Will you please compare the radio telephone sets described by Mr. Clark and shown in plaintiff's Exhibit No. 116 with the invention of the Fleming patent in suit, particularly as set forth in claim 1?

Answer. Exhibit No. 116 shows schematically four vacuum-tube transmitters having specifically different circuit arrangements but all utilizing the same properties of the vacuum bulb, namely its capacity to produce the currents giving rise to the wireless waves. This property of the tube is ordinarily designated as its capacity to oscillate, and when operating in this way the tube is said to be oscillating or in a state of oscillation. It was demonstrated to Judge Mayer in the DeForest case by demonstrations made in court with the apparatus that the device of the Fleming patent was capable of generating oscillating currents when used in the identical arrangement shown in the patent, a battery being inserted, of course, to furnish the necessary energy. It is this function of the vacuum tube that is employed in the arrangement shown in plaintiff's Exhibit No. 116. I believe that I have already referred to this function of the tube when provided with three internal elements, in my former testimony, in considering the so-called ultraaudion, which makes use of this same property in a receiving apparatus. In exercising this function, it will of course be understood that the tube is not in any sense generating

or furnishing energy. It is merely transferring energy delivered to it in a modified form. When performing the receiving function, as specifically described, in the Fleming patent, the bulb receives oscillatory current and delivers direct current capable of actuating the receiving instrument. In a transmitting circuit, conversely, the tube is receiving direct current and delivering in the form of oscillatory currents. In either case the currents have to be furnished to the bulb, and which ever kind is delivered to the bulb is by it transformed to the other kind; thus, the one function is the converse of the other. Thus, in the diagram Figure 1 of the patent, oscillatory current received by the antenna MO is delivered through the transformer MK to the bulb and it in turn produces through the indicating instrument L direct current, capable of actuating the in-[fol. 412] dicator L, although the original current delivered to it was incapable of actuating the indicator. Conversely, if a current from a battery is delivered to the bulb, as for example by inserting it into the conductor J, then the bulb will deliver through the transformer KM pulsating energy to the antenna NMO, resulting in the production of wireless waves radiated by the antenna, as the result of the oscillatory current delivered to the antenna NMO. In the several circuit arrangements of Exhibit No. 116, the bulb T is in each case furnished with direct current by a battery, that is, by a source of energy typified by the battery E^2, and it delivers this energy to the antenna in the form of oscillatory current with the result that wireless waves are radiated.

In the court demonstrations made before Judge Mayer in the De Forest case it was demonstrated by working apparatus that the bulbs of the Fleming patent, which had been made for a detector—that is, receiving—purposes, would oscillate and furnish oscillatory currents when direct currents were supplied to them, and in a variety of circuits, including that specifically shown in the patent. The vacuum-tube transmitters, referred to by Mr. Clark, are merely instances of the application of this property, the particular bulbs employed for the purpose being three-element bulbs, which, in small sizes at least, are more easily controlled than are the two-element bulbs.

It is characteristic of all of the transmitters shown by Mr. Clark that each contains a vacuum tube or bulb, which,

in the language of the Fleming patent, is a vacuous vessel. Within the bulb there are two conductors—in fact, three, lettered, respectively, F, G, and P. Associated with each tube is a source of current acting as a means for heating the conductor F. This is typified in the drawings by the battery B^1. There is also in each circuit outside the vessel, connecting the two conductors. There is, in fact, in each of these transmitters such a circuit for each of the two cold elements. As I have explained, the three-element bulb differs from the two-element bulb in having two cold elements insulated from one another and adjacent, but not touching, the incandescent filament instead of only one, as in the Fleming patent. This provides the means for separating the two functions and exercising them in two circuits. This is done in each of the four transmitters illustrated by Mr. Clark. Thus in the arrangement marked "De Forest," in Exhibit No. 116, the element P of the tube T has a circuit formed by a wire leading therefrom to the upper end of condenser C' to the earth and thence, as explained by Mr. Clark, through the capacity of the apparatus itself with respect to the earth back to the filament F. The grid circuit passes from the grid G to the upper end of the oscillatory circuit c^2 c^3, thence from the lower end of that circuit to the upper end of condenser c^2 and leak resistance L, and thence from the lower end of this combination back to the filament. The antenna circuit is indicated at A and is connected to the earth at E. Thus all of the elements referred to in claim 1 are present in this transmitter.

The transmitter indicated by the diagram marked "General Electric No. 1" similarly comprises a vacuous vessel containing the two cold elements G, P, and the filament F is provided with means for heating the filament indicated at B^1. The cold element P and filament F are connected [fol. 413] outside the vessel by the wire, shown passing through coil d^2, connector 2, and battery B^2. Similarly the grid element G is connected to the filament F through the coil g^3, connector 3, and condenser and leak combination c^1, L. The antenna is indicated at A as before. Thus this transmitter also combines the combination of elements described in claim 1.

Referring to the diagram of Exhibit No. 116, marked "General Electric No. 2," this is substantially identical with General Electric No. 1, the only apparent differences

being that the coil d^2 is in parallel relation through the condenser c^2 with the battery B^2 instead of in series therewith and that the coil marked d^1, corresponding in its circuit relation with coil d^3 of General Electric No. 1, is included in the antenna circuit. The combination recited in claim 1 in the Fleming patent is therefore equally found in the transmitter General Electric No. 2.

The diagram illustrating the Western Electric transmitter, on Exhibit No. 116, only differs in that the coupling is electrostatic instead of electromagnetic, as has been explained by Mr. Clark. There is the same vacuous vessel T, containing cold elements 2 and 3, and the filament F arranged to be heated to incandescence by a source of energy d^1. The plate P is connected by a circuit outside the vessel to the filament through the coil g and condensers c^1, c^3. The cold element g is similarly connected to the filament by way of the condenser g, 4, shunted by the leak L. The antenna is again indicated at A.

There is thus found in each of these transmitters the combination elements recited in claim 1 of the Fleming patent associated in the same way to produce the reversible function performed in the device of the Fleming patent, as demonstrated to Judge Mayer in the De Forest case.

* * * * * * *

3. Question. On what did you base your statement regarding the demonstration made before Judge Mayer?

Answer. On the fact that I made them. That is to say, testifying as a witness before Judge Mayer, I was called upon to make and did make the demonstrations referred to. I was assisted by Mr. R. A. Weagant.

* * * * * * *

4. Question. Will you compare the receiver referred to by Mr. Clark, as being arranged with terminals with any form of detector and shown schematically in this drawing, Exhibit No. 113, with the invention of Marconi patent in suit No. 763772?

Answer. The receiver shown in Exhibit 113 comprises an antenna circuit having therein an adjustable condenser h^1 and an adjustable inductance j^1, which also serves as the primary of the receiving oscillation transformer; the secondary circuit has the inductance j^2 serving as the sec-

ondary of the oscillation transformer and the variable con- [fol. 414] denser h^2. There is also in the antenna circuit and the secondary circuit additional variable inductance described by Mr. Clark, but not shown. These constitute additional tuning means. No local indicating circuit is shown, but terminals marked RA RE are shown, whose purpose is to permit the connection to the apparatus of any desired detector and indicator system.

It will be seen that the receiver is substantially identical with that which I have already fully described in making a similar comparison with the apparatus of the Wireless Specialty Co., illustrated in plaintiff's Exhibit No. 87, the testimony beginning on pages 381 and 421 of the manuscript record. The comparison which I there made applies fully to apparatus of Exhibit No. 113. I request that it be understood as applying to this exhibit without repetition.

Exhibit No. 113 also contains an additional coil h^3 connected to two binding posts marked "Tickler." The presence of this coil does not in any way alter or modify the operation of the remainder of the apparatus shown. It is merely a coil sometimes used in connection with the particular type of detector known as the three-element vacuum-tube detector, or audion, and may or may not be used with that detector at the pleasure of the operator.

5. Question. Will you now please compare the receiver described by Mr. Clark in paragraph seven of his answer No. 2, and shown in drawing, Exhibit No. 114, marked "Vacuum-tube receiver arranged for both operation and regeneration," with the invention of the Marconi patent No. 763772, and of the Fleming patent No. 803684?

Answer. The arrangement of apparatus shown in Exhibit No. 114 is identical with that shown in Exhibit No. 113, considered in my last answer, with the addition thereto of a three-element vacuum-tube detector and indicating instruments R. Everything that I have said with respect to Exhibit No. 113 applies therefore to Exhibit No. 114 and I will make the same request that I made that the full description and comparison of the Marconi patent inquired about, which I have given with respect to the Wireless Specialty Apparatus Co.'s receiver, be understood as made with respect to that of Exhibit No. 114.

The vacuum tube detector T is connected in circuit in the manner already described by me in my former testimony in answer to Q. 34, with reference to Exhibit No. 83, drawing

PN audion, and plaintiff's Exhibit No. 82, De Forest PN audion, and also as referred to in plaintiff's Exhibits Nos. 71, 72, and 74.

This circuit of Exhibit No. 114 shows in addition the leak resistance L and the tickler coil j^5. These elements, however, in no way alter the application of the testimony given in answer to Q. 34, since the leak resistance L is merely a means of increasing the sensitiveness of the device as a detector and maintaining stability of operation, while the coil j^5 serves to enable the coil to function not only as a detector but as a regenerative amplifier. I will ask that the description and comparison which I have already made of such a structure with the Fleming patent in suit in my answer to Q. 34 be read as applying also to the apparatus of plaintiff's Exhibit No. 114.

6. Question. Please compare the direction finder described by Mr. Clark in paragraph 10 of his second answer, and shown in his drawing, Exhibit No. 115, with the invention of Marconi patent 763772 and with the invention of the Fleming patent 803684.

[fol. 415] Answer. The direction finder shown in plaintiff's Exhibit No. 115 comprises an ordinary coupled circuit receiver, such as is shown also in Exhibits Nos. 113 and 114, just considered, having associated with the secondary circuit thereof an additional antenna circuit of the loop form. The antenna A contains, as in the other exhibits referred to, a variable capacity h^1 and a variable inductance j^1, as tuning elements and the secondary circuit comprises the oscillation transformer coil j^4, and the tuning condenser h^2. It also has the inductance j^2, constituting the secondary of the oscillation transformer, whose primary j^3 is connected in circuit with the loop antenna LA, this circuit also containing the variable condenser h^3.

In use the antenna A is tuned to the wave length of the incoming signals and the secondary circuit is tuned to the same wave length. There are therefore the two receiving circuits of the Marconi patent inquired about and this much of the apparatus constitutes a distinct receiving apparatus for any desired use. The association therewith of the loop antenna LA enables it also to be used for dir ction finding purposes, so that the direction from which a received signal is arriving can be ascertained. This added association and function in no way alters the normal organization and function of the antenna system A and the secondary cir-

cuit. Associated with this secondary circuit is a three-element vacuum-tube detector and signal-indicating device, exactly as in Exhibit No. 114, and I will ask that the answer which I have given as to Exhibit No. 114 in my last preceding answer be understood as applying to Exhibit No. 115.

7. Question. Will you please explain the relation of the wave charge referred to in paragraph 16 of Mr. Clark's answer to Q. 2 to the Marconi patent No. 762773?

Answer. In a transmitter wherein a primary condenser circuit containing a spark gap is associated with a radiating antenna circuit, it is essential to the effective operation that the two circuits should be tuned to resonance the same wave length as set forth in the Marconi patent, as I have already explained in my former testimony. It is frequently desirable that the same transmitter should be able to transmit more than one wave length, but in order that this may be done, it is necessary to change the inductance or capacity or both in each of the two circuits in order that the resonant relation may be maintained. For the proper operation of the spark gap it is also desirable that the coupling—that is, the association of the two circuits in their relation to one another—may be maintained. The wave changer referred to by Mr. Clark is simply adjusting means associated with the two circuits of the transmitter, whereby an operator may by the single movement of a switch arm or control means simultaneously adjust both of the circuits so that they will be in tuned relation for any one of a number of wave lengths for which the wave changer is arranged. It would thus be possible for the operator at will to select the wave and to tune the apparatus to any one of a number of wave lengths, as, for example, 450, 600, and 750 meters.

In this way an operator could avoid interference with other stations. In general, therefore, the wave changer is an apparatus applied to a transmitter, such as is described in the Marconi patent, for enabling the tuning of the two circuits to be more readily performed. Or, putting the matter in another way, the tuning to any one of several [fol. 416] wave lengths as required by the Marconi patent is effected initially and by the aid of this switch is automatically preserved for any wave length for which the transmitter is adapted.

8. Question. Please explain the relation of the spark set vacuum-tube excitation referred to by Mr. Clark in paragraph 4 in answer to Q. 2 to the Fleming patent.

Answer. It appears from Mr. Clark's testimony that certain two-circuit spark transmitters were modified by removing the spark gap and associating with the remainder of the apparatus the necessary vacuum tube to convert the transmitters into oscillating vacuum-tube transmitters of the class I have already considered in comparing the structures of Exhibit No. 115 with the Fleming patent. Referring, for example, to diagram marked "General Electric No. 2" of Exhibit No. 116, it is evident that the spark transmitter would have the necessary oscillation transformer, such as d^1, d^2, and the loading inductance gxd, and would also have the source of current typified by the battery b^2 and condensers such as c^2. Associating with these, the bulb such as T would convert the apparatus into an oscillating vacuum-tube transmitter, such as I have already fully considered in my answer to Q. 2 of this deposition. I will ask that that answer be taken as applying to these transmitters inquired about.

9. Question. In view of the objection to your testimony regarding what transpired before Judge Mayer in connection with the demonstration of the oscillating capacity of the two-element valve, I will ask you if you can produce a copy of the record of that particular trial.

Answer. Yes; I produce a copy of the record as reported in that case and including the testimony with respect to the demonstration as to which I have testified.

Mr. Peters. I request that this testimony be marked for identification and I offer it to defendant's counsel for such use as he may see fit.

* * * * * * *

Cross-examination.

By Mr. Edwards:

10. Cross-question. At the time of the so-called demonstration before Judge Mayer to show that a two-element bulb which would detect would also oscillate, did you inform Judge Mayer that such oscillation as you obtained was due to the presence of gas in the tube?

Answer. No representation was made to Judge Mayer that any bulb that would detect would oscillate nor was any made as to the cause of the oscillation as I did not know the

cause and do not now except as it is a result of the capacity of the bulb to amplify resulting in some way from the electron discharge.

11. Cross-question. Do you now say that you do not know that such oscillation as you obtained before Judge Mayer was due to the presence of gas in the tube?

Answer. Yes; I do. My recollection is that voltages as high as 150 volts were used and that the bulbs gave no indication of ionization phenomenon and the bulbs were as [fol. 417] highly vacuous bulbs as the Marconi company was able to produce at the time they were made and I am confident that they are higher vacuum tubes than could have been produced at the date of the Fleming patent.

12. Cross-question. Was the 150 volts just referred to the plate voltage?

Answer. I do not assert the 150 volts as other than my present recollection. If I remember rightly, a considerable number of different bulbs were used at the several tests which were made during the trial, and if my memory serves me the voltages ran from about 90 to 150 volts. The voltage referred to is the plate voltage; that is, the voltage between the plate and the filament.

13. Cross-question. What filament voltages were used?

Answer. My recollection is that it was about 6 volts; certainly not over 12.

14. Cross-question. Do you say now that you do not know that if the bulbs shown Judge Mayer had been bulbs with a vacuum of the degree now obtainable that the bulb would not have oscillated?

Answer. Yes; I know that it is not easy to make small bulbs with the high degree of vacuum obtainable at the present day oscillate when they have only two elements. I also know that larger bulbs will oscillate much more readily.

15. Cross-question. Will you state the order of the vacuum obtainable at the time of the Fleming patent and that attainable to-day?

Answer. I doubt if I can do that. I can give you my recollection if you wish, but as the question goes to a matter of fact I would rather confirm it. My impression is that about ten to the minus third power millimeters represented a high vacuum at the date of the Fleming patent; perhaps ten to the minus seven to-day.

16. Cross-question. What is the order of the vacuum of the incandescent lamp at the date of the Fleming patent?

Answer. Somewhere in the vicinity just stated; I have no closer knowledge.

17. Cross-question. That would be in the order of ten minus three millimeters?

Answer. That is my present impression; but, as stated, I would prefer to look the matter up.

18. Cross-question. Are you prepared to say with your present knowledge that if the bulb or bulbs demonstrated before Judge Mayer by you had had a vacuum of the order of ten to minus seven power it would have oscillated?

Answer. Since I do not know exactly what the vacuum was in the demonstration above and have not made sufficient tests with bulbs of definitely measured vacuum, I am not prepared to say whether they would or would not in that particular size.

19. Cross-question. Is it your belief that the bulbs demonstrated before Judge Mayer would have oscillated if these bulbs had been high vacuum bulbs?

Answer. My understanding is that the bulbs were what we call high vacuum bulbs at the present day, although not presumably the highest vacuum obtainable at present. As to whether they would oscillate if they had been different from what they were I can not say, but my belief is that it is highly probable that two-element bulbs with [fol. 418] the highest obtainable vacuum will be the bulbs ultimately used in high power bulb installations.

20. Cross-question. Are you prepared to say that such oscillation as you obtained before Judge Mayer was due solely to the electrons and was not due to such gas characteristics as the tubes may have had?

Answer. Of course, it was due solely to the electron discharge as the primary cause. I do not think anyone would undertake to say that there are no ions other than electrons present in any bulb, no matter how high the vacuum, or that they may not be secondary causes of what goes on. I certainly do not say so.

21. Cross-question. Then you do not assert that such oscillation as you obtained before Judge Mayer was not due to the gas characteristic of the tube, do you?

Answer. I do not assert either that it was or was not, but only that there was no evidence that it was.

22. Cross-question. Is it your belief that if these tubes demonstrated before Judge Mayer had had no gas charac-

teristic that oscillation would nevertheless have been obtained?

Answer. As I have said, I can not say what the bulbs would have done if they had been different. I can only say that my belief is that the highest present-day vacuum does not defeat the oscillation of the two-element bulb, although they do not oscillate readily in small sizes.

23. Cross-question. Do you now say that you do not know that if these tubes exhibited before Judge Mayer had had no gas characteristics you could not have obtained any oscillation therefrom?

Answer. Yes; I do say that—I have already said it.

24. Cross-question. Was the bulb, or any of the bulbs, exhibited to Judge Mayer and demonstrated before him similar to the bulb in evidence in this case and marked "Plaintiff's Exhibit No. 29"?

Answer. No; a flat plate was used for the cold element instead of a cylinder.

25. Cross-question. Can you make a sketch showing the type of bulb which was used before Judge Mayer?

Answer. Yes; I offer you such a sketch, made roughly in pencil. This illustrates the general construction and approximate size.

Mr. Edwards. The sketch is offered in evidence as defendant's Exhibit No. A.

26. Cross-question. Can you produce any tubes similar to those which you say were demonstrated before Judge Mayer and which will oscillate?

Answer. I have none in my possession and do not know whether or not those used or others like them are still in existence.

27. Cross-question. Will you endeavor to procure some from the claimant and report to us at a future session?

Answer. I will be glad to endeavor to obtain one. I have no idea whether or not I shall succeed.

28. Cross-question. How many of the bulbs were demonstrated before Judge Mayer?

Answer. I don't know—if I ever did know I have forgotten. I remember that I had several—perhaps half a dozen at court and that several of them were used. One was found to show traces of ionization and was discarded, and the others were used thereafter.

[fol. 419] 29. Cross-question. Were all of the bulbs operated at the same voltage during the time they were oscillating?

Answer. I don't know just what the question means. I remember that when the same bulbs were operated at a given time the same voltage was not necessarily employed, but in general all that was done was to stop the operation by disconnecting the filament current and simply relight the bulb when it was desired to have the operation begin, and naturally no change was made in the voltage in the plate circuit. In other words, to demonstrate that it was oscillating and that the cause of the sound heard was not due to some other cause, the filament of the oscillating was disconnected from its lighting battery and connected again as often as desired by Judge Mayer or counsel and experts.

30. Cross-question. In order to get the several bulbs into oscillating condition it was, I take it, necessary to adjust the plate and filament voltages for that bulb, was it not?

Answer. Yes; it was necessary. These particular bulbs were experimental bulbs made for detecting purposes and had different separations between the plate and the filament. They would, in general, call for different plate voltages in use for any purpose.

31. Cross-question. Do you mean that the separation between plate and filament was different as between the several bulbs which were exhibited before the court?

Answer. Yes. These bulbs were taken from a number made in the course of a study of two-element bulbs some years before the demonstration in court referred to and in general were made with varying separation of the elements. They were made in the particular shape illustrated because it was an easy form in which to obtain approximate accuracy of the desired separation.

32. Cross-question. After you adjusted each bulb to the particular plate voltage and the particular filament voltage necessary to put the bulb in an oscillating condition, were these voltages left unchanged during the entire time that particular bulb was being demonstrated, excepting, of course, the making and breaking of the filament circuit for the purpose of starting and stopping the operation?

Answer. I can not positively assert that such was always the case; certainly it was in general. I remember that one or more bulbs were tried—I think not in court, but for some one on the other side—Professor Stone, I think—over

a considerable range of voltage, perhaps twenty or thirty volts, I do not now remember, but I can not now say that that was done for Judge Mayer's benefit or that it was not done. There were a good many tests made and in general the voltage on the plate circuit was not changed, but the filament was made and broken.

33. Cross-question. What is the longest period of time during which any one of these bulbs continued to oscillate in the demonstration before Judge Mayer?

Answer. I do not remember; not very long I should say. I do not think at any time over half an hour; perhaps not more than 15 or 20 minutes.

34. Cross-question. Do you think that any one of them oscillated as long as 15 minutes during the demonstration before Judge Mayer?

[fol. 429] Answer. I can not swear to it, but I have no doubt of it. My recollection is that in general the demonstration referred to was made for Judge Mayer, and after he had finished his observations then counsel on both sides and the defendant's experts and witnesses listened, and I have no doubt that in more than one instance the time consumed was more than 15 minutes; also after testimony was resumed the court adjourned in one or more instances, the bulbs continued in use while defendant's witnesses were testifying.

35. Cross-question. And is it your recollection that during this 15 or 20 minutes the adjustment of the plate and filament circuits remained as originally set?

Answer. I have no doubt that they did on one or more occasions but I do not think they always did—my recollection is that at least on one occasion the voltage was varied purposely for the benefit of Doctor Stone or some one representing the defendant.

36. Cross-question. What is the longest period of time during which any one of these bulbs oscillated before Judge Mayer without readjustment of plate or filament voltages?

Answer. As already stated, I do not know.

37. Cross-question. Have you any recollection?

Answer. None other than I have given—I do not see how the question differs from those already asked.

38. Cross-question. How far apart were the sending and receiving stations in this so-called demonstration before Judge Mayer?

Answer. No measurement was made. It was merely a table demonstration, perhaps 6 feet, something of that order, I think.

39. Cross-question. In your direct examination in answer to Q. 2 you said that this bulb was demonstrated before Judge Mayer in a variety of circuits, "including that specifically shown in the patent." Is this quoted part of your answer literally true?

Answer. Yes; I think so. At least I do not note any inaccuracy on hearing it read. I believe the question does not quote the entire answer.

40. Question. The question is directed particularly to that part of your answer where you say that the circuit specifically shown in the Fleming patent was demonstrated before Judge Mayer. Is that statement literally true?

Answer. Yes; I think so, unless the question intends to distinguish between the quoted part in the present question and the entire answer which, if I remember rightly, states that a battery was employed, as, of course, the tubes could not make oscillations out of nothing. You have to have current supplied to it; in other words, before it could cause that current to oscillate.

41. Cross-question. Then when you say that you demonstrated that the Fleming bulb would oscillate in the circuits specifically shown in the Fleming patent, you mean that circuit with a battery added to it, do you?

Answer. Certainly, I so stated in my direct examination.

42. Cross-question. Well, you took care to make the statement that a battery was used in an altogether different part of your answer from that in which you state you used the circuit specifically shown in the patent, did you not?

Answer. No. The statement which counsel quotes immediately follows the full explanation of the insertion of the battery in the circuit of Figure 1 of the Fleming [fol. 421] patent. The quoted statement being made immediately after the explanation of the need for and function of the battery. Also I call attention to the first paragraph of the answer where I said, "It was demonstrated to Judge Mayer in the De Forest case by demonstrations made in court with the apparatus that the device of the Fleming patent was capable of generating oscillating current when used in the identical arrangement shown in the patent, a battery being inserted, of course, to furnish the necessary

energy." Here the statement quoted is in the same sentence with the statement that the battery was included.

43. Cross-question. Without the battery referred to the bulb of the Fleming patent could not be made to oscillate in any event, could it?

Answer. I should say that it could not, for the same reason that a boiler will not make steam without a fire under it.

44. Cross-question. But the bulb will act as a detector without the battery referred to, will it not?

Answer. No; not if no signal is furnished to it. If energy is furnished to it at either end, so to speak, it will respond.

45. Cross-question. But even if energy in the shape of a signal is furnished to the bulb in the circuit shown in the Fleming patent, without the battery, which you added in your so-called demonstration, the bulb would do no more than detect, would it?

Answer. Without a battery in the plate circuit, the bulb, of course, would only detect when the signal is supplied to it.

46. Cross-question. And under these same conditions the bulb, while detecting, will not amplify, will it?

Answer. It will not.

47. Cross-question. And, using your illustration, a fire is useful for warmth even though it is not under a boiler, is it not?

Answer. I do not get the point of the question. Fire, of course, has many uses.

48. Cross-question. So far as you know, is the Fleming two-element bulb used commercially in wireless telegraphy at the present time?

Answer. I do not know whether it is or not.

49. Cross-question. Did you ever have knowledge of any commercial use of the Fleming two-element bulb in wireless telegraphy or telephony?

Answer. I have never been connected with the commercial business. I remember seeing one in use in a station which, to the best of my recollection, was the Wanamaker store station, and also one in a station operated by the Marconi company, but I have forgotten where it was located, except that it was here in New York. When I say one, I mean a receiver known at that time as a Fleming valve receiver in each of these stations. Each receiver had two bulbs. In each case the receiver was being employed as the commercial means of receiving the signals. I may, perhaps, have seen others, but I never went to

any stations for the purpose of seeing a Fleming valve used; I merely remember incidentally noting these two in use.

50. Cross-question. In all of these instances was the bulb used in the circuit shown in the Fleming patent—that is to say, without the battery which you inserted in the circuit in your so-called demonstration before Judge Mayer?

Answer. I did not notice what the circuit or adjustment employed was.

[fol. 422] 51. Cross-question. Will you identify or make sketches showing the various circuits which you used before Judge Mayer?

Answer. I do not know that I can do that from my recollection at this time. The first circuit used was Exhibit No. 2 in the record before Judge Mayer, the receiving circuit being shown in Exhibit No. 3 in the same record. My recollection is that the next test was the same, except that condenser 3 was omitted and the receiving apparatus was changed by removing the bulb detector and substituting a crystal used without a battery. Of course, the so-called tickler coupling was removed when the tube was removed. I indicate the transmitting and receiving circuits in this test on the sketch that I hand you, marked, respectively, "Sketch A" and "Sketch B." The next transmitter arrangement that I recall was, I think, like sketch C, which I have made, the receiver being the same as shown in sketch B, except that a file and a bit of wire were inserted into the receiving circuit for the purpose of interrupting the oscillations. I should note that in sketch A the element which I mark "K" was a file and a wire arranged to be rubbed over so as to break up the transmitted oscillations.

Another arrangement used I indicate to the best of my recollection in sketch E, but whether it was the next in order or not I do not remember. Sketch E illustrates the receiver in which K indicates a crude type of ticker consisting of a file with a wire arranged to be drawn across.

Sketch F illustrates the last arrangement used to the best of my recollection. It is the arrangement shown in Figure 1 in the Fleming patent plus the energy supplying battery.

I do not assert the accuracy of these, they merely represent my best present recollection.

Mr. Edwards. Defendant's counsel offers in evidence the Exhibits 2 and 3 and sketches A to F, referred to by the witness, and asks to have the Exhibits 2 and 3 marked together as "Defendant's Exhibit B." and the sketches A to F, inclusive, marked together as "Defendant's Exhibit C."

53. Cross-question. Will you indicate on the sketches A to F, inclusive, how the various transmitter circuits were coupled to the antenna circuit, if one was used, or otherwise describe how all of these transmitter circuits, including that of Exhibit No. 2, were coupled to the antenna?

Answer. I do not remember the precise arrangement. My recollection is that we informally agreed with the defendant's expert to use the same arrangement that had been used for a long series of tests in the prior case of Marconi against DeForest wherein the three-element bulb as a detector and amplifier were more particularly in question. If I am right in this recollection then the circuit which in sketch B contains a conventional antenna indication, did not in fact have the antenna but was an artificial antenna coupled loosely to both the transmitter and the receiver. I think the coil 2 in the transmitter was inductively coupled to the antenna circuit indicated in sketch B and in point of fact the coil indicated in the antenna directly below the variable condenser therein was the coupling coil and that it was located some six or eight feet away from the receiver and in inductive relation to the coil 2 of the transmitter.

[fol. 423] 54. Cross-question. Was the antenna circuit conventional represented in sketch B an open or a closed circuit?

Answer. If the recollection stated in my last answer is correct, it was a closed circuit, so far as oscillation is concerned.

55. Cross-question. What was the function and purpose of the induction coil Z in sketches A and C?

Answer. It was primarily an impedance to keep the high frequency out of the battery circuit as used in the circuit of sketch A. I have assumed also in my use of such a coil that it acts as an energy storage device, at any rate, I have used it in general because it seems to facilitate the oscillation of the tube.

56. Cross-question. What part of the circuit of sketches C, D and F, was coupled to the antenna or other circuit to which the receiving circuit was coupled?

Answer. I don't know as to sketch C—I think there was a coupling for the antenna circuit but I can't remember where it was located.

In sketch D, the coil 2 is the same coil as coil 2 in sketch A, and coil Z is absent. The coupling I think was made to coil 2, simply by placing the coupling coil of the receiver in its vicinity, say a foot or two away. The same statement is true as to sketch F.

57. Cross-question. Did the operation of the two electrode tubes, as demonstrated before Judge Mayer, in any way resemble an arc?

Answer. Not that I know of.

58. Cross-question. In the record, marked for identification, after the answer to Q. 9 of your direct examination, I find the following testimony

"40 X Q. Is not in fact the blue glow striking an arc between the two electrodes, when this bulb is generating oscillations, as you say it does, have you not established an arc between the two electrodes?—A. Well, Mr. Darby, I began working with arcs in 1888, and I have not yet heard anyone define one. If you can define an arc to me I can answer your question.

"41. X Q. Will you please answer the question?—A. I do not call that an arc, nor do I call that anything which in any way resembles an arc?

"42. X Q. You say that it does not in any way resemble an arc?—A. Yes; that is my understanding of it."

Did you so testify before Judge Mayer?

Answer. I assume so. I have no independent recollection of just what I said apart from the typewritten record.

52. Cross-question. Are the statements in the quotation in accordance with your present understanding?

Answer. Yes.

60. Cross-question. In the accounting proceedings in the DeForest case, did you testify as follows?

"Q. Do you maintain that all two-electrode bulbs will oscillate in some degree?—A. No; because I do not know whether they will or will not.

"Q. How can you tell whether a given two-electrode bulb will or will not oscillate?—A. By trying it.

"Q. How do you try them?—A. By connecting it in circuit and observing what happens.

[fol. 424] "Q. What does happen?—A. Sometimes it oscillates and sometimes it does not.

"Q. Is there any way to tell beforehand whether it will oscillate or not?—A. Not that I know of.

"Q. If you want to build one in order to make it oscillate, do you know of any feature of construction or other characteristic that should be present in order to insure oscillation?—A. I have not personally followed that branch of the development, that is to say, the design, and I am unable to say. In general, the bulbs, which are mechanically well constructed and whose filaments give off a plentiful supply of electrons, oscillate.

"Q. When you refer to features of mechanical construction, what features have you in mind?—A. That the bulb should be tight and the initial component parts clean, well put together, so as to remain in proper relative position.

"Q. Any others?—A. No.

"Q. What is necessary in order to insure that the filament will give off a plentiful supply of electrons?—A. That the material should be proper and have the property of giving off electron. It is a physical property that is not definable by any other term that I know of.

"Q. Can you furnish us with a characteristic curve of the plate current of the bulb which you demonstrated, or a similar one?—A. No; I have no such curve.

"Q. Could you draw a curve that would approximately illustrate the plate-voltage curve of this valve?—A. No; I could not. I do not remember having seen a characteristic curve of any of them.

"Q. You produced in the main case, I believe, several characteristic curves of different detectors. For example, I call your attention to plaintiff's Exhibit No. 71, at page 2459 of the main record, also page 2485 of the same record and 2467 of the same record. Will you look at these exhibits as reproduced in the printed record and say if the characteristic curve of the valve which you tested was anything like any of those curves [handing book to witness]?—A. I am not able to compare, because I stated I do not remember having seen the characteristic curves of any of those demonstrated and I do not know whether or not they were taken.

"Q. Do you know if any characteristic curves were taken of any of the lot from which the demonstrated bulbs were selected?—A. No; except that I know that when those bulbs

were built some years before, it was the custom in the Marconi laboratory to take the characteristic curves. Therefore, it is probable that the characteristics were taken at the time they were made.

"Q. Did you make any characteristic curves of any of the two-electrode type of Fleming bulbs?—A. If you mean any bulb at any time, yes; I have taken many of them, but if you mean any of the bulbs of that lot, I am not able to say.

"Q. Do you think that you could reproduce, even approximately, the characteristic curve that would be substantially the same as the characteristic curve of either the lamps, the two-electrode bulbs that were tested, or any others of the lot from which they were taken?—A. No; I certainly could not, for reasons already given. In general, the charactertistic curves that I have taken are more [fol. 425] or less like this on page 2459 of the printed record, but I can not assign values to co-ordinates.

"Q. Could you say, from looking at the curves on page 2459, whether or not any of the valves from which these curves were taken would or would not oscillate?—A. No.

"Q. So far as you know, is any particular form of characteristic curve necessary in order that a given two-electrode bulb shall oscillate?—A. I have never investigated the relation between the performance of the bulb in this respect and its characteristic curve, and I do not know whether or not any one else has.

"Q. Can you assign any reason as to why some of the lot of two-electrode Fleming bulbs would detect and not oscillate, whereas others would both detect and oscillate?—A. No; I do not know what causes any of the variations. Some of them are excessively poor even as detectors; that is very unusual. Some of them require a local battery and some do not. I do not know what causes these variations.

"Q. If the two-electrode valve is a good detector, does it necessarily follow that it is also an oscillator?—A. I do not know.

"Q. I take it that I may assume that if the valve will oscillate it will also amplify, may I?—A. I think so; that at least is the general understanding.

"Q. So far as you know, in any two-electrode Fleming valve which which will detect, is any special degree of vacuum necessary in order to make it an oscillator?—A. Not that I know of.

"Q. Is any special kind of gas necessary?—A. No.

"Q. Any special density of gas?—A. Not that I know of.

"Q. Is the presence of a blue glow in the lamp necessary in order to attain oscillation?—A. It is not.

"Q. If present, does it prevent or interfere with oscillation?—A. It behaves as in any bulb. If there is too much, it prevents operation.

"Q. One place in your previous testimony I think you referred to the necessity of having a sufficiently high vacuum in order to insure that a two-electrode bulb would oscillate. Are we to understand that your present view is that a special degree of vacuum is not necessary?—A. The vacuum must be high enough or the devices will not operate as detectors or as oscillators.

"Q. If the vacuum is high enough for the device to act as a detector, does it follow from that that it will also act as an amplifier or oscillator?—A. No; I think not.

"Q. Is it true that the higher the vacuum the more certain will be the prospect of making the two-electrode tube amplify or oscillate?—A. I am not able to answer so broad a question; in other words, I do not know.

"Q. So far as you know, if the vacuum is as complete as it is possible to attain by the most modern methods, does that prevent or interfere with a given two-electrode tube which will detect, also amplifying or oscillating?—A. I am unable to say.

"Q. Have you any reason to believe that the highest attainable vacuum would present oscillation by a two-electrode valve which will detect?—A. No. I have not sufficient experience to generalize.

"Q. In the valves which you found and which you say oscillated, did they oscillate at all voltages or only at some [fol. 426] special plate voltage?—A. I think the answer would be neither; that is to say, I never tested one at all voltages and I never found one that would oscillate only at one particular voltage.

"Q. When you found one that would oscillate at some particular voltage, would it oscillate at all other plate voltages within the range attainable?—A. As I stated, I do not know, as I never tried all those voltages. In the valves tested in court, for example, the same bulb oscillated at different voltages.

"Q. What was the range of voltages used on the same bulbs in the demonstration?—A. I do not remember, but, roughly, probably 80 volts to 140.

"Q. Are we to understand that the same bulb would oscillate equally well within this same range, from 80 to 140 volts?—A. I do not know that there was any perceptible difference. None was apparent to me.

"Q. You did, however, test it at different voltages within this range, did you, the same bulb?—A. I have given my best recollection. I do not swear that that was the range.

"Q. Is it true that according to your best recollection, the same bulb oscillated equally well at ranges between 80 and 140 volts and that the lamp was actually so tested with these different voltages?—A. That is what I have said. I am unable to say. I have said it was tested at different voltages and that it appeared to oscillate equally well at different voltages. My best estimate of the range I gave at 80 to 140.

"Q. Give us your best recollection of all of the different voltages at which any two-electrode bulb was actually tested by you.—A. I can not do better than I have already done."

And also—

"Q. Is it your understanding that any given two-electrode Fleming bulb which will detect must inherently and of necessity also oscillate?—A. I have answered that at least four times.

"Q. Will you answer it again?—A. I do not know that that is so.

"Q. So far as you know, would increasing the degree of vacuum increase the possibility of getting oscillation with a given two-electrode Fleming valve?—A. I do not know over what range that is true. I know that if the vacuum is too poor, that it will not operate at all, and that over a wide range they improve with improvement in vacuum.

"Q. Would it be true that the better the vacuum the more probability there is that the valve will oscillate?—A. I do not know.

"Q. In the two-electrode valves which were tested and found to oscillate did you make any tests as to the length of time they would continue to oscillate?—A. No; that is, I made no exhaustion test. They oscillated long enough

for any observance we wanted to make, and naturally we spent no time merely seeing how long they would keep it up.

"Q. For how long a time did you actually keep it up?—A. I should think the longest I ever saw one bulb oscillate was a few hours, maybe two or three hours."

And also—

"Q. Will you explain how it is possible, even at the present day, to design a two-electrode tube which will have a given amplification constant?—A. I personally do not know.

[fol. 427] "Q. Do you know of anybody who manufactures and sells such a tube?—A. I do not understand that there are any on the market.

"Q. Do you know of any place where the defendant or its representatives, can obtain such a tube?—A. I do not know if the Marconi company is willing to sell or give them away or not."

And also—

"Q. Will you describe the two-electrode tube which you demonstrated before the court in order to get oscillation?—A. The glass bulb was cylindrical, perhaps three-fourths or seven-eighths of an inch in diameter, and contained the short filament in the form of a loop, that is, U-shaped, and a plate which was a simple circular disk mounted with its plane at right angles to the plane and direction of the filament and perhaps half an inch away from the curved portion of the filament.

"Q. Did it have any portion of the circuit exposed outside of the tube?—A. It did not.

"Q. Or anything corresponding to the circuit which you said was outside of one of the two-electrode tubes yesterday when you were testifying?—A. It did not.

"Q. Do you know what kind of gaseous medium was in the tube?—A. None; except what residual air was necessarily present.

"Q. Do you know how much vacuum there was?—A. Only in a general way that it would be classed as a very high incandescent lamp vacuum.

"Q. Do you know by what means the vacuum was attained?—A. No; except that the bulbs were pumped in an oven with the highest vacuum that could be obtained by best forms of mechanical pump.

"Q. Do you know what kind of pump was used?—A. I do not remember; no.

"Q. Was it a mercury pump?—A. I think so, but I am not positive.

"Q. Do you know where the tubes were made?—A. Yes; they were made by the Marconi company at Aldeen.

"Q. Do you know who would be able to inform us specifically as to how these tubes were made?—A. I think it is found in the record. Mr. Weagant was examined about that.

"Q. Well, I have looked in the record and fail to find out how they were made, and if you can do so, I would like to know someone who had actual knowledge of the way in which the bulbs were made?—A. They were made under Mr. Weagant's direction, and all I know about the matter is that I was familiar with the room where they were made and saw from time to time many bulbs of this general description, and I think of the same lot from which these were selected, made. I know that they were the highest vacuum which the Marconi company was able to obtain at that time and that it was obtained by a series of pumps, the last one of which was a mercury pump, but I am not sure.

"Q. And the other pumps, do you recall what kind of pumps they were?—A. I think there were two mechanical pumps, first a rough vacuum pump and then a pump such as would have been sufficient for ordinary incandescent lamp exhaustion and finally a more refined form of pump. [fol. 428] "Q. The two pumps of which you speak, were they mercury pumps, if you recall?—A. No. I think the first one was a mechanical pump, but I am not certain; that is, a piston pump.

"Q. Could you produce one of the bulbs for our inspection?—A. No; because I haven't got one.

"Q. Could you reassemble the apparatus and make one of these bulbs oscillate again?—A. No. The apparatus is none of it in my possession.

"Q. What became of it?—A. I don't know. It may be filed in court for all I know.

"Q. Would you be willing to undertake to repeat the experiment and produce oscillation by one of these tubes again, if so directed by counsel for the Marconi company?—A. Certainly.

"Q. You said, I believe, that these tubes were originally constructed for some other experimental work. Can you

tell us the nature of that work?—A. It appears in the record that they were part of a long series of bulbs that were made for the purpose of ascertaining the effect of varying different elements in the construction, particularly, the spacing, that is, the shortest distance between the filament and the plate element. It was for this reason that they were made in the cylindrical form and with the flat plate, so that the distance could always be accurately determined.

"Q. So far as you know, is any special distance between plate and filament essential in order to make the two electrodes essential in order to make the two-electrode tube amplify or oscillate?—A. No.

"Q. Can you state approximately the date when these tubes were originally made?—A. Only in a very rough way. I should guess that it was the fall of 14."

Answer. As to the first quotation, my impression is that there is probably something omitted from the second sentence of the next to the last answer quoted—I presume the word "more"; further or something of like import was intended to be inserted after the word "say."

With respect to the last quotation I do not know what the second and third questions and answers quoted mean. I assume that the remainder quoted portions are substantially what I said, although apart from the typewritten record I have no independent recollection.

59. Cross-question. Is all of the above-quoted testimony in accordance with your present recollection?

Answer: Yes; in the sense that I have no present recollection in contradiction of it.

60. Cross-question. Will you look at the plaintiff's Exhibit No. 85 and say whether or not in your opinion that exhibit embodies what you understand to be the invention of the Fleming patent in suit when the terminals X, Y, of that device are connected to an ordinary telephone-wire circuit so that the device receives audio frequency current from the telephone wires?

Answer. I have had no experience with such use and do not know whether it would be operative. I can only say that so far as I have considered the use of these bulbs it has been in connection with the receipt or transmission of radio signals.

[fol. 429] 61. Cross-question. Have you any reason to suppose that the device would not be operative to amplify

ordinary telephone currents if suitably connected to the wires of a telephone circuit?

Answer. I do not at present remember enough about the constants of a telephone circuit or the actual wiring thereof to have any opinion. The device shown in Exhibit No. 85, so far as I have any information about it, is used in connection with a radio receiver.

62. Cross-question. You have no opinion about the device except when it is operated by currents of radio frequency?

Answer. I do not know sufficiently definitely just what the question is intended to convey to answer it categorically. My understanding of the device shown in Exhibit No. 85 is that it is in normal use a part of the wireless receiving apparatus—whether just as it stands it has other capabilities or not, I have not investigated and have no information.

63. Cross-question. Assume that the terminals X Y of this device are connected to a crystal detector circuit in which latter circuit radio-frequency current is rectified by the crystal detector and the audio-frequency current from the crystal detector circuit is amplified in the device of Exhibit No. 85. Would the device then embody what you understand to be the invention of the Fleming claims in suit?

Answer. Yes; my understanding is that in the case supposed the crystal detector and three bulbs of Exhibit No. 85, together constitute the complete detector of the assumed receiving apparatus.

64. Cross-question. In both of the illustrations I have given, that is to say, if the terminals in Exhibit 85 connected to a telephone wire on the one hand and the terminals of Exhibit No. 85 connected to a crystal detector circuit on the other hand the device would be receiving audio frequencies, would it not?

Answer. I assume that in both cases there would be what perhaps might be called audio-frequency modulation. In the first case, if the currents went through they would be, I assume, already in the form of mere ordinary telephone currents and I do not know just what would happen to them in such an apparatus as Exhibit No. 85 indicates.

65. Cross-question. What would be the form of the currents in the apparatus in the second illustration?

Answer. I assume that they would be in the form of radio-frequency pulsations.

66. Cross-question. In all of the bulbs?

Answer. Yes; so far as I have investigated the matter they go through them all.

67. Cross-question. If the pulsations in the last bulb are radio-frequency pulsations, how can any sound be heard in the receiving instrument?

Answer. It is what I have referred to as audio-frequency modulation that is heard, in the receiver R, in Exhibit No. 85.

68. Cross-question. Does what you call audio-frequency modulation in this case amount to anything more than saying that you have audio-frequency amplification and that it is the amplified audio frequencies that are heard in the receiving instrument?

Answer. If I understand the question, I would answer it yes. In other words, it is possible to put in place of [fol. 430] the receiver R a radio-frequency circuit tuned to the original radio frequency and through another detector system take off radio frequency from the last bulb C, and in fact to add further radio frequency amplification. In fact, the term "audio frequency" as used in this series of questions does not mean very much, except as designating the fact that signals can be heard when the receiver is connected either at R, R^1 or R^2, in Exhibit No. 85.

69. Cross-question. In your deposition in this case, have you used the term "audio frequency" in any sense other than meaning such frequency as will enable the signal to be heard?

Answer. No; I think not—I understand it to designate such a modulation of the direct current in the plate circuit as will permit the telephone to respond.

70. Cross-question. Now, under the assumption that the terminals of Exhibit No. 85 are connected to a crystal detector circuit, the incoming radio frequencies would be rectified into audio frequencies by the crystal detector, would they not?

Answer. No; they are rectified into a succession of radio-frequency pulses.

71. Cross-question. And these radio frequency pulses—would they be heard if passed through a telephone in the crystal detector circuit?

Answer. If the telephone has in shunt with it a sufficient capacity which can be charged and thereafter is discharged through the telephone, this discharge would be in the form of the so-called audio-frequency pulse due to the time constant of the telephone circuit.

72. Cross-question. And these audio-frequency pulses are then passed on to the grid filament circuit of the first bulb of Exhibit No. 85 and there amplified in the plate circuit of the first bulb of Exhibit No. 85, are they not?

Answer. Exhibit 85 does not indicate how the connection to the plate circuit is made, and I do not remember ever having seen any authoritative investigation as to just what happens, but I do know that radio frequency goes through the first tube and apparently is amplified. I understand that what probably happens is that the capacity of the transformer winding is probably sufficient so that there is in effect a combination of frequencies which passes through, the resulting output of the last tube being a direct current modulated at both radio and audio frequency rates.

73. Cross-question. Do you understand that the radio frequencies, which you say pass through all of the bulbs, are increased in power from one bulb to the next and so on to the last bulb?

Answer. Apparently they are.

74. Cross-question. Do you understand that there is in the art such a thing as a radio-frequency amplifier?

Answer. Yes; there are numerous forms.

75. Cross-question. All of them employ the three-element vacuum bulb, do they not?

Answer. In practice, so far as I know; yes.

76. Cross-question. What do you understand to be the difference between the radio-frequency amplifiers and the audio-frequency amplifiers?

Answer: The difference lies chiefly in the inductance of the transformer circuit. In a resistance coupled amplifier [fol. 431] there hardly seems to be any difference and the several functions of the tubes seem to be inextricably mixed. In the most popular type of present-day transformers the difference seems to be that radio-frequency transformers have a minimum impedance at about the radio frequency whereas the audio-frequency transformers have a minimum through some more or less broad range of audio frequencies.

77. Cross-question. May we take it as being your view that there is no essential difference in function or mode of operation between the radio-frequency amplifier and the audio-frequency amplifier?

Answer. The question is in such general terms that I would not know what any categorical answer to it would mean. My view is that either constitutes a useful part of a detector when the received energy of itself does not produce a sufficient response.

78. Cross-question. Do you understand that both of these devices embody what you understand to be the invention of the Fleming claims in suit?

Answer. Yes.

79. Cross-question. Do you understand that there would be any essential difference in function or mode of operation of the amplifier device if the audio frequencies were received from a telephone circuit instead of from a radio-detector circuit?

Answer. I have already said I do not know what the device of Exhibit No. 85 would do if connected to an ordinary telephone circuit. I am familiar with the device connected to a radio-receiving circuit and that use in my opinion constitutes a part of the receiving detector.

80. Cross-question. Please consider that the amplifying device is of the type indicated in the sketch which I now show you, instead of that specifically shown in Exhibit No. 85, and say whether or not there would be any essential difference in function or mode of operation of the device if the audio frequencies are received from a telephone circuit instead of from a wireless-detector circuit?

Answer. I don't know in what sense of the word "type" is used in the question nor do I know anything about the bulbs, the transformers, or the battery values. I am personally familiar with the Forest audion amplifier, as shown in Exhibit No. 85, but I do not know anything about the type of apparatus shown in the blue print handed me.

Mr. Edwards. The sketch shown the witness is offered in evidence by defendant's counsel and marked "Defendant's Exhibit D."

81. Cross-question. Have you any difficulty in understanding that a device such as shown in this sketch would operate to amplify telephone currents if connected to a telephone circuit?

Answer. I assume that that depends on the design of the transformer and tubes, the proper selection of battery voltages, of course, I am familiar with the fact that tubes are used for amplifiers in telephone circuits but I have no personal information as to how they are used nor do I remember the circuits employed.

82. Cross-question. You have no difficulty in understanding that an amplifier of the kind shown in this sketch employing the three element bulbs as shown could be adjusted with suitable design of transformers, tubes, battery voltages, etc., and connected to a telephone circuit to amplify telephone currents, have you?

[fol. 432] Answer. Very likely, it might, I do not know whether it would or not. Of course, in such case there would be no radio frequency present and it would simply be a question of whether the arrangement is one that can handle voice currents, in a proper manner. I had not assumed that such an arrangement as the sketch shows was actually used, but I do know whether it can be used or not.

83. Cross-question. Do you not know that these three-element tubes are in every day use throughout the country in telephone circuits for the purpose of amplifying telephone currents?

Answer. As a matter of information, yes; but whether the diagram shown me is even schematically correct, I do not know and, as I say, I did not have the impression that that sketch showed what was used.

84. Cross-question. Do you not know that the use of these tubes in telephone circuits for amplification purposes far exceeds their use for wireless purposes at the present time?

Answer. I know that such tubes are used in telephone circuits and in very many other ways other than radio, but I have no information as to just how they are used in telephone circuits.

85. Cross-question. Do you not know that when the tubes are used in telephone circuits for amplifying telephone currents, they are connected up in circuits which are approximately the same as those schematically shown in this sketch Exhibit D?

Answer. I do not know—such information as I have would lead me to doubt it.

86. Cross-question. Wherein do you think the telephone circuits differ schematically from the circuit shown in this sketch?

Answer. I have not sufficient information in the matter to answer.

87. Cross-question. When these tubes are used in telephone circuits, do you understand that they embody what you understand to be the invention of the Fleming claims in suit?

Answer. I have no opinion to offer in the matter—I can only say that I have not assumed that they did.

88. Cross-question. What is your opinion on this subject?

Answer. I have no considered opinion to offer.

89. Cross-question. Do you understand that there is any essential difference in the function or mode of operation of the tube when connected in the telephone circuit from its function and mode of operation when connected in a wireless detector circuit?

Answer. When used in a wireless-telegraph combination, it handles frequencies of the order used in wireless communication—when used in telephone lines for commercial telephony, I assume that it does not.

90. Cross-question. What is the order of the frequencies used in wireless communication?

Answer. At the present time, I suppose that the range is approximately comprehended between 20,000 and a million and a half cycles per second.

91. Cross-question. And what is the order of the frequencies used in telephone lines?

Answer. I don't know.

92. Cross-question. Have you any idea?

Answer. I suppose it runs from sixteen to three or four thousand.

[fol. 433] 93. Cross-question. And what is the order of the frequencies which you have referred to in your testimony as audio frequency?

Answer. I assume that audio-frequency transformers are best adapted to handle about a thousand cycles of audio frequency. That is, I assume that the minimum impedance is at about that frequency.

94. Cross-question. Does that mean that the order of the frequencies referred to in your testimony, as audio frequencies, is about 1,000 cycles per second?

Answer. I have in the main had the term put in my mouth by counsel. I have assumed that 1,000 cycles might be taken as illustrative of what he meant and so far as I

remember my answers are in accordance with that understanding.

95. Cross-question. When Mr. Clark, whose testimony descriptive of the apparatus concerning which you testified in your direct examination you referred to, used the term "audio frequency" with reference to this apparatus, what order of frequency do you think he was referring to?

Answer. A frequency which would distinctly actuate the receiving telephones, I assume, it being the purpose of the detector only to produce such a result. I suppose 1,000 cycles would be a correct assumption.

96. Cross-question. Do you think that there is any difference in function or mode of operation of these vacuum tubes when operated by the current at 20,000 cycles, from what it is when operated by currents at 1,000 cycles?

Answer. Speaking broadly, that is in the most fundamental sense, no—but, of course, everyone who is practically familiar with what is known as high-frequency currents knows that the phenomena attending the use of high-frequency currents are very different and that properties of the circuit and the apparatus which do not manifest themselves at all at low frequencies, become of extreme importance in high frequencies; therefore, the general statement that the mode of operation is the same may easily be misleading.

97. Cross-question. Have you made inquiry of the Marconi company to ascertain if you can get some two-element bulbs, similar to those which you claim were demonstrated before Judge Mayer?

Answer. No; I have not; I am sorry to say that I forgot it.

98. Cross-question. Will you report the result of your request to the commissioner as soon as you can?

Answer. Yes; I will.

Mr. Peters. I offer in evidence pamphlet entitled "Elemental Principles of Radio Telegraphy and Telephony," prepared in the office of the Chief Signal Officer, 1921 (Washington, Government Printing Office, 1922), Radio Communication No. 1, marked "Plaintiff's Exhibit No. 119."

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The examination by counsel being concluded, the witness, in compliance with the rule of the court requiring him to

state whether he knows of any other matter relative to the claim in question, and if he does to state it, says he does not. [fol. 434] In compliance with the request of cross-question 98, I report to the commissioner as follows:

I have made careful inquiry as to the possibility of obtaining one of the two-element bulbs used in the demonstration made before Judge Mayer of the oscillating capacity of the bulbs of the Fleming patent or in lieu thereof to obtain one from the same original lot of tubes or one of similar construction. Up to now, however, I have been unsuccessful in ascertaining whether or not there are any still in existence. It is possible, I understand, to reproduce them should the United States Government desire, if sufficient time is allowed to ascertain their dimensions from old records and to obtain the necessary materials.

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[fol. 435] STIPULATION—Filed December 3, 1924

It is stipulated, by and between the attorneys for the respective parties, that the annexed is a true copy of the testimony given by Guglielmo Marconi on the 17th, 18th, and 25th of June 1913, in the suits brought by Marconi Wireless Telegraph Company of America, plaintiff, *vs.* National Electric Signaling Company, defendant, in equity No. 23 on reissue patent No. 11913 and patent No. 609154, and Equity No. 31, on patent No. 763,772 both in the United States District Court for the Eastern District of New York and that said Guglielmo Marconi, if called as a witness in this case and duly sworn, would repeat said testimony, and that said testimony may be read into and made a part of the record in this case and used with as full force and effect as if taken herein.

It is further stipulated that copies of the exhibits offered in evidence on behalf of the plaintiff in connection with the said testimony, marked 14 A, Marconi Sketch No. 1; 14 B, Marconi Sketch No. 2; 15, Copy of L'Elettricista of Aug. 1, 1897; 16, Article in Times London, Sept. 23, 1896; 17, Clipping from Daily Chronicle on Dec. 14, 1896; 18, Article in Electrical Engineer of London, Dec. 18, 1896; 19, London Engineer, June 18, 1897; 20, A, Bristol Channel Tapes; 20 B, Bristol Channel Tapes; 21 A, Article by Prof. Slaby, dated April, 1897; 21 B, Translation of Article by Prof. Slaby, dated Berlin April 1897; 22, Rivista Marittima;

23, Proceedings of Naval Institute; 24, Marconi Patent No. 884,986; 25, Marconi Original Note Book; 26, Marconi Royal Institute Lecture; 27, Publication of Prof. Banti of 1897; 30, Letter of the Minister of Marine; 31, Marconi No. 10,245, of 1902 (British); 32, Brazilian Patent, August, 1902; 33, Electrician of Jan. 20, 1902 (p. 346); 34, Electrician of July 18, 1912 (p. 520); 35, Electrical World and Engineer, N. Y., of July 12, 1902; 36, La Telegraphie Sans Fil, by M. E. Ducretet; 38, Partial Translation of Ducretet Pamphlet, Defendant's Exhibit No. 70; 41, No. 30,506, of Nov. 3, 1900 (French); 42, Clipping of Daily News of St. John Newfoundland; 43, Clipping of Evening Herald; 44, Extract from Minutes of St. John's Municipal Council Meeting; 45, Original Philadelphia Tapes; 46, Original Philadelphia Charts; 47, Report of Admiral in Command of Carlo Alberto; 49, Electrical World and Engineer of January 18, 1902, may be marked in evidence herein by the plaintiff as Plaintiff's Exhibits 117 to 149 inclusive, and that said copies may be used with the same force and effect as the original exhibits.

Dated New York, January 19, 1924.

L. F. H. Betts, Attorney for Claimant. Clifton V. Edwards, Special Assistant to the Attorney General. Robert H. Lovett, Assistant Attorney General of the United States.

[fol. 436] UNITED STATES DISTRICT COURT, EASTERN DISTRICT OF NEW YORK

Before Hon. Van Vechten Veeder, *J.*

D. E. No. 23. In Equity. On U. S. Patents. Re-Issue No. 11913, and 609154

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA, Complainant,

versus

NATIONAL ELECTRIC SIGNALING COMPANY, Defendant

U. S. Post Office Building, Borough of Brooklyn, City of New York, Tuesday, June 17th, 1913

The Court met pursuant to adjournment at 10:30 o'clock A. M.

Present:

Parties as before.

The Court: Proceed, gentlemen.
Mr. Betts: Mr. Marconi, will you take the stand?

GUGLIELMO MARCONI was called as a witness by and on behalf of the complainant, and having been first duly sworn, testified as follows:

Direct examination.

By Mr. Betts:

Q. Will you please state your name, residence, and occupation?
A. Age, 38 years; residence, Italy—I might say Italy and England; occupation, electrical engineer.
Q. Where were you born?
A. I was born in Italy, in the Town of Bologna.
Q. Where were you educated?
A. I was educated in Italy.
Q. At what institution of learning?
A. At various primary and secondary schools, and I also attended some lectures at Bologna University.

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[fols. 437-438] Q. Are you the G. Marconi to whom was granted reissued letters patent of the United States No. 11913?
A. I am.
Q. Will you please state what you did, if anything, towards putting into successful use the invention of this patent, prior to the time that you filed your application?
A. I might say that from a boy I was always interested in physics and in electric phenomena generally, and I think in the summer of 1894 I read of the experiments and results of Hertz in Germany. I also was acquainted with the works of Lord Kelvin, and with the theoretical doctrines of Clerk Maxwell. I experimented with electrical waves, as I considered that line of research very interesting, and during these tests or experiments I thought that these waves, if produced in a somewhat different manner from the way that had been produced by Hertz, that is,

if they could be made more powerful, and if receivers could be made more reliable, they would be applicable for telegraphing across space to great distances.

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[fol. 439] Q. How far did you actually succeed in transmitting intelligible messages, using the exact connections shown in your patent No. 11913, that is with the spark gap and the detector directly connected between the earth and the antenna?

A. About thirty or forty miles. I think it was forty.

Q. When first, if ever, did you actually try to send a message from a transmitting station in which the spark gap was inductively connected to the antenna and the ground?

A. In 1898, 1899. About the end of 1898.

Q. When first, if ever, did you try to send any messages in which the receiving apparatus was arranged with the coherer or detector inductively connected between the antenna and the ground?

A. 1897 or 1898. The beginning of 1898; the end of 1897, if I remember correctly.

[fol. 440] X Q. Is not Professor Fleming connected with your company—the complainant company?

A. Yes.

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[fol. 441] Q. I believe that you have already testified as to what you did toward putting into successful operation your wireless telegraph apparatus up to the year 1900. I show you a copy of United States Letters Patent to G. Marconi, No. 763,772, being the patent in suit, and ask if you are the Marconi to whom was granted these letters patent?

A. Yes.

Q. Have you obtained any patents in any other countries foreign to the United States for the invention corresponding to your patent No. 763,772 of the United States?

A. Yes, in many other countries. I might mention, particularly, in England and in France.

Q. Can you produce a certified copy of the British patent, and also a certified copy of the French patent?

A. Yes, I can produce certified copies of both the British and the French patents to which you referred.

Mr. Betts: I offer in evidence certified copy of British Marconi patent No. 7,777, of 1900, and ask that it be marked

Complainant's Exhibit No. 40. Also, certified copy of French patent No. 30,506, to G. Marconi, dated November 3, 1900, and ask that it be marked Complainant's Exhibit No. 41.

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(The papers so offered and identified were thereupon marked, respectively, "Complainant's Exhibit No. 40" and "Complainant's Exhibit No. 41" of this date.)

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[fol. 442] By Mr. Betts:

Q. Has the invention of your United States patent No. 763,772 been put into use by you or by the companies owning the patents for your wireless telegraph inventions?

A. Yes, it has been put into use. I should say, put to very great use.

Q. How great a distance were you able to actually transmit and receive intelligible messages prior to the adoption and utilization of the invention of your patent No. 763,772?

A. About eighty miles. I think eighty-three miles is the exact distance.

Q. You have stated that the invention of your patent No. 763,772 has been put into large and successful use. How great a distance have you successfully transmitted messages, due to the utilization of the invention of your patent No. 763772?

A. 6,600 miles.

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Q. When first was the invention of your patent in suit, No. 763,772, put into commercial use by you, and where?

A. In the year 1900, in England.

Q. Whereabouts?

A. It was first installed at stations on the Isle of Wight, and on the coast of England, and afterward, at other stations, all around the coast of the United Kingdom, and on ships.

Q. And when first was the invention of your patent No. 763,772 in suit, used outside of England by you or by your company?

A. It was used—I remember a definite case—on the Nantucket Lightship in the United States of America, in

August, 1901. At least, it commenced to be used that month, and it has been used, I think, ever since.

Q. And after August, 1901, when did you utilize this invention for long distance transmission?

A. It was utilized in the tests of transatlantic transmission, which took place in the autumn of 1901, between [fol. 443] Poldhu and Newfoundland. It was also utilized in a number of other test tubes, which, perhaps, I need not refer to.

Q. When did you first succeed in transmitting an intelligible Morse letter or word across the Atlantic? A. December, 1901.

Q. Did you use the invention of this patent during that test?

A. Yes, I did.

Q. Can you produce any evidence corroborating or tending to corroborate you in the statement that you transmitted an intelligible signal across the Atlantic in December, 1901?

* * * * * * *

A. I produce a copy of the *Daily News*, of St. John, Newfoundland, of 16th of December, 1901, and also a copy of the *Evening Herald*, December 16, 1901, which describe, I think, what I did in Newfoundland. I also produce an official extract from the minutes of a meeting of the St. Johns Municipal Council, held on Friday, December 20, 1901, which states:

"On Thursday, 12th of December, at 12:30 P. M., Signor G. Marconi, with his wireless telegraphic receiving apparatus, stationed at Signal Hill, and by means of an aerial wire supported by a kite, received signals sent by a prearrangement from his transmitting station at Poldhu, Cornwall.

"On Monday evening, 16th of December, the Anglo-American Telegraph Company, having learned of Signor Marconi's success, served a notice of their monopoly rights upon him, and threatened legal proceedings in the event of his not stopping operations at once.

"The Council are much gratified at Signor Marconi's success, marking, as it does, the dawn of a new era in Trans-Oceanic telegraphing, and deplore the action of the Anglo-American Telegraph Company.

"It was further ordered that the above minutes be engrossed and transmitted to Signor Marconi.

(Signed) H. C. Burchell, Chairman."

Mr. Betts: I offer these in evidence, and ask that they be marked, respectively, Complainant's Exhibits No. 42, 43 and 44.

[fol. 444] (The papers so offered and identified were thereupon marked, respectively, "Complainant's Exhibit No. 42," "Complainant's Exhibit No. 43," and "Complainant's Exhibit No. 44," of this date.)

By Mr. Betts:

Q. Were you yourself at St. John's in December, 1901?

A. Yes, I was.

Q. When did you return to England?

A. I returned to England some time in January, 1902.

Q. On what boat?

A. I think it was the "*Philadelphia*," of the American Line.

Q. Did you conduct any tests while on the "*Philadelphia*"?

A. Not on that trip. On my return from England to the United States, a few weeks afterward, I conducted some tests.

Q. And the tests were with what station?

A. The tests were with a station at Poldhu, in Cornwall.

Q. And the station at Poldhu, in Cornwall, was that equipped with the invention of your patent in suit?

A. It was equipped with the invention of my patent in suit.

Q. Now, when you were on the *Philadelphia*, coming from England, how great a distance from Poldhu did you actually receive telegraphic Morse signals or messages?

A. I received them up to a distance of 2,099 miles. These messages were not simply received on a telephone. They were received on tape. They were recorded signals, and in nearly all the tests a printing instrument, actuated by a coherer receiver, was employed. As those tests were of considerable importance, both from a technical as well as from an historical point of view, I got the captain and the chief officer of the ship to prepare a chart, duly signed by them, showing the positions at which messages and signals

had been received from England, and also to countersign the tapes received on the Morse apparatus, which showed messages or signals, which messages or signals were received on those tapes in the presence of the officers who signed the tapes.

Q. Look at the two cardboards which I hand you and state, if you know, what they are.

A. The first cardboard represents messages, the actual tapes received at varying distances, and signed by the captain of the *Philadelphia*, and I think, in certain cases, by the chief officer as well. They represent messages and signals received at distances from one thousand and thirty-two miles up to two thousand and ninety-nine miles. I should say, to the second cardboard is attached the original chart, to which I have referred in my previous answer, which shows the positions where messages and signals were received. This chart was prepared and signed by the captain of the *Philadelphia* and by the chief officer, and their signatures appear on the chart.

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[fol. 445] Mr. Betts: I offer in evidence the two charts, or at least the two cardboards, identified by the witness, the first being the cardboard containing the original *Philadelphia* tapes, and ask that it be marked "Complainant's Exhibit No. 45"; also, the second cardboard, being the chart of the *Philadelphia*, and I ask that that be marked "Complainant's Exhibit No. 46."

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By Mr. Betts:

Q. Were you on the *Philadelphia* yourself when these messages were received which are indicated on the *Philadelphia* tapes?

A. Yes, I was.

Q. Did you actually receive any of these messages?

A. All of them.

(The cardboards so offered and identified were thereupon marked, respectively, "Complainant's Exhibit No. 45" and "Complainant's Exhibit No. 46," of this date.)

By Mr. Betts:

Q. What kind of a detector did you use in December, 1901, when receiving the signals from Poldhu?

A. I used the ordinary coherer, which has been referred to in the previous case; and I also used another form of coherer, which did not require tapping, and by means of which the signals were received telephonically instead of by means of the Morse instrument.

Q. And what kind of detector did you use on the *Philadelphia* in these tests for which you have produced the original tapes?

A. I used the original coherer, as described in the patents that we have been discussing here, in the previous case.

Q. Now, what next did you do in 1902 toward demonstrating the successful use of the invention of your patent in suit?

A. On my return to England, in the Spring of 1902, I was invited by the Italian government to carry out tests between this station established at Poldhu, and a war ship of the Italian Navy. Receiving apparatus and also transmitting apparatus was installed on the war ship, and, I think, commencing about the 18th of June, tests were made between England and this war ship in various parts of Europe. Thus signals were obtained between Poldhu and Kronstadt, in Russia, fifteen hundred miles, I believe. Also, when this ship was at Kiel, in Germany, and at other places in Germany; also, at Gibraltar, to the south of England, the distance between the two places being one thousand miles, and the waves having to travel over the whole of Spain and the mountains which divide Spain from France, and then, later on, communications were successfully established between Poldhu and this ship in the Mediterranean—at various points in the Mediterranean, the great point of interest [fol. 446] being then that these waves traveled across the whole of France and across the Alps, which happened to be in a line between the transmitting and receiving instruments. The tests were considered very interesting and important at the time, and an official report was prepared by the Admiral in command of the squadron to which this cruiser "*Carlo Alberto*" belonged, and which report I produce. I should add that the report shows the arrangement of the aerials, sets forth the various places where messages

were received, and also gives a reproduction of the tapes received by means of the recording instrument at various places, showing the messages which were actually recorded at those places, and over given distances.

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Mr. Betts: I offer the report in evidence, and ask that it be marked "Complainant's Exhibit No. 47,"

(The paper so offered and identified, was thereupon marked "Complainant's Exhibit No. 47," of this date.)

By Mr. Betts:

Q. What kind of a detector did you use on the *Carlo Alberto* during these tests at Kronstadt, in the Mediterranean, and at Kiel?

A. The signals shown on the tapes reproduced in the report were obtained by means of what I might call an ordinary coherer receiver, but during those tests a magnetic receiver was also used, and also a telephone or an imperfect electrical contact.

Q. What kind of transmitting and receiving apparatus was the *Carlo Alberto* equipped with?

A. It was equipped with transmitting and receiving apparatus according to the invention described in Patent No. 763,772.

Q. Was the invention of your patent in suit ever put into use by the complainant company after the Nantucket Lightship installation? If so, when first for long distance work?

A. It was put into operation at the long distance station at Cape Cod, and very shortly afterwards, at the station which was erected, partially at the expense of the Canadian Government, at Cape Breton, in Canada.

Q. Did you ever conduct any tests for the British Admiralty with apparatus involving or utilizing the invention of the patent in suit?

A. Yes, tests were carried out for the British Navy, [fol. 447] about the end of 1900, and shortly afterwards, it was adopted on all the ships of the navy which were using wireless, and, I think, now its use is general on every ship in the British Navy.

Q. What commercial use is made of the invention of the patent in suit by you or your companies owning corresponding patents—Marconi patents?

A. It is used at four or five long distance stations; I mean, stations having a range of two thousand miles or so. It is used at about twenty shorter distance stations—stations having a range of eight hundred to a thousand miles; and it is also used at about a thousand shore-and-ship stations, which conduct business over what I should call a short distance—anything from two hundred to five hundred miles.

Q. Have you ever used a transmitter where the spark gap was in inductive relation to the antenna, but such a spark gap circuit was not tuned to the antenna circuit?

A. Yes, I have.

Q. Where and when?

A. In England, I think in 1899 or some time about that.

Q. With what success did you meet in using such a transmitting apparatus?

A. I met with no success. I found that it was no good, compared to what I had been originally using.

Q. Referring now to your patent No. 763,772, you have illustrated and described on pages 3 and 4 certain apparatus. Did you ever build and use any of the apparatus therein illustrated and described, and if so, when first?

A. I use the apparatus described in the patent to which you have referred in the Spring of 1900—I think in March or April of that year.

Q. Was that before or after you had filed your application for your British patent No. 7,777?

A. That was before.

Q. The defendant contends in this case that the two circuits at the transmitting station, shown in your patent No. 763,772, are tightly coupled, or closely coupled. What have you to say as to this?

A. I have to say that they are not. Of course, I have got to interpret the term "closely coupled," or "tightly coupled," as what is meant in regard to these circuits,

Q. What is the degree, approximately, of coupling of the transmitting circuits using the apparatus as illustrated and described in the specification of your patent in suit?

A. I have not got the figures before me, but I think that the first four or five tunes are loosely coupled; that is, of an order of ten per cent, or perhaps under. The tune [fol. 448] No. 6 is also loosely coupled, but probably of a degree of coupling of over ten per cent. I think I remember Prof. Fessenden stating somewhere that he considered any-

thing under fifty per cent loosely coupled, and anything over fifty per cent was tightly coupled. Therefore, according to his definition, with which I, to a certain extent, agree, I should say these are all loosely coupled.

Q. Even if it be true that an oscillation transformer be tightly coupled, if such a transformer is connected into an antenna or open circuit of a wireless telegraph station, the antenna being, say one hundred feet high, what effect, if any, does this have on the degree of coupling of the two circuits?

A. The coupling depends entirely on the linking or coupling of the two circuits, the closed oscillating circuit and the radiating circuit or the receiving circuit which includes an aerial—the whole of the aerial and every other connection. That circuit may include an oscillation transformer, which may be itself tightly coupled, but it does not necessarily make the whole circuit tightly coupled, because that coil is only a very small part of the circuit, and only a small part of the magnetic lines of force are common to the two circuits. One might have a coil, or rather, I should say, a transformer, connected to earth and to a radiating wire, which would be tightly coupled to its other circuit, if the radiating wire were only a foot or two long; but if the radiating wire were a hundred feet long or a thousand feet long, or as it is in some aerials now, about ten thousand feet long, it would hardly be coupled at all. Any such circuit which may include an oscillation transformer, would be coupled very weakly indeed. Therefore, in considering the coupling between two circuits such as are described in this patent and such as we are discussing now, it is absolutely absurd to take only the transformer part of the circuit and say that the whole circuit is tightly or loosely coupled.

Q. The defendant contends that a coherer circuit cannot be tuned. What have you to say as to that?

A. I do not agree with him.

Q. How do you tune a coherer circuit?

A. We tune it by proportioning the inductance and the capacity of the circuit in which it is, so that that circuit will be in tune w-th the oscillations which you want to receive. The exact proportion of the inductance of the circuit, of course depends, in certain cases, on whether you are using a high resistance coherer or a low resistance coherer.

Q. Now, please look at your patent No. 627,650, which is

Defendant's Exhibit No. 61. I understand that there is a condenser shown in that patent. Is that true?

A. Yes. There is a condenser shown in figure 1.

Q. What was the purpose for which you put that condenser in the circuit shown in Figure 1 of your patent—of Defendant's Exhibit No. 61?

A. The purpose of a condenser K-1, shown in Figure 1, is to prevent the short-circuiting of the battery through the coil J^2, and at the same time, to enable the high frequency oscillations from the coil J^2 to reach the terminal of the coherer T.

Q. What was the purpose of using the transformer shown in Figure 1 of Defendant's Exhibit No. 61?

A. The purpose of using the transformer was to increase the potential of the oscillation at the terminals of the tube T, and therefore, make it act at a greater distance.

[fol. 449] Q. Suppose that a condenser is shown or described as being utilized in the secondary of two oscillating circuits, without any mention being made as to the purpose of utilizing such a condenser. What have you to say as to whether or not those two circuits are or will be in tune with one another?

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I would assume they were not in tune.

Mr. Betts: I should like to offer in evidence, at this point, a certified copy of the decision of Judge Parker in the suit of Marconi's Wireless Telegraph Company against the Radio Company, upon British patent No. 7,777, of 1900. I ask that Judge Parker's decision be marked "Complainant's Exhibit No. 48."

The Court: You may mark it for identification. I will reserve decision on it.

(The paper referred to, was thereupon marked "Complainant's Exhibit No. 48, for Identification," of this date.)

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[fol. 450] By Mr. Betts:

Q. Referring to pages 3 and 4 of the patent in suit, in which you give details of the construction of the transformer, induction coils, and so forth, where did you get the information contained in this part of the specification of the patent?

A. I got it from actual tests carried out at one of my stations in England—rather, at two of my stations in England. I want to add something to that, if I may.

[fol. 451] Q. Yes.

A. And the details and dimensions are taken from actual apparatus, which was used for the purposes described.

Q. Dr. Kennelly, the defendant's expert, on page 467 of the defendant's record, says:

When the associate circuits are so closely interlinked as those the sending station of the Marconi plant in suit, and particularly when they are as closely interlinked as those at the receiving station, the statement is incorrect.

A. To what statement does that refer?

Q. This statement of Dr. Kennelly's was made with reference to the following question. "The Marconi patent in suit states, in effect, that the product of capacity and inductance of the four circuits must be equal?" Do you agree with Dr. Kennelly's statement that the oscillating circuits at the receiving stations and the sending station are so closely interlinked that the product of capacity and inductance of the four circuits is not equal?

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A. I am just looking at this, your Honor. I do not agree with Dr. Kennelly's statement, and I also do not agree with his opinion that the circuits in the patent in suit are tightly coupled.

Q. By "circuits", do you mean those only at the transmitting station, or do you include the receiving station as well?

A. I include both.

Mr. Betts: That is all.

Cross-examination.

By Mr. Clay:

Q. On the following page Dr. Kennelly says that the principles he is referring to were demonstrated in an article by Houston himself, dated July 10, 1897, in the *Electrical World?*

A. What page is that?

Q. 468, which refers to one of the defendant's exhibits, No. 86, on the theory of electrical oscillations in mutually inductive circuits; and he does you the credit to say that he does not consider the inaccuracy of your statement in your patent would prevent the direction of the patent from being executed, because in practice, the tuning would be effected experimentally by trial and not by computation. That is true, is it not?

A. No, I do not think so.

Q. Do you think that in the practice of wireless telegraphy the tuning of the circuit is made by calculation and not by trial?

A. Yes, sir. In most cases it is made by measurement.

Q. In your experiments at Newfoundland, you had a kite, didn't you?

A. Yes, sir.

Q. And I do not suppose the kite remained still?

A. It did sometimes.

Q. Didn't it move up and down?

A. Not enough to vary it much.

Q. Didn't that change the tuning of the antenna?

A. Varies its movement slightly.

[fol. 452] Q. You do not intend to have the Court understand that an antenna which is held by a kite at an unknown elevation can be calculated as to its tune?

A. It does not vary much.

Q. You could not calculate beforehand even how high the kite was going, could you?

A. No, sir; but I could know what—I would know how to tune a local circuit to that wire when the kite was at a certain given height: if it varied its height it would not receive.

Q. You couldn't know beforehand the electrical tuning of the antenna?

A. Yes, sir, I could.

Q. By using a kite?

A. If it was at a certain angle and the wire at a certain length.

Q. How do you know what the wire is going to be?

A. You measure it.

Q. You measure it as the kite goes up?

A. Certainly.

Q. Does the height above the earth make any difference?

A. Certainly.

Q. Would not the height vary without changing the wire.

A. Yes, sir. You can measure that by the angle.

Q. Which angle?

A. From the position of the kite. If it is vertical you know it is at the height equal to the length of the wire, but when the kite is not vertical then it is at another height, which you can calculate from the angle. I should add that balloons were also used in Newfoundland, not always kites.

Q. In that case there were wires in the form of a catenary, and its length depends upon the tension? A. Its length depends on hiw long it is.

depends on how long it is.

Q. The height of the antenna depends on the tension, the angle, or the wind force?

A. I don't understand.

Q. Don't you, as a matter of fact, tune the local circuit of the antenna instead of trying to figure what the period of the antenna is beforehand?

A. No, sir. I do not do that exactly.

Q. In that case didn't you?

A. No, sir. I knew the length of the wave radiated from Poldhu, then I had to let out sufficient wire, which I knew would be tuned to that length of wave and then I had to tune my local circuit to that length of wire and to the wave radiated.

Q. Did you take the trouble to read Dr. Kenneily's article in which he gives the laws of such tuning?

A. No, sir; I did not.

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Q. When he spoke about your inaccuracies, isn't it strange that you did not take the trouble to look up his article which he says gives you the laws of this tuning?

A. Well, I think I have said I have not read his testimony; therefore, I did not see his statement.

Q. Do you undertake to answer his statement without reading either the whole of the statement——

A. I am not answering any of his questions. I am an- [fol. 453] swering your questions. I haven't said whether he is right or wrong. I think he is wrong, but I would like to see his article.

Q. I thought Mr. Betts asked you whether he stated it correctly?

A. As to 467. That is all I know.

Q. Taking this figure of this chart, take the complainant's illustrative chart and take the sending station of your patent in suit, you were speaking of the linkage or coupling there and, as I remember it, you said that the linkage did not depend on the mere inductance of those two coils dd', but partly on the rest of the antenna, is that true?

A. No. I should say that it does not depend on the two coils dd'. It is not a question of inductance, it is a question of how close they may be together.

By Mr. Clay:

Q. You could have a coupling that was a loose coupling in one direction and not in the other?

A. I don't understand what you mean.

Q. What has the length of the antenna to do with it?

A. We are talking of the coupling of the two circuits?

Q. The coupling of the two circuits depends on the linkage?

A. Of the two circuits?

Q. Between the coils d and d', doesn't it?

A. No, sir, not at all.

Q. They certainly do not depend on anything that is occurring anywhere else in the antenna?

A. I absolutely disagree with you, and you put your question in such a way that it is scientifically absurd, with all due respect.

Q. That may be. I do not claim to be a scientist. But my understanding was that the coupling— Let me say. If all the magnetic lines of the two upon the magnetic lines and forces that were common to the two circuits, isn't that true?

A. Yes. Let me say. If all the magnetic lines of the two circuits are common to each other, then the coupling is perfect, it is 100 per cent; but if a great number of the magnetic lines are not common to the two circuits then the coupling is only a part of a unit. It is only a fraction of complete coupling, therefore, it is obvious to me if there are a great number of lines running away from that wire and from the other connections, as you have stated quite correctly, in that case the coupling cannot be strong because a great number of those lines are independent of the two circuits.

Q. In my opening argument, I used this sketch, which I think I will put on a little corner of the chart to make it convenient. I have stated to the Court that that was [fol. 454] an open and closed circuit linked or coupled together, is that true?

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A. This shows an inductance shunted by a condenser which may be taken to represent a closed circuit, attached to the ends of the inductance, or two straight wires which we may take to represent an open circuit. I agree to that.

By Mr. Clay:

Q. It is an open circuit and a closed circuit linked together, or inductively connected together, is it not?

A. It shows an inductance shunted by a condenser which may be taken to represent a closed circuit attached to the ends of the inductance, or two straight wires which we may take to represent an open circuit. I agree to that.

Q. Don't you agree that it is an inductive coupling of the two circuits?

A. An inductive coupling?

Q. Yes.

A. Yes. I take it as an inductive coupling.

Q. Do you call it a loose coupling or a tight coupling?

A. I really don't know. I don't quite understand how these two circuits are coupled.

Q. If the antenna were elongated and become the kite that you used in your Trans-Atlantic test, would the antenna circuit and the local circuit be loosely coupled or tightly coupled?

A. I would have to think over that part for a little.

Q. You say in your patent in suit, and indeed I think in some of the claims, that the local circuit there in red ed and the antenna circuit a d'; earth, may be tuned to each other or to octaves. Do you think now that is true?

A. I think that is true in certain cases. Instead of the fundamental oscillation taking place in the antenna, the antenna may be oscillating to an octave or to a higher harmonic. In that case you can tune the circuit d e, to the octave. That has been done sometimes, but it is not the best way of utilizing the invention. I do not think it has been put in the claim.

[fol. 455] Q. Well, I stated to the Court in my opening argument that an electrical oscillation in this sketch of mine, between the aerial and the earth, passing through the coil, which is common to the two circuits, and inducting into the condenser circuit an induced current, would of necessity produce a current in the local circuit which is timed to that in the antenna. Is there anything wrong with that statement?

A. Yes, sir; I think it is wrong.

Q. What is wrong with it?

A. If an oscillation is produced there I think it will be a forced oscillation, and I really think the only effect of that condenser there will be to possibly decrease the period of the whole arrangement and possibly to make a larger current go through the inductance coil. I do not think you can take them as two circuits that can be turned together.

Q. You evidently recognize that as one of the references, don't you?

A. Yes, sir. I have seen it.

Q. When did you first telegraph across the ocean with the apparatus shown on the upper right hand side of that Chart 36-A, built as there shown?

A. The first intelligible signals were transmitted by the arrangement there shown in December, 1901, and actual messages, lengthy messages were transmitted in February, 1902.

Q. Now, in your figures in your patent for every one of those stations you give a length of aerial, and in this patent that means vertical height from the top of it to the ground, doesn't it or does it?

A. Where it is stated to be vertical I suppose it means vertical. I will have to read that.

Q. It does not say. It says at the top of page 4, 36,576 meters of cable is the aerial conductor?

A. I think it is described somewhere. It is vertical.

Q. Does that include the length of that coil as shown in the figure?

A. It does not unless the coil is described as being included, then the number of turns of the coil are given.

Q. Now, this Trans-Atlantic station could not have had any definite known length, height predetermined, put down like these figures are, could it?

A. I don't see why not.

Q. And you said in that Trans-Atlantic station experiment in 1901, when the antenna was a kite, you used magnetic and other imperfect contact receivers. Did you intend to intimate that the magnet was an imperfect contact receiver like the one disclosed in the patent?

A. I have already testified before that I am uncertain as to whether it can be classified as an imperfect contact.

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[fol. 456] Q. The question now is that when you were testifying a short while ago you meant to intimate that it was an imperfect contact, didn't you?

A. I said that it can be considered to act in the same way. It opposes a variable resistance to the current that is going through it.

Q. When all of these messages were received, as illustrated on the exhibit charts and described in the exhibit newspaper articles, the persons responsible for the chart and the articles got that information from you, didn't they, that there were messages received and that they came from a certain place?

A. In many cases both the stations were watched, the transmitting end and the receiving stations.

Q. You did not answer my question. The persons who were responsible for those reports, newspaper articles and charts got their information as to the receipt of the signals and as to where they came from from you?

A. No, sir.

Q. Who did they get it from?

A. They got it themselves, by watching the tests in most cases; by seeing the messages come in and by receiving such news in mid-Atlantic or inaccessible parts of Newfoundland which they afterwards found to be accurate news, from England, and other parts of the civilized world at that time.

Q. They didn't know where they came from?

A. They certainly did know.

Q. How?

A. By the signals received and by the characteristics of the signals. A great number of people that were concerned with the messages, especially on the warships, were experts and knew perfectly well what the signals looked like and how they sounded and what they tuned to.

Q. Are any of those officers here as experts?

A. On the *Carlo Alberto* they were.

Q. Operators?

A. Experts; better than operators.

Q. How did they know they came from Poldhu, rather than across the street?

A. The same way as I could know, through expert knowledge. I mean they knew that Poldhu would be sending at a certain time with a certain wave length and in a certain manner. Those things had been arranged before. When they went to the instrument to see whether messages had been received or not they would perfectly well know it.

Q. Didn't you point out on one of these taps a dot which you said might have been made by an atmospheric disturbance or from a spark?

A. Not on one of these taps. You are speaking of long distance taps.

Q. I say a tap you had this morning?

A. That is a three-mile tap.

Q. My statement is true, is it not?

A. Any dot may be made by an atmospheric condition, yes.

Q. In that first Transatlantic signal your dot—your first Transatlantic sending of your signals were composed entirely of dots, weren't they?

A. Not entirely. There were dashes too. The first [fol. 457] letters were dots, were s's, but some letters including a dash were sent too, but I am quote ready to admit those which were sent, these long successions of s's, consisted of a repetition of dots.

Q. That is like this? (indicating by tapping a pencil three times on the railing)?

A. Yes, sir.

Q. Three ticks on the ticker separated by longer intervals between the s's, separating the clicks?

A. Yes, sir.

Q. That was all?

A. Yes, sir.

Q. You depend on the spacing to tell an atmospheric disturbance?

A. On the spacing, on the rhythm and on the way they were sent and at the time they were sent.

Q. An intelligible message with a series of clicks arranged in a certain predetermined order?

A. What is that?

Q. An intelligible message was a series of clicks arranged in a certain predetermined order?

A. Yes, sir; and I must add, at a certain prearranged speed and at a certain prearranged time.

Q. Yes. That is what I meant by order. I think, Mr. Marconi, you testified that Fessenden or Kennelly, or whoever it was said that you had a tight coupling was wrong, because they had considered only the lines of force concerned with the linkage of the two coils D and D' in your transmitting station, isn't that about what it was?

A. Yes. I think they were wrong and I gave that as a reason. I am not sure that it was that reason, but I thought that they had overlooked the fact that they had to consider the whole circuit and not only part of the circuit in deciding whether it was loosely or tightly coupled.

Q. Can you make it clear to the Court how any part of the radiating circuit, say above the point I have marked in pencil, has anything to do with the coupling?

A. It certainly has everything to do with the coupling because it is part of the circuit, and it is part of the circuit which is not coupled.

Q. But it is not a part that is linked with the local circuit?

A. What?

Q. It is not a part which is linked with the local circuit?

A. No, sir; but it is a part of the circuit, and it is the only part of that which is linked to the other circuit. You must take the whole circuit from A to the earth, as a whole. There is only a very small length or part of this circuit which is linked to that. That is why that circuit is loosely coupled. If it was all coiled up in a coil around this circuit and none of it sticking up, or a few inches sticking up, then it would be very tightly coupled. That was my understanding of it.

Q. You say you have not read the defendant's testimony in this case?

A. I have read some of it. I haven't read it all.

Q. What part?

A. I have read only a very little of Fessenden's, and I haven't read Kennelly's at all.

Q. You are not undertaking to question their testimony about what is a loose coupling and what is a tight coupling?

A. I will undertake to answer the question to the best of my ability, but I cannot refer to a statement of others which I am not acquainted with.

Q. Don't you recognize Dr. Kennelly as an authority on the subject?

A. I think he is known in electrical engineering in America. And I have got no reason to say he is not an authority on those matters. I don't know if he has studied this particular subject as deeply as others have.

[fol. 458] Q. I understand that you do not claim to be a mathematical electrician, in the sense of being able to treat of the laws of resonance, like Kennelly does, for instance, in the article he refers to.

A. Yes; but I am afraid that my confidence in Dr. Kennelly is rather shaken by what you have just shown me. I am sure that he has come to a wrong conclusion about these circuits of mine which he has just discussed, therefore, whether he is a mathematician or not, like everybody else, he is apt to be wrong.

Q. Do you contend that you are as good a mathematical electrician as Kennelly?

A. I won't go into comparisons with you. I cannot answer that question.

Q. Well, he has given you, in the language you were asked about, he has given you the laws of resonance. You say you have not read them?

A. I am not a mathematician. Whether I am poorer or a better man, I am probably not at all as good as he, but I cannot take and compare myself with anybody else, on the witness stand, and you ought not to ask it.

Q. I think Kennelly and Fessenden both say your apparatus there does not radiate a wave with one predetermined frequency, and they give the reasons and cite the laws. What do you have to say?

A. They cite on premises which are wrong. They state that these circuits are tightly coupled, and that is not true. Of course, it is always a question of degree as to what is tightly coupled or loosely coupled, but taken in the ordinary phraseology of wireless telegraphy of the present day, those circuits are not tightly coupled.

Q. In your eight figures of your patent, all but two show the total construction of the coupling there between the coils of the transformers, and they say you have a tight coupling, and that when you have got a tight coupling, you cannot produce one wave, and therefore, you have not got a true four circuit tuning. That is a plain, frank statement

of what I think the defense shows. I want to know what your answer to that is?

A. I do not agree that these are tight couplings.

Q. And if they are tight couplings, they are right?

A. If they are tight couplings, they are right. You can get tuning between the four circuits just the same. If you radiate two waves and receive two waves, you can receive the same energy at the receiving station, whether the station is tightly coupled or not, the difference being that the tuning, that is, the elimination of interference will not be so good with tight coupling as it is with loose coupling.

Q. The loose coupling is the better?

A. In some respects it is better, and in others it is worse. If the coupling is too loose, you are throwing away energy at both ends, at the receiving end and at the sending end.

Q. Haven't you testified that you were the first to produce a wireless telegraph apparatus at which there was here an open circuit and here a closed circuit inductively coupled to it?

A. I think I was the first to try it, but simply stated like that, the thing didn't work. The two circuits had to be tuned to each other.

Q. Fessenden said that in 1899 he had this circuit that I have put on my little sketch, and used it. What is the electrical difference, if any, between that sending station shown on my little sketch and yours there, supposing this to be a spark gap, making an oscillating circuit, what is the [fol. 459] electrical difference, essentially?

A. The electrical difference is that my circuit is tuned to it, the closed circuit E-D has to be tuned to the open circuit, earth E-A. In the other sketch at the top of the drawing, I do not see that anything is tuned to anything else at all. I don't know what description goes with that figure, but there is nothing shown that is adjustable, no means for adjusting the two circuits, one to the other, and I doubt very much, I would like to know how those circuits can be tuned so as to have the same period.

Q. Suppose you were told to build a wireless telegraph apparatus in which that local closed circuit was to excite the antenna?

A. This (indicating)?

Q. No, in my sketch. You were told to make a local closed oscillation circuit so that it would excite the radi-

ating antenna, wouldn't you inevitably make them so they had the same electrical period?

A. In view of the knowledge of the present day——

Q. No, in view of the knowledge in 1899?

A. I would not know what to do with it.

Q. Do you think it would be possible for anybody, in 1899, with their then knowledge? Suppose, for instance, you had telegraphed across the British Channel, and with your own knowledge as a consequence, would you not on being told to build an apparatus and cause the radiation to be excited by the local closed circuit, do you think it possible that you would build them in such a way that they did not have the same time period?

A. I would have nothing to go on to show that they should have the same time period.

Q. You said they were the same time period?

A. No, sir; I did not.

Q. You said forced oscillation?

A. Mr. Clay, please do not make me say something, or attempt to make me say something I have not said.

Q. I thought a forced oscillation was an oscillation that was perfect?

A. No, sir. It is due to your incomplete knowledge of the subject.

Q. It is just like taking a spring with your hand and forcing it back and forth?

A. It is forcing it to do something it is not willing to do.

Q. Now, that force cannot be out of tune with the forcing power?

A. Not at all.

Q. Then whenever there is a forced oscillation in either one of those circuits it has got to be an oscillation in time to the force that is moving it?

A. Yes, sir; but that is as different from tuning as night is from day.

Q. Now, my question is, would you make those two circuits, would any electrician build those two circuits in such a way that that creation of oscillation in one circuit by the oscillations in the other would be out of tune so that they would interfere instead of working? That is my question.

A. I think that is what would have happened if that circuit had been tried at that time.

Q. Everybody knew at that time that the time period of this local circuit was dependent on the value of the condenser in the coil.

Q. They also knew that the time of oscillation in the antenna was dependent upon that condenser A-D?

A. No, sir.

[fol. 460] Q. And the coil?

A. No, sir; they didn't know anything of the kind. It is all mixed up between the two circuits as to what is the period of each.

Q. Did you see the exhibit which shows Fessenden's publication of September 16, 1899, before you testified?

A. I would like to see it in order to be able to answer the question. Yes, sir; I saw it some time ago.

Q. Do you consider that that shows two forms of loose coupled transformer at the receiving station? Or do you think that the third figure does not show a loose coupling? Of course, I suppose you have no question but that the second one is a loose coupling?

A. I cannot say as to No. 2, whether it is a loose coupling or a tight coupling. I don't know what transformer it is referring to, whether there is iron in it, or not, and what is the length or the dimensions of the circuit connected to it.

Q. I thought you understood that is a glass tube there. That is, two coils of wire on the glass tube sliding to and from each other. There is no iron there; it is an air core transformer. The question is whether that shows two forms of loose coupling or only one.

A. I should say the second figure shows some form of transformer. I really, I cannot say whether it is loose or tight. It is not very tight, but I cannot say whether it is very loose.

Q. What about the third figure?

A. The third figure shows a coil shunted by a condenser with a coil, a galvanometer coil inside of the coil I have just mentioned. I do not see that that can be called a transformer. I think it is a form of galvanometer.

Q. In your patent in suit, is there any possibility of physically moving the primary and secondary of the transformer with respect to each other?

A. No.

Q. Dr. Fleming is the scientific adviser of the Marconi Company, isn't he?

A. He is one of the scientific advisers.

Q. He is a prominent authority in England?

A. Yes.

[fol. 461] Q. In 1899 were loose coupled transformers used at all?

A. Excuse me; for what purpose do you mean? Any purpose?

Q. The purposes of the patent in suit; for instance, wireless telegraphy?

A. I think some were used in some receivers which I constructed.

Q. You think only in your own work?

A. That is all I know of.

Q. Do you think there is any meaning to the statement that a transformer may be a loose coupling in one direction and tight coupled in the other?

A. I don't follow your question.

Q. Could the transformer be loose with respect to the transfer of energy in one direction and tight with respect to the transfer of energy in the other direction?

A. It might be so if it had a saturated iron or steel core in it, but I do not quite see how it could be so if it had not.

Q. I mean, supposing your local circuits were transferring the energy through the transformer into the antenna in the one case, and in the other, supposing there were a circuit passing through the antenna and into the local circuit, could the same transformer be loose coupled in one instance and tight coupled in the other?

A. No, sir; I don't think it could.

Q. The adjustment of the tuning coil in the transmitting station is a step by step adjustment in your patent, is it not?

A. It may be, or it may be a circular movement, continuous adjustment. It is exactly, I suppose, as it is described. I don't remember the exact description of that.

Q. I want to get this chart right, because I do not think it is clear. That ought to be represented as a lot of leads coming out here so that it is changeable step by step, and not turn by turn. Look at the patent and see if that is not true.

* * * * * * *

A. No, sir; I don't think the patent shows that.

Q. Well, I understand you to agree to that, if the coupling is tight in your sending station there would be radiation two waves and not one?

A. Yes.

Q. Then how could there be four circuits tuned to the same period? Which of those two periods would it be?

A. If you take the two circuits separately, separate them from each other, you will find they are tuned to the same period.

Q. Well, which period?

A. The period of each other.

Q. There are two waves being radiated, wave A and wave B; to which one of those are your four circuits tuned?

A. When the circuits are separated they are tuned to a wave that is intermediate between those two; but they are nevertheless tuned to each other. The product of the capacity by the self-induction in each circuit will be equal.

Q. That is what I want the Court to understand. The effect of this coupling is to change the tune of each circuit?

A. If coupled very tight, but if it is loose that effect will be negligible.

Q. It vanishes gradually?

A. Yes, sir.

Q. But a close coupling, or anything approaching a close coupling, will make it necessary for the wave actually radiated not to be in harmony with either the antenna or the local circuit, isn't that so?

A. That is if the coupling is very tight.

[fol. 462] Q. Yes.

A. But that is not the case of this patent.

Q. Now, when you say the four circuits are tuned to a particular wave length you mean a wave length which is not being radiated, don't you?

A. No, sir, I don't mean anything of the kind, because I have stated that in this case you are considering in the invention described in the patent in suit, the circuits are loosely coupled, not tightly coupled, therefore they radiate one wave, and the two circuits have the same tune and the same period.

Q. There is a difference of opinion and the defendant's witnesses give a mathematical demonstration and you do not answer it. We will suppose at least that they are right. If they are right, how can there be four circuits to the particular wave when there is not any particular wave?

A. Assuming that they are right, and I am certain they are wrong, because we have taken measurements in regard to the coupling of those circuits, but assuming they are right, the period of the two circuits taken independently would still be the same. The product of the self-induction by the capacity would be the same in both cases.

Q. But in actual work——

A. In actual work, two waves would be radiated.

Q. And the waves radiated would not be of the periodicity of either one of your sending circuits, would they, or would they not?

A. If the coupling was tight it would differ from the period of the two circuits by a certain percentage. Each wave would differ a little bit one way and a little bit the other.

Q. And that does not interfere with your object of selecting of a station?

A. No, sir; but I have not shown in the patent, nor do I use, tightly coupled circuits; therefore, it is a condition that does not arise.

Q. The radiation of two waves would certainly be, if not fatally, very deleterious to a receiver which made a response in proportion to the energy radiated, wouldn't it?

A. No, sir. If the coupling at the receiver is also tight the receiver will receive or will integrate the energy of the two waves.

Q. And it will be tuned to which one of them?

A. To both of them.

Q. To both?

A. To both.

Q. Its time period will be the same as both waves?

A. The time period will be such as to respond to both.

Q. But not exactly either?

A. Well, what do you mean by not exactly either?

Q. Why, Mr. Marconi, Mr. Fessenden says that exact tuning is not possible with your apparatus, and I am trying to find out whether he is right or wrong. You say that there are two waves radiated. I assume that there are two waves received.

A. I am only assuming that there were two waves radiated just to enable you to go on, but I am not accepting that as a fact.

Q. I appreciate that, but all this on the assumption that there are two waves radiated now?

A. Yes, sir.

Q. When you come to the receiving station, are those two circuits tuned to the same time period?

A. They are.

Q. If they are, it is not the time period of the wave received, is it?

A. Why not? Are you still assuming a tight coupling?

[fol. 463] Q. If they are, it is not the time period of the wave received?

A. Why not? Are you still assuming a tight coupling?

Q. I assume that two things that are alike cannot be like two other things which are different.

A. Are you assuming a tight coupling?

Q. Yes.

A. In that case with a tight coupled receiver, the tuning would certainly not be as good as with a loose coupled receiver, but due to the fact that the tuning is not so good, the energy of the two waves will be received, I think, with a pretty high degree of efficiency.

Q. But there is not any four circuit tuning of one particular definite wave, is there?

A. The four circuits, if you take the four circuits, they all have the same time period, whatever happens to the wave.

Q. That is, when they are not working, but when working?

A. Taking the assumption of something which I do not use and which I do not describe, I think that would be a fact.

Q. That is, they are not tuned to any particular one wave?

A. The circuits themselves are tuned by the waves which are transmitted and received, differ slightly from the periods of those circuits.

Q. I want to get some definite figures, because this seems to me a very important point. Assume a wave length, of whatever is a convenient number, 1,000 meters?

A. Yes, sir.

Q. And your other wave you may assume what you please, what would it be, 1,100?

A. Well, put it like that, 1,100, yes.

Q. Is that a likely assumption?

A. Yes, sir.

Q. Now, you have a reduction of a wave 1,100 meters to a wave 1,000 meters?

A. Yes, sir.

Q. What is the time period of the sending antenna, in its position and while it is radiating?

A. It will have both periods of alteration.

Q. It will be first tuned to one and then to another?

A. Yes, sir.

Q. What changes the tune?

A. The reaction between the primary and the secondary circuits. it will be caused by this circuit pushing that, and it has a certain frequency, and then part of the energy goes back again if the coupling is too tight.

Q. And that is the result of the tight coupling?

A. That is the result of the tight coupling.

Q. If you had a loose coupling it would only radiate one wave?

A. Yes, sir.

Q. And in that circumstance you could have a local circuit and antenna both exactly in tune with the wave being transmitted?

A. Yes, sir.

Q. And in that case you could get a response which represented the sum total of all the energy in all the waves that were radiated, couldn't you?

A. You will get tuning. I don't say you could get the sum total of all the energy radiated, or that you would get very high efficiency if the coupling is very loose, because the receiver becomes less efficient in consequence of the loose coupling. The energy does not go through from one circuit to another so well when the coupling is loose, and when you use the spark it couldn't get through quick enough; therefore, a very loose coupling will reduce the efficiency of your receiver.

Q. In your patented apparatus, your object is to build up as high a voltage as you can for the terminals——

A. The object is to establish resonance in that circuit [fol. 464] to build up the voltage sufficient for what is necessary to make the coherer act.

Q. That would be done when you were working with two waves almost as well as when you have got one wave? You build up a voltage there notwithstanding you have got two waves?

A. If the coherer circuit is closely coupled it is easier to get up a potential, even if it is not tuned very accurately,

but with the coupling given in the patent the tuning is and can be proved to be good.

Q. Now, suppose that in this defendant's device, suppose that I am correct in saying that every pulse of the current in the secondary current takes effect wave by wave, every pulse without exception takes effect on the receiver, do you think that could possibly be done if you had the two waves?

A. I don't see why not.

Q. There could not be two waves of the same period, could there?

A. There can. If they are the same period they are the same period.

Q. They are the same wave?

A. They might be.

Q. If there were to be two waves to take the circuit, it could not be tuned to both?

A. If they are tight coupled they will both go through.

Q. I didn't ask you whether they would be. I asked you whether they could be tuned to both when the two are different? It seems to me an axiom that if two waves are different you cannot tune the both of them in the same circuit.

A. Depends on what your circuit is.

Q. Suppose it is the circuit shown there, practically a simple oscillating circuit?

A. I think the detector there, whatever it is, would be affected by the two waves if the two waves were there.

Q. And the two waves would be operating in a circuit tuned to which one?

A. Tuned to either or tuned to an intermediate between them.

Q. Well, which one? Call them A and B. Which one?

A. Anyone you like.

Q. Assume one?

A. If the circuit is tightly coupled and if the damping circuit is great it would be affected by one or two waves or maybe ten waves, that happened to be going around that circuit.

Q. I don't think we are getting anywhere, Mr. Marconi. The circuit cannot be tuned to two things which are different, can it?

A. A circuit can be, a good resonant circuit which is very exclusive and which only wants one wave and which does not want any other wave.

Q. And that is what you call good tuning?

A. But the circuit may be, and that circuit looks very much like it, a circuit that is not at all exclusive or particular, a circuit that will respond to anything. A circuit that is very universal in its likes and in its sympathies. In that case even if you are a bit out of tune the wave will affect it substantially the same.

Q. The more universal its likes, or just in proportion to the universally of its likes, it fails to be well tuned, doesn't it, to anything?

A. It certainly is not a good tuned circuit if it will respond to a very large range of waves, and without differentiating between them in a definite manner.

Q. The commercial use of your invention that you have testified to all took place between the filing date and the issue date of your patent, didn't it?

A. Between the filing date——

[fol. 465] Q. Between the filing date and the issue date of your patent, that is, between November, 1900 and June, 1904?

• • • • • • •

A. No, sir, I do not agree with you.

Q. Well, I may be mistaken about your dates.

A. It is not the date——

Q. To what dates did it run?

A. Run what?

Q. The commercial use of your invention?

A. It commenced in 1898, I should say, or 1899, the British Navy began to use it; 1899 it was used for important New York yacht races—excuse me, are you speaking of the patent in suit?

Q. Yes. I understood you to say the first use in the United States was August, 1901, at Nantucket?

A. The patent in suit, yes. You asked about my invention and I took that generally.

• • • • • • •

[fol. 466] Q. At how early a date did you introduce into this country knowledge of a system having an open circuit and a closed circuit at each station, the four circuits being tuned to the same electrical time period?

A. Some time in 1900.

Q. 1900?

A. Yes.

Q. Do you still regard as your invention the combination of four circuits having the same time period?

A. Yes, I do.

Q. That is, your idea of your invention is that it is a closed oscillating circuit at the sending end, connected to an open radiating circuit and at the receiving end, an open absorbing circuit connected to a closed operating circuit?

A. Yes, the circuits being in resonance.

• • • • • • •

Q. Let us get the Court clear on that resonance question. Does that mean anything else than that those four circuits are so adjusted that when an electric pulse flows in them it takes the same time to flow through one as it does through the other three? It simply means that they are [fol. 467] timed together, like my illustration of the boy on the spring-board, isn't that right?

A. I cannot accept your definition. I would rather put it my way. They are tuned so as to have the same, or substantially the same time period. They are tuned, if I might put it this way, so as to be in tune with each other, but the sound principle underlying the system in the invention is that all four circuits should have the same period of electrical oscillation, and I think it is so expressed in the patent, in this way: That the product of the capacity multiplied by the self-induction should be the same in each circuit.

Q. When I tried to get you to state the laws of resonance you refused to do it. Now I want it stated in plain everyday English, isn't it that the electric pulse flowing in the circuit takes the same time to travel in one circuit as in the other?

A. I don't know what you mean by electric pulse.

The Court: Then describe what you mean by time period.

A. Well, every circuit that is resonant has an electrical period of its own; has, as we would call, a time period.

By the Court:

Q. That is the time it takes to go through, isn't it?

The Witness: It is not the time it takes to go through. I object to the word pulse because it is not really a pulse; it is a wave, it is longer than a pulse.

The Court: Then substituting wave for a pulse, would you agree with the statement counsel makes?

A. Yes. It takes a certain time for each complete oscillation to go around that circuit. For example, we may have a circuit in which the electricity oscillates one thousand times a second, in which it completes a thousand complete oscillations to a second, and another circuit in which the electricity will execute say only five hundred oscillations to a second. The period of those two circuits is very different,—different from each other.

By Mr. Clay:

Q. I want the Court to understand that it is because the electricity takes a longer time to traverse the circuit.

A. Because the circuit is electrically longer. — In other words, in 36-A, the sending station of the patent in suit, in the righthand sketch, any manifestation of the electricity which traverses that red circuit from one side of the condenser around to the other side it takes the same time to do it as a pulse of the electricity moving from the earth up to the top of the antenna?

A. And back; yes.

Q. And back again in either one?

A. Yes, sir.

Q. What other movement occurs in either of those circuits does in the same time?

A. Yes, sir; with the same time period.

Q. In your patent 627650, you say, at page 1, line 32:

"It is desirable that the induction coil should be in tune or syntony with the electrical oscillation transmitted." Notice the words "the induction coil in tune or syntony." What does that mean, except that the two members of the [fol. 468] induction have the same time period?

A. It does not mean that there, at least I do not think it does, because I didn't know it at the time that this specification was filed.

Q. What is that date?

A. That date was the 5th of January, 1899.

Q. In 1899 you didn't know it?

A. I didn't know that it was necessary to tune the two circuits of the receiver or transmitter in order to attain those effects.

Q. See if this language does not describe the condition of affairs you have always supposed to be synchronism between these four circuits:

"The combination with the transmitting instrument, comprising a transformer, having its secondary connected to ground and to an elevated terminal, respectively, and means for impressing electrical oscillations upon its primary, of a receiving instrument comprising a transformer having its primary similarly connected to the ground, and to an elevated terminal and a translating device connected with its secondary, the capacity and inductance of the two transformers having such values as to secure synchronism with the impressed oscillation."

If that fails to describe what you have got there in that chart 36-A, as showing the invention of your patent, 763-772, point out wherein it fails.

(The paper was handed to the witness.)

A. I think the idea expressed in that paragraph has nothing whatever to do with the idea of the invention shown in the patent in suit. What I think he means here, whoever is the writer of this, is that he is impressing electrical oscillations upon the primary of a transformer, and everything has got to be, at least, a transfer has got to be in synchronism with the impressed oscillations. It seems to me that he speaks of a transformer here; it must be connected to an alternator, an alternating current dynamo which works at a certain frequency, he is thinking of tuning his transformer so as to take up those impulses, or in other words, to be in synchronism with the impressed oscillations which are coming from the machine, which is not mentioned in the paragraph.

Q. But whatever movement of the electric there is in any one of the four circuits moves with the same speed, has the same time period, has the movement of the electricity in any of the four circuits, does it not?

* * * * * * *

The Court: Which one are you referring to?
Mr. Clay: The one he has just described.

* * * * * * *

[fol. 469] A. No, sir; it is not stated in that paragraph.

By Mr. Clay:

Q. What did he mean by this expression: "The capacity and inductance of the two transformers having such values as to secure synchronism with the impressed oscillation?"
What does he mean by the capacity and inductance of the transformers of having such values as to secure syntonism?

* * * * * * *

A. I would really have to read the whole article. The whole patent. It looks like a patent. I really don't know what he means.

Q. I want to see if you can answer as a pure matter of description. I will change the question. I want to know whether, simply as descriptive language, speaking to an electrician who knows what a transformer is, when a man says that the capacity and inductance of the two transformers have such values as to secure synchronism with the oscillations impressed on one of them, does not that mean that those four circuits are tuned together?

A. If he said circuit it would be different, but he says transformers.

Q. That is just what you said in your patent, in your patent of 1899, I think that is just the expression you used.

A. I just told you that I didn't mean tuning of the circuits.

Q. You said it is desirable that the induction coil should be in tune or syntony with the electrical oscillations transmitted. The induction coil includes two circuits, does it not?

A. Yes, sir; but I did not mean that there. The circuits in the transformer as shown in that patent are not tuned, at least the closed receiving circuit and the open absorbing circuit are not tuned to each other, and it was not conceived at the time of that patent that they should be tuned to each other. What I meant by saying the induction coil is tuned there was that the period of its primary, the pri-

mary period of the coil which was connected to the aerial should be such as to make the period of that circuit—by circuit I mean a coil in the aerial—such as to be in tune with the other station, but I had not conceived at that time that the two circuits of the transformers or the two receiving circuits, to be more accurate, should be in tune with each other. It is not described there, and I do not take it to have the meaning which you suggest it has.

[fol. 470] Q. When you say the induction coil is in tune or syntony with the electrical oscillations, the word coil refers only to the secondary?

A. To the primary there. I don't know what you call primary and secondary. I call the one attached to the antenna the primary.

Q. Oh, no. Well, if you are going to take the other end of the station, very well. You say in this passage the induction coil should be in tune or syntony with the electrical oscillations transmitted. You say that means the primary?

A. Oscillations transmitted are the oscillations coming from the station from which you want to receive.

Q. And the oscillations coming are certainly in tune with the sending antenna, aren't they?

A. Not necessarily. They are, I think, in that case, yes.

Q. Could they be anything else?

A. It might be a forced oscillation.

Q. Oscillations must be in tune with the sending antenna, must they not?

A. They are.

Q. Well, they must be. They cannot be anything else?

A. You must not say must in questions like this. They are. There is very little must about electricity.

Q. Explain how you would get a million a second off an antenna that was not tuned to a million a second.

A. You might have forced oscillations from a generator of some kind which would not be very efficient, but not commercially useful, but take a million a second of something that was not tuned to a million a second—that is not what we are discussing. The oscillations which we are receiving are certainly of the period of the transmitting wire. I think we are in agreement over that.

Q. Now, your remarks about impressed oscillations just now show that they must be in tune with the impressing source?

A. I don't follow your line at all. I am sorry.

Q. That patent says the receiving antenna is in tune with the sent oscillations.

A. It does not say that. Which patent?

Q. Your patent 627,650, page 1, line 32. It certainly says that the receiving antenna, including the primary induction coil, is in tune with the oscillation sent, does it not?

A. Thirty-two?

Q. Yes.

A. It does not say that. What it says is it is desirable that the induction coil should be in tune or syntony with the electrical oscillation transmitted. That is what it says.

Q. And you say that means the coil corresponding to this coil J' in your Chart 36-A is tuned to the sent oscillation.

A. What that means is that you have a definite length so as to make the whole circuit in tune with the received oscillations.

Q. If it is in tune with the sent oscillations it must be in tune with the sending antenna?

A. Yes, sir.

Q. The sending antenna, in order to have oscillations produced in it, must be in tune with whatever is producing the oscillating current?

A. At that time, there was nothing except a spark gap to produce the current.

Q. When the current impressed itself onto the antenna——

[fol. 471] A. It never did it before the date of that patent, or at the date of that patent,—this patent, 627,650 applied for on the 5th day of January, 1899.

* * * * * * *

Q. Now, I show you a drawing that is described in the language I have been quoting to you, and which you will see is a patent of Tesla in evidence. Look at the drawing alone, please, and let me read you another description and see if it does not define a four-circuit tuning. That one is Exhibit No. 6. The quotation is this:

"It will be readily understood that when the above prescribed relations exist, the best conditions for resonance between the transmitting and receiving circuits are attained and, owing to the fact that the points of highest potential

in the coils or conductors AA are coincident with the elevated terminals the maximum flow of current will take place in the two coils and this further necessarily implies [fol. 472] that the capacity and inductance in each of the circuits have such values as to secure the most perfect condition of synchronism with the impressed oscillations."

Now, I want to know wherein that fails to describe four circuit tuning.

A. Do you object to my reading that patent?

Q. Reading it on that drawing only.

A. Do you object to my reading it myself?

Q. No; I do not want you to read it. I want you to hear the language and see if the language is not a description.

* * * * * * *

A. I cannot answer that question intelligently, because it refers to other conditions which you do not state at the beginning of the paragraph, and I really have got to know more about it. If you will let me read more of the patent, and try to find out what he means, I may be able to give you an intelligible answer. If I answer like this I may give an answer which is not accurate. I do not understand what he is driving at in that paragraph.

Mr Clay: If your Honor please, I don't know whether I have actually put in evidence Tesla's patent 649621, which is a division off of our Exhibit 6, which is patent 645576. For fear I have not, I want to offer in evidence now the Tesla patent 649621, dated May 15, 1900, divisional application being February 19, 1900, divisional application 650343 of September 2, 1897, which is the application for patent 645576, Defendant's Exhibit 6, and ask to have this divisional patent marked Exhibit 6-A.

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[fol. 473] By Mr. Clay:

Q. In the apparatus of your patent in suit, would it make any difference if the transformers, instead of being constructed as you have shown them, were constructed as in Defendant's Exhibits 6 and 6-A?

A. I don't know how they are constructed here. They do not look like operative transformers. I cannot answer that

question. I don't know whether it is a transformer, or whether it is a plate, or what this thing is I am looking at. I would have to read the specifications, but you won't allow me to do that; therefore, I cannot tell you.

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[fol. 474] Q. Would your invention of the patent in suit, as you understand it, be embodied in the apparatus I show in my sketch 2, provided the antenna circuits, both of them, and the local circuits, both of them, were closed, and the local circuits being enclosed, were all four tuned to the same time period?

A. What do you mean by closed? Do you mean no spark gap?

Q. You testified the other day that a circuit with a spark gap was closed, didn't you?

A. Yes; I did; but if a spark is there you get a certain effect which you do not get if there is no spark.

Q. I am referring to that feature of your invention, or supposed invention, which involves the tuning in unison of four circuits without regard to how the current works, except that it is a transmission system for intelligence by oscillating current.

A. You give me a circuit that won't work, I cannot say that it is covered by my patent or intended to be covered by my patent.

Q. Do you know any reason to suppose Tesla's patents and publications do not describe what is on my sketch 2?

A. No, sir. I do not see anything in Tesla like your sketch at all.

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[fol. 475] The Court: Mark that Exhibit 49. It is the same sketch that you have referred to in the complainant's map, but we must know what the witness is talking about.

• • • • • • •

By Mr. Clay:

Q. Will you look at Defendant's Exhibit 6 and see if that transformer is what you were describing yesterday as a loose coupled or tight coupled transformer?

• • • • • • •

A. I must read a little to understand it. Looking at this exhibit I should say that the transformer shown, if it is a transformer, or rather the circuits shown, are very tightly coupled. That is my impression. I would have to read it carefully to be absolutely certain. The patentee speaks of obtaining very high voltages, hundreds of thousands or [fol. 476] millions of volts, which are absolutely useless in regard to wireless telegraphy. But, in order to obtain these high voltages, I think it would be necessary for him to use a very tightly coupled transformer, and I think that is what he has shown.

Q. Well, suppose two circuits tightly coupled, do I understand you to admit that you cannot tune one, we will say to the frequency N and the other to an octave higher and have them co-operate?

A. You can tune one to an octave of the other. You cannot tune the other one to an octave of itself, because otherwise it would not be an octave of its own fundamental period.

Q. What relation is the time period of a wave that is an octave higher than the wave of the period N?

A. In wireless it would be generally as 50 say to 150.

Q. Where did you get that definition of an octave?

A. I got it from the results of my experiments.

Q. It is a new definition of octave?

A. It is a definition of what occurs.

Q. Did anybody other than you ever hear of an octave being anything else than a note which has twice as high a frequency?

A. Yes. That is correct. That is, what I am referring to, is a harmonic really. An octave would be double, as you say.

Q. You could tune to a third harmonic, but not to an octave?

A. It can be made to oscillate to an octave.

Q. I didn't ask you that. Please hear my question repeated and answer. I didn't ask you if it could be made to oscillate. I want to know if you can, in your apparatus, tune the antenna an octave higher than the excited circuit?

A. That is a question, is it?

Q. That is a question?

A. Yes, you can.

Q. And get good radiation?

A. No, sir. The radiation will not be as good as if it is tuned to the fundamental.

Q. Then if you do tune it to an octave, as you suggested in your patent, it would not work?

A. I do not recommend it in my patent. I stated that it can be done. It does work, but it will not work so well as when it is tuned to the fundamental, or when it is tuned in the way I describe all through the patent.

Q. In the case of tuning the octaves you have just mentioned, you would get your time period varied between waves, wouldn't you?

A. I don't understand what you mean, time period varied between waves.

Q. Supposing you have got a tight coupling and suppose you have tuned to an octave, wouldn't you get two waves instead of one and an unequal time period between waves?

A. If the coupling is tight, very tight, you certainly would get two waves. I do not understand what you mean by a difference in the time period between waves. I don't see that.

Q. Did your original radiator send out more than one wave, or not?

A. What do you mean by my original one? The patent of 1896?

Q. Yes.

A. That I should say sent out one wave.

Q. What about the original apparatus of this patent in suit that you have described using?

A. That sends out one wave.

Q. One wave?

A. Yes.

Q. Is it not a fact that all your stations now send out a double wave?

[fol. 477] A. Not unless it is intended that they should do so. I have never heard of that. I do not agree with you. We can send out five waves if we wish to.

Q. Can you send out a single pure wave with the use of the apparatus in suit?

A. Certainly.

Q. You think that your stations do that?

A. I am absolutely certain of it. We have got to do it under the prescriptions of the British Admiralty in England. If you send out more than one wave, unless you are

licensed to do so, you are called upon to stop. Also, on board ships which work under the international convention on wireless telegraphy, you have got to send out one wave and one wave only, and the apparatus we use is the apparatus which we have been talking about.

Q. I want to be quite sure that you understand what I mean. I will put on the corner of the chart a little sketch of a wave with a double hump. Do you deny that your station sends out a double humped wave?

A. Absolutely and most decidedly. I should add to that, that stations can be made to send out a wave like that, but it is not done unless it is for particular purposes.

Q. Do your stations send out a wave which is resonant to two frequencies?

A. I don't understand a wave that is resonant to two frequencies. You mean two waves?

Q. No.

A. A wave is not resonant to anything. It is a circuit that is resonant.

Q. Didn't you say yesterday that the two coupled circuits, closely coupled circuits, could be tuned simultaneously to more than one wave?

A. What? No, I did not.

Q. Tuned simultaneously to more than one wave?

A. No, I said a receiving circuit could be tuned to have a broad range of tuning and be affected approximately equally well by two waves which do not differ too much from each other. That is what I said or meant to say.

Q. Did not Prof. Fleming demonstrate that if you have two circuits, each of which is carefully tuned to the same frequency, then bring them together and couple them, they have neither of those frequencies acting together?

A. No; I don't think he showed that. I do not agree with you.

Q. Taking the Chart 36-A, either one of the figures showing the patent 763772, suppose you tuned the red circuit to the frequency N and the black circuit to the frequency N, entirely separate from each other, now you couple them together, what will be the frequency of the radiated wave?

A. If they are coupled loosely it will be the frequency N.

Q. And if tightly?

A. Two waves will be radiated.

Q. Will that be N and N?

A. That will be N and N.

Q. Will either one of them be the frequency N?

A. No, sir.

Q. In other words, when they are coupled, the frequency of the combination is not the frequency of either one of the circuits separately?

A. The frequency of each circuit remains the same, but the frequency of the wave given out, due to the reaction of the two waves is different from the fundamental, always when the coupling is tight.

Q. Now, we have got three frequencies to deal with. The circuits themselves have the frequency N?

A. Yes, sir.

Q. The wave radiated has not the frequency N, but the frequency N^1, we will suppose?

A. Yes; and another one.

[fol. 478] Q. And the frequency N^2?

A. Yes, sir, if the coupling is tight.

Q. Now, we have got three frequencies. Go to the receiving station, to which of those three frequencies is your receiving antenna tuned?

A. There are two ways. One is to let your receiver receive both the waves, if two waves are radiated; and the other is to tune the receiver to one of those waves, that is, the longest or the shortest.

Q. What becomes of the other?

A. The other one goes loose. There is nothing done with it.

Q. It does no work, does it?

A. It does no useful work.

Q. Then in your apparatus there is no possibility of a cumulative receiver, in the sense of making a response by virtue of all the energy?

A. No, I am simply proceeding with you on an assumption of the fact that the coupling is tight.

Q. All of your testimony is based on the assumption then that the coupling in your patent is not tight?

A. No. The examples given in my patent, all of them are loose. If they were tight, I do not think—or if they were very tight—which is not shown in any of the examples—I do not think it would depart from the principle laid down in the patent, because you would lose the energy of one wave, but still you could tune perfectly well through the other wave, and get the cumulative effect from whichever

wave you were using, which would be what we may call a tuning effect, and also extremely useful, and an advance on what was done before.

Q. You seemed to me to testify that your wireless telegraph system was a gradual development. Now, in that development, which came first, this four-circuit tuning idea, or the use of the transformer at the two stations?

A. The four-circuit tuning idea came at the same time with the idea of the transformer at the two circuits, so far as I am concerned.

Q. The transformer at that time was old and well known, was it not?

A. What transformer?

Q. Any transformer in a system of sending energy by electro-magnetic waves?

A. Not connected that way.

Q. Why, Lodge in 1898 had a transformer, did he not?

A. He had a transformer in his receiving circuit. I do not see any in his transmitting circuit.

Q. And you are neglecting Tesla and Thomson, and all the whole tribe of Americans?

A. I do not see—I have not been shown that Tesla or Thomson described any transformer at all.

Q. The point is, the use of the transformer came at about the same time that you made use of the four circuits tuning?

A. No. If I have to answer you literally—you do not put your question so I can answer it easily.

Q. Answer it as you please.

A. I described a transformer in my first patent of 1896, applied for June 2nd, 1896. I speak of a transformer there. Therefore, I might say that I thought of a transformer at that time, and probably before that time, but what I am alluding to now is a transformer which is connected in the way shown in the patent in suit, and which is constructed in such a way as to be able to transform or to be operative with these high frequency currents which are used in wireless telegraphy, or which were used in wireless telegraphy at that time. That is what I understand to be a transformer. [fol. 479] Transformers were used a long time before, but they were different transformers, and they were used in a different manner.

Q. Do you think anybody, even in 1896, would have employed a transformer—and, mind you, it is a transformer of

alternating current— * * * and not make the two sides of the apparatus with the same period?

A. * * * I do not think that anybody knew about the tuning of the two periods at that time—the tuning of the two circuits of a transformer, at that time.

Q. You do not think anybody knew it was necessary to have them with the same time period?

A. No. There is nothing that I know of that suggests that.

Q. Now, this matter of the Nobel prize, that you testified about, that was divided between you and Prof. Braun, was it not?

A. No. The money part of it was divided—was given half to myself and half to Prof. Braun, but I had a full diploma and prize for physics, and a gold medal.

Q. Did he not have the same?

A. Will you allow me to finish?

Q. Yes.

A. And Prof. Braun had also a diploma and a medal, and half of the total sum of money.

Q. What is the distinction then, from my statement, that you divided the prize?

A. If you take the money as being the prize——

Q. (Interposing) Oh, no. I would not think of anything so mercenary as that, but the honor?

A. No. I was given a diploma with my picture on it, and several other things, and not a mention of Braun or anything to do with Braun, and that is the Nobel diploma. Braun was given one for himself, with his own picture on it, and nothing else that I know of. Therefore, I cannot say that the prize was divided between myself and Braun, because, in that case, we would have been given a joint diploma, I presume.

* * * * * * *

Q. Is it not a fact that from the beginning there has been a prize in physics awarded every year?

A. Yes.

* * * * * * *

[fol. 480] The Court: In this particular year that is referred to, Mr. Marconi, the fact is, as I understand it, that Prof. Braun—if he is a professor—and you received exactly similar recognition?

The Witness: Yes, sir.

The Court: And that the maximum prize of $30,000, so far as the money goes, was divided?

The Witness: Yes, that is absolutely correct. Except, I might add this, if I may be allowed to, that I took precedence over him, in the fact of the prize being given first, and in the position amongst the prize winners, I took precedence over all the Nobel prize winners of that year, because the prize for physics is awarded by the King, and it was awarded first to me, and then to Braun.

The Court: But in the same sphere in physics?

The Witness: Yes, in the same sphere in physics.

* * * * * * *

By Mr. Clay:

Q. Do you recall the fact that in the prosecution of several of your patents in the Patent Office you have discussed and made affidavits with respect to the Tesla patents?

A. With respect to what?

Q. The Tesla patents which were cited against you as references?

A. I made affidavits, do you say?

Q. I think so. Do you recall the fact that they were discussed in the file wrappers in several cases, and affidavits were made by you respecting them?

A. Yes, I remember that we had, through our patent attorneys, frequent correspondence with the Patent Office, in order to give explanations and to meet objections, and I know that I did execute several affidavits. I cannot say I remember the substance of them all, or that I am very clear on the substance of any of them, but I take it that what you say is a fact.

* * * * * * *

[fol. 481] Q. But I want to ask you to point out, if you can, where you show the conductor coupling in the original patent—the use of the transformer in your original patent, and then that is all. Take your time about it, and have it put on the record afterward.

A. My original patent?

Q. Are you willing to do that, without comment?

A. You mean my original American patent?

Q. I thought you meant the British, but it does not make any difference.

A. No. It is in one of those, I think. In the original patent, page 3—I mean, there may be other references; I am just giving the first I see—page 3, line 18.

The Court: Give the number of the patent, Mr. Marconi.

The Witness: Patent No. 12,039, of 1896, the British patent. At line 18, it is stated: "In the transmitting instrument R is an ordinary induction coil (a Ruhmkorff coil or transformer)."

By Mr. Clay:

Q. Where was that?

A. Page 3, line 18.

* * * * * * *

Redirect examination.

By Mr. Betts:

Q. On page 266, you were asked, on cross-examination, whether the commercial success that you testified about utilizing the invention of the patent in suit, did not take place between the filing date of the patent in suit, and before the issue. Has the invention of the patent in suit been put into use by you or your companies since its grant?

A. Since its what?

Q. Since its grant—its issue date?

A. Yes, it has been put into use very extensively in all parts of the world, and it is used now in practically every wireless telegraph installation which is worked by the Marconi companies and their associates. I think I am right in saying that it is used on every ship that is equipped with wireless telegraph, or that my companies have equipped with wireless telegraph, and it is used at every shore station in every country where these stations have been erected, and I say that the number of installations runs considerably over a thousand.

Q. When were telegraph messages actually first sent between Canada and England, and who was present when those messages were transmitted?

A. The first messages were transmitted from Canada [fol. 482] to England in December, 1902, in the presence of

officers of the Italian warship *Carlo Alberto*, and including other persons, I might mention the correspondent of *The Times*, in North America, Dr. Parkin. These first messages consisted of telegrams sent by myself, by the Governor-General of Canada, and by prominent persons, to the King of England and to the King of Italy, and to other eminent or prominent persons in Europe.

Q. How did the American electrical profession take the achievement of this successful transmission of messages across the Atlantic in 1902?

A. The American Institute of Electrical Engineers gave a dinner in my honor in January, 1902, at which were present all the most prominent scientists and electricians of America. I might mention Mr. Edison—Mr. Edison was not present, but he sent a mes age—but Prof. Pupin, Prof. Elihu Thomson, and many others. At this dinner messages were received congratulating me on what I had done, from Mr. Edison, from Mr. Tesla, and others, and I should also state that a very laudatory address or speech was made in regard to what I had done by Prof. Elihu Thomson. All this is reported in the *Electrical World and Engineer* of the issue of January 18th, 1902, which I ask leave to put in evidence.

Mr. Betts: I offer in evidence the copy of the *Electrical World and Engineer* of the issue of January 18th, 1902, and ask that it be marked Complainant's Exhibit No. 49.

* * * * * * *

(The publication so offered and identified was thereupon marked "Complainant's Exhibit No. 49," of this date.)

By Mr. Betts:

Q. Is there any other advantage in the utilization of the invention of your patent in suit except that of long distance transmission?

A. Yes. There is considerable advantage which is of extreme importance in the practical use of wireless telegraphy. That is, in making communications independent of each other, or, in other words, avoiding interference. The commercial application of wireless telegraphy is dependent, to a very large extent, on these messages not getting mixed up, when numerous wireless stations are working in the

vicinity of each other, and by tuning these transmitters and receivers to definite wave lengths, and by not only tuning them, but by being successfully able to tune them without interference, tapping and mixing up of messages is avoided. This is obviously essential to any wide commercial application of the system.

* * * * * * *

[fol. 483] The demonstration of messages not mixing up, and of the independence of various communications, was first given by me to the English navy at the end of 1900, and was described in certain publications, which, if I were asked I could refer to.

Mr. Betts: That is all, your Honor.

Recross-examination.

By Mr. Clay:

Q. How many attempts did you make to telegraph across the ocean before you succeeded? How many sets of apparatus were built for that purpose?

A. I think I succeeded in getting messages across the Atlantic with the first or the second set, or not later than the second day I tried.

Q. Will you look at this pamphlet, describing Marconi wireless as it was in 1903, and see if that correctly shows your apparatus, and also whether it shows the chart you have put in evidence, on the back page?

A. You mean on the cover?

Q. I mean the whole thing.

* * * * * * *

A. The last page does show a reproduction of the chart you referred me to—at least, I believe it does. With regard to the remainder of the pamphlet, it shows a number of pictures—an artistic reproduction of stations and towers.

The Court: What is your question?

Mr. Clay: Whether it does not show his apparatus as it was in 1903.

The Witness: No, it does not. At least, I do not think it does. It shows pictures.

* * * * * * *

By Mr. Clay:

Q. Does it not show your tower antennae as they are?

A. It shows the towers, yes.

Q. As you used them in 1903?

A. Not necessarily. It shows the actual towers as they were in 1903. I cannot say what apparatus it shows connected with them, because it is simply a picture.

Q. Just let me pick out the ones that you agree show your apparatus as it was. It may be shorter, perhaps, to pick out the ones that do not. Which ones of the pictures do you think do not properly show your apparatus as it was in 1903?

A. I will say that none of them show it. The definition "apparatus" is a lot of apparatus. Here is shown a tower, [fol. 484] which is part of the apparatus. Here is shown a field, which I suppose must necessarily be somewhere.

Q. Mr. Marconi, I wanted the Court to see the kind of antennae you used in 1903, and I will be frank to say to you that I expect to show that you had ideas of antennae which other people did not have and therefore, ideas of electric wave radiation which other people did not have.

A. Well, that helps me, if you intend to show that.

* * * * * * *

My answer was that none of them show it accurately as it was in 1903, but the first picture, after my own portrait, shows the towers as they were—substantially as they were, not accurately—as they were placed in 1903.

* * * * * * *

Q. The pages are not numbered, but take the photographs of the transmitter and receiver on the page that is headed "Simplicity of Apparatus." Is that a correct showing, so far as it shows anything?

A. It shows some apparatus there that resembles very much the apparatus which I used experimentally in 1895 or 1896, I believe.

Q. You think not as late as 1903?

A. No.

Q. Is that a photograph of you at your desk, with apparatus which includes a bell and coherer receiver?

* * * * * * *

A. The picture represents me, I believe. I do not remember it having been taken on the *Philadelphia*. As to the apparatus on the table, one cannot say what the apparatus is very definitely. I think a bell and a relay are shown. The remainder of the apparatus might be anything. It is too small to be distinguishable.

Q. Have you any reason to doubt that these are true photographs of your stations at the places they say?

* * * * * * *

[fol. 485] A. They are a reproduction—rather, they appear to be reproductions of photographs. I do not know at what time the actual photographs were taken, of course.

Q. Do you think this pamphlet could have been issued without the knowledge and consent of the complainant company, or some of its officers, or of yourself?

A. It certainly was not issued with my consent.

Mr. Clay: I offer the pamphlet shown the witness, in evidence, and ask to have it marked Marconi Cross Exhibit No. 3—rather, Defendant's Exhibit, Marconi Cross Exhibit No. 3.

* * * * * * *

The Court: You may mark it for identification, if you wish to.

* * * * * * *

By Mr. Clay:

Q. Do you deny that these are photographs of the complainant company's stations?

A. I neither deny nor affirm it. Certainly, the apparatus shown there is not the apparatus I was using in 1901 or 1902 or 1903. I am referring to "apparatus," understand, not to towers.

Q. About the middle of the book there is what purports to be a photograph of your wireless station on the steamship *Minneapolis*. Is or is not that a photograph of that station (handing pamphlet to witness)?

A. I cannot say. I have never been on the steamship *Minneapolis* in my life. It may be.

Q. You do not recognize your apparatus?

A. You did not ask me that. It certainly looks like some of the apparatus used at that time—that particular picture to which you have referred me.

Q. When was the apparatus put on the *Minneapolis?*

A. I cannot remember. In equipping hundreds of ships, I cannot remember the date of installation on any particular one.

Q. Near the beginning of the book there is what purports to be a photograph of the Marconi Trans-Atlantic Station at Wellsfleet, Cape Cod, Massachusetts. Is that a photograph of your said station?

A. I think it is a fair representation of the outside of the station.

Q. That was there in 1903, was it?

A. Yes.

Q. That shows the antenna you used at that time, does it not?

A. No, it does not. It shows the towers I used. It does not show the antenna.

Q. If anybody can see an antenna, it is the antenna you used there?

A. No.

[fol. 486] Q. I think I can see one. If it can be seen, it is the one you used there in 1903, is it not?

A. None can be seen there.

Q. They were strung between the tops of those towers, were they not?

A. Yes, they were.

Q. In 1903?

A. And they were extended to two other masts around there, that cannot be shown.

* * * * * * *

Q. Will you look at this pamphlet of the DeForest Company, dated September 1, 1902, and state whether you saw it or otherwise knew of the apparatus DeForest was using as early as that.

* * * * * * *

[fol. 487] A. I have never seen this before, which is a stock selling publication, and I do not think I remember having seen anything in connection with the stations he mentions here, at that time, or knowing anything about them.

* * * * * * *

Q. Mr. Marconi, have you not claimed from the beginning to be the only man who has had any wireless telegraph?

A. Let me understand. What do you mean by "had any wireless telegraph"?

Q. Produced any.

A. No. I recognize that for certain limited distances Preece in England, and I think Trowbridge, in America, did transmit messages between places without connecting wires, by using these long extended wires at each place. I believe—I am not saying it myself, but I think it is admitted generally that I was the first to employ electric waves or high frequency oscillations for transmitting telegrams to a distance, without wires.

* * * * * * *

Q. Did you not say, since you came to America this time to testify, that the Arlington Station—this defendant's station—"I think it will be found is mainly a Marconi station, although it has a Fessenden apparatus. The Federal Court of Appeals has already held that the main Fessenden patent is borrowed from Marconi and Lodge." Did you say that?

A. That statement appeared, I think, in what I said before the Parliamentary Committee in England. I did not say that when I came to America. I stated that, if I remember correctly, before the Select Committee of the House of Commons, which was investigating the question of wireless telegraphy.

[fol. 488] Q. Did you ever think that the Court had held that Fessenden's main patent was borrowed from Marconi and Lodge?

A. Yes, I think the Court of Appeals—I have not the facts here—held that one of the Fessenden patents or one of the Fessenden claims was invalid, because Fessenden had utilized Marconi's and Lodge's inventions. I cannot give you the number of the decision of the Court, but I could, if I am given time.

Q. Will you look at this copy of the *Marconigraph*, for June, 1913, and see if you are correctly reported in the Technical Committee's report of Mr. Marconi's evidence, at page 394 (handing book to witness)? Do you know anything about it?

A. I see it here. I have had nothing to do with putting it in.

* * * * * * *

Q. First, will you state if you know what that publication is, and whence it emanated?

A. It is a publication called the *Marconigraph*, edited by J. Andrew White, published in America.

The Court: Well, all that appears on its face. Do you know anything about it?

The Witness: I know that it is directed or it is controlled by the Marconi Company.

The Court: This complainant?

The Witness: I believe so, yes. This is the American publication.

* * * * * * *

By Mr. Clay.

Q. Do you think it is safe to presume that they have given that report correctly?

A. They may have.

Q. I mean, in general substance. I do not mean the particular words.

* * * * * * *

[fol. 489] A. Page 394, I think, may certainly be assumed to be correct, but I have not checked it, or I have not read it. I think that is practically correct.

The Court: Well, you may look it over at your leisure, and see if it is. Mark it for identification.

Mr. Clay: Now, I want to offer this last one in evidence.

The Court: Let the witness look it over at his leisure first.

Mr. Betts: I offer in evidence a certified copy of the file wrapper and contents of Fessenden patent No. 706735 and also certified copy of United States Letters Patent of Fessenden, No. 706736, which letters patent have been offered in evidence as Defendant's Exhibits Nos. 2 and 2-A, and ask that these file wrappers be marked respectively Complainant's Exhibits Nos. 50 and 51.

* * * * * * *

(The papers so offered and identified were thereupon marked respectively "Complainant's Exhibit No. 50," and "Complainant's Exhibit No. 51" of this date.)

[fol. 491] It is hereby stipulated, subject to correction should error appear, that various uncertified copies of

United States and foreign letters patent, and the following publications, to wit, defendant's Exhibits L, M, N, Q, R, S, T, U, V, W, Y, A-1, B-1, C-1, E-1, F-1, G-1, H-1, I-1, J-1, [fol. 492] K-1, O-1, Q-1, S-1, T-1, U-1, V-1, W-1, Y-1, Z-1, C-2, D-2, F-2, G-2, H-2, J-2, K-2, N-2, A-4, B-4, C-4, D-4, E-4, F-4, G-4, H-4, I-4, J-4, K-4, P-4, Q-4, W-4, Z-4, B-5, C-5, D-5, E-5, F-5, G-5, I-5, J-5, K-5, L-5, M-5, R-5, G-6, H-6, I-6, J-6 and O-6, may be received in evidence with the same force and effect as though original copies had been offered, and that the same were published on the printed dates borne by the respective exhibits, or stated in the record at the time of the introduction of the exhibit.

It is also stipulated, subject to correction should error appear, that the following exhibits may be received in evidence with the same force and effect as though original copies had been offered, and that the same were published on the dates indicated thereafter: X, December, 1901; L-1, February 28, 1890; M-1, 1898; N-1, subsequent to July 1, 1896; X-1, 1898; K-6, 1910.

As concerns defendant's Exhibit I-2, it is stipulated that the quotation made by the witness Loftin on page 556 of the typewritten record is a correct quotation from a paper published in the transaction of American Electro-Therapeutic Association in New York, 1894.

In entering into the above stipulation claimant does not waive any objections heretofore entered on the record regarding said exhibits and in cases where said exhibit publications have not been objected to on the ground as being incompetent evidence as proofs of the facts stated therein, said objection is hereby entered thereto.

Dated July 7, 1925.

Richard A. Ford, Sheffield & Betts, Attorneys for Plaintiff.

Approved: Herman J. Galloway, Assistant Attorney-General.

C. V. Edwards, Special Assistant to the Attorney General, for the Defendant.

Deposition of John M. Miller for defendants, taken at New York City commencing on the 30th day of March, A. D. 1923

* * * * * * *

JOHN M. MILLER, having been produced as a witness on behalf of the defendant, was by me sworn before any question was put to him to tell the truth, the whole truth, and nothing but the truth relative to the said question, and thereupon deposed and said that his name is John M. Miller; that his occupation is radio aid in the Bureau of Engineering, Navy Department; that he is 40 years of age; that his residence is Washington, D. C.; that he has no interest direct or indirect in the claim in controversy; and that he is not related to the plaintiff, and thereupon the said John M. Miller was examined by counsel for the defendant and in answer to interrogatories testified as follows:

Direct examination.

By Mr. Edwards:

1. Question. Please state briefly your education and experience in the wireless telegraph and telephone art, having particularly in mind the vacuum tube development of that art.

[fol. 493] Answer. I was a graduate of Yale University in 1904, receiving the degree of B. A. From 1904 to 1907 I was a student in the graduate school of Yale University and also an assistant instructor in the physical laboratory. I specialized in the study of physics. In 1907 I received a degree of master of arts in Yale and later, in 1915 received the degree of doctor of philosophy in Yale. From 1907 until August, 1919, I was employed as assistant and associate physicist in the Bureau of Standards, Department of Commerce, Washington, D. C. For the last seven or eight years I have been engaged in radio research and testing work for the Bureau of Standards. About six or seven years ago I became interested in the theory and operation of different types of vacuum tubes. I started this work at the Bureau of Standards, and when the work became of importance I was put in charge of that branch of the work. During the war a great deal of the research and testing work on these tubes was transferred from the Signal Corps to the Bureau of Standards and I was in charge of this work. My work now is practically such as to be entirely concerned with vacuum tubes, so that I may call this to be my profession. I am at present assigned to duty at the radio naval research laboratory at the Bureau of Standards, and

I am in charge of the vacuum-tube section at that laboratory. In the course of my work I have examined and operated many different types of vacuum tubes.

2. Question. Have you read the depositions of plaintiff's witness, Frank M. Waterman in this case?

Answer. I have.

3. Question. Have you read the record which was produced by Mr. Waterman in his answer to Question 9 of his second deposition and marked for identification in this case?

Answer. I have.

4. Question. Do you find set forth in that record any demonstration or demonstrations which show that the two element valve possesses inherently the same capacity for generating radio waves as is possessed by the three-element device?

Answer. No, I do not. The statement that the two-element valve possesses inherently the same capacity for generating radio waves as is possessed by the three-element device is contrary to thoroughly established scientific facts and it is impossible to make any such demonstration. The two-element valve does not possess inherently the same capacity for generating radio waves as is possessed by the three-element device; in fact, the two-element valve does not possess inherently the capacity for generating radio waves at all. In the demonstrations before Judge Mayer advantage was taken of an obscure, freak, impractical phenomenon in order to demonstrate the alleged inherent capacity of the two-element device for generating radio waves. Even this freak operation of the two-element device is basically different from that of the three-element device. These facts were not presented in the record in the case referred to. On the other hand, testimony was given which was not in accordance with the facts.

The two-element device referred to in the record in question consists of an incandescent filament and cold plate insulated from each other within an evacuated inclosure. The device is physically illustrated in the Edison patent No. 307031, October 21, 1884, Figure 4; and also in the Fleming patent No. 803684, November 7, 1905.

[fol. 494] It is a unilateral conductor; that is, it conducts only in one direction. Thus it can be used as a rectifier or as a detector of radio waves. Normally the device is incapable of generating radio waves. If the exhaustion of the

bulb is not complete so that a definite amount of gas is left in the inclosure, it is possible by reason of the action of this residual gas to obtain oscillations with some two-electrode tubes. In order to obtain this freak behavior, it is also necessary to operate the filament at a high degree of incandescence and to impress a high and critical value of voltage between the plate and filament electrodes of the tube. The operation takes place on the critical border line, beyond which the gas renders the device inoperative for all purposes. The requirements for this freak operation are such as to be destructive of the device itself. Such oscillations as are obtained are unsteady and unreliable, so that the phenomenon is incapable of practical use and is of no utility whatsoever.

If the two-electrode tube is to have any capacity at all for generating radio oscillations there must be a considerable amount of residual gas left in the bulb or must be what is known as a "soft" tube. A high vacuum or "hard" two-element device can not generate radio waves. It will, however, operate as a rectifier or radio detector. The two-element device can only operate as a generator by reason of the residual gas, by reason of what is known as "gas ionization." This critical, worthless operation of the two-electrode tube is not a proof of its inherent capacity for generating radio waves.

Even this freak operation of the two-electrode tube in generating radio waves is basically different from the operation of the three-electrode tube, so that the statement is absolutely untrue that the two-electrode tube has the same capacity for generating radio waves as is possessed by the three-electrode tube.

The three-element device referred to in the record before Judge Mayer is illustrated in the De Forest patent 879532, February 18, 1909. It comprises an incandescent filament, a plate, and another electrode usually grid-like in structure which may be interposed between the filament and plate inside of an evacuated inclosure. It operates as a reliable generator, whether or not gas is present in the tube and irrespective of how high the vacuum is made in the vessel. For purposes of comparison, I produce a drawing which I mark "Miller Drawing A" in which in Figure 1, I have copied Figure 4 of the Edison patent showing the two-element valve, and in Figure 2 I have copied that portion of

Figure 1 of the De Forest patent which shows the three-element device.

Three electrode vacuum tubes will operate as generators if the vacuum is the highest attainable with modern methods of exhaust; in such case the residual gas is one hundred thousandth to a millionth of the amount which is requisite for the generation of oscillations with the two-electrode tube. This fact alone proves that the two devices do not possess the same capacity for generating radio waves and that the basic mode of operation is different.

Even taking the case of a three-electrode tube which does have a considerable amount of residual gas, its basic mode of operation does not depend upon gas. It is a well-known fact that every gas has what is known as an "ionizing potential"; that is, a definite minimum voltage below which the particular gas can not be ionized and therefore can not take part in the conduction through a vacuous space. [fol. 495] The three-electrode tube can be operated as an oscillation generator with applied voltages which are lower than the ionizing potential for any known gas. In this case the operation is completely independent of any gas which might be present in the tube.

The art recognizes two distinct classes of devices which are capable of amplifying or of generating oscillations. One of these classes consists of the so-called "negative characteristic" or "falling characteristic" devices, such as the well-known Poulsen or mercury arcs. When residual gas is present in the two-element valve the device may under certain critical conditions generate oscillations in an uncertain way, due to the falling characteristic of the gas, and hence would come under this class. The other class of amplifiers or generators are of the "amplifying relay" type, such as the mechanical relays and microphone relays used to some extent in telephony. The three-electrode vacuum tube which has replaced these devices in the telephone and wireless telephony field falls under this class. The first of these classes is distinguished by having what is known in the art as a "falling characteristic," and it is by reason of this falling characteristic that they can operate as amplifiers or oscillation generators. The two-electrode vacuum tube does not normally possess this falling characteristic and can not act as an amplifier or oscillation generator. It can only do so under abnormal and critical operating conditions when by reason

of the presence of residual gas left in the bulb it can sometimes be made to have this characteristic and hence be capable of amplifying and oscillating in a worthless manner as a sort of laboratory stunt. The arcs, both the Poulsen and mercury, are commonly known to possess falling characteristics. The former is a well-known and useful generator of radio waves. The basic principle of operation of the two-electrode vacuum tube when generating oscillations by reason of residual gas is identical with that of the arc and the circuit in which it acts as an oscillation generator is identical with the circuit which is used with the arc. This was not pointed out to Judge Mayer. In fact, when Mr. Waterman was asked in cross-examination if the two-electrode device when in an oscillatory condition was acting like an arc, Mr. Waterman answered:

"I do not call that an arc, nor do I call that anything which in any way resembles an arc.

"42. Cross-question. You say that it does not in any way resemble an arc?

"Answer. Yes, that is my understanding of it."

I have repeated many times in my laboratory the demonstration which was made before Judge Mayer and I have investigated the characteristic of the two-electrode vacuum tube which must be obtained in order to make it oscillate. The statement made by Mr. Waterman is not in accordance with the facts, the characteristic which the two-electrode tube must have in order to permit it to act as an oscillation generator is similar to the characteristic of the arc and the mode of operation and circuits of the two devices are entirely similar. The high vacuum two-electrode tube does not have this "falling characteristic" and will not generate oscillations.

The three-electrode vacuum tube operates by reason of the controlling action of the grid. It amplifies or oscillates without residual gas or a falling characteristic. The grid [fol. 496] acts as an electrostatic control over the current flowing between the plate and filament of the tube or what is called the plate current. If the potential of the grid is varied, the plate current varies; if the grid becomes more positive the plate current increases, and vice versa. Thus, if an alternating voltage is applied between the grid and filament of the tube so as to make the potential of the grid vary up and down, the resulting variations of the

plate current will be similar and equivalent to an alternating current superimposed upon the steady plate current which flows when the grid is not acted upon. To produce these potential variations of the grid of the tube requires in general a very small amount of power, but the power represented by the alternating current produced in the plate circuit or the output power can be thousands of times as great. The output power is of the same frequency and wave form as the input power. This is the action of the three-electrode vacuum tube as an amplifier, viz., the output power is an amplified or enlarged reproduction of the input power. It is only necessary in an appropriate circuit to take some of the enlarged output power and feed it back to the input, so that the output itself supplies the input power to make the device operate as a self-generator of alternating currents or an oscillator. This controlling action of the grid is effective no matter how high the vacuum is made; it would still be effective in a perfect vacuum if such were obtainable, and a three-electrode vacuum tube with a perfect vacuum would amplify and oscillate in just the same way as they do in the vacuum which is obtainable in actual practice. Thus I find no demonstration in the record of the case before Judge Mayer which justifies the conclusion that the two-element and three-element devices have the same inherent capacity to generate radio waves and, as a matter of fact, such a conclusion is entirely contrary to well-known and thoroughly established scientific facts.

The above statements are not only my own observations and testimony but are in accord with the accepted views of scientists of the present day. In the recent authoritative work of Dr. H. J. Van Der Bijl, one of the foremost scientists in this field, entitled "The Thermionic Vacuum Tube," I find on page 271, following a mathematical demonstration on the conditions for oscillation of a two-element device, the following:

"From this we see that in order to obtain sustained oscillations from a device having only two electrodes it is necessary that the device shall have a negative resistance. Examples of negative resistances have already been given in the previous pages. Thus, an arc may have a negative resistance, its characteristic being of the form shown by the curve AB in Figure 34. The resistance is given by the

slope of the characteristic and this is a negative quantity for a characteristic of the kind shown. Figure 16, page 48, shows another characteristic which over a region ABC' has a negative slope and is obtained as the result of the emission of electrons from metals under the impact of electrons. Such characteristics as these are sometimes referred to as 'falling characteristics.'

"The thermionic valve does not show a falling characteristic like the curve AB of Figure 34, when it is sufficiently well evacuated to prevent the effects of ionization by collision from appreciably influencing the discharge. The characteristics of thermionic valves are those given and discussed in the previous chapters and it will be seen that [fol. 497] for such devices the resistance is always positive. It is, therefore, impossible to obtain sustained oscillations from a well-evacuated thermionic valve containing only two electrodes. If such a device contains an appreciable amount of gas during the operation, the characteristic becomes unsteady and sometimes, especially at the higher voltages, exhibits regions over which the slope is negative, and when operated over that region it is, of course, possible to obtain sustained oscillations. The condition which makes this possible in a two-electrode device is unfortunately due to the cause which makes such a device unsatisfactory, namely, the presence of too much gas in the device, thus causing unsteadiness of the discharge and making reproducibility practically impossible. If a controlling electrode or grid be added to the two electrodes of a valve, the operation becomes different and we now have a device which can produce sustained oscillations with facility while at the same time satisfying all the conditions that are necessary to secure satisfactory operation in every respect, namely, freedom of gas with consequent steadiness and reproducibility of results and comparatively long life."

* * * * * * *

Doctor Van Der Bijl distinguishes clearly between the two classes of devices represented by the arc on the one hand and the three-electrode vacuum tube on the other, as I have pointed out, is the practise of the art. Thus on page 108 he states:

"It is the negative resistance of the arc which enables it to produce sustained oscillations. It will be shown in Chap-

ter VIII that a device containing only two electrodes can only produce sustained oscillations if it has a negative resistance or a falling characteristic. The principle involved in the production of sustained oscillations by the audion or three-electrode thermionic tube is entirely different and depends on the controlling action of the grid on the electron flow from filament to anode."

Doctor Eccles, an eminent English authority on radio subjects, performed an experiment before the London Physical Society which was analogous to the demonstration before Judge Mayer. Utilizing a special combination of crystals, he was able to obtain oscillations having an audible frequency. His lecture appears in the proceedings of the London Physical Society, volume 22, page 360, 1910. In explaining the operation of his peculiar crystal contact he discusses the characteristic curve of the device, and states on page 361:

"Along this latter part of the curve increasing current is associated with decreasing electromotive force, an unstable state of affairs."

And on page 361:

"The phenomena resembles that of the electrical arc. The unstable portion of the above curve corresponds in fact to the 'falling characteristic' of the arc."

In his book entitled "Wireless Telegraph and Telephony," page 220 (1917 edition), he states:

[fol. 498] "Like the contact detector and for a similar reason, some samples of the Fleming valve can be arranged to give oscillatory current in a shunt circuit."

Outside of this special crystal contact which Eccles utilized I know of no crystals which have other than a rising characteristic. Crystals are incapable of generating oscillations, though a great number of crystal contacts have been and are being utilized as radio detectors. Similar to the demonstration before Judge Mayer, this experiment of Eccles, which was sufficient of a curiosity to exhibit before a learned society, cannot be taken as a proof that crystal detectors are inherently capable of generating oscillations. Further, Eccles points out that it is the "falling characteristic" of the arc which enabled his peculiar crystal con-

tact and some samples of the Fleming valve or two electrode device to oscillate after a fashion.

The very recent (1921) publication of Bernard Leggett entitled "Wireless Telegraphy" shows that the two-electrode device is not considered to be an amplifier or oscillator. Thus on page 160:

"The Fleming valve was purely and simply a rectifier or detector. In no way was it an intensifying device; it did not use a very high vacuum, as is the case in the modern valves of Langmuir and Meissner, and was not a means of generating oscillations like these later valves."

5. Question. Please examine copies of the patents to Hewitt, 781001 and 781002, and also the copies of opinion in the case of Hewitt *v.* American Telephone & Telegraph Co., reported at 272 Federal Reporter, page 194, a copy of which I show you, compare the operation of the device of the two Hewitt patents with the defendant's device referred to in this opinion, and state to what devices the following statement of Judge Mayer in this opinion referred to:

"It was further proved to my satisfaction that defendant's devices amplify not because of any characteristic of the conducting space as in the Hewitt inventions but because of the use of the De Forest grid."

Answer. The Hewitt patents Nos. 781001 and 781002 relate to the use of inclosed gas or vapor conductors as amplifiers in particular to the use of what is commonly known as the mercury arc. Thus the patents state:

"In the present invention I avail myself of the peculiar features of electrical resistance in a gas or vapor conductor to vary or magnify the effects produced by potential variations in a circuit. By virtue of the described characteristics of gas or vapor conductors it is possible, for instance, to translate variations of potential in a circuit into variations of current or quantity, and inasmuch as the conducting gas or vapor responds practically instantaneously to the applied variations of potential currents of any practical rapidity or frequency can be made to undergo the described transformation and produce their effects upon a suitable receiving apparatus."

As I have pointed out in my previous answer, the characteristic of a mercury arc or other two-electrode device, which is necessary in order to permit it to amplify or generate oscillations is the "falling characteristic." Both the two-electrode valve when capable of amplifying or oscillating and the mercury arc are gas devices and operate by virtue of the arc characteristic.

[fol. 499] A device has a falling characteristic when the potential across its terminals decreases under increase of current.

Relative to the Hewitt device, Doctor Millikan, defendant's expert, testified:

"The condition for amplification in such a circuit is that there be a falling electromotive force current characteristic."

In this opinion Judge Mayer makes the following statement relative to the Hewitt device which is likewise applicable to the two-electrode valve used in the demonstration referred to in my previous answer.

"As the result of this and other testimony I am satisfied that, as contended by defendant in the Hewitt circuit, if amplification results it is entirely due to the device having the characteristic that the potential across its terminals decreases under increase of current, and this is the 'peculiar feature of electrical resistance in a gas or vapor conductor' referred to in the specification. Mr. Hogan, plaintiff's expert, in effect, came to the same opinion."

The defendant's device, on the other hand, was the three-electrode vacuum tube, the device with the De Forest grid, as illustrated in my drawing A. Thus the opinion states—

"Defendant's device consists of an evacuated glass vessel with three electrodes sealed in it: (1) The filament heated by an electric current; (2) a grid; (3) a plate. The input circuit is connected with (1) and (2), and the output circuit with (1) and (3)."

"The fundamental principle of operation of defendant's device, according to defendant's contention, is that of a relay."

"Devices of this sort, connected to operate in this manner, are known as 'relay' devices, and a relay in the sense here

used is a device connecting two individually distinct circuits, whereby the signals of one are repeated into the other."

In this later case Judge Mayer was fully informed as to the facts, and the statement to which my attention is called in the question is in accordance with well-known and thoroughly established facts. In this quotation from Judge Mayer's opinion in your question the defendant's device referred to is a hard vacuum three-electrode tube, illustrated in my drawing A, and the Hewitt device is the gaseous two-electrode device.

In other words, the Hewitt inventions referred to in the question are the same thing and oscillate for the same reason as the gaseous two-electrode device demonstrated before Judge Mayer in the record referred to in your Question 3.

* * * * * * *

6. Question. Referring to your drawing A showing the two-element valve and the three-element device, respectively, please explain the fundamental operation of each of these devices.

Answer. The operation of both the Edison two-element valve which is Figure 1 of my drawing A and the three-element De Forest device which is Figure 2 of that drawing [fol. 500] depend upon the peculiar property of a heated filament of emitting what are called electrons or thermions. These electrons are minute negatively charged particles which are shot out from an incandescent filament in enormous numbers per second. The filament of any ordinary incandescent lamp is always emitting these electrons when the lamp is lighted. The mass of these minute particles is about one two-thousandth of that of an atom of hydrogen. In the case of the ordinary incandescent lamp, the electrons shoot out from the filament and after an excursion of greater or less extent return to and enter the filament again. Thus the heated filament is at all times surrounded by a swarm of electrons which are continually being shot out and returning to the filament again.

When a metal plate is sealed in the bulb, in addition to the heated filament as in the Edison tube, the vacuous space between the filament and plate exhibits a unilateral conductivity.

When the plate is made positive with respect to the filament it will exert an attractive force upon the cloud of negatively charged electrons around the filament and a fraction of these will be drawn continually across the space to the plate electrode. These electrons will enter the plate and flow back through the external circuit to the filament again. The convection of these negative charges constitutes an electrical current around the circuit and if a galvanometer is included in the circuit it will indicate a flow of current. The flow of electrons is from the filament to the plate inside the lamp and from the plate back to the filament in the external circuit. It is a flow of negative charges and has the same effect upon the deflection of the galvanometer as would be produced by a motion of positive charges in the opposite direction around the circuit. The direction of current flow has always, by convention, been based upon an assumed motion of positive charges, hence the galvanometer deflection according to the convention would indicate a current flowing from the plate to the filament inside the tube.

If the plate is made negative with respect to the filament, it will tend to repel the negatively charged electrons and hence drive them back into the filament. Thus there will be no flow of current between the plate and filament when the plate is made negative; in fact, in high-vacuum tubes even a hundred thousand volts will not produce an appreciable flow of current in this reverse direction. The device is, therefore, a unilateral conductor, as such it can be used as a rectifier for alternating voltages.

Figure 1 of the sketch which I now produce and mark "Drawing B" illustrates the operation of the Edison two-element valve as a rectifier. The filament F is heated by the battery A. A single circuit connects the plate P and the filament, and in this circuit is a source of alternating voltage and a direct current indicating device I which may be a galvanometer or direct-current ammeter. The alternator voltage makes the plate successively positive and negative with respect to the filament. When the plate is made positive, electrons are attracted to it and flow across the space from the filament to the plate. They enter the plate and return through the external circuit, the indicating device, and the alternator to the filament again. When the alternator voltage makes the plate negative, the electrons are repelled rather than attracted, so that there is no motion of charges through the space between the filament to the plate. There

[fol. 501] is no flow of electricity in the circuit during this interval. Hence a pulse of current flows around the circuit during the alternation of the voltage which makes the plate positive, and these pulses are all in the same direction. Between these pulses or during the negative alternation, the current is zero. The lower part of Figure 1 shows these pulses of current; the base line represents zero current. Such a succession of unidirectional pulses constitute a direct current and will affect a direct current galvanometer, the galvanometer after a fashion averages these pulses and indicates a deflection which corresponds to the average rate of transfer of electricity in the circuit. Thus the action of an alternating voltage upon the two-element valve is to produce a flow of direct current which can actuate a direct current instrument. The two-element device is, therefore, a rectifier.

The three-electrode device of De Forest, which is Figure 2 of drawing A, is an amplifying relay or amplifier. The function of such a device is to magnify alternating current power. When stimulated by an alternating voltage, the device should take little or no power from the voltage source, but should put out an alternating current of exactly the same form as the stimulating voltage and which represents a very much greater amount of alternating current power. Thus the function of an amplifier is to keep the character of the alternating quantities unchanged but to increase their power. This is quite the opposite from the function of a rectifier which is required to change the character, viz., convert from alternating current to direct current and in which the power is all supplied by the source.

The operation of the three-element tube is shown in my Figure 2 of drawing B. In addition to the filament F and plate P of the Edison device, there is a grid G, which as its name implies, is usually a grid of wires interposed between the filament and plate. This device has always two distinct circuits, one connecting the grid and filament in which the stimulating alternating voltage is impressed or the input circuit and the other connecting the plate and filament which is the output circuit and contains the device T which in this case must be responsive to the same frequency as is supplied by the input generator. The operation of the three-element tube requires the insertion of a battery B or a direct current generator in this output circuit. This battery has a voltage of roughly twenty to a hundred volts for low-power

tubes but may be as high as ten or fifteen thousand volts for high-power tubes. The battery is poled so that a positive voltage is always applied to the plate of the tube. Thus the electrons which are being emitted by the filament are always being attracted over to the plate. They pass between the grid wires on their way to the plate. Thus a current called the plate current is always flowing between filament and plate inside the tube and back again through the external circuit. In the grid circuit there is either no battery as shown in the figure, or if any battery is used in this circuit it is poled so as to make the grid somewhat negative with respect to the filament. A flow of electrons to the grid is not desired in this amplifying device; in fact, if any such flow were to here take place it would reduce the efficiency of the device as an amplifier or completely destroy its functioning as such. While the grid does not share in the electron flow through the vacuous space, it can control the flow which is taking place between the filament and plate. A mere [fol. 502] variation of the potential of the grid serves to control the flow of electrons to the plate. Thus if the grid is made more negative, the flow to the plate is reduced; if it is made less negative, the plate current increases. Even with a positive voltage of several thousand volts applied to the plate of the tube, a few hundred volts negative voltage applied to the grid can cut off the flow of current to the plate completely. This controlling action of the grid results from the screening effect which it exerts on the attractive force due to the plate. When the grid of the tube is negative, the attractive force of the plate is exerted primarily on the grid itself and does not get through the wires to the cloud of electrons around the filament. The so-called "lines of force" from the plate terminate largely on the grid itself. When the grid is made less negative, fewer lines of force terminate on the grid and a greater number get through and act on the electron cloud around the filament causing an increase in the electron flow to the plate. This screening action of a grid of wires on electrical forces was recognized and treated mathematically by James Clerk Maxwell many years ago and is given on page 310 of volume 1 of his classic work electricity and magnetism. I have applied the results of Maxwell to the case of the three electrode vacuum tube, and I have shown how the constants of such a tube depend upon the structural dimensions. Thus it is made possible to design, on paper, a tube which is to

have definite values of its electrical constants and hence operate in a definite predetermined manner.

These results of mine are given in a paper entitled "The dependence of the amplification constant and internal plate circuit resistance of a three-electrode vacuum tube upon the structural dimensions, published in the Proceedings of the Institute of Radio Engineers, volume 8, page 64, 1920.

When an alternating voltage is impressed between the grid and filament of the tube, as represented in Figure 2 of my drawing B, the potential of the grid varies up and down in accordance with the impressed voltage. The plate current in the tube will vary up and down in a similar manner as illustrated by the wavy line in the lower part of Figure 2. The dash line represents the undisturbed value of the plate current, the base line corresponding to zero current. The variations in the plate current are symmetrical on either side of the dash line and are an exact reproduction of the voltage variations applied to the grid of the tube. This varying plate current is identical with what is obtained when an alternating current is superimposed upon a direct current, and in fact the alternating and direct current components of the plate current can be separated out. The direct current component is the same as the undisturbed plate current and is of little interest. The alternating component, however, represents the useful output of the amplifier.

Since, as I have pointed out, no appreciable flow of electrons takes place in the grid circuit, the alternator in that circuit does not furnish any current, it merely varies the electrostatic potential of the grid. It is therefore running "light" and is supplying practically no power at all. On the other hand, the alternating component of the current in the output circuit represents a considerable amount of power which can be utilized as desired. The device can [fol. 503] actually proach the condition of being an infinite amplifier of power, viz., a finite alternating current power output for a zero alternating current power input. This does not violate the principle of conservation of energy, for the output alternating current power is supplied by the B battery through the action of the grid. This B battery power is, however, cheap and readily available, while the input voltage may be the weak but precious signal at the end a long telephone line which we want to preserve and strengthen.

This explains the remarkable amplifying property of the three electrode vacuum tube which is due to the De Forest grid and which is responsible for the important position of the device in the electrical art.

7. Question. Is the operation of either of these bulbs changed in any way when operated by high frequency currents from what the operation is when operated by low frequency?

Answer. If both of the devices have a high vacuum there will be no difference in their operation whether operated with low or high frequencies. Thus the alternators in my drawing B could have a frequency as is used in ordinary power installations such as 60 cycles per second or frequencies of the order of those important in wire telephony say 800 cycles per second or frequencies such as enter into radio telegraphy and telephony, fifteen thousand to several million per second and the two-element valve would act as a rectifier, the three electrode device as an amplifier in just the same way and with equal facility in each case. The electrons which represent the moving parts in these devices are, as I have pointed out, extremely light; roughly, an atom of hydrogen which is the lightest atom of matter weighs two thousand times as much as an electron. Thus the moving parts have almost no inertia and both devices operate with the same facility whether the frequency be one per second or fifty million per second. It is true that when either of the devices is so "soft" that the residual gas affects the operation appreciably, these gas effects can depend somewhat upon the frequency. Here we are concerned with charged atoms of matter and in some cases the inertia of these relatively heavy atoms can be appreciable at high frequencies. This is true of gaseous devices in general. It is well known that the Poulsen arc does not operate at high radio frequencies in the same manner that it operates at the lower frequencies. Similarly in the case of the two electrode valve generating oscillations by reason of the action of the residual gas as demonstrated before Judge Mayer, I have not been able to obtain oscillations with this device at high radio frequencies while the three electrode high vacuum tube operates readily at these high frequencies. In fact the three electrode tubes have been used to generate oscillations having a frequency of a hundred million per second.

It is recognized as an obvious fact that devices which

depend upon electronic conduction will operate the same regardless of the frequency.

Thus I note that in the record of the case of Marconi Wireless Telegraph Co. *v.* De Forest, et al. on the Fleming patent (263 F. R. 942) the plaintiff itself offered the Electrical World article of December 12, 1914, explaining the operation of the three electrode device, and called as a witness Edwin H. Armstrong, the author of the article, who [fol. 504] testified that the operation described in the article was based upon experimental investigations conducted at low frequencies, and that—

"Xq. 73. You think then that with electrons in a vacuum there would be no reason for supposing that there would be any different action whether you were working with high frequency; that is to say, radio frequencies or low frequency?

"A. No difference at all.

"Xq. 74. Can you give some brief explanation of why you and other scientists make this assumption that in devices of the vacuum type using electron discharges they would operate under both high and low frequencies in exactly the same way, other conditions being equal?

"A. The mass of the electron is so very small, and the speed so enormously high, that the device is practically without inertia and we would expect for all frequencies within reason, or certainly all frequencies such as used in radio telegraphy, the operation would be the same."

* * * * * *

8. Question. Explain the uses of the two-element valve and the three-electrode vacuum tube in connection with radio signalling?

Answer. The two element valve can only be used as a rectifier at either radio or audio frequency, or as a radio detector in which latter case it is also acting as a rectifier.

The three elemeat device may be used as—

(*a*) An amplifier, at either radio or audio frequency.

(*b*) A combined amplifier and radio frequency detector.

(*c*) An oscillation generator.

(*d*) A combined oscillation generator and radio frequency detector.

Exclusive of the freak gas action which I have discussed before and which is of no practical utility and has never

been used in practice, the two-element valve can only operate as a rectifier or as a detector of radio waves in which case it is, as stated, also rectifying. Even as a detector it is inferior to other available detectors and has had little use in the art. The requirements of a device called a "detector" in the radio art arises from the employment of the very high frequencies which are essential for the effective propagation of radio waves. The currents which flow in the transmitting antenna are high in frequency, the electromagnetic waves which these currents produce and which travel out in all directions have this same frequency.

When these waves impinge upon a receiving antenna they set up feeble currents of like high frequency. The art has instruments which will indicate when there is a flow of high frequency current through them, such as the hot wire and thermo-couple ammeters, but the most sensitive of these instruments is relatively insensitive as compared with the instruments available for the indication of frequencies in the audible range or of direct current. Thus it is difficult to obtain indications with the thermal high frequency meter [fol 505] for much less than a thousandth of an ampere. On the other hand, an audible signal is obtained with good telephone receivers when the current through them is a hundred millionth of an ampere and the frequency of the current is 800 or 1,000 cycles per second. Direct current galvanometers are likewise extremely sensitive and will respond to approximately a billionth of an ampere of direct current. It is obvious therefore that a device which can convert the radio-frequency currents over into currents of audible frequency or into direct current is of great importance in radio signaling. The device which produces this conversion is known in the art as a "detector." Thus Eccles, in the glossary of his Wireless Telegraphy and Telephony, defines a detector as—

"Detector: A receiving instrument for converting high frequency current or voltage into a form of current or voltage capable of affecting an indicating instrument such as a galvanometer or telephone receiver."

Without discussing the operation of the various detectors employed in the radio art, I will enumerate the various important types and indicate their importance: The coherer, the magnetic detector, the electrolytic detector, the crystal detector, and the vacuum tube detector.

The coherer was the original detector in wireless. It was very insensitive and only of historical importance. The magnetic detector while rather insensitive was very reliable in operation and has had a moderate use up until recent years. The electrolytic detector was quite sensitive and at one time appeared to be destined for wide use. The chief objection to this type was its liability to be put out of action permanently by strong signals or atmospheric disturbances. The crystal detector in many forms superseded the electrolytic and all other types. It has held the first place for extensive use, and even to-day is widely used.

The vacuum tube detector in the two element form is said to have had a limited use some years ago. Personally, although I have examined and become familiar with many types of American and foreign commercial radio receivers utilizing various types of detectors during the last ten years, I have never seen a commercial radio receiving equipment adapted to utilize the two element tube as a detector and in fact the only specimens of commercial two element vacuum tube detectors that I have ever seen in the past were in a vacuum tube museum at the Washington Navy Yard. On the other hand, I have been familiar with many types of receiving equipment utilizing the three-electrode vacuum tube as a detector and have tested or used thousands of these tubes of perhaps fifty different types. The three element tube has been used extensively for a number of years and at present is being manufactured at the rate of many thousands per day.

Some forms of crystal detectors such as the carborundum detector are very stable in operation but are relatively insensitive; the two-element valve compares in sensitiveness with these detectors but is less convenient because of the requirement of a battery to heat the filament. The more sensitive crystal detectors such as the galena and "perikon" usually require a rather delicate contact and several preliminary adjustments to find a sensitive point of contact, are liable to require readjustment if jarred or if sub-[fol. 506] jected to severe electrical shocks such as atmospherics or static. These objectionable features are not, however, serious enough to prevent their use by close to a hundred thousand novices to-day. These crystal detectors are sensitive and cheap and use, in general, no batteries. In sensitiveness they even compare favorably with the three electrode vacuum tube when the latter is used in the

old circuits which did not fully utilize the amplifying property of the tube. In the more modern circuits a single three-electrode tube can give a response which is perhaps twenty or thirty times greater than that of the best crystal detector. Excepting for this high sensitiveness which arises solely from the amplifying capability of the three-electrode tube, I am confident that the crystal detector would not have been replaced to any extent as a detector by the three-electrode vacuum tube.

The telephone has been and is almost universally used as the indicator in the reception of radio signals. Thus the conversion of frequency, which is the function of the detector to perform, is from the high radio frequencies to audible frequencies or so-called audio frequencies.

In order for this conversion to take place the radio-frequency oscillations impressed upon the detector must be "modulated" at audio frequency. By this is meant that the amplitude of the high frequency oscillations must be varying at an audio frequency rate. Figure 1 of my drawing C which I now offer, illustrates a radio frequency oscillation which is not modulated. This is what is known in the art as a "continuous wave" or C. W. The amplitude of the oscillations is constant; it differs only from ordinary alternating current in that the frequency may be a million per second. Figure 2 illustrates a so-called "sinusoidally modalated wave." The dotted sine curves show how the amplitude of the oscillations rises and falls. If this variation occurs at a high enough rate so that the oscillations reach a maximum or minimum value, say eight hundred or one thousand times per second, then the oscillations are modulated at an audio frequency. Figure 3 shows the type of modulated wave used in radio telephony, the dotted lines or envelope showing again the variation in amplitude. Either dotted line is the same curve as would represent the variations in current in a microphone transmitter circuit when the vowel "a" (as in father) is spoken into the transmitter. In order to transmit this sound by radio, the high-frequency oscillations in the transmitting antenna must be varied in amplitude or modulated so that the envelope has this form. Figure 4 shows another type of modulated high-frequency oscillations which is characteristic of the spark transmitters used in radiotelegraphy. Each spark discharge of the transmitter sets up a group of high-frequency oscillations in the transmitting antenna. Figure

4 shows two of these groups or "wave trains." If these sparks occur, as is customary, at the rate of about 1,000 per second, there will be a thousand of these wave trains set up per second. Thus the amplitude of the oscillations rises to a maximum and falls again to zero at an audio-frequency rate or the oscillations are modulated at an audio-frequency rate.

The form of the oscillations in the receiving antenna will be in each case a duplicate of the oscillations in the transmitting antenna. But none of the types of oscillations shown in my figure can affect directly either a galvanometer [fol. 507] or telephone receiver. For the amplitude of the high-frequency oscillations is at each instant the same in both the positive and negative directions and the average current is zero for an interval of time longer than the period of the high-frequency oscillation. The action of the detector is to suppress the amplitude of oscillation in one direction; that is, to cause a distortion of the symmetry of the oscillation. In the case of a perfect rectifier, the oscillations in one direction are completely suppressed. We may consider such an action to wipe out completely the portions of the oscillations below the center line in all of the figures. As discussed in a previous answer, the oscillations of Figure 1 then are converted into a succession of unidirectional pulses of current following each other at a rate of say, a million a second. The average of these is a direct current which will affect a galvanometer but would not produce a sound in a telephone receiver. The oscillations of Figure 2 likewise become a succession of unidirectional pulses; however, these pulses are not equal in magnitude but increase and decrease at an audi--frequency rate. This is equivalent to a direct current which is varying at an audio-frequency rate; in fact the upper dotted sine curve represents the form of this varying current. This is the equivalent of an audio-frequency alternating current superimposed upon a direct current. If a galvanometer were used as an indicator, its deflection would correspond to the direct current component; a telephone receiver responds only to the alternating current component. If the original oscillation were modulated, as we assumed, at a frequency of 800 or 1,000 cycles, then the telephone receiver will respond to the rectified oscillations giving out an 800 or 1,000 frequency note. The case of Figure 1 and Figure 2 show wherein modulation at an audio-frequency is required for

telephonic reception which is the method employed almost universally.

When the oscillations of Figure 3 are rectified the varying direct current will likewise have a form similar to the upper dash line. A telephone receiver will respond to only the varying component, which, as was pointed out before, is the form of the microphone transmitter current corresponding to the vowel "a." The response in the telephone will therefore be the vowel "a."

The rectified pulses of current of Figure 4 will again produce a varying current following in from the upper dash line of that figure. The varying component of this, while not a pure sine wave, has a frequency of 1,000 cycles per second, if, as assumed, the sparks at the radio transmitter occur at a frequency of 1,000. The note in the telephone receiver will therefore correspond to the spark frequency of the radio transmitter.

Summarizing thus far, the action of a detector is to convert from radio-frequencies to direct current or audio-frequency current. The latter conversion can only be effected when the radio-frequency oscillations are modulated as in Figures 2 to 4.

Oscillations of the type of Figure 1 are largely used in radio telegraphy and, in fact, are displacing the spark type of Figure 4. These continuous oscillations are also received with telephone receivers by a method known as "beat note" reception. This consists essentially in producing a modulation of the high-frequency oscillations at the receiver instead of at the transmitter. For this purpose a radio-frequency oscillation generator is required at [fol. 508] the receiving station. The frequency of this local oscillator is made slightly different from that of the incoming oscillations and the two sets of oscillations are superimposed. The resultant oscillation is similar to that of Figure 2 and when this is acted upon by a detector there results a note in the telephones.

In general, the detector is not a perfect rectifier and the oscillations in one direction are not completely suppressed but distorted. The mode of operation is, however, not materially different from that explained above. The distorting action of the various types of detectors is similar whether it be a crystal detector, magnetic detector, two-electrode valve or three-electrode vacuum tube. The latter, however, possesses the important function of amplifying

which is not possessed by the other types. This amplifying action may take place simultaneously with the distorting action, in which case the device is called a detector, or some other detector can be used to produce the distortion and the three-electrode vacuum tube used as an amplifier pure and simple. It is this amplifying property which is responsible for the revolution in the radio art brought about by the three-electrode vacuum tube. The latter tube is used as an amplifier of both audio and radio frequency currents or voltages. Suppose that the signals from a distant station, when converted by the detector to audio frequency, produce currents too feeble to cause an audible response in the telephone receivers. Doubtless if telephone receivers were available having five hundred or a thousand times greater sensitiveness, the signals would be audible. The use of the three-electrode vacuum tube as an audio-frequency amplifier permits this result to be obtained. For the weak audio-frequency currents can be applied through a transformer to the input of a three-electrode vacuum tube. They are then magnified and if the telephone receivers are inserted in the output circuit of the tube, the current through the telephone receivers will be twenty to fifty times as great as those obtained without amplification. Or these currents which have been magnified twenty to fifty times can be applied through a transformer to a second vacuum tube and the current in the telephones multiplied again by twenty to fifty times, a resultant magnification of four hundred to twenty-five hundred fold. An apparatus which thus combines transformers and three-electrode vacuum tubes is called an audio-frequency amplifier. Such an amplifier with the telephone receivers constitutes an audio-frequency indicating device of extreme sensitiveness. It is to be noted that its function is entirely different from that of the detecting device. The latter distorts radio-frequency currents and converts them into audio-frequency currents, the former magnifies and preserves audio-frequency currents. Audio-frequency amplifiers are built and sold in large numbers to the public and have been used extensively by the Government. They may be used in radio signalling with any type of detector, amplifying the audio currents supplied by the detector. Or they may be applied to uses entirely separate from radio signaling. For example, during the war both the French and American armies employed such

amplifiers extensively in what was called T. P. S. signaling which utilized audio-frequency currents transmitted through the ground. The use of similar audio-frequency amplifiers employing three-electrode vacuum tubes makes possible long-distance wire telephony.

[fol. 509] Of late years the use of the three-electrode vacuum tube as a radio-frequency amplifier has become of increasing importance. In this use the weak radio-frequency currents which constitute the received signal are magnified before they are applied to the detector and converted into audio frequencies. Such an amplifier usually consists of three-electrode vacuum tubes and transformers, each tube magnifying the radio-frequency output of the tube ahead. The radio-frequency voltage may by successive stages of amplification be increased thousands of times before being applied to the detector. The importance of such results in radio signaling is obvious.

Quite frequently both types of amplification have been utilized in one instrument, called a radio-audio-frequency amplifier. Thus three tubes may be used to amplify at radio frequencies; the output is applied to the detector and then amplified again at audio frequencies through perhaps two tubes more. For convenience the detector is usually a three-electrode tube also though in numerous instances the crystal detector performs the detecting function. With such an instrument radio signals from Europe can be received in America using a small coil indoors for a receiving device instead of the usual outdoor antenna.

As I have pointed out, when the three-electrode vacuum tube is used as a detector, the amplifying action is also going on simultaneously. It may be the equivalent of a detector and audio-frequency amplifier or radio-frequency amplifier and detector depending upon the circuit utilized. In one circuit the distortion is produced in the input circuit of the tube and the resulting audio frequency is amplified into the output circuit. In another circuit the radio frequency is first amplified into the output circuit and is there distorted into audio frequency. That the detecting action is very inefficient as is the case with the two-element valve, is proven by the fact that the net result of the detection and amplification in simple circuits is very little better than that furnished by a crystal detector which does not amplify at all. As stated before it is only when circuits are employed that enhance many times the amplification

which is secured, that the three-electrode vacuum tube decidedly bests the crystal detector in net results.

By reason of the fact that the three-electrode vacuum tube is a power amplifier, it can be made to act as an oscillation generator. As such it has two important uses in radio signalling.

First, it is an extremely convenient source of local oscillations in "beat note" reception discussed above. It can at the same time supply the local oscillations to modulate the received continuous wave signals and also serve to distort the resultant modulated oscillations into audio frequency thus acting simultaneously as a generator and detector, or with equal results a crystal can be employed as the detector, the three-electrode tube functioning solely as an oscillator.

Second, the three-electrode tube can be utilized as an oscillation generator to supply the radio-frequency currents to the transmitting antenna. In this respect it has a number of advantages over other available generators of radio-frequency currents. It is very flexible and readily generates frequencies as high as a million per second. Its competitors, the alternator and arc are not capable of generating such high frequencies. Further the output current of vacuum-tube generators is easily controlled and thus the tubes are particularly valuable for radiotelephony. [fol. 510] At present, single tubes of the three-electrode type have been produced which are capable of supplying 5, 10, or 25 kilowatts of radio-frequency power to transmitting antennas and the available power can be further multiplied by operating the tubes in parallel.

Another important use of three-electrode vacuum tubes is that of acting as "modulators" in radiotelephony. The oscillating vacuum tube supplies continuous waves to the antenna as illustrated in Figure 1, drawing C. In order to transmit telephony, these oscillations must be modulated so that the envelope of the oscillations is a reproduction of the current variations produced by the voice in the microphone transmitter as in Figure 3, drawing C. With very low power vacuum-tube oscillators, this modulation can be effected by the microphone itself. This requires, however, that a certain percentage of the total power be supplied by the microphone. This instrument is capable of supplying only a very small amount of power, so that, the micro-

phone itself can not modulate high-power tubes effectively. Hence a three-electrode vacuum tube is employed to amplify the audio frequency output of the microphone and this amplified output is employed to modulate the oscillations produced by the generator tube. In the case of very high-power tubes, two stages of amplification may be required before sufficient audio-frequency power is produced. The action of the so-called "modulator tube" in wireless telephony is therefore simply action as an audio-frequency amplifier.

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9. Question. Explain what is meant by the characteristic curve of a device, what is meant by a "rising" or "falling" characteristic and what the various types of characteristics indicate?

Answer. The characteristic curve of a device or a conductor is a graph or plotted curve showing the relation between the current through the device and the voltage applied to it. Such a curve is obtained simply by applying various voltages to the device and noting the current which flows through it for each voltage value. Points are then plotted for each pair of corresponding values of voltage and current and a smooth curve drawn through the plotted points. Since the opposing voltage offered by the device is always equal to the applied voltage, the characteristic curve can also be regarded as a graph of the opposing voltage offered by the device for different values of current flowing through it. Figure 1 of my drawing D which I now produce illustrates the characteristic curve of an ordinary resistance such as a wire coil. Such conductors are said to obey Ohm's law, that is, the current is proportional to the voltage. The characteristic curve is for this reason a straight line. Figure 1 represents the characteristic curve of such a coil having a resistance of two ohms. When a voltage of 2 volts is applied to this coil the current will be 1 ampere. This is denoted by point A on the curve. When the voltage is raised to 4 volts the current will be 2 amperes, denoted by point B. If this latter voltage [fol. 511] be reversed the current will also be reversed but will still have a value of 2 amperes. The voltage and current are then considered to be negative and correspond to point C on the curve. If an alternator giving a sine wave alternating voltage having a maximum value of, say,

4 volts is applied to this resistance, the current during a cycle will increase from zero as the voltage increases from zero reaching the point B when the voltage is at its maximum value in the positive direction. As the voltage falls to zero again the current will likewise decrease to zero. The voltage will then reverse and increase in the negative direction. The current will also flow in the reverse direction increasing with the voltage until the point C is reached corresponding to the maximum value of the voltage in the negative direction. Since the current flows in the direction of the alternator voltage and is always proportional to it, the wave form of the current will be a sine curve identical with that of the voltage. While the alternator voltage is, at each instant, in the same direction as the current flow, the opposing voltage offered by the resistance is in the opposite direction to the current. The alternator is supplying the power, the resistance is absorbing the power. We have here a criterion as to whether a device is a generator of alternating current power or absorbs such power. If the variations in voltage across a device are in the same sense or direction as the variations in current through the device, then it is a generator of power; if the variations in voltage across the device are in opposition to the variations in current through it, then it is an absorber of power. In Figure 1 I have introduced the letters, N, S, E, and W, to indicate the directions of the compass, as on a map. The characteristic curve of the resistance at all points runs in the general direction of NE to SW or vice versa.

If I had assumed a higher value of resistance the curve would run more nearly E and W for a given current would cause a greater opposing voltage or voltage drop. If the resistance were infinite then the current would be zero for all voltages and the curve would run E and W. For low values of resistance, the curve would run more nearly N and S approaching that direction as the resistance approaches zero. Thus the curves of all ordinary resistances run in the general direction of SW. to NE. Any conductor which has a characteristic curve that runs at all points in this general direction will exhibit the same behavior as a resistance with regard to the sense or direction in which the opposing voltage varies with varying current. Hence, any device of this type must be a power absorber. Such a characteristic curve is said to be a

"rising characteristic." I shall show later that there are some conductors possessing a characteristic which throughout or at some portion runs in the general direction of SE. to NW. These devices are said to possess a "falling characteristic" and in virtue of this characteristic can function as amplifiers or oscillation generators. In devices having a rising characteristic, increasing current is associated with an increasing voltage drop, or vice versa. The characteristic is also said to have a positive slope. The falling characteristic entails an increasing current associated with a decreasing voltage drop or vice versa. In this case the characteristic is said to have a negative slope.

In the case of such devices as have a falling characteristic or negative slope, when the current through the device increases, the opposing voltage decreases, when the current decreases the opposing voltage increases. This action [fol. 512] assists the changes in current and is just the opposite of the behavior of an ordinary or positive resistance. On this account these devices are sometimes said to act as "negative resistances." In reality they act as alternators, when the current through them is an alternating current, they supply an alternating voltage which assists the flow of alternating current. Suppose, for example, that an alternator is supplying current to a long line of high resistance and one of these "failing characteristic" devices is inserted in the line. As the alternator tends to force current through the line in one direction the voltage drop across the resistance increases and opposes the flow of current. The voltage drop across the falling characteristic device, however, changes in the opposite direction and counterbalances to a greater or less degree the opposition offered by the resistance of the line. For a given change in current the net opposing voltage is reduced or the line behaves as if its resistance were lowered. Thus a given alternator voltage will produce a greater alternating current in the line. If, for example, the alternator were a microphone transmitter operating into a long telephone line, the speech currents in the distant receiver would be increased by the insertion of such a falling characteristic device in series in the line. Thus such a device can act as an amplifier. For stability to obtain in an electrical circuit, the opposing voltage must at each instant be equal and opposite to the impressed voltage in the circuit just as action and reaction counter-

balance each other in mechanics. Thus stability requires that the opposing voltage due to the positive resistance be somewhat greater than the assisting voltage produced by the falling characteristic device. The less this margin becomes, the greater becomes the alternating current produced by a given impressed voltage; theoretically when the margin is reduced to zero, no matter how small is the impressed voltage, it will produce an infinite alternating current in the circuit. This result is, of course, impossible, but represents the condition under which a falling characteristic device such as an arc can self-generate oscillations. Suppose that we have a circuit of inductances and capacities which has a certain natural period of oscillation and a negative resistance device is included in the circuit. Suppose that the characteristic of this device is such and the positive resistance of the circuit has a value such that an alternating current of a frequency corresponding to the natural period of the circuit will produce a greater assisting voltage than opposing voltage. The disturbance produced by closing the circuit, or otherwise, will originate a minute electrical oscillation in the circuit, the voltage assisting this oscillation will exceed the opposing voltage and the oscillation will grow, theoretically without limit. Actually the oscillation will grow up to a limiting value determined by the limitations of the falling characteristic device and will continue indefinitely at this limiting value. It is in this way that such a device operates as a self-generator of oscillations or alternating current. A device having two terminals and not having an auxiliary controlling means or member so as to put it in the relay class, must have a falling characteristic in order to operate as an amplifier or oscillation generator. The possession of a falling characteristic is, however, not conclusive evidence that the device can self-generate oscillations of a high frequency. In order to determine this point it is necessary to know something of the mechanism which pro- [fol. 513] duces the falling characteristic, viz, as to its inertia, time lag, etc. Thus there are cases where a device can have a falling characteristic which results from thermal changes in a filament or from slow changes in the character of the surface of a filament. A falling characteristic will be observed when the characteristic curve is obtained experimentally by slow methods which permit plenty of time for the changes to take place but the device for very

rapid changes would not possess a falling characteristic and could not operate as a high frequency amplifier or oscillator.

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In Figure 2, I show the characteristic curve of a carborundum detector. This curve is taken from Figure 238, page 304, of The Principles Underlying Radio Communication, a Signal Corps, United States Army (1918) publication. It will be noted that this characteristic curve differs from the straight line curve typical of the ordinary conductors that obey Ohm's law. It is, however, a rising characteristic throughout.

It is the fact that the characteristic curve deviates from a straight line or has curvature that permits the carborundum crystal to act as a radio detector. We have seen that the application of a sine wave voltage to an ordinary resistance results in a current which is of the same wave form as the applied voltage. This would not be the case for a carborundum crystal. Referring to the figure, it is observed that an application of 20 volts to the crystal in one direction results in a current of more than 800 microamperes, while a reversal of this voltage causes only some 20 microamperes to flow in the reverse direction. In other words, such a crystal produces distortion which, as pointed out in my answer to question 8, is the necessary requisite for a device to operate as a radio detector. It is evident, therefore, that there is no connection between the functioning of a detector and an amplifier or oscillation generator. The former requires that the characteristic be curved; the latter that in two-element devices it be a falling characteristic. Thus, as in the case of the carborundum crystal, a device can have a curved characteristic and function as a detector without any possibility of its functioning as an amplifier or oscillation generator. On the other hand, the device can have a falling characteristic and function as an amplifier or oscillation generator without functioning as a detector. If the characteristic be both curved and falling, then both functions are possible.

In Figure 3 is shown the characteristic curve of the two-electrode vacuum tube taken from Figure 244, page 313, of the same publication. This is likewise a curved and also a rising characteristic excepting perhaps for high plate voltages where the curve tends to become horizontal.

and approximates the slope of an infinite resistance. For such high plate voltages all of the electrons emitted from the filament are being attracted to the plate as fast as they are being emitted. It is obvious that an increase in the plate voltage can not result in the attraction of any more electrons than the total available number. This is called the "saturation current" of the tube and the filament temperature must be increased and more electrons [fol. 514] emitted from the filament per second in order to obtain a greater current. The dotted curve marked Temp T_2 corresponds to such an increased filament temperature.

Figure 4 taken from Figure 220, page 288, of the same book shows the characteristic of the arc. This is a "falling characteristic" throughout. Descriptive of this curve the 1920 edition of this publication states on page 402, "It is this 'falling characteristic' of the arc that makes possible its use as a generator of undamped oscillations."

Figure 5 is an experimental characteristic curve which I have obtained and which explains the possibility of obtaining oscillations with a "soft" two-electrode vacuum tube as in the demonstration before Judge Mayer. The region of the curve from O to P has a negative slope or is a "falling characteristic." The rest of the curve is a "rising characteristic." I found that oscillations started with this tube when the voltage on the tube reached the point O. At a somewhat higher voltage the tube went over into a "blue glow" and the oscillations stopped. This blue glow is a well-known accompaniment of gas ionization and shows that the tube was a "soft" tube. The characteristics of the two and three electrode high vacuum tubes are rising characteristics throughout, the two-element tube cannot act as a generator, the three-electrode acts as a generator by reason of the grid control and belongs to another class of devices.

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10. Question. You have referred to the arc as having a falling characteristic and as operating by reason of this characteristic. Is this explanation in accordance with the accepted knowledge of the art?

Answer. It is. Figure 4 of my drawing D is taken from the Signal Corps textbook Principles Underlying Radio Communication, which was written by experts from the

Bureau of Standards in conjunction with a number of eminent professors of physics and electrical engineering from various universities. In Fleming's book, Principles of Electric Wave Telegraphy and Telephony, 1916 edition, is given in Figure 86, page 109 (copy of fig. 86 inserted opposite), experimental characteristic curves for a carbon-carbon arc in air and a copper-carbon arc in hydrogen. These are both falling characteristics, the latter being the steeper. They are representative of the so-called Duddell and Poulsen arcs, respectively, the latter being the type utilized extensively in radio signaling. The accompanying theory on the action of the arc as an oscillation generator points out in numerous places that the important characteristic of the arc is that it has a falling characteristic. The Duddell arc is an open arc in air and was capable of generating only frequencies in the audio range and not capable of generating radio-frequency oscillations, at least to any degree of efficiency. Poulsen, however, introduced modifications which are shown, in the figure referred to, as having changed importantly the characteristic of the arc and Poulsen's modifications made possible the utilization of the arc for radio-frequency current generation.

[fol. 515] On page 108 of Vander Bijl's book, The Thermonic Vacuum Tube, already referred to, he shows in Figure 34 a curve A B which represents the falling characteristic of the arc and compares it with a rising characteristic O C which is typical of hard vacuum tubes. The text states:

"Since the slope of the curve A B is negative, the arc has a negative resistance, while the resistance of a gas-free tube is positive.

"It is the negative resistance of the arc which enables it to produce sustained oscillations. It will be shown in Chapter VIII that a device containing two electrodes can only produce sustained oscillations if it has a negative resistance or a falling characteristic. The principle involved in the production of sustained oscillations by the audion or three-electrode thermonic tube is entirely different and depends on the controlling action of the grid on the electron flow from filament to anode."

Also in the book, Wireless Telegraphy, by B. Leggett, on page 375, after discussing the Duddell and Poulsen arcs, the statement is made:

"The existence of the oscillation depends upon the fact that the resistance of the arc varies with the current in such a manner that the potential difference between the carbons diminishes with increasing current, and the arc behaves as though it had a negative resistance."

Eccles in the 1918 edition of his Handbook of Wireless Telegraphy and Telephony states on page 215:

"The ability on an arc to sustain oscillations in a shunt circuit depends on the fact that in the circumstances in which it is used, an increase of current through the arc involves a decrease of the voltage at its terminals, and vice versa. The curve connecting i and v with values of i as abscissæ is called the 'characteristic' curve of the arc: it has a negative gradient."

On page 216, Figure 130, he shows the falling characteristic curve (M P M') of the arc.

Eccles uses a different method of plotting the characteristic curve than is usual. Where he plots currents as abscissæ and voltages as ordinated, the usual custom which I have followed is the reverse. The result is the same; that is, it shows increasing current associated with decreasing voltage, and vice versa.

Almost any textbook on radio will furnish a similar explanation as to the action of the arc as depending upon its falling characteristic, so that I could multiply the number of confirming references indefinitely. It is a fact, therefore, that my explanation is in accordance with the accepted knowledge of the art.

11. Question. Refer to the diagram identified by Mr. Waterman in answer to cross-question 51 and explain how the circuits in these diagrams compare with the circuits of the oscillating arc.

Answer. A typical circuit for the oscillating arc is shown in Figure 1 of my drawing E. This is taken from page 98 of Fleming's book, The Principles of Electric Wave Telegraphy and Telephony, 1916 edition. The arc A is an ordinary carbon arc in air. The battery B supplies direct current to the arc through the resistance R. In a shunt circuit to the arc is a condenser C and inductance L. The oscillations produced by the arc flow in the circuit A C L. In Figure 2 of this drawing I show the identical circuit ex-

[fol. 516] cepting that the arc is replaced by a two-electrode vacuum tube marked "V. T." If this tube is a "soft" tube, as used in the demonstrations before Judge Mayer, then it is possible to obtain oscillations as in these demonstrations. I have done this on numerous occasions. The arc circuit shown in Figure 1 is typical of all arc circuits, but specifically relates to the Duddell musical arc, which was described in 1900 by W. Duddell in an article in the London Electrician, published at London, December 21, 1900, pages 310 to 313, inclusive.

In this paper Mr. Duddell derives mathematically the conditions necessary for the arc to self-generate oscillations. This abstract mathematical treatment is just as applicable to the gaseous two-element tube demonstrated before Judge Mayer as it is to the arc. He shows that—

(1) The characteristic must have a negative slope or its must be a falling characteristic.

(2) The negative resistance of the device must be numerically equal to or greater than the positive resistance of the oscillatory circuit.

On page 12 of the record before Judge Mayer Mr. Waterman states:

"The fact that a two-element valve will oscillate has been known to me for several years, and one circuit in which it will oscillate is the ordinary oscillating circuit used with the oscillating arc, which has been known for many years—as early in fact, as the year 1900, which is prior to the date of the Fleming patent in suit."

Thus Mr. Waterman admits that the two-electrode tube generates oscillations in the identical circuit used with the arc, though in his cross-examination he states that "it does not in any way resemble an arc." In fact, both the circuits and basic mode of operation of the two devices are the same.

Both devices will also operate if the resistance R is placed by an impedance or choke coil, or both the resistance and impedance coils may be utilized.

The impedance coil is most generally used with the arc. Also, while my Figures 1 and 2 show the condenser C and inductance L connected in series, both devices will operate

with the condenser and inductance connected in parallel, although the former circuit is the more usual one employed with the arc. The circuit of Figure 3 shows the impedance Z in place of the resistance R and the parallel connection of the condenser C and inductance L. The condenser C is inserted in order to prevent a short circuit of the battery B through the coil L. This circuit is identical with that used in the demonstration before Judge Mayer and shown in defendant's Exhibit B in this case, excepting for the telephone receivers and condenser C_2, which are not essential. I have also utilized the circuit of Figure 3 in generating oscillations with a "soft" two-electrode tube, as in the demonstration before Judge Mayer.

A distinguishing feature of an arc circuit is the use of either a resistance or the impedance coil such as Z. In each of Mr. Waterman's sketches of the two-electrode tube as a transmitter, the choke coil is utilized excepting in sketches D and F. These sketches, however, show a telephone receiver which is a high impedance and usually a high resistance also and therefore operates in place of the choke coil Z.

. . . . . .

[fol. 517] 12. Question. What tests have you made to demonstrate the correctness of your testimony to the effect that such oscillations as were obtained before Judge Mayer were due to the gas characteristic?

Answer. I was a witness for the defendant in the Marconi-DeForest case in New York. I entered this case after the demonstration before Judge Mayer and after his opinion was rendered. My testimony was given before the master in February, 1920. Prior to this time I had heard of this demonstration and although I had studied vacuum tubes, experimented with them for a number of years, and had made several contributions to the knowledge of their operation, I was entirely at a loss to explain how oscillations could be obtained with a two-electrode vacuum tube. This was contrary to well-established scientific principles and to the well-understood mode of operation of such devices for which the laws had been worked out mathematically by such scientists as Child and Langmuir. In fact it is not possible to obtain oscillations with a two-element vacuum tube. It is necessary to add another characteristic, the characteristic of gas, in order to obtain the freak be-

havior which was taken advantage of in the demonstration before Judge Mayer.

Prior to my testimony before the master, I made a careful study of the record in that case in an effort to determine how this demonstration was worked. The clue resulted from the description of tests in the record, the testimony given by Mr. Waterman and my knowledge of the work of Richardson and Buzzoni published in the Philosophical Magazine, volume 32, page 426, 1916, entitled "Experiments with electron currents in different gases —1— mercury vapor."

In the first test described in the record, the tube showed a blue glow while it was generating oscillations. Such a glow results from the ionization of gas. Thus Mr. Waterman testified:

"34. Cross-question. You noticed this blue glow that occurred in this circuit, Mr. Waterman, when it was acting as an oscillator, as a so-called oscillator?

"Answer. There was a trace of blue glow.

"35. Cross-question. What is the explanation of that?

"Answer. It is the incipient state of the ionization which is occurring around the edge of the plate."

In the second test described in the record oscillations were obtained with another tube which did not show a blue glow. Mr. Waterman testified relative to this test:

"188. Question. Will you explain, Mr. Waterman, the demonstration which has just been made?

"Answer. The demonstration is identical with that which was made yesterday, with three exceptions. The alve which is being used is a different valve and one which on account of a higher vacuum or some characteristic that we do not know, does not require the blue glow in order to oscillate."

Now Richardson and Buzzoni studied the flow of current between a heated filament and another electrode in an evacuated inclosure with mercury vapor present to a cer- [fol. 518] tain degree. They found that in a given range of pressures of the mercury vapor present and under particular values of the external voltage applied upon the tube that they could obtain a critical condition wherein a sudden rise of current through the space was accompanied

with a reduction in the voltage across the space; that is, a falling characteristic. Whether or not a visible glow accompanied this effect depended upon the vapor pressure in the tube. If the vapor pressure was greater than 0.001 millimeter there was always visible glow, but otherwise there was not. In the latter case while the unstable action took place without any visible blue glow, it was accompanied by the production of ultra-violet light.

This corresponds with the tests before Judge Mayer, the vacuum being somewhat higher in the tube tested the second time than in the first, as testified by Mr. Waterman.

Being familiar with the action of an arc as an oscillator, the possibility of obtaining a falling characteristic by reason of gas in a two-electrode tube at once suggested to me the explanation of the demonstration.

I then returned to Washington and attempted to repeat the experiments before Judge Mayer. I wanted a "soft" two-electrode vacuum tube, but this was not available. In fact all of the vacuum tubes used by the Government, both the Navy and Army, were hard vacuum tubes, excepting that in the early days the De Forest audion, a "soft" three-electrode vacuum tube, was employed. The hard tubes had completely displaced the old tube because of the requirement of dependable and stable operation and reasonable operating life, which was not possessed by the soft tubes. I had available one type of two-electrode vacuum tube which was used in connection with the regulation of propeller driven generators in aircraft work, but this also was a high vacuum tube. I then determined to use the old De Forest tube, converting it into a two-electrode tube by connecting the grid and plate electrodes together and using them as one electrode. This is an artifice which is sometimes employed with a three-electrode tube when only the rectifying action of the two-electrode tube is desired. The old De Forest tube was rare at this time, but I managed to borrow four of them for the tests. Later I found that the Signal Corps had a number of them in storage.

I connected up the circuit used before Judge Mayer, which is Figure 3 of my drawing E, and found that by heating the filament of the tube to an abnormal brilliancy and applying a critical voltage to the combined grid plate electrode I could obtain oscillations. At first I could only make two of the tubes oscillate, but later managed to operate all of them. The operation in every case took place

on the ragged edge beyond which the gas became completely ionized and the tube was rendered inoperative for all purposes. The oscillations which were obtained were unsteady, if the tube were left for a time without making readjustments, the oscillations would die out of their own accord. The whole action was typical of the erratic performance of a device in which gas action played a part and which erratic behavior has caused the art to discard soft tubes for commercial work. The operation is destructive of the device itself, for the ionization of the gas produces heavy positively charged ions which, under the action of [fol. 519] the electric field, bombard the filament and literally tear it to pieces. Coupled with the abnormal temperature required, the life of the filament is very short. This freak operation is absolutely worthless from a commercial standpoint. The oscillations furnished by the tube are neither constant in frequency nor in amplitude, and at that the tube requires frequent adjustments of the applied voltages in order to keep it in the oscillatory condition.

In these first tests I observed that the oscillating condition coincided with the unstable behavior of a gas as described by Richardson and Buzzoni.

At the critical point of operation where oscillations commenced the current through the tube increased suddenly, while the voltage across the tube decreased, viz, the device had a falling characteristic like that of the arc.

Lately I have obtained experimental characteristic curves of these devices of which Figure 4 of my drawing D is an example. The difficulty in obtaining such a curve is very great, as can be realized when consideration is taken of the fact that the device is continually changing. This curve shows clearly the falling characteristic portion which permits the freak action.

I also tried to obtain oscillations in the same circuit with the hard two-electrode tube mentioned above. This tube, while not used as a radio detector, is constructed the same way and could be so used. Although I tried various plate voltages up to those which rendered the plate of the tube red-hot and which were many times greater than those applied to the soft tube, and heated the filament to an extreme degree of incandescence, I was unable to obtain any oscillations whatsoever. This is to be expected, for the character-

istics of this tube, which I have investigated with great thoroughness, are rising characteristics throughout.

13. Question. Referring to the testimony of Mr. Waterman concerning the demonstration before the court at which it was claimed that oscillation was obtained, were the conditions of that test such as to indicate the steadiness of the oscillation or the length of its duration?

Answer. In the experiments performed before the court and as described in the record, the methods utilized for showing the existence of oscillations were not methods which would show the variations in the oscillations which were obtained, but would merely show whether or not such oscillations were present.

14. Question. You referred to a test in which the grid of the vacuum tube was connected to the plate, thus making it a two-electrode device. Did you test the same device with the grid disconnected from the plate so that it functioned normally as a three-electrode tube?

Answer. I used the same tube which was utilized in investigating the oscillating effects of the two-electrode tube in such a circuit and with such connections that it operated as a three-electrode tube, in which case the *grid* was disconnected from the plate, operated at substantially filament potential and acted as a control member in the device. With the tube used and operated as a three-electrode tube, I obtained oscillations throughout a wide range of plate voltages impressed upon the tube and of the heating current through the filament. In this case there was nothing critical about the adjustments of either plate voltage or filament [fol. 520] current. Furthermore, the high-frequency current or output current of the device was perfectly steady and the device would operate as an oscillation generator, apparently indefinitely or throughout the life of the tube.

Question 15. How did the presence of gas affect the operation of the tube when it was being operated as a three-electrode device with grid at filament potential?

Answer. The oscillations did not require the presence of a gas. This is proven in the case of this particular tube by the fact that oscillations were obtained on plate voltages so low that it was impossible for these voltages to produce any ionization of any residual gas in the device. It is well known that for any particular gas there is a voltage called the ionization voltage, below which it is impossible to produce ionization in the gas. I operated this three-

electrode tube at voltages below the ionization voltage for any of the known gases.

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16. Question. In your answer to question 12, you state that the operation of a gaseous two-electrode tube as an oscillation generator is worthless from a commercial standpoint. Will you explain this statement further?

Answer. In the present state of the radio art it is impossible to construct tubes to have gas present to a definite degree and to have such tubes exhibit characteristic, depending upon the gas, with any certainty whatsoever. Furthermore, having obtained some tubes which show the desired characteristic, by selection from a great many tubes, these tubes will not show the characteristic permanently, but will throughout their life, show a varying characteristic. In order to make use of this characteristic introduced by the presence of the gas, it is necessary to perform critical adjustments, and the results obtained will vary during the operation of the tube in such a manner as to require continual readjustments of the operating conditions. The unsteadiness and variability of any such device containing gas, and whose operation depends upon gas, is well known to anyone who has investigated the operation of these devices. Further, the critical conditions of adjustment which are required to bring forth these properties in the tube are also the conditions favorable to an early destruction of the tube and short life. In general, it is necessary that the filament should be operated at a very high degree of incandescense. Further, the voltages applying to the device are such as to produce ionization of the residual gas. It is well known that the effect of such ionization is to cause the filament to be bombarded by the heavy positive ions resulting from the ionization and this leads to the destruction of the filament after a relatively short time of operation.

I have pointed out the critical adjustments necessary in order to utilize the possible amplifying or oscillating properties of this device and the necessity for frequent readjustment of these critical conditions. It would be asking too much of the practical wireless operator to require him to [fol. 521] carry on practical operations with a critical device of this kind, even if he were capable of operating it. In the progress of the radio art the striving is always to

simplify and make certain the operations and adjustments of radio apparatus for practical purposes.

The operator's principal function and main concern is to receive messages. Any receiving device which requires a considerable part of his attention would seriously prevent the operator from performing his real duty. It is obviously impossible for an operator to attend to the receiving of messages and at the same time make frequent adjustments of the apparatus by means of which he is receiving those messages.

17. Question. Compare the operation of the two-electrode valve detector in the circuit of the Fleming patent with the operation of the three electrode vacuum tube or audion in the P N circuit of Plaintiff's Exhibit #83 and in the circuit of plaintiff's Exhibit #114.

Answer. In Figure 1 of my drawing F, which I now offer, is shown a simplified diagram of the two-electrode detector in the circuit of the Fleming patent. This figure is similar to Figure 1 of my drawing B, which illustrates the use of the two-electrode device as a rectifier of alternating currents of any frequency whatsoever, excepting that I have replaced the alternator of that figure by the antenna *a* and oscillation transformer *m*, *k*, shown in the Fleming patent. The latter has the same function as the former, viz, the application of an alternating voltage in the valve circuit. In the Fleming use, the frequency of the alternating voltage is a high frequency, as is used in radio transmission. The operation of the valve is the same in both cases; it is to produce rectified currents.

Thus, Fleming states on page 2 of the specification, lines 18 to 27:

"The arrangement described above operates as an electric valve and permits negative electricity to flow from the hot carbon *b* to the metal cylinder *c*, but not in the reverse direction, so that the alternations induced in the coil *k* by the Hertzian waves received by the aerial wire *a* are rectified or transformed into a more or less continuous current capable of actuating the galvanometer *l* by which the signals can be read."

The device is a detector, as I have defined it and as is the accepted terminology of the art, by reason of the fact that it converts or transforms the received high-frequency alter-

nations into direct current. This conversion is effected by a distortion of the high-frequency alternations, the alternations in one direction being permitted to flow while those in the opposite direction are suppressed.

In Figure 2 of my drawing F is a simplified diagram of the P N circuit as used in the reception of radio signals. This diagram is identical in all essentials with plaintiff's Exhibit No. 83. It is similar to Figure 2 of my drawing B, excepting that the alternator of this latter figure is replaced by an antenna and oscillation transformer j^1 j^2, the secondary coil j^2 of which is tuned by a condenser h^1, and, what is of special significance, a small condenser j^3 is inserted in series with the connection to the grid of the tube. To one skilled in the art the presence of this low capacity condenser, commonly called the grid condenser, in this circuit suggests that the three-electrode vacuum tube is intended to operate as a radio detector. It is loosely termed "detector," but actually, as I have pointed out before and will [fol. 522] more fully explain later, the three-electrode tube operates in this circuit simultaneously as a detector and amplifier.

The circuit of Figure 2 of my drawing B, which omits the condenser j^3, is representative of the action of the tube as an amplifier alone. It is true that there are other circuits, which are not detector circuits, in which a condenser is connected in the grid lead; for example, in the circuit of high-power, three-electrode tubes when used for generating oscillations for transmission purposes or in the circuits of direct-coupled amplifiers such as the resistance type amplifier. The purpose of the grid condenser in these circuits is different and the capacity of the condenser need not be small.

The action of the P N circuit is as follows: Suppose, first, that the incoming radio-frequency oscillations in the receiving antenna are of the continuous-wave type; that is, constant in amplitude or unmodulated. Through the intermediary of the oscillation transformer j^1 j^2 a high-frequency voltage is impressed in the secondary coil j^2, and by reason of the tuning of this circuit a greater voltage usually exists across the condenser h^1. This voltage is impressed between the grid G (through condenser j^3) and the filament F of the tube. When the first of these alternations are applied to the tube they produce rectified current pulses between the

grid and filament of the tube, the action being similar in this respect to that of the two-electrode rectifier. These unidirectional pulses consist of a flow of negative electrons from the filament to the grid inside the tube and, as explained before, are the equivalent of a direct current. However, the presence of the small condenser j^3 prevents the lasting flow of direct current in the grid circuit, the current pulses accumulate on this condenser and quickly give it a charge. Since the pulses consist of negative charges moving from the filament to the grid, the plate of the condenser, which is on the grid side, and the grid itself, will accumulate a negative charge. Since electrons will only flow to the grid when it is positive, it is evident that the current pulses will be automatically reduced as the grid receives a negative charge, and no more current pulses will flow when the average grid voltage has become so negative that the alternating voltage, even on its maximum positive swing, does not make the grid positive relative to the filament. Actually there will be a slight leakage of the charge from the grid condenser and the grid, due to the residual gas in the old De Forest tubes which were used in this circuit. Minute pulses of current will flow which are just sufficient to compensate for this leakage.

Summarizing thus far, when the assumed oscillations of constant amplitude first strike the tube, rectified pulses flow in the grid circuit. These pulses, through the action of the small condenser j^3 cause quickly the grid to become negatively charged until the pulses practically cease. No matter how long the oscillations of constant amplitude persist, there will be no further rectification nor will there be any further change in the charge of the condenser j^3 nor of the potential of the grid.

Suppose now the received oscillations cease. By reason of the leakage, the charge on the small grid condenser will quickly dissipate and the grid will attain its original voltage again. Thus the average grid potential responds to incoming oscillations becoming negative when these oscillations are first impressed upon the tube and returning to the normal condition when they are removed.

[fol. 523] Now assume that the amplitude of the incoming oscillations is varying, as is the case of modulated oscillations. It is obvious that the grid will become more negative the greater the amplitude of the oscillations and will return

toward the normal grid potential again as the amplitude of the oscillations decreases. The variations in average grid potential would thus follow the lower dash line curves of figures 2 to 4 of my drawing C for modulated oscillations of these types. These are audio-frequency variations; hence the average grid potential will vary at an audio-frequency rate.

Now, as I have pointed out before, the action of the tube as an amplifier entails that the plate current of the tube shall follow the variations in the potential of the grid. So, as the average grid potential varies in accordance with the audio-frequency modulation of the received oscillations, the plate current will likewise vary in the same manner. These audio-frequency current variations flow through the indicating device I, which is a telephone receiver. The sound which results will be an 800 or 1,000 cycle note or speech, depending upon the type of modulation, as was explained before.

Summarizing, the action of the three-electrode tube in the P N circuit is as follows:

Received oscillations, modulated at audio-frequency, produce rectified current pulses in the grid circuit of the tube when the amplitude of the oscillations is increasing, and thus, by reason of the grid condenser, cause the average grid potential to become more negative. When the amplitude of the oscillations is decreasing, the charge on the grid condenser leaks off and the grid becomes less negative. Thus audio-frequency variations in the average grid potential are produced which correspond to the audio-frequency modulation of the received oscillations. By reason of the amplifying or relay action of the tube corresponding audio-frequency currents are caused to flow through the telephone receivers in the plate circuit. The tube is acting as a detector and simultaneously as an audio-frequency amplifier.

The above explanation stresses the most essential features of the action of the tube in this circuit for the purpose of simplification. The complete action is somewhat more complicated. It can be seen that the grid potential is varying simultaneously at two frequencies. Thus the modulated high-frequency oscillations are varying the grid potential and at the same time the average value of the grid potential is varying at an audio-frequency rate through

the action of the charging and discharging of the grid condenser. The variations of the plate current of the tube exactly duplicate all variations in grid potential, so that in the plate circuit we find both the amplified modulated high-frequency oscillations and the amplified audio-frequency oscillations. The latter, of course, can alone affect the telephone receivers; in fact, the high-frequency oscillations can not flow through its coils. Usually a condenser called a by-pass condenser is shunted across the phones, which provides a by-pass for the high-frequency oscillations while the audio-frequency variations flow through the phones. In this simple P N circuit the amplified radio-frequency oscillations, in reality, go to waste. I have referred to this circuit previously as one which did not fully utilize the amplifying properties of the tube and to the fact that the results obtained with this circuit do not far surpass the results ob- [fol. 524] tained with a good crystal detector. It gives results which are about 50 per cent better than such a crystal and about five times as good as a two-element valve. This circuit has not been used by the Government to any extent. The circuits which have been used are the so-called "regenerative" circuits which utilize the amplified radio-frequency oscillations discarded in the P N circuit and give signals perhaps twenty times as strong. This result is made possible purely and simply by the amplifying property of the three-electrode tube.

In Figure 3 is shown a diagram of the circuit like plaintiff's Exhibit No. 114. A condenser h^2 is connected across the phones to provide a path of low impedance for these high-frequency currents. This condenser, however, is a high impedence for the low or audio-frequency currents and these flow through the telephone receivers. The regenerative feature is brought about by the flow of the amplified radio-frequency currents through the coil j^4, frequently called the "tickler" or "feed-back" coil, which is inductively coupled to the coil j^2. By reason of this coupling, a voltage is fed into the coil j^2 which is in phase with and is additive to the voltage fed into the same coil from the antenna. As a result, when a received radio signal sets up high frequency oscillations in the antenna thus inducing a voltage in the coil j^2, there is simultaneously induced in the j^2 an assisting high-frequency voltage from the coil j^4. This latter voltage can be a number of times greater than the former. The currents which flow in the circuit j^2 h^1 are

multiplied according, as is also the high-frequency voltage across the condenser h^1 which is applied to the tube. Since the change in the average grid potential, as pointed out before, depends upon the amplitude of the radio-frequency oscillations, the audio-frequency variations of the grid potential and likewise the audio-frequency currents in the plate circuit of the tube will be enhanced many times, producing a greatly increased response in the telephone receivers.

The radio-frequency voltage impressed upon coil j^2 by coil j^4 can be, say, four times as great as the voltage coming from the antenna, so that the total voltage is five times as great as in the simple P N circuit. By the well known law of operation of the tube, the audio-frequency current in the telephone receivers, or what is called the signal audibility, will be five squared, or twenty-five times as great. This represents a result which is easily secured by an operator ordinarily skilled in the manipulation of such circuits. This result is only possible by reason of the amplifying property of the three-electrode device which here is utilized twice in the same tube; first, the amplification of the radio-frequency oscillations which supplies the feed-back voltage from the coil j^4, and then the amplification corresponding to the audio-frequency variations in the grid voltage which supplies the audio-frequency currents to the telephone receivers. The device is acting simultaneously as a radio-frequency amplifier, and audio-frequency amplifier, and as a converter from radio-frequency to audio-frequency or a detector. The amplifying property is of the prime importance, for in numerous instances a crystal detector is used in combination with the three-electrode vacuum tube in a similar regenerative circuit, the amplifying functions alone being performed by the tube, the detecting function by the crystal. The results are, in general, even superior to those obtained when [fol. 525] the tube acts as the detector. There is, however, no substitute for the tube as an amplifier. It will be noted that, as in plaintiff's Exhibit No. 114, I have shown a resistance r in parallel with the condenser j^3 in Figure 3. This resistance is universally used in detector tube circuits since the art discarded the old soft tubes. It is a high resistance, of the order of 2,000,000 ohms, and provides the leakage of current essential to restoring the grid potential to its normal value in the action of the tube as a detector as explained above. It is called the "grid leak." The grid

condenser normally has a capacity of about 0.00025 microfarad.

Even the results obtained by the regenerative circuit are dwarfed by the results which are obtained by using the pure amplifying property of the three-element device in multistage radio and audio-frequency amplifiers. For, with two tubes in tandem in a modern audio-frequency amplifier the current in the telephone receivers is multiplied four hundred to twenty-five hundred fold, with both radio and audio frequency amplification there is hardly a limit to the multiplication of the response; the signals can be millions of times greater than would be received with the simple P N circuit, so that signals which with the P N circuit would be of a strength of only one millioneth of that necessary to make them audible would become audible with such an amplifier.

The three-electrode vacuum tube and its circuits as illustrated in the P N and regenerative connections of plaintiff's Exhibits 83 and 114, for example, differ essentially in mode of operation from that of the two-electrode valve detector in the circuit of the Fleming patent. The two-electrode device in the Fleming circuit constitutes essentially a rectifying device in a single circuit in which the received oscillations are rectified and themselves flow through and are indicated by the indicator. On the other hand, the three-electrode device in the P N circuit as well as in the regenerative circuit constitutes essentially a different type of vacuum tube connected to two separate circuits neither of which performs the functions of the Fleming circuit. In the P N and regenerative circuits, while the received oscillations are increasing in amplitude, they produce rectified current pulses which charge the grid condenser, which charges leak away when the received oscillations are decreasing in amplitude or are not being received. Such rectification as occurs is not indicated in either circuit. Even if it were possible to observe this rectification it would not reproduce the audio-frequencies which the detector is intended to indicate. The rectification and flow of current is an incidental action of the tube in properly charging and discharging the grid condenser. What is indicated in the plate filament circuit employed in the three-electrode device is the audio-frequency variation in grid potential caused by the accumulated charges or discharges of the grid condenser. In short, the rectifications in the three-element

device in the circuits of my Figures 2 and 3 are not indicated in the plate-filament circuit nor in the grid-filament circuit. The received oscillations acting upon the grid and grid condenser cause the plate current to vary in a manner so that the plate circuit reproduces the radio-frequencies and also the audio-frequencies caused by the condenser accumulations and discharges.

The fundamental difference in mode of operation is clearly shown by the fact that in the Fleming circuit the feeble [fol. 526] received oscillations must themselves supply the power to actuate the indicator, while in the three-electrode circuits of Figures 2 and 3 the received oscillations are called upon only to vary the potential of an extremely small condenser, and hence supply only a negligible amount of power. The power supplied to the indicator is furnished by the "B" battery under the controlling action of the grid electrode.

In the Fleming circuit the power actuating the indicator must be less than the power of the received oscillations from which it is derived, while in the P X circuit or the regenerative circuit the power actuating the indicator can be greater than that of the received oscillations.

. . . . . .

18. Question. Compare the operation of the two-electrode valve detector in the circuit of the Fleming patent with its operation when a battery is employed. Contrast this with the operation of the three-electrode vacuum tube.

Answer. To simplify my explanations I have assumed in general thus far that the detector, whether Fleming valve or crystal, is a perfect rectifier. Such a device would readily permit a current flow in one direction, no matter how small the impressed voltage, but would not permit any flow in the reverse direction. Unfortunately such an ideal device is not known in the art; relative to the known devices, it can only be stated that they conduct better in one direction than in the other. When an alternating voltage is applied to the ordinary rectifiers the current flow during an alternation in one direction exceeds the current flow in the reverse direction during the opposite alternation of the voltage. The difference between these currents represents the rectified or direct current. The difference in behavior of the device for alternations in the two directions is intimately linked with the characteristic curve of the device. Thus in

my answer to question 9 I pointed out that it is a matter of the bending or curvature of the characteristic curve.

If the characteristic curve is a straight line, such as is the case for an ordinary resistance coil, then the two alternations will produce equal current fluxes in the two directions and there will be no rectification. If, however, the characteristic curve is bending or has curvature as was the case for the carborundum crystal curve shown in that answer, then the rise of the curve in one direction will be more rapid than its fall in the reverse direction, or vice versa, and the current flow in the two directions will be different. The difference represents the rectified current, and it is apparent that the amount of rectified current which results depends upon how sharply the characteristic curve is bending or upon the extent of its curvature. Thus if one crystal were to show a curve with a sharper bend than another, the rectified current furnished by the first crystal would be greater and it would be a better detector. It may be that one portion of the characteristic curve of a given detector is nearly straight, while another portion is decidedly curved. If the straight portion of the curve were to come at zero voltage then when the alternating voltage is applied, so as [fol. 527] to swing equally on either side of zero, there would be little or no rectification and the device would be a very poor detector. Suppose, however, that we apply a steady voltage, frequently called a "biasing" voltage, to the detector which brings it to the portion of the curve which is decidedly curved. There will be, of course, a steady current flowing through the detector due to the biasing voltage. Now, if the alternating voltage is applied on top of, or in series with, the biasing voltage the voltage swings will be equal on either side, but since the curve is decidedly curved at the point around which the voltage is swinging, the increase in current on one swing will be decidedly more or less than the decrease in current on the other swing. Neglecting the steady current, it is clear that the alternating voltage is producing a greater current flow in one direction than in the other, viz, a considerable rectified current is produced. Thus the device becomes a good detector merely because the steady or biasing voltage has fixed the operating point at a portion of the characteristic which is more favorable to rectification. Some devices show a favorable portion of the characteristic at zero voltage and with such devices the biasing voltage is not necessary; oth-

ers show an improvement in sensitiveness when the biasing voltage is employed. For small alternating voltages the carborundum crystal is a very poor rectifier at zero voltage; it can be seen from the curve, which is Figure 2 of my drawing D, that in the immediate vicinity of zero voltage the characteristic curve of the carborundum crystal is nearly a straight line. The sensitiveness of this crystal is improved by applying a positive biasing voltage so as to bring the operation on the curved region of the characteristic. Practically all of the crystal detectors commonly used in the Navy operate so well at zero voltage that the slight improvement in sensitiveness which might be obtained with a biasing voltage is not considered of sufficient importance to justify the provision of a battery and other accessories in order to utilize it. The use of a battery in connection with the Fleming valve is identical to its use with crystal detectors. In some cases the rectification is improved when the operation is shifted to a part of the characteristic curve which has a more favorable curvature; in other cases no improvement is obtainable.

It is necessary to distinguish between an increase in sensitiveness such as is produced in some cases by the use of a biasing battery and what is meant by the technical term amplification. An increase in sensitiveness of a detector produces, it is true, an increased response in the telephone receivers, and this might be popularly termed an amplified response. Technically, however, this is not amplification, and with or without the biasing battery the crystal detectors and Fleming valve are not amplifiers. The function of the detector is to convert the received radio-frequency power over into audio-frequency power. There is always a loss in this conversion and the audio-frequency power is always less than the received radio-frequency power; in many cases the audio frequency power is an extremely small percentage of the radio-frequency power.

The action of the biasing voltage is to improve the efficiency of the conversion; it must, however, always be far below 100 per cent in efficiency. Amplification does not involve a conversion of frequency. The frequency is kept the same, whether it be radio or audio. The power is, however, multiplied perhaps hundreds of times in a single stage [fol. 528] of amplification and this process can be repeated indefinitely. The use of a battery with a detector is optional; the use of a battery with an amplifier is indispensa-

ble by reason of the law of conservation of energy. In the case of the ordinary detector, the received energy is merely converted from one frequency to another; in the case of an amplifier the output of energy is many times the input of energy, which, of course, requires a supply of energy from a local source. The plate or "B" battery of the three-electrode vacuum tube is this local source.

When the three-electrode vacuum tube is used as a detector, it is, as I have pointed out before, both a detector and an audio-frequency amplifier. The frequency conversion will entail a loss of power which, however, may be made up by the amplifying action of the tube, so that there is a possibility in this case of obtaining an audio-frequency response which represents a greater amount of power than is contained in the received radio-frequency signal. There is no such possibility with nonamplifying devices such as the crystal or Fleming valve.

Question 19. Describe the operation of the three electrode vacuum tube as an amplifier, particularly the circuits of plaintiff's Exhibit No. 85 and No. 110, and other types of amplifiers.

Answer. The De Forest audion amplifier, which is plaintiff's Exhibit No. 85, is representative of an old type of amplifier which used the old De Forest three-electrode tubes and was the first audio-frequency amplifier employed by the Navy. Only a few of these amplifiers were put into naval service, they were soon replaced by very much more efficient instruments designed by the Navy at the Washington Navy Yard in particular by a type of audio-frequency amplifier known as the S. E. 1,000, which utilizes high vacuum three-electrode tubes. The Signal Corps of the Army did not use vacuum tubes to any extent prior to the war. During the war, however, they used extensively an audio-frequency amplifier known as the S-C-R-72 which was designed for them by the Western Electric Co. This was also an efficient amplifier which multiplied the audibility of signals some two hundred times and employed high-vacuum tubes. These amplifiers were all intended and designed to handle audio-frequency currents and would only operate to amplify such currents. These currents might be the audio-frequency currents resulting from the action of a detector of any type on received radio-frequency signals, or the same amplifiers could be used to amplify audio-frequency currents in any other field. Thus the S C R-72

amplifier was extensively used in connection with the reception of ground signaling currents, in which method of signaling only audio-frequency currents were employed. It was also used to tap the telephone lines of the enemy. Any of these amplifiers used with a telephone receiver constitutes in effect a telephone receiver which is hundreds of times more sensitive. They replace such a telephone receiver in the various circuits and are designed to have approximately the same electrical characteristics, such as electrical impedance, as is possessed by the telephone receivers.

The more modern amplifiers do not differ greatly, excepting in efficiency, from the circuit of plaintiff's Exhibit No. 85. In the modern amplifiers, the three batteries marked B^2 are replaced by a single battery which supplies [fol. 529] the plate voltage to all of the tubes. Also the amplifier of plaintiff's Exhibit No. 85, is peculiar in that one terminal of the secondary winding of the transformers 1, 2, and 3 is left open and not connected to anything. In all but these earlier amplifiers this terminal of the secondary winding is connected to the negative terminal of the filament, for it is desired to apply the voltage of this secondary winding between the grid and filament electrodes of the tube. In fact, the audio-frequency amplifier shown in defendant's Exhibit D, which is also one of the early De Forest amplifiers, shows this connection completed in the usual manner.

The condenser *h*, which is in the primary winding of the transformer 2 (of Exhibit No. 85), is also not usual in later types. The presence of this condenser shows that this amplifier when used in radio signaling is intended to be used with a crystal detector. Mr. Waterman is incorrect in his statement in answer to question 33, in which he says:

"Referring again to Mr. Graham's diagram, Exhibit No. 85, the two left-hand terminals X Y correspond to X Y on the diagram just produced, being the two terminals which would be connected to the receiver in place of the telephone of Exhibit No. 83."

For in the circuit of Exhibit No. 83, which is the P X detector circuit reproduced as Figure 2 of my drawing F, the plate battery "B" is applied to the plate of the tube through the indicator I which is a telephone receiver and the plate current of the tube flows through the telephone receiver. If now the terminals X Y of Exhibit No. 85 were

connected in place of the telephone receiver, as Mr. Waterman says, the condenser *h* would be put in series in the plate circuit of the tube. Such a condenser is, of course, an open circuit for direct currents and the plate current of the tube could not flow, thus rendering the tube inoperative.

This particular amplifier is therefore not intended for use with a three-electrode vacuum tube detector but for use with a crystal detector, which, as Mr. Clark testified, was the customary method of use of these early amplifiers in the Navy.

In my drawing G which I now offer is shown in Figure 1, a circuit diagram of the Navy type S. E. 1,000 amplifier. This amplifier is intended for use with either a crystal or three-electrode vacuum tube detector, the terminals X Y being connected in place of the telephones in such circuits. It will be noted that there is no condenser such as *h* of plaintiff's Exhibit No. 85 in the primary winding of the transformer T_r1; likewise the secondary circuits of the transformers T_r1 and T_r2 are connected to the grid and filaments of the first and second tubes, respectively.

The later types of amplifiers do not have the condenser *h* and can be used with crystal or vacuum tube detectors.

The operation of such an amplifier is very simple. Where substituted for the telephone receivers, the audio-frequency current which was flowing through the winding of the receivers will flow instead through the primary winding of the first transformer T_r1. This winding is designed to have the same impedance as the usual telephone receiver and hence the same audio-frequency current will flow through it and the same voltage be applied to its terminals.

The secondary winding has three to ten times as many turns as the primary winding in the usual designs, hence the transformer is what is known as a step-up transformer [fol. 530] and the voltage across the secondary terminals is several times higher than that applied to the primary. This result is possible only because of the fact that the grid circuit of the three-electrode vacuum tube, to which the secondary terminals are connected, takes an inappreciable amount of power and hence the current supplied by the secondary circuit of the transformer is negligibly small. A transformer is not an amplifier; the power in the secondary is, if anything, less than the power supplied to the primary. Hence, if the secondary voltage is to be higher

than the primary voltage, the secondary current must be correspondingly less than the primary current. The secondary voltage of T_1 is applied between the grid and filament of the first tube and by reason of the controlling action of the grid a corresponding audio-frequency variation is produced in the plate current of the tube which flows through the primary of the second transformer T_2. Here we have amplification contributed by the vacuum tube, for the power in the primary winding of this second transformer will be many times greater than the power in either primary or secondary winding of the first transformer. Even in the older amplifiers, such as shown in plaintiff's Exhibit No. 85, the audio-frequency current in the primary of the second transformer would be five times as great as that in the primary of the first transformer, which means a twenty-five fold amplification of power.

In the later types, such as the S. E. 1000 and S. C. R. 72, the power will be two hundred to four hundred times greater. The voltage across the secondary winding of T_2 is applied between the grid and filament of the second tube. Again, amplified currents are produced in the plate circuit of this tube which flow through the telephones. The audio-frequency power in the telephones in the case of this S. E. 1000 amplifier is about one hundred and sixty thousand times as great as the power in the primary of the first transformer. This corresponds to a multiplication of current of four hundred times, or the amplifier and phones constitute an indicator which is four hundred times more sensitive than the phones alone. In many amplifiers arrangement is made so that the telephone receivers can be substituted in place of the primary winding of the second transformer if only moderate amplification is desired. In this case the amplifier would consist of one transformer and one three-electrode vacuum tube with the telephone and would be called a single-stage amplifier. If greater amplification is desired, the second transformer and tube is employed and the phones are moved to the plate circuit of the second tube as shown. This is called a two-stage audio-frequency amplifier. The S. E. 1000 and S. C. R. 72 are amplifiers of this type, and provision is made in the S. E. 1000 amplifier to use one or two stages as desired.

In modern efficient amplifiers more than two stages of audio-frequency amplification are rarely employed. The older type of plaintiff's Exhibit No. 85 uses three trans-

formers and three tubes and is a three-stage amplifier. Each stage, however, only multiplies the current about five times, so that the three stages multiply by 5 by 5 by 5 or 125 times, which is less than that obtained with the two stages of the later instruments.

Plaintiff's Exhibit No. 110 might easily be confused with the three-stage audio-frequency amplifier of plaintiff's Exhibit No. 85, and is, in fact, so confused in Mr. Water- [fol. 531] man's description. In reality Exhibit No. 110 shows a combination of the P-X detector circuit and a two-stage audio-frequency amplifier. In my Figure 2 of drawing G, which reproduces Exhibit No. 110, the dash line *a b* and terminals X Y are shown in order to prevent such confusion. The circuit to the left of the dash line is the typical P-X detector circuit and is entirely similar to my Figure 2 of drawing F and plaintiff's Exhibit No. 83 which show this P-X circuit. The presence of the usual grid condenser in the grid lead is to be noted. The circuit to the right of the dash line or from the terminals X Y is a typical two-stage audio-frequency amplifier circuit.

In other words, plaintiff's Exhibit No. 110 shows a P-X circuit in which the telephone receiver is replaced by a two-stage audio-frequency amplifier. The conversion from radio to audio-frequency takes place in the detector circuit to the left; to the right only audio-frequency currents are employed. In his answer to question 34, Mr. Waterman describes the three tubes of this circuit as being detector bulbs; thus he states:

"Three detector bulbs T, T^2, T^3 together constitute the detector, R being the telephone indicator."

This statement is nonsensical; the tandem connection of three detectors is unknown in the art. There is only one conversion of frequency to be performed, viz; from radio to audio. This is accomplished in the first tube circuit. What possible function could any further detectors perform? As a matter of fact, as stated above, tubes T^2 and T^3 act only as amplifiers; they serve only to amplify the audio-frequency output of the first tube.

A similar idea is apparently contained in a later statement in this same answer of Mr. Waterman and with reference to this same circuit.

Thus he says:

"The operation of a tandem series of bulbs is the same substantially as that of a single bulb; that is to say, each

successive bulb repeats the action of the one before it. Thus the first bulb T' (referring to fig. 88a) detects • • •."

The reproduction of figure 88*a* of the Navy manual for 1915 is plaintiff's Exhibit No. 110 and my figure 2 of drawing G. From this quotation of Mr. Waterman the natural inference to be drawn is that he is stating the operation of the three tubes in this circuit to be identical; viz, all three tubes are detectors. Such a statement is not in accordance with the facts, as would be recognized by the veriest amateur in the radio art. It is true that all three tubes are amplifying, for the three-electrode vacuum tube is always an amplifier. As I have pointed out before, the first tube is detecting and amplifying also. It is, however, called a detector in the art by reason of its detecting action. The second and third tubes are amplifying alone and are known in the art as amplifiers. They are not detectors and are not called detectors by anyone skilled in the art.

In the circuit of Exhibit No. 85, all three tubes are acting the same, viz, all three tubes are purely and simply audio-frequency amplifiers. There is sense in a tandem arrangement of amplifier tubes, viz, each tube multiplies the radio-frequency currents supplied by the preceding tube.

In recent years there has been a very great development in the field of radio-frequency amplification; that is, in am- [fol. 532] plifying by means of three-electrode vacuum tubes the received radio-frequency oscillations before subjecting them to conversion to audi-frequencies in a detector. In radio-frequency amplification there are three well recognized types of amplifiers called resistance, reactance, and transformer type amplifiers. These are named from the type of coupling element utilized between the vacuum tubes, which element serves to apply the amplified output of one tube to the input of the succeeding tube. The transformer type of radio-frequency amplifier is the type which has been most widely used, especially by the Government. The circuit is entirely similar to that used in the audio-frequency amplifiers described above, though the transformers themselves are markedly different. The radio-frequency transformers have relatively few turns, usually the same number in the secondary as in the primary, and are either air core or employ iron cores made up of iron sheets having a thickness of a few thousandths of an inch. Usually radio-frequency

amplification is employed together with audio-frequency amplification, and the complete instrument, called a radio-audio amplifier, comprises several stages of radio-frequency amplifications, a detector to convert to audio-frequency, and several stages of audio-frequency amplification. The detector is, for convenience, usually a three-electrode vacuum tube detector though in numerous instances a crystal detector is employed. As employed by the Navy, a radio-audio amplifier utilizes six vacuum tubes, three of which serve to amplify the radio frequency currents, one is a detector, and two amplify audio-frequency currents. A simplified circuit diagram of such an amplifier is given in my drawing H. On the left is the usual antenna and receiving circuit drawn in dash lines, which is, of course, not included in the instrument.

The radio-frequency voltage across the condenser C, resulting from the received signal, is applied between the grid and filament electrodes of tube 1. By reason of the controlling action of the grid, a radio-frequency current variation of like wave form is produced in the plate current and flows through the primary of the transformer T_1. The voltage at the secondary terminals of this transformer can be, say, five times greater than the original voltage impressed on the grid of tube 1. This is applied to the grid of tube 2 and in a similar manner produces a voltage on the input of tube 3 which is again multiplied five times. The radio-frequency voltage applied to tube 4 will then be 5 by 5 by 5 or one hundred and twenty-five times the original voltage applied to tube 1. Tube 4 is the detector tube and includes in its grid lead the usual grid condenser c' and grid leak r. By the use of radio-frequency amplification we have therefore increased the radio-frequency voltage applied to the detector by one hundred and twenty-five times. By the well-known law of operation of such a detector, the audio-frequency current output will be 125 squared, or 15,600 times as great as it would be were such amplification not utilized. The power is proportional to the current squared and hence is two hundred and fifty million times as great as without amplification. The audio-frequency output current of the detector tube is then amplified say four hundred times through the audio-frequency transformers T_4 and T_5 and tubes 5 and 6 in the manner described above.

[fol. 533] The resulting audio-frequency current in the telephone receivers is therefore 400 by 15,600 or over six million times as great for the same received signal as would be received with a detector tube alone. Of course, any signal that would produce an audible response with a detector alone would be far too powerful for such an amplifier to handle. The amplifier would be used to receive signals thousands of times too weak to be received on a detector alone. The values which I have given above represent moderate values, for the amplification obtained in such radio-audio amplifiers employing three-electrode vacuum tubes. I have myself designed and built a number of such amplifiers for the Navy and have made hundreds of measurements of both the radio and audio amplification obtained with such instruments.

The two-electrode valve is incapable of use as an amplifier and there is no possibility of utilizing it in such tandem arrangements as described above for either audio or radio frequency amplification. When by reason of residual gas the two-electrode tube is given a falling characteristic, as in the demonstration before Judge Mayer, there is a possibility that it might amplify after a fashion in a laboratory demonstration. There is the same possibility in the mercury arc which was tried out and discarded in wire telephony. However, this gas action in the two-element valve would be of absolutely no utility commercially, because it is thoroughly unreliable in operation, would require constant attention and adjustment, and the device would have a life of only a few hours. As to the use of such devices in tandem, I cannot conceive how this could be done. It is a two terminal device with a single circuit, and as such I cannot imagine how it would be connected into such circuits as are employed with the three-electrode vacuum tube, which is a three-terminal device with two separate circuits. It has surely never been done practically. Suppose, however, it were possible and one connected up six of these tubes in tandem in an amplifier. Each tube would have to be separately adjusted to the critical condition wherein it exhibited the following characteristic: Each tube would be continually changing, so that doubtless by the time the second or third tube were adjusted the first would be out of adjustment again. It would seem to be beyond human skill to get such an arrangement operating and to keep it in operation.

On the other hand, the amplifiers employing the three-electrode vacuum tube are dependable in operation and are being used by perhaps a hundred thousand novices in the radio art, viz, the broadcast listeners, in addition to their use by hundreds or thousands of commercial operators. These amplifiers use high vacuum three-electrode tubes and are not at all critical in operation. Any reasonable value of filament current or plate voltage can be employed, and the life of the tubes when not abused may be a thousand or ten thousand hours of service, viz, it is of the same order as the life of the ordinary incandescent lamp.

* * * * * * *

[fol. 534] 20. Question. Describe the operation of the three-electrode vacuum tube as an oscillation generator, in particular referring to the ultra-audion circuit of plaintiff's Exhibit No. 109, the vacuum-tube receiver circuit of plaintiff's Exhibit No. 114, and the vacuum-tube transmitter circuits of plaintiff's Exhibit No. 116.

Answer. In my answer to question 8, I have pointed out that there are four important uses of the three-electrode vacuum tube.

(*a*) An amplifier, at either radio or audio frequency.

(*b*) A combined amplifier and radio-frequency detector.

(*c*) An oscillation generator.

(*d*) A combined oscillation generator and radio-frequency detector.

The use (*a*) has just been considered in detail in my answer to question 19. The use (*b*) was discussed in my answer to question 17, in which the operation of circuits such as the P-N detector and regenerative circuit was explained. The uses (*c*) and (*d*) will now be treated. The vacuum-tube circuits of plaintiff's Exhibit No. 116 are intended to show the typical circuits used with the vacuum tube as an oscillation generator. As such they would illustrate the use (*c*). Unfortunately, three of the four circuits which Mr. Clark has given in this exhibit are inoperative for reasons which I shall point out. The only operative circuit in this exhibit is the one marked "General Electric (No. 1)." I find circuits resembling the one marked "De Forest" and the one marked "Western Elec-

tric" in the publication Naval Aircraft Radio, which is plaintiff's Exhibit No. 117, but it appears that, in simplifying these circuits, Mr. Clark has left out features which are essential to the operation. Also I find a circuit resembling the one marked "General Electric (No. 2)" in plaintiff's Exhibit No. 118. This circuit is, however, also inoperative as depicted by Mr. Clark.

The three inoperative circuits utilize what is known in the art as a "parallel plate battery" connection. This type of circuit to be operative requires a radio-frequency choke coil in series with the plate battery marked B^2 in the diagrams of plaintiff's Exhibit No. 116. Such coils are shown in the original circuit diagrams. The operative circuit marked "General Electric (No. 1)" utilizes a "series plate battery" and does not require such a choke. In the circuit marked "General Electric (No. 2)" Mr. Clark has also omitted the grid leak resistance across the grid condenser c_1 which likewise would prevent operation when high-vacuum tubes, such as are used with this circuit, are employed. In fact, a common method of stopping the oscillations in signaling with such a transmitter is to open up the grid leak resistance with the signaling key or to insert a condenser without a grid leak in the lead to the grid.

These circuits, when properly drawn, would be representative of the use of a three-electrode vacuum tube solely as an oscillation generator, in which case the tube is used for the transmission of radio signals, both telegraph and telephone, as distinguished from the use of the tube for the reception of such signals. The tube is functioning as a high-frequency alternator. The tubes used for this pur- [fol. 535] pose are evacuated to an extremely high degree, for in many cases a thousand volts or more is employed for the plate voltage or what is called the "B" battery. Normally the tubes are also very much larger than the tubes used in reception.

The use (*d*) of the three-electrode vacuum tube as a combined oscillation generator and detector is illustrated in the ultra-audion circuit of plaintiff's Exhibit No. 109 and the vacuum tube receiver circuit of plaintiff's Exhibit No. 114. These are the circuits utilized in the so-called "beat-note" method of reception, which is the method employed for the reception of unmodulated oscillations or continuous waves.

The art has progressed strongly toward the exclusive use of continuous waves in radio-telegraphy. To-day, almost without exception, continuous waves are employed in high-power long-distance communication. To receive these waves the beat method is universally employed, which method, as I have pointed out before, requires a local oscillation generator at the receiving station.

When these local oscillations are properly combined with the incoming received oscillations, modulated oscillations are obtained. The local oscillator is made to generate oscillations which differ slightly in frequency from the received oscillations, hence at one instant the local oscillations will be in step with the received oscillations and a little later will be out of step. When the two oscillations are in step, they will assist each other and the combined oscillation will be increased in amplitude; when they are out of step, the two oscillations will oppose and the combined oscillation will be decreased in amplitude. This is similar to the "beats" which occur in music when two notes slightly different in pitch are sounded simultaneously, in which case the ear can recognize the swelling and subsidence of the amplitude of the oscillations. The number of times per second that the oscillations get into step, or the number of "beats" per second is easily shown to be equal to the difference of the two frequencies in the case of both the sound and radio oscillations. Thus, in the latter case, if the received oscillations have a frequency of 100,000 and the local oscillations are adjusted to a frequency which is 1,000 per second higher or lower, the beats will occur at a rate of 1,000 per second, viz, the combined oscillation will rise and fall in amplitude 1,000 times per second. Thus the combined oscillation is modulated at a frequency of 1,000 per second.

It must be remembered, however, that the oscillations are still high-frequency oscillations even though their amplitude is varying at an audio-frequency rate. The oscillations are similar to that shown in Figure 2 of my drawing C. As pointed out before, these oscillations will not actuate a telephone receiver so as to produce an audible response. In order to bring this about, the oscillations must be rectified or distorted by a detector. Then a current varying at a frequency of a thousand per second is obtained and this will produce a response in the phones. To employ this important method of reception it is obvious

that two devices are required at the receiving station, viz., an oscillation generator and a detector. The oscillator can, theoretically, be any type of radio-frequency oscillation generator; the detector can be any type of detector. Thus a Poulsen arc could be employed as the local oscillation generator and a crystal as the detector. Practically, however, the Poulsen arc is cumbersome for a portion of a [fol. 536] receiving equipment and also produces a hissing noise in the telephone receivers, so that it is not a satisfactory device for such reception. The three-electrode vacuum tube is the only practical oscillation generator for this purpose. Any good detector, such as the crystal, can be utilized or another three-electrode vacuum tube can be employed as the detector. Actual measurements show that in both cases the results are practically identical.

It is apparent therefore that this important method of reception is made practically possible solely by reason of the oscillating property of the three-electrode vacuum tube. It is also possible with the three-electrode vacuum tube to combine in one tube the functions of oscillation generator and detector, which is, of course, a convenience. This is exemplified by the circuits of plaintiff's Exhibits Nos. 109 and 114. Both of these circuits employ means to make the vacuum tube operate as an oscillation generator to supply the local oscillations and also employ the typical grid condensers marked j^3 and h^3 which are utilized in the detecting operation. The latter circuit is a more recent one; it employs high-vacuum tubes and has, therefore, also the grid leak resistance L. This method of reception in which the same three-electrode vacuum tube operates as an oscillation generator and detector is called the autodyne or self-heterodyne method of recepion. The method of reception is also frequently employed in which a three-electrode tube acts as an oscillation generator alone and another three-electrode tube or crystal acts as the detector. This method is called the heterodyne method of reception.

The operation of the vacuum tube as an oscillation generator, whether used as a radio transmitter or to produce local oscillations in beat note reception, is dependent upon the fact that it is an amplifying relay. If an alternating voltage is applied to the grid circuit or input circuit of the tube, the controlling action of the grid electrode pro-

duces an alternating current of like frequency and wave form in the plate or output circuit. The alternating current power required to operate the grid is small compared to the alternating current power produced in the output. Suppose that instead of applying the alternating voltage to the grid from an external source, we take some of the output power of the tube itself and use that to excite the grid. Then the device becomes a self-generator of oscillations. In all circuits, therefore, for generating oscillations with the three-electrode vacuum tube there is a so-called "feed-back" feature by which the voltage and power to actuate the grid circuit of the tube is fed into this circuit from the plate or output circuit. This feed-back can be accomplished in a great many ways and hence there are numerous circuits for generating oscillations with the three-element device. This feeding back of power from the output to the input of the tube is similar to the action of the regenerative circuit already described in my answer to question 17. In fact, it is only necessary to increase the amount of voltage fed back in this circuit to transform it into an oscillation generator. Thus the same circuit, if provided with a variable feed-back arrangement, can be used as a regenerative circuit or an oscillation generator.

The regenerative condition is employed as explained previously, where modulated oscillations are being received and leads to an enhanced response by reason of the more complete utilization of the amplifying property of the tube. The oscillating condition is used either when unmodulated [fol. 537] oscillations or continuous waves are being received by the beat method, in which case the tube is acting as both *as* an oscillation generator and detector, or for the generation of radio oscillations to excite the antenna in the transmission of radio signals, in which case the tube is an oscillation generator alone. In the latter case the grid condenser and grid resistance are not requisite but are frequently employed for a purpose entirely different from the detention use as will be explained later.

Also when the tube is used as a radio transmitter the indicator R of plaintiff's Exhibit No. 114 corresponding to the telephones of Figure 3 of my drawing F are not required and are not present in the circuit. Such a typical circuit for utilizing the three-electrode vacuum tube as an oscillation generator is shown in Figure 1 of my drawing

I, which I now offer. This circuit is similar to those just mentioned. The batteries "A" and "B" serve, respectively, to heat the filament and supply the voltage to the plate. The feed-back from the plate circuit to the grid circuit is effected through the magnetic coupling or induction between the coil j^1 and the coil j^2.

If this coupling is at first very loose, so that only a feeble voltage is induced in coil j^2, no oscillations will be set up. As the coupling is increased the regenerative action increases; that is, a given alternating voltage impressed upon the circuit j^2 h^1 will produce greater and greater currents in that circuit because of the assisting voltage furnished by the coil j^1. Finally as the coupling is increased to a certain point the tube will itself start to generate oscillations without the need of any impressed alternating voltage from the outside. The question might be asked "What starts the oscillations?" A similar question might be asked with respect to a ball balanced on a needle point, viz, "What starts it falling?" Some little accidental disturbance destroys the balance; the forces thus brought into play destroy the balance still further and the fall is accelerated. In the case of the oscillating tube, we must assume some slight initial disturbance which produces a minute electrical oscillation in the circuit j^2 h^1, and hence applies a minute voltage to the grid of the tube. By reason of the controlling action of the grid a corresponding oscillation in the plate current is produced which flows through the coil j^1. Because of the coupling between coils j^1 and j^2, an alternating voltage is induced in the circuit j^2 h^1 which will assist the initial oscillation and increase it.

Thus the voltage applied to the grid of the tube will be increased and the corresponding variations of plate current will become greater. This in turn leads to an increased e. m. f. induced back to the input circuit through the coupling between coils j^1 and j^2. This cyclic action continues indefinitely. The strength of coupling between these coils which is required to produce oscillations is such that on each cycle the assisting voltage is increased more than the cycle before. If the coupling is such that the increase in the assisting voltage becomes less on each succeeding cycle, then only regeneration is obtained. For example, if the increase in the assisting voltage is only half as great in each succeeding cycle the final e. m. f. will be the sum of a series such as—

$$1 + 1/2 + 1/4 + 1/8 + 1/16 + \text{---},$$

which is equal to 2. In this case a given alternating voltage will produce twice the currents and voltages in all parts [fol. 538] of the circuit which it would produce were the coupling between j^1 and j^2 absent. The effect will cease when the voltage ceases. If, however, th coupling is sufficiently strong so that the assisting e. m. f. is doubled on each cycle, the final e. m. f. will be the sum of a series

$$1 + 2 + 4 + 8 + 16 + \text{---},$$

which is infinite. This indicates that an initial disturbance will grow without limit. The oscillations start to grow in this manner, but, as they increase to a large amplitude, limitations finally arise which prevent a further growth and the oscillations will then persist indefinitely at the maximum value to which they have grown. The limiting value of the amplitude is imposed by limitations in the power that can be drawn from the plate battery with a given circuit and vacuum tube and by the inevitable power losses which increase rapidly as the oscillation increases beyond a certain point. One of these power losses which limits the useful output of the tube takes place in the grid circuit. When the oscillations are small, the alternating voltage on the grid is also small; no appreciable current flows between the filament and grid of the tube and there is no appreciable power loss in this portion of the circuit. As the oscillations grow, however, and the amplitude of the oscillating voltage on the grid becomes larger and larger, on the positive alternation the grid becomes considerably more positive than the filament and on each swing pulses of current flow from the filament to the grid. These pulses are not indicated nor are they useful in the operation of the tube, and in fact exert a detrimental effect in the operation of the tube as an oscillator, for they take power away from and reduce the amplitude of the oscillations. They represent, therefore, a loss of power in the apparatus. To reduce this loss, it is possible to make the initial voltage of the grid of the tube negative with respect to the filament by including what is known as a "C" battery in the connection between the filament and grid electrodes as shown in Figure 2 of my drawing I. This battery is poled with the negative terminal toward

the grid. In this manner, since we start with the grid at a considerable negative potential, it is made possible for the oscillations to grow to a higher value before the grid begins to swing positive with respect to the filament and the power losses from this cause are reduced. This requires, however, an additional battery. Another method of accomplishing the same result, shown in Figure 3 of drawing I, is to include a grid condenser h^2, and grid leak resistance r in the lead to the grid, which has the effect of making the evil mitigate itself. For when the grid begins to take current this current must flow away from the grid through the grid leak resistance. This current is a flow of negative electrons from filament to grid inside the tube and from grid to filament in the external circuit. The voltage drop across the resistance r makes the grid negative with respect to the filament when the objectionable grid current begins to flow; the more negative becomes the grid automatically, thus mitigating the loss of power from this source. It is evident that the purpose of the grid condenser and grid leak in the vacuum tube transmitter circuit is entirely different from that in detecting tube circuits. We are here not concerned with detection at all, for there are no received signals to detect nor is there any indicator to actuate.

[fol. 539] In the circuits of my drawing I the transmitting antenna is not shown. Such an antenna is a capacity and can be connected in place of the condenser h^1. This is called a "direct-connected" tube transmitter circuit. Or the antenna can be in a separate circuit tuned with an inductance and coupled to either of the circuits of my drawing I. This is called a "coupled" tube transmitter.

The complete diagrams of the circuits used with the oscillating vacuum tube frequently appear quite complicated but usually can be simplified to one of the elementary types shown in my drawing J. For simplicity, I have eliminated the customary batteries from these typical circuit diagrams, and while I will name these circuits as I am accustomed to speak of them and hear them mentioned, I am not positive of the identity of the originator of these circuits. Figure 1 of my drawing J shows the so-called Meissner circuit, perhaps the earliest circuit used. In this diagram the oscillations in the tuned circuit L_3 C are sustained by the induced voltage fed by the coil L_2, in the plate circuit, to the coil L_3. The voltage to work the grid

is fed to the coil L_1 from the coil L_3. In the Hartley circuit of Figure 2, direct coupling is utilized instead of the inductive coupling of the Meissner circuit, thus eliminating the coil L_3. In the tuned plate circuit of Figure 3, the condenser C is connected across the coil L_2 alone; the voltage to actuate the grid is derived from the coupling between coil L_2 and coil L_1. The tuned grid circuit of Figure 4 has the condenser across coil L_1; the voltage to maintain the oscillations is derived from the plate circuit by the coupling between L_2 and L_1. The Colpitt's circuit of Figure 5 is likewise a direct-coupled circuit like Figure 2, excepting the condensers C_1 and C_2 replace the coils L_1 and L_2 of Figure 2. The voltage to maintain the oscillations is applied at the terminals of C_2 while the voltage across C_1 actuates the grid. Either a series or parallel plate battery connection can be used to apply the plate battery voltage to the tube in the circuits of Figures 1-4. When the parallel connection is utilized, a choke coil must be connected in series with the battery and a condenser inserted to prevent a short-circuit of the battery. In Figure 5, because the filament is insulated by the condensers C_1 and C_2, the parallel connection must be used. Also in this circuit a condenser must be used to prevent the high voltage of the plate from being applied to the grid also through the coil L. A grid leak resistance or choke coil must also be used to provide leakage between the grid and the filament. In my drawing K, I show the series and parallel plate battery connections as applied to the circuit of Figure 4 of drawing J. In the series connection Figure 1, the plate battery is applied through the coil L_2. In the parallel connection, Figure 2, the plate battery is applied through a choke coil L_3, and the condenser C' prevents a short-circuit through the coil L_2. This circuit is identical in essentials with the General Electric (No. 2) circuit of plaintiff's Exhibit No. 116, excepting that the necessary choke coil was omitted by Mr. Clark. In a transmitter directly connected to the antenna, the antenna replaces the condenser C of my diagrams excepting in Figure 5, where the antenna replaces the condenser C_2.

[fol. 540] 21. Question. Point out the difference in structure and mode of operation of the Fleming valve in the circuit and as shown in the Fleming patent with the Audion or the three-electrode vacuum tube in the P X circuit, re-

ferring, in particular, to the comparison as made by Mr. Waterman in his answer to question 34.

Answer. The Fleming valve as shown in the Fleming patent is identical in structure with the device shown in the Edison patent No. 307031 of October 21, 1884, and illustrated in my Figure 1 of drawing A. Both structures consist of an incandescent filament and cold plate insulated from each other within an evacuated inclosure and both devices utilize the emission of electrons from such an incandescent filament and the flow of these electrons through the space between the filament and the plate. The shape and location of the cold plate is somewhat different in the two cases. Edison shows a plane plate located between the two legs of the filament while Fleming shows a cylindrical plate surrounding the filament. This, however, is an immaterial difference which does not change the principle of operation.

The three-electrode vacuum tube has a third electrode called the grid which is utilized as a sensitive control member over the electron flow between the hot filament and the cold plate. The addition of this third electrode and the manner of its use gives the device new properties and a new mode of operation, not possessed by the two-element device. And it is the addition of this grid electrode and the new mode of functioning, which the grid made possible, that is entirely responsible for the use of thermionic vacuum tubes in radio signalling. Mr. Waterman, in his answer to question 34, describes the grid as "a bit of wire bent back and forth to form a sort of grid." In the introduction to his book on The Thermionic Vacuum Tube, Dr. Van Der Bijl thus describes the results of introducing this "bit of wire" into the two element valve:

"In fact, the insertion of the grid into the valve resulted in a device of tremendous potentialities—one that can justly be placed in the category with such fundamental devices as the steam engine, the dynamo, and the telephone."

And on page 42 Van Der Bijl states:

"It is hardly necessary to say that the insertion of the grid has made the audion a device of immense practical importance and enabled it to perform functions that would otherwise have been impossible."

Also Dr. W. H. Eccles, of England, a recognized authority on radio matters states, in his article "The three-electrode thermionic vacuum tube and the revolution in wireless telegraphy," in the Radio Review, published in England, October 1919 (p. 26):

"During the war dark hints reached the civilian that a revolution was taking place in wireless telegraphy, the principal agent in which was reported to be an instrument called a 'valve,' a 'lump,' or a 'tube.' This instrument seemed to have risen suddenly into a predominant position among all the apparatus of the wireless experimenter and operator and appeared to be of use in every corner of [fol. 541] his outfit. The complete name of the instrument is the three-electrode thermionic vacuum tube. It must be emphasized that it is the three-electrode valve, and not the valve with two electrodes, that has been responsible for the overthrowing of the old methods and apparatus. That it has been a veritable revolution can be seen by comparing the common practice in wireless telegraphy of 1914 with that of 1919."

Mr. Waterman argues that in the Fleming valve there is a single cold element while in the three-electrode device "the cold element is divided into two."

A mere glance at the construction of the grid elements of modern three-electrode vacuum tubes is sufficient to dispel the contention that the fearful and wonderful structures which constitute the grid elements of these tubes are a mere subdivision of the single cold plate of the Edison and Fleming tubes or else the designers of these tubes have let their imaginations run riot. As a matter of fact, the designer of these tubes can predict in advance from mathematical formulas derived from fundamental electrical laws, exactly how the controlling effect of these grid structures depends upon the size of the individual wires which makes up the grid mesh; how it depends upon the distance between these wires and the location of the grid element relative to the filament and plate electrodes. The substitution of a metal plate for the grid structure would be ruinous to the operation of the device. If in the use of the three-element device, the grid and plate were connected together electrically where the leads to these elements emerge from the vacuous space, so that in all circuits and uses these two elements would be at the same

electrical potential at each instant and would merely share the current flowing to them, then it would be correct to state that the Fleming cold element has merely been divided into two. The device would, however, under this condition of use, be a two-element tube, would function in a manner identical with the Fleming valve, and could accomplish no more than could be accomplished with the Fleming valve. This is well understood in the art and is utilized when it is desired to convert a three-electrode tube into a two-electrode tube when only the rectifying property of the latter device is required.

In the use of the three-electrode vacuum tube as a three-electrode device the grid and plate are operated at different voltages, the plate may have a positive voltage of 20, 40, or several hundred volts, while the grid may be at approximately zero voltage or may have a negative voltage of 20 volts; these two elements are connected to different circuits or parts of a circuit; the grid will be varying so as to become more positive at the same instant that the plate is becoming less positive, a considerable current will be flowing to the plate while no current is flowing to the grid. It is evident that the grid and plate are two separate, independent elements and not a single element divided into two.

As a matter of fact, the Fleming valve is a two-element device and a two-terminal device, having only two terminals to which connections are made to the external circuit while the three-electrode vacuum tube is a three-element device and a three-terminal device having three terminals to which connections are made to three different points of the external circuit or circuits. The two filament terminals are considered, of course, as a single terminal being connected together by the filament itself.

[fol. 542] It is the third electrode and hence the third terminal which gives the three-electrode tube the new and wonderful property of amplification not possessed by the two-terminal device. To exercise this property, the third or grid electrode must be connected to a different external circuit or different part of the external circuit. It is obvious that a device having only two terminals can not be employed in the circuits of a device having three separate and distinct terminals connected to three separate and distinct points of the circuit. If this is attempted two of the points of the circuit which were formerly separate and dis-

tinct must be brought together and made to coincide and the circuit is changed and the functioning is changed. I am surprised to find in his answer to question 34 that Mr. Waterman says this obviously impossible thing can be done; thus he says, "The Fleming valve may be used in the P N circuit." This statement is absolutely contrary to fact. In this P N circuit the points of the circuit which are connected to the grid and plate electrodes are and must be at widely different steady voltages, the point connected to the grid has approximately the potential of the filament while the point connected to the plate is twenty volts or more positive with respect to the filament depending upon the voltage of the battery B^2, the variations in potential of these points when signals are being received are also different: at the instant the point of connection to the grid is becoming more positive, the point of connection to the plate is becoming less positive and vice versa. Further, in this P N circuit the three-element device is functioning both as a detector and amplifier, as I have explained before. Suppose we try to put the Fleming valve in this circuit. We have now a two-terminal device instead of a three-terminal device; either we must utilize only two of the points of connection with the circuit leaving the other disconnected, or we must connect two of the points of the circuit together and use them as one point. The first alternative renders the Fleming valve inoperative for we leave either the receiving circuit or the indicator out in the cold. The second alternative destroys the P N circuit and we get a different circuit and a different mode of functioning. For when the connection is made everything changes, the two points of the circuit which were at different potentials are immediately brought to the same potential, likewise these two points must now vary in potential together.

What has been done is to short-circuit these two points and a short circuit in electrical circuits between points at different potentials is a matter of decided importance. In this destroyed P N current the Fleming valve is, at best, no better off than in the circuit of the Fleming patent, even if the circuit does superficially resemble the P N circuit. The device is a detector only and is even no better as a detector.

Conversely, how are we going to use the three-terminal device in the circuits of the two-terminal device? We must either leave one of the terminals disconnected or connect two of them together and use them as one terminal. In

either case we would get the functioning of the two-terminal device and no more; in fact the latter alternative is a well-recognized way of converting a three-electrode tube into a two electrode tube as I have mentioned before.

Mr. Waterman discusses the single circuit of the Fleming patent and then the P N circuit used with the three-electrode [fol. 543] audion and then makes the statement that "These two forms of circuit I may say are very well known equivalent forms." It is true that two well known equivalent forms of circuit can be used with the Fleming valve just as two well known equivalent forms of circuit can be used with the three-element valve. But neither of these equivalent forms of circuit which can be used with the two-element valve nor any other circuit which can be used with the two-element valve is the P N circuit. The two equivalent forms of circuit are analogous to the series and parallel connections of the plate battery which I have already considered in connection with the three-electrode device. This artifice can be applied to split up and separate out, currents of different frequencies so as to make them flow in parallel branches of a single circuit instead of in the same branch. But the application of this artifice to the single circuit of the Fleming patent does not convert it into the P N circuit, it merely results in splitting the single circuit of the Fleming patent into two branch circuits which run in parallel to each other between the two terminals of the Fleming device, one carrying the radio-frequency current and the other audio frequency or direct current. The operation of the device is unchanged, it is still a detector, only a detector and no better as a detector. In the P N circuit we have two really distinct circuits, one from the filament to the grid, and one from the filament to the plate; the plate and grid are distinct and separate terminals which as I have pointed out are different in electrical potential and in variations of electrical potential.

Mr. Waterman also states that—

"In the Fleming patent no local battery is employed in the indicating circuit, the only battery being the heating battery. In the P N circuit, a battery B is shown. Such a battery may also be used in the Fleming valve circuit, or the Fleming valve may be used in the P N circuit. My practical use of these valves of the Fleming patent shows that some

of them are very much improved by the use of a battery and that others are not."

What Mr. Waterman does not mention, however, is the important fact that the battery B shown in the P N circuit is absolutely essential to the functioning of the three-electrode tube as such. It is necessary to the functioning of the tube in every circuit in which the tube is employed, for without this battery the three-electrode device could not function as an amplifier, and unless it functioned as an amplifier it would be a practically worthless device. The law of conservation of energy requires a local source of power in any amplifying device.

On the other hand, as Mr. Waterman admits, the Fleming valve does not require such a battery. In fact, it can not use such a battery for it can not amplify. As fully explained in my answer to question 18, a battery called a biasing battery is sometimes employed with detectors such as the crystal detector or Fleming valve and in some cases improves them as detectors. This sensitizing battery is not the same nor does it function the same as the B battery used with the amplifying three-electrode vacuum tube. I have already pointed out the incorrectness of the statement that "the Fleming valve may be used in the P N circuit."

Finally Mr. Waterman contends that in the P N circuit the two functions of impressing the oscillations on the tube [fol. 544] and indicating them have been merely separated into two circuits instead of one as in the Fleming patent. I have explained in detail the functioning of the P N circuit in my answer to question 17; I have shown there that the received oscillations are not indicated in either of the two circuits in the manner of the Fleming device. Variations in grid potential at an audio-frequency rate are produced in the input circuit by the received oscillations. These grid potential variations produce amplified currents through the indicating device. The P N circuit entails both detection and amplification, the former differing widely in essentials from the action of the Fleming valve as a detector and the latter function not exhibited by the Fleming valve at all.

In his drawing "Fleming and De Forest compared," which is Plaintiff's Exhibit No. 107, Mr. Waterman shows the single circuit of the Fleming patent and the P N circuit. Even despite the fact that some minor features such as the filament circuit common to Edison, Fleming, and De Forest

have been over emphasized and some of the major features such as the grid condenser and plate battery of the De Forest circuit have been minimized and despite the fact that no drawing can show the difference in functioning of the two devices, it seems that even a person not skilled in the art would be impressed more with the dissimilarity of the two circuits than with their similarity. Mr. Waterman attempts to explain away these dissimilarities by the following arguments, which I have shown to be contrary to fact:

1. That the grid and plate elements of the De Forest device are a mere splitting up of the single cold element of the Fleming device.

2. That the Fleming valve may be used in the P N circuit.

3. That a battery B like that in the P N circuit can be used in the Fleming valve circuit.

4. That all that is accomplished in the P N circuit is a separation of the detecting and indicating functions of Fleming's arrangement.

The real facts are:

1. The grid and plate elements of the De Forest device are distinct and separate elements connected to different circuits or circuit points, operating at different fixed and varying potentials to produce a mode of operation not possible with the Fleming device.

2. The Fleming valve can not be used in the P N circuit, for a two-terminal device can not fit in a three-terminal circuit; nor can the three-element tube be used in the Fleming circuit, for a three terminal device can not fit in a two terminal circuit.

3. That a battery B, like that in the P N circuit can not be used in the Fleming valve circuit, for the battery B is the adjunct of an amplifying device and the Fleming valve is not an amplifying device.

4. That the P N circuit accomplishes both detection and amplification, the former in a different manner from the detection by the Fleming valve and the latter not exhibited by the Fleming valve at all. Hence it is not true that we have merely separated the detecting and indicating functions of Fleming's arrangement. Nor does either, or both

of the P N circuits perform the function of Fleming's tube and circuit of receiving, rectifying, and passing the rectified pulses of received current through an indicator actuated by the power of the rectified current.

[fol. 545] In my Drawing L I have given circuits illustrating the fallacy of Mr. Waterman's contentions. Figure 1 illustrates the two-element valve in the single circuit of the Fleming patent. The only way the three-element device could be connected in this circuit would be that shown in Figure 2, where the grid and plate electrodes are connected together, and hence operate as one element or the three terminal device is converted into a two terminal device. Used in this way, the two cold elements of the De Forest device are in fact nothing more than a splitting up of Fleming's single cold element and likewise the operation and mode of functioning becomes the same as that of the Fleming valve. The contral feature of the grid is lost and with it the amplifying function. Both devices now function the same, both can operate only as rectifiers or detectors. The addition of a biasing battery in either case can only result in a possible increase in sensitiveness as detectors.

In Figure 3 I show the "well-known equivalent" form of circuit which Mr. Waterman considers to be the use of the Fleming valve in the P N circuit. To one not skilled in the art, there might appear to be a similarity between this circuit and the P N circuit shown in Figure 4, though it would be obvious to such a person that considerable changes have been wrought in the original Fleming circuit of Figure 1. However, the circuits of Figure 3 and 4 are not similar and what is still more fundamental, the mode of operation of the two devices in the two circuits are dissimilar. First, relative to the circuits the artifice which has been applied to the simple Fleming circuit is analogous to the series and parallel battery connection which I have discussed before. This artifice merely permits one to take a series circuit in which both high frequency and low frequency or direct currents are flowing and separate the high frequency into one branch and the low frequency or direct current into another branch, these two branches being merely in parallel with each other. The way Figure 3 is drawn, with the low frequency branch to the right of the bulb and the high frequency branch to the left, makes it appear that the separation has been made into two circuits. Figure 3*a* dispels this

illusion: this is the same identical circuit as Figure 3 and shows that the separation has been merely into two branches which are in parallel between the points *a* and *b*. The condenser C' and choke coil L are the features typical of this artifice as I have pointed out before: the condenser C' permits the flow of high frequency currents and stops the flow of low frequency or direct currents; the choke coil L stops the flow of high frequency currents and permits the flow of low frequency or direct currents. In the P N circuit we have two distinct circuits both carrying high frequency currents and low frequency or direct currents. The circuits are distinct and separate because they terminate respectively at the grid and plate terminals which are points having different potentials both steady and varying. Radio-frequency voltage variations are applied to the grid, and, as I have explained before, these variations produce through the action of the grid condenser and leak, low or audio-frequency variations of the grid voltage also. Through the controlling action of the grid, amplified variations of both radio and audio-frequency are produced in the plate current of the tube. The amplified audio-variations affect the indicator I which is a telephone receiver, the radio variations go to waste in this circuit. The fundamental thing, the difference in mode of operation of the two devices in the two circuits is this. In the circuits of Figure 1, Figure 3, and Figure 3*a*, the Fleming valve operates just the same to accomplish the same result, viz, the incoming oscillations are rectified and themselves supply the power to actuate the indicator. The device is only a detector and no better as a detector in either circuit, excepting for any possible sensitizing action of the biasing battery in Figures 3 and 3*a* which would be just as effective if such a battery were employed in Figure 1. In the circuit of Figure 4 the incoming oscillations produce, it is true, some feeble rectified current pulses, but only so as to vary the electrostatic potential of the grid electrode. This takes no appreciable power from the received oscillations. There is no indicator for the received oscillations to actuate. The variations in grid potential produce corresponding variations in the plate current which flowing through the indicator produce the response. Thus the detecting action is different in the two devices and the P N circuit, in addition, entails amplification which is a functioning not possessed [fol. 546]

by the Fleming valve. To make the operation of the tubes and circuits of Figures 3 and 4 the same we must in Figure 4—

(*a*) Connect grid and plate electrodes together. This immediately destroys the amplifying function of the three-electrode tube and brings the grid electrode to the same instantaneous potential as the plate. The three-terminal device and circuit is now converted to a two terminal device and circuit.

(*b*) Insert a choke coil in series with the indicator unless the indicator itself happens to be a choke for radio-frequency currents. Otherwise the circuit will be inoperative as a detector. In the circuit of Figure 4 no such choking action is required, in fact it is customary to connect a condenser, known as the telephone condenser, in parallel with the indicator to prevent such a choking action.

(*c*) Eliminate the grid leak resistance which now becomes useless even with the highest vacuum tubes, though indispensable in such a case in the P N circuit.

(*d*) Reduce the voltage of the battery from 20 or 40 volts to a few volts or a fraction of a volt for now we have not a "B" battery used for amplification, but a biasing battery used for sensitizing a detector. A voltage as high as twenty or forty volts would practically kill the detector instead of sensitizing it.

Obviously with these changes the P N circuit is the P N circuit no more in substance and in functioning and there is no justification in Mr. Waterman's statement that the Fleming valve may be used in the P N circuit.

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22. Question. Please look at Mr. Waterman's comparison of the amplifier device illustrated in plaintiff's Exhibit No. 85 with the Fleming patent and say whether you agree with Mr. Waterman's comparison.

Answer. The type of apparatus called the audion amplifier discussed by Mr. Waterman in his answer to question [fol. 547] 34 and exemplified by plaintiff's Exhibit No. 85 is known in the art as an audio-frequency amplifier. This particular type of audio-frequency amplifier is one of the

earliest types and utilized the old De Forest three-electrode audion. I have discussed its operation in answer to my question 19 and also the more modern types of audio-frequency amplifiers exemplified by the Navy Type S. E. 1000 and the Signal Corps Type S. C. R. 72 which utilize the modern high vacuum three-electrode tubes. These instruments are used purely and simply to amplify voltages or currents having frequencies ranging from about 400 to 2,000 cycles per second. An input voltage of such a frequency is applied to the input terminals of the amplifier and the output voltage into the telephones is of the same frequency, but is multiplied several hundred times in magnitude. These amplifiers are useful wherever it is desirable to magnify such audio-frequency currents or voltages. Thus the S. C. R. 72 amplifier was used to tap the enemy's telephone communication lines and was also used for ground signalling where the signalling employed alternating currents of a frequency of 500 to 1,000 cycles per second. In radio signalling the currents and voltages which these amplifiers handle have a frequency of about 1,000 cycles per second for radiotelegraphy and a range of frequencies corresponding to that of the human voice or of musical instruments in the case of radiotelephony. When used in connection with radio signalling, some type of detector must be used in advance of the audio-frequency amplifier, the detector acts upon the received radio-frequency currents, which may have a frequency of several hundred thousand or a million per second, and converts these into currents of, say, a thousand per second. These latter currents are then impressed upon the amplifier, which is designed to handle only these low or audio-frequency currents. In the use of Exhibit No. 85 in the United States Navy the separate detector which was used to bring about the conversion in frequency was a crystal detector. Both of plaintiff's witnesses, Graham and Clark, identified this instrument of Exhibit No. 85 as the type of amplifier used by the Navy.

Mr. Waterman, however, apparently had difficulty in finding similarity between this amplifier and the Fleming tube and circuit, for he says little about this amplifier of Exhibit No. 85, but chooses to talk about another old type of instrument, which, to the best of my knowledge, was never employed by the Navy. The circuit diagram of the instrument Mr. Waterman discusses is given in plaintiff's Exhibit No. 110 and also in figure 2 of my drawing G. This is a com-

bination instrument; it combines in one piece of apparatus a detector and an audio-frequency amplifier. Explanatory of this instrument in my answer to question 19, I have called attention to the dash line in my Figure 2 and pointed out that the first tube circuit to the left of the dash line is the typical P–N detector circuit, while the second and third tube circuits to the right of the dash line have the transformers and connections typical of the audio-frequency amplifier. In this instrument, therefore, the conversion of frequency takes place in the first tube, the second and third tubes solely serve to amplify the audio-frequency output of the first or detector tube. The second and third tubes are not detectors but are amplifiers. Having thus changed the discussion to an instrument which contains in one box or case a detector, as well as an amplifier, Mrs. Waterman proceeds [fol. 548] to argue that, therefore, the device as a whole is a detector and leaves the impression, although he does not say so outright, that Exhibit 85, which is an amplifier only, is a detector. Mr. Waterman not only confuses the combined detector and amplifier with Exhibit No. 85, but he also errs in describing the combined instrument. Thus he says:

"Three detector bulbs T^1, T^2, T^3, together constitute the detector."

and later:

"The operation of a tandem series of bulbs is the same substantially as that of a single bulb, that is to say, each successive bulb repeats the action of the one before it. Thus the first bulb T^1 (referring to fig. 88a, reproduced above) detects the receipt of an electric wave."

In this combined detector and amplifier instrument the three bulbs are not detectors, the first bulb only is a detector, the next two are amplifiers. I have already pointed out that the tandem connection of three detectors is an absurdity, a thing not known in the art.

Applied to the amplifier of plaintiff's Exhibit No. 85, which the testimony of plaintiff's witnesses, Graham and Clark, identified as the instrument used by the Navy, Mr. Waterman's statements are completely inapplicable, for none of the three tubes in this instrument is operated as a detector.

The question arises as to why Mr. Waterman introduces this confusion. The answer is, I believe, obvious, viz:

The Fleming valve is a detector and a detector alone.

The three-electrode vacuum tube is an amplifier and Exhibit No. 85 is a clean-cut example of the use of the tube as an amplifier alone.

The same reason probably also explains the fact that Mr. Waterman continually and unnecessarily adds on the word "detector" when he uses the word "amplifier," viz: "I note that Exhibits 72 and 73 are contracts for the supply of amplifiers of this audion detector type," and on page 1922 "the audion amplifier detector," and "the audion amplifier detector were before the court."

Near the end of this answer Mr. Waterman makes the following statement, which appears to be a secondary line of defense provided in case his attempt to make a detector out of an amplifier should fail.

"It should be understood that as a matter of fact not all bulbs, whether they have one cold element as shown in defendant's patent, or two, as in the so-called audion, are able to work efficiently enough to produce an amplification. The bulbs which will amplify have to be selected by trial."

This statement is not in accordance with the facts. The actual facts are:

1. The two-electrode tube of the Fleming patent is not an amplifier and can not amplify.

2. The three-electrode tube with the controlling grid is an amplifier and always amplifies.

These are the facts regardless of the possible quibbles that a smashed, burned-out, or defective three-electrode tube may be inoperative or that a useless laboratory stunt can be performed with a gaseous two-electrode tube.

. . . . . .

[fol. 549] 23. Question. Does paragraph 208 of the Navy Manual of 1915 (plaintiff's Exhibit No. 78) merely refer to a lamp detector and battery, as stated by Mr. Waterman in his answer to question 34 in his 1917 deposition?

Answer. The paragraph 208 of the Navy Manual for 1915, which states "The audion has the further advantage over

the valve in that the telephone can be replaced by the primary of a transformer, the secondary of which is connected to another audion, with the result of amplifying the signals produced (see fig. 88*a*)," is intended to call the attention of the reader to the "result of amplifying the signals" which the audion device possesses and which is not possessed by the valve with or without a battery. It does not refer to a result obtained of the use of the incandescent lamp detector with a battery, as stated by Mr. Waterman, but to a result obtained by the De Forest invention of control by the grid electrode.

This answer of Mr. Waterman, to which reference is made, conveys the impression that a detector when supplied with a battery is capable of amplifying; that it is only necessary to take a detector and add a bettery to it and you have an amplifying device. This is obviously not true, as a plain matter of fact. The best known and most widely used detectors are the various crystal detectors. None of these is capable of amplifying when supplied with a battery. In some cases the addition of a biasing battery will improve the crystal detector as a detector, merely increasing the sensitiveness of the device, but in no case does the addition of a battery make an amplifier out of it. The same is true of the Fleming valve. The addition of a battery to the Fleming vaive may or may not improve its sensitiveness as a detector, but it still remains a detector and only a detector. Thus the statement which Mr. Waterman makes that "either the two or the three element bulb can be used to amplify when used with a local battery" is incorrect in so far as it concerns the two-element valve and emphasizes a feature which, while essential to all amplifiers, is not the distinguishing feature of the three-element bulb. The real feature of the three-element bulb which enables it to be used as an amplifier is the grid-control member.

Detection and amplification are fundamentally different operations, and the considerations which determine whether a device is capable of acting as a detector are entirely distinct from and foreign to the considerations which determine whether a device is capable of acting as an amplifier. In the case of the detector the inquiry is: Can the device function to distort radio-frequency oscillations so as to convert them into audio-frequency or direct current? In the case of the amplifier the question is: Can the device when supplied with a given stimulating alternating voltage or

current of high or low frequency function so as to supply a similar alternating voltage or current of the same frequency but of increased power?

The one operation requires distortion, the other requires reproduction and the absence of distortion.

The biasing battery applied to a detector, if effective, increases the distortion which the detector produces, and hence makes it a better detector.

[fol. 550] The battery employed with an amplifier supplies the increased power represented by the undistorted output.

In the case of a detector we are interested in the curvature or rate of bending of the characteristic curve, for, as I have explained in my answer to question 9, it is this feature of the characteristic which determines the distortion, and hence the detecting function of the device.

In the amplifying devices it is desirable to have a minimum of distortion, and therefore a characteristic curve which is as nearly a straight line as possible.

Relative to one type of amplifiers we are interested in the question as to whether the device has a characteristic curve, which runs in the S. E. to N. W. direction or in the S. W. to N. E. direction. If the device has a characteristic with the former slope, then it is a falling characteristic device, and may be an amplifying device by reason of its type of characteristic curve. For faithful reproduction, it is desirable that the characteristic be both falling and straight. Thus the requirements of the detecting function and the amplifying function in these cases where both functions depend upon the type of characteristic curve are clearly dependent upon totally variant essential features of the curves themselves.

Thus the crystal detector and Fleming valve have curved characteristics, and can detect because the characteristics are curved. They cannot amplify, because their characteristics are rising.

The mercury arc and some other devices of this type have falling characteristics, and can amplify because of the falling characteristic. The "soft" two-element tube demonstrated as an oscillation generator before Judge Mayer also was adjusted to the critical gas condition wherein it showed a similar arc characteristic, and therefore might possibly operate as an amplifyer by reason of

this gas characteristic, though it has never been so used, and would be no more than a worthless laboratory trick.

The other type of amplifier, to which the three-electrode vacuum tube belongs, is a totally different device. The amplification in these devices depends upon the control feature; that is, the provision of an easily operated control which varies the current of a local source of power. The ordinary telephone transmitter or microphone is an example of this type, for the vibrations of the diaphragm by varying the pressure on a microphonic substance such as carbon vary its resistance, and hence the current flowing through the substance from a local battery. The variations in battery current which are produced represent more power than is required to operate the diaphragm, hence the device is an amplifier. Amplifying devices of this microphone type have been tried out in long-distance wire telephony and as audio-frequency amplifiers in radio signaling, but have been completely superseded by the three-electrode vacuum tube in both uses.

It is true that the same device may operate both as a detector and as an amplifier. This combined functioning is exhibited by the three-electrode vacuum tube in the P N circuit. The distortion which takes place in the grid circuit produces, through the action of the grid condenser and grid leak, audio-frequency variations in the grid potential. This is the detecting operation. These variations in grid potential are faithfully reproduced in the variations of [fol. 551] the plate current resulting from the controlling action of the grid. This is the amplifying operation.

24. Question. Point out the difference in structure and mode of operation between the Fleming valve in a circuit and as shown in the Fleming patent, and the transmitting sets referred to in Mr. Waterman's answer to question 2 of his 1922 deposition.

Answer. I have already pointed out in my answer to question 21 the difference in structure between the Fleming valve and the three-electrode vacuum tube which latter is the device utilized in the transmitting sets referred to in Mr. Waterman's answer to question 2 of his 1922 deposition and of which plaintiff's Exhibit No. 116 purports to represent the circuit diagrams. Briefly the difference is this:

The Fleming valve consists of a heated filament and an insulated plate in a vacuous inclosure and is identical in

structure with the Edison device shown in Patent No. 307031 of October 21, 1884.

The three-electrode vacuum tube contains an additional third electrode in the form of a grid or mesh of wires located between the filament and plate electrodes. As to mode of operation:

The Fleming valve is a detector alone, it acts upon the received signal oscillations and distorts them, thus converting them to audio-frequency or direct current. The three-electrode vacuum tube is an amplifier, and, by reason of this fact, it is likewise an oscillation generator. When supplied with direct current power it is capable in appropriate circuits of generating the high frequency oscillations used in the transmission of radio waves.

The operation of detection and of oscillation generation are, it is true, converse operations. The operations are, however, not reversible, viz., a device which is a detector and therefore capable of converting the received high frequency oscillations over into low or direct current is not for this reason capable of being operated in the reverse sense so as to generate high frequency oscillations when supplied with direct current power. This is a plain matter of fact illustrated by the crystal detectors and Fleming valve detector. These devices are not capable of generating oscillations. Neither the "gas" trick demonstrated before Judge Mayer or the crystal trick demonstrated before the London Physical Society by Doctor Eccles are of sufficient moment to require a qualification of this statement of a well-recognized scientific fact. There is, in fact, no connection between the capabilities of detection and of oscillation generation, just as and for the same reasons that there is no connection between the detecting and amplifying properties. There is an intimate connection between the amplifying and oscillation generating properties. A device which is an amplifier is capable of generating oscillations. For an amplifier can in appropriate circuits supply the power to actuate itself and thus operate as an oscillation generator. Perhaps everyone is familiar with the squealing which results in the case of the ordinary telephone instrument, when the receiver is held up in front of and close to the transmitter. This is an illustration of a device which is an amplifier, viz., the telephone transmitter, operating as an oscillation generator (of audio frequencies) when the output circuit (the receiver) is coupled to the

input (transmitter diaphra-m). In this case the coupling is effected by sound waves in the air.

Since the amplifying and oscillating properties are thus intimately connected and interlinked it is not necessary for [fol. 552] me to again take up the explanation as to the fundamental differences in requirements and mode of operation of the detectors and oscillation generators as this is explained at length in my previous answer with regard to amplifiers.

As to the statement of Mr. Waterman that it was demonstrated before Judge Mayer "that the device of the Fleming patent was capable of generating oscillating currents," I contend that this was not demonstrated before Judge Mayer. What was demonstrated was that by reason of a freakish gas action in soft two electrode tubes under critical impractical operating conditions temporary oscillations could be obtained. If this represents the device of the Fleming patent, then the three-electrode vacuum tubes used in the transmitting sets in question have, for this reason alone, nothing in common with the device of the Fleming patent. These tubes have the highest vacuum attainable by modern methods of exhaust and gas or gas action plays absolutely no part in their operation.

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25. Question. Point out the difference in structure and mode of operation between the Fleming valve in a circuit and as shown in the Fleming patent and the receiving sets referred to in Mr. Waterman's answer to question 4 of his 1922 deposition.

Answer. The receivers of plaintiff's Exhibits Nos. 113, 114, and 115 discussed by Mr. Waterman in his answers to questions 4, 5, and 6 of his 1922 deposition are all characterized by the presence of a so-called tickler or feed-back coil marked "j[3]" in each of the exhibits. This coil can be used only with the three-electrode vacuum tube and these receiver circuits are known as regenerative receivers. I have already explained the operation of these receivers and pointed out that these circuits enable the operator to obtain signals twenty or thirty times louder than can be obtained by the use of the ordinary P N circuit by reason of the fact that the amplifying property of the three-electrode vacuum tube is more completely utilized; the amplified radio frequency currents discarded in the P N circuit

are here utilized through the medium of the ticker or feed-back coil. It is impossible to utilize these circuits with any other form of detector, since none of these devices are amplifying devices. Excepting for the great improvement in response made possible by regeneration, which depends solely upon the amplifying property of the three-electrode vacuum tube, the feed-back coil would be absent and the crystal detector would have been the detector used in these receivers, for even the three-electrode vacuum tube in the ordinary P X circuit gives a response only some 50 per cent better than a good crystal detector. The output of the crystal would, then, be amplified using the three-electrode vacuum tube amplifiers. This in fact was the method of reception primarily used in the Navy before the advent of the regenerative receiver.

The Fleming valve has been of no importance in the radio art in the Navy or elsewhere. Being only a detector, a detector inferior to the crystal and also less convenient and [fol. 553] more costly, the crystal has been and always would be used in preference. It is the amplifying property of the three-electrode vacuum tube which has enabled it to replace the crystal and which is the reason for the existence of these regenerative type receivers. Throughout the whole radio art the use of vacuum tubes is predicated entirely upon the amplifying property possessed only by the three-electrode vacuum tube.

In any of these receivers, by increasing the coupling between the feed-back coil j^3 and the coil j^2 which is in the input circuit of the vacuum tube, oscillations can be obtained and the receivers can then be utilized for the reception of continuous waves by the beat note method. The oscillating property is dependent on the amplifying property, hence this method of reception basically depends upon the amplifying property of the three-electrode vacuum tube and is not possible with either the crystal detector or Fleming valve.

The amplifying property of the three-electrode vacuum tube has in fact revolutionized the radio art.

26. Question. What have you to say as to whether the operation of the three-electrode device with respect to amplification is obscure, as stated by Mr. Waterman in his 1917 deposition (q. 31)?

Answer. Relative to the Fleming valve, Mr. Waterman states in his answer to question 31 that—

"Why the device operates in the manner set forth in the patent, or what the particular mechanism of the space within the bulb may be which secures the result, is not certainly or clearly understood, but Fleming sets forth the construction and the apparent functioning of the apparatus in the above statement."

In this I do not agree with Mr. Waterman. In fact, the mechanism of the space within the bulb was clearly understood prior to the date of the Fleming patent. It was known as early as 1899 by the work of the eminent physicist, J. J. Thompson, that the incandescent filament is a source of electrons or of those minute negative electrical charges which seem to be at the basis of all physical phenomena. In fact, in 1903 O. W. Richardson derived mathematically the famous law relating rate of emission of these electrons from a heated filament to the temperature of the filament, a law based purely on physical reasoning. This law is accepted to-day and is known as Richardson's law. Before 1904 the mass and electrical charge of an electron had been determined and its behavior under the action of electrical forces was well understood. In fact, the knowledge of the physicists with regard to the electron had progressed to an extent that in 1903 they were concerned with such matters as the manner in which the apparent mass of an electron varied with its velocity of motion when this velocity approached that of the velocity of light, the transverse and longitudinal mass of such a moving electron, whether the apparent mass of an electron is entirely due to its electrical charge, etc. In 1903 the well-known experiment of Kaufmann was published. This experiment proved that the inertia or mass of an electron is entirely due to its electrical charge. Thus the mechanism which caused the curious unilateral conductivity between a filament and cold plate which was observed by Edison in 1883, and which, at that time was a curiosity, had been completely explained even prior to 1904.

Again, in his answer to question 33, Mr. Waterman states relative to the three-electrode vacuum tube that—

"The precise details of the operation of these vacuum valves are not fully understood, and my statements are therefore to be regarded as a general indication of what [fol. 554] happens rather than a precise definition of the way it happens."

There is nothing concerning the operation of these tubes which is not fully understood. In fact, the operations are so well understood that the mathematical formulas and laws of operation have been worked out and are given in numerous standard treatises. A mere glance at Doctor Van der Bijl's book on The Thermionic Vacuum Tube or the German publication by Dr. Hans G. Moller on The Electron Tubes or any other of the numerous standard treatises is sufficient to dispel any illusion that the operation of these devices is not completely understood. In these books are found complete explanations in words and by diagrams of the operation of the three-electrode vacuum tube as a detector, amplifier, and oscillator together with the mathematical treatment which gives the laws of operation. In Doctor Van der Bijl's book will be found the mathematical laws which permit the tubes to be designed to have definite constants and the experimental methods employed in determining these constants. Knowing the constants of the tubes and of the circuits one can predict in advance the amplification which will be secured with an amplifier whether or not a tube will generate oscillations in a given circuit and, in fact, all of the results which can be obtained. These operations would not be subject to mathematical calculation if the operation were not thoroughly and completely understood.

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27. Question. Has the two-element device as disclosed by Fleming gone into any considerable use in the radio art?

Answer. The Fleming valve has never occupied a position of even slight importance in the radio art. It has never been used as a radio detector excepting in a few scattered instances. The reason for this is very simple; the device is not a good detector, and the art has had other simple devices which were better detectors, such as the electrolytic and crystal detectors. The latter was the universal detector used in the past and, in feat, is in very extensive use to-day. The three-electrode vacuum tube has displaced the crystal as a detector, not because the detecting property alone of this tube is superior to the crystal, but because it combines amplification and detection and gives better results because of the amplification, in particular, in the regenerative circuits where the amplification is more fully utilized. Also because of the amplification feature, the

three-electrode tube can be used as a combined detector and oscillation generator for the reception of continuous or unmodulated waves. The other uses of the three-electrode vacuum tube as a straight amplifier and as an oscillation generator for transmission purposes—uses which are of extreme importance in the radio art—do not concern detection at all. At the present day the art could absolutely forego the use of the three-electrode tube as a detector without suffering a whit; the crystal could be employed wherever detection is required without any sacrifice whatsoever. If, however, the art were compelled to sacrifice the amplification feature of the three-electrode vacuum tube, it would be demoralized.

[fol. 555] That the Fleming valve is relatively poor as a detector is well recognized in the art. Evidence in this regard is given by Mr. Clark, plaintiff's witness. Mr. Clark testified both in this case and in the De Forest case as to experimental comparisons which he made of the sensitiveness of the Fleming valve furnished to the Navy by the Marconi Co., with some sample direction-finder apparatus and the sensitiveness of crystal detectors. He is evidently hazy as to the date when these comparisons were made, for in the De Forest case he gives the date as 1913 or 1914 and in this case as 1910 or 1911, but in answer to recross-question 45 identifies them as the same. Evidently his recollection of the results which he obtained are likewise hazy. Thus in answer to redirect-question 38 he states:

"The two-element valve was of the same general order of sensitiveness as the crystal.

"I recall that the valve was, of the two, the more sensitive. Possibly it was twice as sensitive."

And later in recross-question 47, after describing one test relating to the direction finder itself, states:

"A second subsidiary test was to try the efficiency of the detector supplied with the direction finder, namely, the two-element valve, with the standard detector in the Navy at that time, and that test, while related to the main test, was also a separate and complete test of its own."

I have looked up Mr. Clark's official report to the Navy Department on these tests. This report was entitled "Bellini-Tosi Direction Finder Tests" and dated October

5, 1915, the experimental work being done in 1914 as stated on page 4 of the report. I find that Mr. Clark compared the sensitiveness of both the insensitive carborundum detector and Fleming valve supplied by the Marconi Co., with the standard Navy detector, the galena crystal. The following were his experimental results as to the audibility of the same signal with the three detectors as given on sheet 8 of the report: Carborundum detector, audibility 80; Fleming valve, audibility 160; Galena crystal, audibility 400. So that we find the standard Navy crystal detector to be three and one-half times superior to the Fleming valve instead of the Fleming valve being twice as sensitive, as one would gather from Mr. Clark's testimony. These experimental results are followed in the report by the following short significant statement:

"After the first few tests on the direction finder, the galena detector was used for all tests."

Mr. Clark's procedure represents that of the art. The report concludes with "Recommendations," of which the second is interesting, viz:

"2. Replace carborundum detector and Fleming valve by more sensitive crystal detector (as galena or silicon-arsenic) and De Forest audion amplifier. Possibly it would be sufficient to supply binding posts for this, and use the detectors available at the station of use."

In passing it might be noted that the Fleming valve as tested by Mr. Clark was provided with the biasing battery voltage to which Mr. Waterman has referred at various times.

In further confirmation of the standing of the Fleming valve in the radio art the following are a few references taken from the literature.

[fol. 556] Relative to the Fleming valve as a detector the Navy Manuals for 1915, page 143, and 1918, page 159, stated tersely:

"It is not found to be a very sensitive one."

The 1915 Manual states, on page 139:

"There is but one type of detector now in general use, viz, the crystal or rectifying detector."

In the 1918 Manual this statement is revised so as to read (p. 156):

"There are two types of detectors now in general use, viz, the audion, and the crystal, or rectifying detector."

In Doctor Van Der Bijl's book is found, on page XV of the introduction:

"As a detector of electro-magnetic waves, the valve has no commercial value. The device which is used for detecting purposes is the three-electrode tube which in addition to the anode and hot cathode, also contains a grid to control the flow of electrons from cathode to anode. The grid was inserted by De Forest in 1907, who called the device the "audion" and it is the insertion of the grid which has made the termionic tube of such great value."

On page 112 of the same book I find:

"By our present standard of measurement the two electrode tube is a very inefficient detector."

And also the book Wireless Telegraphy, by Leggett, previously referred to, which says, on page 112:

"4. Contact detectors: These are the detectors most used at the present day. They consist essentially of contact points between a suitable metal and crystal such as molybdenite or galena. * * * These detectors are the most sensitive for ordinary working, can not be greatly damaged, are always ready for use, and require no auxiliary apparatus. They are therefore very widely used."

And on page 161:

"As a detector the Fleming valve was fairly sensitive, but from the author's own personal experience, a result also noticed by Stanley, it was not so sensitive as a crystal detector. As well as being more sensitive, the crystal detector has the advantage of not requiring any heating battery, with consequent adjustment and maintenance troubles."

Also I find in the book Wireless Telegraphy, by L. B. Turner, published 1921 by the Cambridge University Press, London, on page 88:

"The introduction of the grid was the work of L. de Forest in 1907, and although the rationale of the triode does not appear to have been fully understood at the time, and its uses have only recently been developed, this addition to the Fleming valve marks the conversion of the thermionic tube from a mild convenience into the potent and indispensable instrument it is to-day."

And in the book Guide to the Study of the Ionic Valve, by Owen, published by Isaac Pitman & Sons, England, in 1919, on page 19:

"The two-electrode valve is now obsolete except in a modified form called the 'kenetron' to which reference is made later on. It was abandoned in favor of carborundum, which is more sensitive and requires less auxiliary apparatus. By the introduction of a third electrode into the valve between the filament and plate, Dr. Lee de Forest, of New York, made use of an entirely different principle."

[fol. 557] I could multiply such statements in the literature of the art, but will conclude with two experimental papers on the relative sensitiveness of these detectors. In a paper by P. R. Coursey in the proceedings of the Physical Society of London for February, 1914, page 102, a comparison is made of a great number of well-known detectors as to their relative sensitiveness. This work, I believe, was done in Professor Fleming's laboratory. The results were expressed in terms of the sensitiveness of the Marconi magnetic detector, assumed to be unity. It is well known that this detector is one of the less sensitive detectors. On this basis the well-known perikon crystal detector was found to be twelve times as sensitive, the galena plumbago crystal detector nearly thirteen times, and a number of other well-known crystal detectors varying between these figures. Three samples of Fleming valves were also investigated, two of which were found to be only equal in sensitiveness to the Marconi magnetic detector. One, however, was found to be the equal of the perikon. In a bulletin from the Bureau of Standards, volume 6, No. 4, page 527, is a paper by Dr. L. W. Austin on the comparative sensitiveness of some common detectors of electrical oscillations. In this paper Doctor Austin finds the Fleming vacuum valve detector to be inferior to the perikon crystal detector in the ratio of two to ten times.

It is also a matter of fact that the radio art has not used the Fleming valve to an appreciable extent. The United States Navy has been the largest user of radio apparatus in this country and has never employed the Fleming valve. This accords with the testimony of Mr. Clark who in his answer to question 1 claims to be familiar with every type of set, both transmitting and receiving that the Navy obtained between the dates 1908 and 1919 and who states in his answer to recross-question 44 that the only Fleming valves he ever tested were those on the direction finder set referred to above. I have been generally familiar with Navy apparatus since about 1912 and been seen and operated practically all of their receiving apparatus but have never seen or heard of the Navy employing the Fleming valve. I also have been generally familiar with the apparatus used by others in this country and to some extent abroad and know of no case where the Fleming valve was employed in such apparatus. The Fleming value receiver, which is Plaintiff's Exhibit No. 28 and which was described by Mr. Waterman in question 36, immediately succeeding his description of the Navy three-electrode apparatus, was not to my knowledge ever employed by the Navy. It appears from the record (Brennen, q. 53 to q. 61) that a single receiver of this type was shipped to a Marconi employee and addressed to the U. S. S. *Louisiana* at the Norfolk Navy Yard, but it does not appear from the record that this receiver was intended for or used by the Navy. This receiver was shipped presumably on October 25, and was received back again by the Marconi Co. on October 31, 1910. I am quite sure that no receiver like this was used by the Navy.

It also appears that receivers employing the Fleming valve were rare even in the case of the Marconi Co. itself. I have compiled a list of the various receivers put out by the Marconi Co., from the book Practical Wireless Telegraphy, written by Elmer E. Bucher, instructing engineer, Marconi Wireless Telegraph Co. of America, and published in 1917. I find only one mention of a receiver utilizing the Fleming valve. This occurs on page 143, and the statement reads: [fol. 558] "The diagram Figure 162 shows the fundamental circuit of the widely used Marconi-Fleming valve receiver."

Immediately following this statement I find, on page 144:

"The American Marconi Co. has developed a crystal holder to fit in the Fleming valve socket, as shown in Figure 163."

Also I find on page 144 that the Marconi Type 107 A tuner (American Marconi Co.), which is a redesign of the above tuner, does not employ the Fleming valve, but (p. 145) "is designed for the carborundum detector, an extra set of posts is provided for an additional crystal such as cerusite."

The other receivers mentioned in this publication are the following:

Page 148. Marconi multiple tuner (English Marconi Co.). Uses magnetic detector.

Page 151. Marconi type 106 receiving tuner (American Marconi Co.). Uses crystal detector.

Page 154. Marconi receiving tuner, type 101 (American Marconi Co.). Uses cerusite and carborundum crystal detectors.

Page 157. Marconi Universal receiving set (English Marconi Co.). Uses crystal rectifiers as carborundum, zincite, bornite, etc.

Page 172. Marconi balanced crystal receiver. (English Marconi Co.)

Page 174. Type 112 receiving tuner (American Marconi Co.). Uses carborundum detector.

The type 106 receiving tuner using a crystal detector is also described in 1916 by Harry Shoemaker, research engineer of American Marconi Co., in an article in the Proceedings of the Institute of Radio Engineers, August, 1916. The article is entitled "Recent standard radio sets."

It is a fact well known and recognized by all radio engineers that the Fleming valve has never occupied a position of even slight importance in the radio art.

28. Question. Please refer briefly to the prior art and say whether it was obvious prior to 1904 that the Edison bulb would act as a rectifier at all frequencies?

Answer. As early as 1883, Thomas A. Edison discovered the device which is the forerunner of all the so-called thermionic devices which have become so extremely important in telephone and radio communication. Edison inserted a metal electrode inside the bulb of an incandescent lamp and provided a circuit connecting the metal plate and the incandescent filament. He inserted a galvanometer

in this circuit and discovered that electrical currents could flow through the vacuum between the incandescent filament and the plate. If the metal plate were connected externally through the galvonometer to the positive terminal of the filament, the galvonometer would indicate a current, if the external connection were made to the negative terminal of the filament then no appreciable current would flow. At this time the mechanism underlying Edison's discovery was completely unknown, and the phenomenon was mystifying. It was called the "Edison effect." In 1884 Edison obtained a patent on his device, utilizing it as a means of controlling the voltage supply for incandescent lamps.

The discovery of Edison aroused considerable interest and numerous investigators continued experiments upon the Edison effect. Among these were Prof. Edwin J. Houston, who gave a paper in 1884 before the American Institute of Electrical Engineers, and Sir William Preece, [fol. 559] who in '85 published a paper in the London Electrician on experiments which he made on lamps which were furnished to him by Edison. Professor Fleming was one of the investigators and published a number of papers on the Edison effect. In 1890 in the Proceedings of the Royal Society, volume 47, 1890, he pointed out the unilateral conductivity of the space between the filament and plate and the possibility of rectifying alternating current. Thus he states in this paper:

"When the lamp is actuated by an alternating current a continuous current is found flowing through a galvanometer, connected between the insulated plate and either terminal of the lamp.

"The vacuous space between the middle plate and the hot negative leg of the carbon possesses, however, a curious unilateral conductivity. * * * The cell is thus able to force a current through the vacuous space when the direction of the cell is such as to cause negative electricity to flow across the vacuous space from the hot carbon to the cooler metal plate, but not in the reverse direction."

In 1897 in the discussion of a paper on the Edison effect by Howell before the American Institute of Electrical Engineers (Trans. Amer. Inst. Elec. Eng. vol. 14, pp. 42, 43), Dr. A. E. Kennelly says:

"It has long been known that the passage of a continuous current through a Geissen tube sets up a series of pulsatory currents or discharges which are capable of producing alternating currents in a separate circuit through the intermediary of an alternating current transformer. So far as I know, however, it has been pointed out for the first time in this paper that an alternating current passed through an incandescent lamp, giving the 'Edison effect' is capable of producing in a branch circuit through a third wire in a lamp, continuous or at least unidirectional currents. Consequently it is interesting to observe that a vacuum tube, in the broadest sense of the term, is capable of supplying not only alternating currents from continuous currents, but also continuous currents from alternating currents."

Doctor Wehnelt, who worked with special type of filament similar to that which is extensively used in thermionic devices to-day, the so-called oxide-coated filament, also showed in October, 1904, that the Edison device could be used to rectify alternating currents. In his article in the Physikalische Zeitschrift, under date of October 20, 1904, Wehnelt says:

"if, therefore, we connect the electrodes A and K with an alternating source of current, then the tube acts as an electric valve in that it allows to pass through only one phase of the alternating current. The tube (fig. 4) can consequently serve for the purpose of transforming alternating current into pulsating direct current."

Thus prior to the date of application for the Fleming patent, which I am advised was November 16, 1904 (British application), the two-electrode valve was well known among engineers as a rectifier of alternating currents.

During the decade prior to this date there was also taking place a tremendous revolution in the knowledge of mankind with respect to physics and the laws of physics. During this period the electron theory was born and proven to be fundamental in all branches of physical theory and in fact in the construction of matter itself. The electron theory explained and correlated the phenomena in all branches of physical science and incidentally completely [fol. 589] explained the mechanism underlying the Edison effect. Thus in 1899 in a paper in the Philosophical Magazine, volume 48, page 547, J. J. Thomson, the most promi-

nent worker in these exciting times, showed that the Edison effect was due to the emission of negative electrons from a heated filament and identified them with the electrons which were fundamental in physical phenomena in the whole domain of physics. This work was followed by a complete explanation by O. W. Richardson as to the mechanism of the emission of the electrons from the heated filament, published in two papers—Proc. Camb. Phil. Soc., volume 11, page 286, 1901, and Phil. Trans. Roy. Soc., volume 11, page 497, 1903. In the latter paper, Richardson derived the law of emission of the electrons, that is a relation between the number of electrons emitted per second and the temperature, a law well known as Richardson's law. The characteristic of electrons which identified them in optical and electrical phenomena as being fundamental in all physical phenomena was the ratio of the charge to the mass or quantity, known as $\frac{e}{m}$. This quantity had been determined in numerous ways in connection with various phenomena and was found to be the same in all. Its value for an electron is about two thousands times as great as the same quantity for a hydrogen ion in electrolysis. Hence, either the charge of an electron must be two thousand times greater than the charge of the hydrogen ion or the mass of an electron must be only one two-thousandth of that of a hydrogen atom. Various phenomena tended to prove that the latter was the case. In the period between 1897 and 1903, the matter was definitely settled by five separate experimental determinations of the actual electrical charge carried by an electron. This charge was shown to be identical with that of the hydrogen ion and hence the mass of an electron is about one two-thousandth of that of a hydrogen atom. This work was published as follows:

Townsend, Proc. Camb. Phil. Soc. IX, p. 244, 1897.
Wilson, C. T. R., Proc. Camb. Phil. Soc. IX, page 333, 1897.
Thomson, J. J., Phil. Mag. XLVI, page 528, 1898.
Thomson, J. J., Phil. Mag. V, page 354, 1903.
Wilson, H. A., Phil. Mag. V, page 429, 1903.

Thus in the years immediately prior to 1904 it had been established—

1. That the incandescent filament of Edison served to emit electrons.

2. The mass of these electrons were only a two-thousandth of that of a hydrogen atom.

These facts would be known to any scientist of that day, for the subject was at the forefront of scientific interest. Therefore any scientist could have predicted in 1904 that the Edison device, a known rectifier for alternating currents, would operate just the same at radio-frequencies.

I will quote again the answer of E. H. Armstrong, expert on behalf of the Fleming patent in the case in New York, in explaining the operation of the three-electrode tube.

"74. Cross-question. Can you give some brief explanation of why you and other scientists make this assumption that in devices of the vacuum type using electron discharges they would operate under both high and low frequencies in exactly the same way, other conditions being equal?

[fol. 561] Answer. The mass of the electron is so very small, and the speed so enormously high, that the device is practically without inertia, and we would expect for all frequencies within reason, or certainly all frequencies such as used in radio telegraphy, the operation would be the same."

This statement, accurate when made, was just as accurate in 1903, and any scientist at that date would have known it from his reading of the literature of the art. Indeed he would have had no reason to think otherwise.

The further question remains as to whether the use of rectifier as a radio detector was known to the art prior to 1904. The use of a rectifier as a radio detector was pointed out with extreme clarity in a French patent No. 328687, to M. Gillet de Valbreuze, dated May 7, 1903. In fact, Figure 2 of the Valbreuze patent is identical with Figure 2 of the Fleming patent. The rectifier which Valbreuze utilized was the well-known sphere and point rectifier. His Figure 2 shows two such rectifiers in parallel so arranged as to utilize both alternations of the wave, which is exactly the arrangement shown by Fleming in his Figure 2 and for the same purpose. The indicating

device shown by Valbreuze is a relay with two differential windings; that shown by Fleming is a galvanometer with two differential windings. In both cases the rectified currents supplied by the two rectifiers are additive in their effect upon the indicating device. It is doubtless true that the Valbreuze type of rectifier is even less sensitive than the Fleming type, but the use of a rectifier as a detector is clearly disclosed. In my drawing M, I show for comparison, the corresponding figures from the two patents. I have turned the Fleming figure on its side in order to make it correspond in arrangement with the Valbreuze diagram and have eliminated many of the letters used as symbols in the Fleming figure because they confuse the circuit diagram. The sphere in the Valbreuze rectifier corresponds to the plate of the Fleming device, the point of Valbreuze to the filament of Fleming. I have also shown the antenna omitted in this Fleming figure, as it is shown in Fleming's Figure 1.

The following is a translation of claim 2 of the Valbreuze patent:

"2. The use of a device called an electric valve formed by a vacuum tube, or of several similar valves combined together in order to transform into currents always in the same direction, the alternating currents of very rapid frequency transmitted to the receiving apparatus."

Thus I find the following to be the facts regarding the history of the Edison device and the art prior to 1904.

1. The Edison device was well known as a rectifier of alternating currents.

2. In the years just prior to 1904, it was shown that the incandescent filament was an emitter of electrons and that electrons had unappreciable inertia, so that any scientist could predict that the Edison device would operate the same regardless of the frequency.

3. In 1903 the use of the re-tifier as a detector of wireless waves was clearly disclosed.

The mystery surrounding the Edison effect had been completely dispelled and the whole mechanism explained during the years just prior to 1904, a period which was revolutionary in the whole domain of physics. Instead of there

being a distinct lapse in time between the earlier work [fol. 562] on the Edison effect and the Flemington use of this "curiosity" the fact is that the progress of scientific knowledge had completely bared the innermost mechanism of the Edison effect and made it possible for any scientist to predict that the device would operate as it was operated by Fleming. It was, therefore, incorrect as a matter of fact to say that "at the date of Fleming's application it was not known to men skilled in the radio art that a rectifier would act as a detector or that anything that would rectify oscillations of a low frequency could rectify waves of the order used in radio communication."

As a matter of fact:

1. It was known to men skilled in the art at the date of Fleming's application that a rectifier would act as a detector.

2. One skilled in the art at the date of Fleming's application would have understood the complete mechanism of the Edison effect and would have been able to predict that the Edison device would rectify waves of the order used in radio communication. Such a prediction would be based on the facts discovered prior to Fleming.

* * * * * * *

29. Question. In connection with your testimony regarding the ultra audion, I neglected to call your attention to the testimony of Mr. Waterman in his answer to question 33 (p. 526), where he refers to the device continually detecting the fact that it is detecting. Will you say if you agree with this testimony?

Answer. The statement to which reference is made reads:

"Any detector which is also able to control the local battery current so as to amplify the received energy is capable of being put in the oscillating condition, this being done by transferring part of the energy of the battery circuit back to the controlling circuit, to keep the latter continuously excited. In other words, the continuous repetition of the detecting function is the so-called oscillating state and a detector in the oscillating state may be said to be continuously detecting the fact that it is detecting."

This is another confused statement which attempts to connect up the detecting function of the Fleming valve with the functioning of which it is not capable, viz, amplification. The use of the term "detector" in the first sentence is gratuitous and superfluous. The matter of detection is not pertinent—a device which can amplify can be put in the oscillating condition, a device which can not amplify can not be put in the oscillating condition. The detectors such as the crystal and Fleming valve, which are not amplifiers, can not generate oscillations; the three-electrode vacuum tube and other amplifying devices can generate oscillations regardless of the fact as to whether or not they can be used as detectors. This first sentence would become a more sensible expression of fact if it were revised to read:

"Any device which is able to control a local battery current so as to amplify the input energy is capable of being put in the oscillating condition, this being done by transferring part of the energy of the battery circuit back to [fol. 563] the controlling circuit, to keep the latter continuously excited."

The second sentence of Mr. Waterman's statement is to me devoid of sense or meaning. I do not understand what is meant by a detector "detecting the fact that it is detecting."

In comparison with this confused statement of Mr. Waterman, I would like to quote a statement on the same subject matter by Doctor Van Der Bijl, taken from page 266 of his book, already referred to:

"Since the three-electrode tube can operate as an amplifier, the energy in the output circuit is greater than that in the input circuit. Hence, if part of the energy in the output be returned to the input, there will be a further amplification of energy resulting in an increased output. If the amplified energy gets back to the input in sufficient amount, and if the phase relations of the output and input currents are right, there will be a constant reamplification and feeding back of energy from the output to the input, and the device will then produce sustained oscillations without it being necessary to supply potential variations to the grid by external means. In other words, the device will then operate as an oscillation generator."

It will be noted that Doctor Van Der Bijl does not find it necessary to introduce the terms "detector" or "detection" in any phase of his discussion, nor does he say anything about "detecting the fact that it is detecting." Anyone at all familiar with such devices knows that there is no connection whatsoever between the detecting function and the functions of amplifying or oscillating.

30. Q. You have referred to the use of the S. C. R. 72 amplifier in ground signaling. Will you explain more fully this use of vacuum tubes?

Answer. Ground signaling was a method of communication extensively employed in the war.

This method of signaling used only audio-frequency currents transmitted through the ground. In the reception of these signals, the S. C. R. 72 audio-frequency amplifier was employed. This amplifier utilizes three-electrode vacuum tubes. The method of signaling and the apparatus employed are thoroughly described in a Signal Corps pamphlet entitled "Ground Telegraphy, or T. P. S." This pamphlet was a confidential publication during the war, but has since been released. The method is described on pages 3 and 4, as follows:

"Ground Telegraphy, or T. P. S. (from the French 'telegraphie par sol') is a means of communication which requires no wire connection between the sending and receiving stations, but it is different from radio telegraphy in that it involves the use of pulsating or alternating currents of comparatively low frequency (600 to 1,800 cycles per second) instead of oscillations of high frequency, of the order of 100,000 to two or three million cycles per second. Also, the transfer of electrical energy from the transmitting to the receiving apparatus take place by induction and conduction through the ground, instead of through the air, as with radio.

"The principles on which the theory of this means of communication are based are quite simple. They are illustrated in Figure 1. A generator A (alternator or buzzer) producing an audio-frequency high voltage alternating or pulsating current is connected to the ground by means of two wires, AB and AC, which are grounded at points B [fol. 564] and C. These two grounds are 50 yards to 200 yards apart. The circuit followed by the current generated at A is then made up by the two wires AB and AC and by

the conducting ground between B and C. Since the ground is a fair conductor of electricity, the electric current will not be concentrated on the straight line BC, but it will follow a great number of paths through the ground, called lines of current flow, and represented schematically in Figure 1 by the dotted lines. These lines of current flow may, under suitable geological conditions of the ground, spread out as far as 2 or 3 miles away from the sending circuit ABC.

"If now at a certain distance from the sending circuit ABC a metal wire is grounded at two points D and E, the current from A will not flow through the ground between points D and E along the corresponding line of current flow. Instead, it will flow through the wire DFE, which is a low resistance path shunting the line of current flow DE in the ground. A suitable instrument F inserted in series with the wire DE may therefore be employed to utilize this current in signaling work. The current in the circuit DFE is extremely small due to the rather high resistance of the ground and to the fact that the current generated by A spreads over such a considerable area that the wire DE picks up only a very small portion of the total current flowing through the ground in the various paths between B and C. The instrument F must therefore be very sensitive. It is usually a telephone receiver.

"In most cases, the current in the wire DE is even too faint to produce a sound in a telephone receiver directly inserted in series with the wire. This has made it necessary to use amplifying devices, which amplify the currents received."

(For convenience I insert a copy of Fig. 1 opposite.)

On pages 5 to 8 the transmitter is described (quoting from page 5):

"The T. P. S. transmitting set, type SCR-71, consists of a power buzzer, used for generating a high-voltage, audio-frequency, pulsating current."

On page 7 the range of frequencies generated by this transmitter is stated to be variable from 650 to 1,750 cycles per second.

The receiving set is described on pages 8 to 12, of which I quote the following (pp. 8-9):

"The T. P. S. receiving set, type SCR-72, is a low-frequency amplifier, consisting of a vacuum-tube amplifier with the necessary storage batteries and telephone receivers and a ground equipment similar to that of the SCR-71 transmitting set. A complete parts list is given at the end of this pamphlet.

"The amplifier consists of two type VT-1 three-electrode vacuum tubes connected for cascade amplification, and making possible the use of either one or two stages of amplification. As shown on the circuit diagrams, Figure 6, the T. P. S. current to be amplified is made to flow through the primary winding of an iron core input transformer, by connecting the two grounded receiving line wires to the binding posts of the amplifier box marked 'T. P. S.' The secondary of this input transformer is connected between the filament and the grid of the first vacuum tube. The plate circuit of this tube comprises a 22-volt, type BA-2 dry battery connected in series with the primary of an iron core transformer which couples the plate circuit of the first tube to the grid circuit of the second tube. The secondary winding of this coupling transformer is [fol. 565] connected between the grid and the filament of the second tube, while a type BA-2 dry battery furnishes the plate current."

(Page 9):

"This amplifier is not limited in its use to the reception of T. P. S. signals. It may also be used to amplify damped or modulated radio signals after they have been detected (rectified). For this purpose, the entire primary winding of the input transformer is used, the corresponding terminals on the amplifier box being marked 'Radio.' These terminals are connected to the telephone terminals or plug of the radio receiving set used in the reception of the radio signals it is desired to amplify. This inserts the amplifier in the audio-frequency circuit of the radio receiving set."

On page 11 is given a wiring diagram (fig. 6) which is essentially the same as the diagram of the Navy S. E. 1,000 amplifier, which is Figure 1 of my drawing G. From this figure it is seen that the only difference in the circuit when connection is made to the "Radio" binding posts instead of the "T. P. S." binding posts is that all of the primary turns of the input transformer are used instead of a por-

tion of them. This is merely a matter of fitting the amplifier to the circuit in which it is being used, the circuits being lower in resistance in the T. P. S. work than in the radio work and hence permitting the use of a higher step-up ratio in the transformer. In both cases only audio-frequency currents actuate the amplifier.

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31. Question. In your answer to question 12 you referred to having made certain tests to demonstrate the correctness of your testimony to the effect that such oscillations as were obtained before Judge Mayer were due to the gas characteristic. Are you ready and willing to repeat these tests in the presence of counsel for the claimant, if so requested?

Answer. I am.

(At this point counsel for the defendant reads upon the record the following letter, which was sent on the date given in the letter, to claimant's counsel:)

Marconi v. *U. S. No. 33642*

FEBRUARY 14, 1923.

Messrs. SHEFFIELD & BETTS,
52 William St., New York City.

"GENTLEMEN: Upon receiving from the commissioner the minutes of Mr. Waterman's deposition, we note the addition of a statement by him to the effect that it is possible to reproduce the two-element bulbs used in the demonstration made before Judge Mayer, if sufficient time is allowed to ascertain the dimensions of the bulbs from old records and to obtain the necessary materials.

We would like to procure some of these bulbs, and if the Marconi Company is willing to reproduce them we would like to know how soon we may expect to receive them.

Yours very truly, C. V. EDWARDS (Signed).

[fol. 566] 32. Question. In your testimony you have referred to the S. E. 1000 amplifier. Can you produce one of these devices?

Answer. The device which I here produce is one of these amplifiers.

(The device produced by the witness, together with the tubes therein, is offered in evidence and marked "Defendant's Exhibit E.")

33. Question. Can you produce samples of some of the three-element tubes?

Answer. I have here three samples taken at random. One is a small VT-1 tube used for receiving purposes. Another is a small VT-2 tube used for transmitting purposes. I also have here a type P Pliotron, which is a fairly high power tube used for transmitting purposes. I think this latter tube particularly emphasizes the fact that the grid is not in any sense a mere subdivision of the plate element. In this device the plate is in fact in two parts, both of which are however, connected together and connected to one terminal. These are the heavy outside plates. Between these plates is a substantial frame upon which the light grid wire is wound. Within the grid is located the M-shaped filament. I might note that the practice of dividing the plate into two large outside plates connected together is quite common. This is the case with respect to the VT-1 and VT-2 tubes. I believe that all of these tubes show that the grid element is in no sense a part of or subdivision of the plate element.

(The tubes produced by the witness are offered in evidence and marked, respectively, "Defendant's Exhibit F, VT-1 Tube;" "Defendant's Exhibit G, VT-2 Tube;" "Defendant's Exhibit H, Type P Pliotron.")

(Defendant's counsel offers in evidence the following drawings, patents, and publications referred to by the witness, the same being marked as follows:)

I. Miller drawings, A to M, inclusive.

J. U. S. Patent No. 307031, granted October 21, 1884 to Edison.

K. U. S. Patent No. 879532, granted Feb. 18, 1909, to De Forest.

L. The Thermionic Tube, by Van der Bijl, published at New York, 1920, pages XV, XVI and XVII, and pages 42, 108, 112, 266 and 271.

M. Proceedings of the London Physical Society, 1910, vol. 22, pages 360-363, inclusive. (Article by Eccles.)

N. Wireless Telegraphy, by D. Leggett, London, 1921, pages 112, 160, 161, and 375.

O. U. S. Patent No. 781,001 to Hewitt, granted January 31, 1905.

P. U. S. Patent No. 781,002 to Hewitt, granted January 31, 1905.

Q. Electricity and Magnetism, by James Clark Maxwell, published at Oxford, in 1892, vol. 1, page 310 to 313, inclusive.

R. Proceedings of the Institute of Radio Engineers, published at New York, 1920, vol. 8, pages 64 to 74, inclusive. (Article by Miller.)

S. The Principles Underlying Radio Communication published at Washington, 1919, pages 288, 304, and 313.

T. The Principles Underlying Radio Communication, published at Washington, 1922, page 402.

U. Electric Wave Telegraphy and Telephony, by J. A. Fleming, published at London, 1916, pages 98 and 109.

[fol. 567] V. Wireless Telegraphy and Telephony, by Eccles, published at London, 1918, pages 215, 216, and 220.

W. The Radio Review, published at London, England, October 1919, pages 26 to 29 incl. (Article by Eccles.)

X. Journal of the Institution of Electrical Engineers, London, 1900, vol. 30, page 232.

Y. Philosophical Magazine, published at London, England 1916, vol. 32, pages 426 and 427.

Z. Certified copy from the records of the Navy Department of the report by George H. Clark, on the Belli-Tosi Direction Finder Tests, dated Oct. 5, 1915.

A-1. Manual of Wireless Telegraphy for the use of Naval Electricians, published at Washington, 1915, pages 132, 133, 134, and 139 to 144, inclusive.

B-1. Robinson's Manual of Radio Telegraphy and Telephony published at Annapolis 1918, page 156.

C-1. Wireless Telegraphy and Telephony by Turner, published at London, 1921, page 88.

D-1. Guide to the Study of the Ionic Valve, published at London, 1919, page 19.

E-1. Proceedings of Physical Society of London, published at London, February 1914, page 102 (article by Coursey).

F–1. Bulletin of the Bureau of Standards, vol. 6, No. 4, published at Washington, 1911, pages 527 to 542, inclusive (article by Austin), on the "Comparative sensitiveness of some common detectors of electrical oscillations."

G–1. Practical Wireless Telegraphy, by Bucher, published at New York in 1918. Pages 143, 144, 145, 148, 151, 154, 157, 172, and 174.

H–1. Proceedings of the Institute of Radio Engineers for August, 1916, published at New York, August, 1916 (article by Shoemaker), pages 322 and 325.

I–1. Proceedings of the Royal Society, published at London, 1890, vol. 47, pages 118 to 126, inclusive.

J–1. Proceedings of the Royal Institute, London, 1890-1892, pages 34 to 49.

K–1. The Electrician, published in London, England, February 21, 1890, pages 393 to 395 inclusive.

L–1. The Electrician, published at London, England, February 20, 1890, pages 417 to 420, inclusive.

M–1. Proceedings of the American Institute of Electrical Engineers, published at New York, 1897, vol. 14, pages 31 to 35, 42 and 43, inclusive.

N–1. Proceedings of the Physical Society of London, published at London, England, March 27, 1896, pages 187 to 242, inclusive.

O–1. The Physikalische Zeitschrift, published at Berlin, Germany, October 20, 1904, pages 680 and 681.

P–1. Translation of defendant's Exhibit O–1.

Q–1. Annalen der Physik, published Berlin, Germany, April 20, 1904, pages 425 to 467, inclusive.

R–1. Translation of defendant's Exhibit Q–1.

S–1. Philosophical Magazine, published at London, England, 1898, vol. 46, page 528 (article by Thomson), beginning page 528.

[fol. 568] T–1. Philosophical Magazine, published at London, England, 1899, vol. 48, page 547 (article by Thomson), beginning page 547.

U–1. Philosophical Magazine, published at London, Englan, 1903, Vol. V (article by Thomson), beginning page 354.

V–1. Proceedings of the Cambridge Philosophical Society, published at London, England, 1901, vol. 11, page 286 (article by Richardson), beginning page 286.

W–1. Philosophical Transactions of the Royal Society, published at London, England, 1903, vol. 11 (article by Richardson), beginning page 497.

X–1. Proceedings of Cambridge Philosophical Society, published at London, England, 1897, vol. 9 (article by Townsend), beginning page 244.

Y–1. Proceedings of Cambridge Philosophical Society, published at London, England, 1897, Vol. IX (article by Wilson), beginning page 333.

Z–1. Proceedings of Cambridge Philosophical Society, published at London, England, 1903, Vol. V (article by Wilson), beginning page 429.

A–2. French Patent No. 328,687, granted May 7, 1903, to Valbreuse.

B–2. Translation of defendant's Exhibit A–2.

C–2. The Thermionic Valve, by J. A. Fleming, published at London, England, 1919, pages 102 to 116, inclusive.

D–2. Ground Telegraphy or T. P. S., Radio Pamphlet No. 10, published at Washington, 1918.

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Cross-examination of Dr. J. M. Miller:

34. Cross-question. Doctor Miller, please state what practical experience you have had in connection with the radio art, particularly in connection with vacuum tubes?

Answer. I have seen and operated practically all common types of radio apparatus employing vacuum tubes. In the laboratory I have investigated the operation of the tubes themselves and of the apparatus in which the tubes are used.

35. Cross-question. Your work has been substantially entirely experimental work, has it not?

Answer. It has been largely experimental, but in many cases the experiments duplicated commercial transmitting and receiving work.

36. Cross-question. The work was largely conducted in laboratories, was it not?

Answer. It was largely conducted in a laboratory, though some of my work has been on board the ships of the United States Navy; also in radio compass stations of the United States Navy.

37. Cross-question. Please define the word "detector" in the sense that you have been using it in your direct examination.

Answer. My definition of the term "detector" as I have used it in my direct examination coincides very closely with the definition given by Eccles and quoted in my answer [fol. 569] to question 8. "Detector—a receiving instrument for converting high-frequency current or voltage into a form of current or voltage capable of affecting an indicating instrument such as a galvometer or telephone receiver."

38. Cross-question. That is, you have used the word in the restricted sense as referring to that particular device which modifies the radio-frequency currents in such a manner as to make them detectable to the human senses?

Answer. I do not know that I have used the term in the restricted manner, but believe that I have used it in accordance with the art.

39. Cross-question. Have you used it in the sense defined in cross-question 38?

Answer. No; I do not think I have. It is not necessary that the output of a detector should be detectable to the human sense. The operation of the detector is such as to convert to a type of current which may be detectable by the human sense if of sufficient intensity.

40. Cross-question. Please state what experience you have had with detectors other than those of the vacuum-tube type.

Answer. My experience with other types of detectors has been largely confined to the crystal detectors.

41. Cross-question. Is the term "detector" synonymous with the term "rectifier"?

Answer. I would not consider them to be synonymous.

42. Cross-question. Please give some examples of detectors that are not rectifiers.

Answer. I do not believe that I would classify the original coherer as a rectifier; likewise the so-called Zehnder trigger tube.

43. Cross-question. How about the Marconi magnetic detector and the so-called dynamic telephone?

Answer. I would not classify these as rectifiers.

44. Cross-question. Please state what experience you have had with vacuum tubes containing only two electrodes.

Answer. The vacuum tube containing only two electrodes is not very common in the art, and I have not had a great deal of experience with such tubes. I have investigated and made tests on high vacuum two-electrode vacuum tubes

known as "kenotrons". I have investigated the functioning of these tubes to some extent in the laboratory.

45. Cross-question. Were these "kenotrons" designed or sold for radio work?

Answer. They were not sold for radio reception. They were used in connection with radio equipment, but not as detectors for radio reception.

46. Cross-question. What was the purpose for which they were sold?

Answer. They were utilized to regulate the voltage of generators used in aircraft-radio transmission.

47. Cross-question. They were used in low-frequency circuits then, were they not?

Answer. I would say they were used in connection with direct current.

48. Cross-question. Please state what physical portion of a complete vacuum-tube receiving set you refer to as the detector.

Answer. I refer to the portion of the receiving set which brings about the frequency conversion referred to in my definition under Cross-question 37. In my direct examina-[fol. 570] tion I have pointed out, however, that the term "detector" is loosely applied to a three-electrode vacuum tube, which is simultaneously performing both the functions of detection and amplification.

49. Cross-question. Does not a three-electrode vacuum tube performing those functions come within your definition of the work "detector"?

Answer. It does, in my definition of a detector, but includes more.

50. Cross-question. Referring to Miller drawing H, please state what portion of the apparatus and circuit shown therein is the detector.

Answer. In vacuum tube No. 4 there is taking place both detection and amplification; commonly tube 4 and its circuits would be called the detector. It is very difficult to separate and clearly distinguish those parts which enter into the detecting action and those which enter into the amplifying action. The grid condensed C' and grid leak r indicate to me that this tube is intended to operate as a detector in this amplifying unit.

51. Cross-question. Does not a certain amount of detecting action also occur in vacuum tubes Nos. 1, 2, and 3?

Answer. There may or may not be a certain amount of detecting action taking place in tubes 1, 2, and 3; such action, however, if present would have no effect on the operation of the amplifier.

52. Cross-question. Comparing two-electrode and three-electrode vacuum tubes, both of them are inclosed in a glass vessel, are they not?

Answer. They are.

53. Cross-question. And this vessel is highly evacuated?

Answer. Yes, to varying degrees.

54. Cross-question. Each contains at least two conducting members or electrodes sealed within the vessel and both physically and electrically separated, does it not?

Answer. Yes.

55. Cross-question. One of these electrodes is designed to act as a cathode or source of electrons, is it not?

Answer. Yes.

56. Cross-question. This effect is obtained in substantially all present-day types of vacuum tubes by heating the cathode to incandescence?

Answer. Yes.

57. Cross-question. A source of energy for heating the cathode to incandescence must necessarily be used with both two-electrode and three-electrode vacuum tubes in order to make them operate?

58. Cross-question. Is it also necessary that a circuit outside of the vessel connecting the two electrodes must be used?

Answer. In the case of the two-electrode tubes there is such a circuit; in the case of the three-electrode tube there are in general two circuits.

59. Cross-question. Each of those two circuits is connected to the cathode, is it not?

Answer. Yes.

60. Cross-question. Is it true that in both two-electrode and three electrode vacuum tubes there is a nonheated electrode (commonly called an anode), which is used as a [fol. 571] collector of the electric charges carried by the electrons emitted from the cathode or a portion of them?

Answer. Yes; such an anode is present in the two-electrode tubes of Edison and Fleming and also in the three-electrode tube of DeForest.

61. Cross-question. When the two-electrode and three-electrode tubes are being used, is there not associated with

each of them some means for impressing upon the cathode and another electrode within the vessel the variations in potential caused by the received oscillations?

Answer. There is a means of applying the variations in potential caused by the received oscillations. These variations are applied in general between the plate and filament in the case of the two-electrode tube and between the grid and filament of the three-electrode tube.

62. Cross-question. Is it also true that in each case there is an indicator either in or electrically associated with the anode-cathode circuit for the purpose of making the reception of oscillations detectable to the human senses?

Answer. There may or may not be such an indicator?

63. Cross-question. Please explain how these devices could be commercially useful without such an indicator?

Answer. My drawing H, to which reference has just been made, shows the connections of a commercial receiving device. In this device tube 4 performs the conversion from radio to audio frequencies. The telephone receiver, which is the indicator, is, however, not located in the circuit of tube 4 at all but is included in the circuit of tube 6.

64. Cross-question. Would you not say that the telephones were electrically associated with the anode circuit of tube 4?

Answer. No; I would not.

65. Cross-question. Do they not indicate the variations in current flowing in the anode circuit of tube 4?

Answer. The indications are perhaps proportional to the variations in the current flowing in the anode circuit of tube 4 but are many times multiplied.

66. Cross-question. Do they not indicate the existence of variations in the current flowing in that circuit?

Answer. Yes; if the multiplication is sufficient.

67. Cross-question. In order to be of commercial value, is it not necessary that the telephones indicate the existence of such variations?

Answer. Yes.

68. Cross-question. Is it true that in the case of both two-electrode and three-electrode vacuum tubes there is an indicator for the purpose of indicating the existence of variations in the current flowing in the anode-cathode circuit?

Answer. Yes.

69. Cross-question. Is it not true that the elements and characteristics of three-electrode vacuum tubes and their associated circuits, which you have stated exist in your answers to cross-questions 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, and 68, are necessarily present in all commercial installations?

Answer. No. The indicator, for example, is not necessarily present and is in general not present in many commercial installations of three-electrode vacuum tubes.

[fol. 572] 70. Cross-question. Is it not necessary that there be some indicator to indicate the existence of current variation in the anode circuit?

Answer. In the use of the three-electrode vacuum tube for radio reception an indicator is used somewhere in the receiving system. In the use of the three-electrode vacuum tube for transmission purposes no such indicator is required.

71. Cross-question. Even when the three-electrode vacuum tube is used for transmission purposes, such an indicator is always present in the receiving end of the system, is it not?

Answer. There would be an indicator at the receiving end of the system which might be thousands of miles from the three-electrode vacuum tubes, which are effecting the transmission.

72. Cross-question. Even then the indicator would indicate the variations in the anode current of the transmitting tube, would it not?

Answer. No; it would not in general.

73. Cross-question. It would, however, indicate the existence of such variations, would it not?

Answer. It would doubtless indicate the existence of variation in the transmitter tube, but the variations affecting the indicator could be entirely different from the variations taking place in the transmitting tube.

74. Cross-question. Leaving out of consideration the indicator, how would you answer cross-question 69?

Answer. I will also have to qualify my answer with respect to the matter of impressing received oscillations. In the case of three-electrode vacuum tubes when used as transmitters, there is no means for impressing received oscillations upon the tube. Otherwise, I believe that the elements and characteristics stated in my answers to the

questions indicated are necessarily present in a commercial installation.

75. Cross-question. Even in the case of transmitters, is it not true that some oscillations are impressed upon the tube?

Answer. Yes.

76. Cross-question. Comparing the mode of operation of two-electrode and three-electrode vacuum tubes, is it true that both devices operated by virtue of variations in the flow of the electrons from cathode to anode?

Answer. Yes.

77. Cross-question. Is it true that the anode current to which we were referring this morning varies simultaneously with and in phase with the variations in electron flow?

Answer. Yes; they are practically identical currents.

78. Cross-question. And is it true that the variations in electron flow are caused by variations in the potential impressed upon the electron stream or a part of it from a circuit outside of the vacuum tube?

Answer. No. In the case of the two-electrode tube it may be said that the variations in electron flow are caused by variations in the potential impressed upon the electron stream, but in the case of the three-electrode tube the variations are not produced by a potential impressed upon the electron stream, or a part of it.

[fol. 573] 79. Cross-question. What causes the variations in the electron flow in the three-electrode vacuum tube?

Answer. The variations in flow in the three-electrode tube are caused by potentials which are impressed upon the grid of the tube. In general, the electron flow does not take place between the cathode and the grid member and hence the potential variations are not impressed upon the electron flow. The action of the grid is such however, as to influence the flow taking place between the cathode and anode of the three-electrode tube. This point is of considerable importance in distinguishing between the operation of the two devices. The action of impressing the potential variations upon the current flow is one which requires power. The control exerted by the grid of the three-electrode vacuum tube is one which requires little or no power.

80. Cross-question. Is it true that in both the two-electrode and three-electrode vacuum tubes the flow taking

place between the cathode and anode is influenced by variations in potential which are caused by the received oscillations?

Answer. Yes; in the case of two-electrode tube this is direct; in the case of the three-electrode tube it is in indirect, or through the action of the grid.

81. Cross-question. In the case of the two-electrode tube, is it true that the electron flow from cathode to anode increases when a positive potential is impressed upon the stream?

Answer. Yes; and the impressed positive potential directly produces the increased current flow.

82. Cross-question. And in the case of the three-electrode vacuum tube, is it true that the electron flow from cathode to anode is increased when the grid is positively charged?

Answer. Yes; but in this case the positive charge on the grid does not directly produce the increased current flow. It is merely the controlling effect of this charge upon the current flow between the anode and cathode that permits a greater current flow between these two electrodes. A positive potential upon the grid does not supply the increased flow of current.

83. Cross-question. Am I correct in understanding that the chief difference between the influence or control of the grid in the three-electrode tube and of the anode in the two-electrode tube is that one is indirect and the other direct?

Answer. No. In the first place, I do not like the use of the term "control" in connection with the voltage applied to the anode of the two-electrode tube. This term is usually reserved for the action of the grid of the three-electrode tube. The main difference is that of a device which is an amplifier and another device which is not an amplifier. The voltages applied to the grid of the three-electrode tube do not themselves produce the current flow or changes in current flow, and hence little or no power is expended in varying the potential of the grid. The variations in grid potential, however, control the current between the anode and cathode. These latter current variations represent considerable power. Hence the variations of considerable power are produced by original voltage variations which are required to supply little or no power. This is an amplifying device. In the case of the two-electrode [fol. 574] tube, when variations in voltage are impressed between the cathode and anode, the changes in current flow

are directly produced by the applied voltage variations and the applied voltage must supply the power represented by these currents. This is not an amplifier and the variations in current would not be called control variations.

84. Cross-question. Is it true that the instantaneous potential of the anode in the two-electode tube determines the electron current at that instant?

Answer. Yes.

85. Cross-question. Is it true that the instantaneous potential of the grid in the three-eletrode tube determines the electron current at that instant relative to the normal electron current caused by the anode battery?

Answer. Both the instantaneous potential of the grid and of the anode determine the electron current in the anode circuit at any instant in the case of the three-electrode vacuum tube.

86. Cross-question. In general, to what extent and in what way, if at all, is the anode potential influenced by the receiving oscillations?

Answer. In the case of the three-electrode vacuum tube, when being used as a radio-frequency amplifier, the variations in plate or anode potential are directly opposite to the variations of potential upon the grid. Thus, when the grid is becoming more positive, the anode is becoming less positive. In the case of the three-electrode vacuum tube when being used as a detector, the voltage variations of the grid are of two kinds, viz, radio-frequency and audio-frequency. In general, in this use of the vacuum tube the variations of anode potential would be audio-frequency variations alone and oppositely directed to the audio-frequency variations upon the grid. The variations in the anode potential depend upon the electrical apparatus included in the anode circuit of the vacuum tube, or rather upon the impedance of such electrical apparatus.

87. Cross-question. Are your answers to cross-questions 76, 77, 81, 82, 84, and 85 correct, regardless of the purpose for which the vacuum tubes are being used?

Answer. My answers to these questions are correct for any ordinary and usual purposes for which vacuum tubes are used.

88. Cross-question. Including detecting, amplifying, and generating oscillations?

Answer. Yes; in so far as they go.

89. Cross-question. Is your answer to cross-question 80 correct as applied to both detecting and amplifying?

Answer. Yes; excepting that in the actual uses of the tubes we are not restricted to variations in potential which are caused by received oscillations.

90. Cross-question. With the same exception, your answer would be correct as applied to the use of vacuum tubes for generating oscillations, would it not?

Answer. I find that my previous answer implies that the two-electrode vacuum tube can be used as an amplifier. This is not true. In answering the present question, I would be admitting by implication that the two-electrode vacuum tube is capable of operating as as oscillator. This is also not true. In so far as the flow between the cathode [fol. 575] and anode is influenced by variations in potential, my answer to cross-question 80 is correct.

91. Cross-question. And is correct as applying to three-electrode vacuum tubes whether detecting, amplifying, or oscillating?

Answer. Yes; that is, the flow taking place between the cathode and anode in the three-electrode vacuum tube is influenced by variations in potential of the grid.

92. Cross-question. What are the physical differences that exist between all two-electrode vacuum tubes and all three-electrode vacuum tubes?

Answer. The main distinguishing feature between the two-electrode vacuum tubes, such as the Edison or Fleming devices, and the three-electrode vacuum tubes, such as the De Forest audion, is the inclusion in the latter of a control electrode or element. There are numerous other variations from tube to tube with respect to size, arrangement of the electrodes, degree of vacuum, etc.

93. Cross-question. Outside of the inclusion of the third electrode and the necessary terminal therefor, is there any other difference which is always present?

Answer. I can think of no other important difference in the tubes themselves.

94. Cross-question. So far as you know, was there anyone prior to John Ambrose Fleming who disclosed the use of a two-electrode vacuum tube in connection with radio signaling?

Answer. Limiting my answer to the type of two-electrode vacuum tube with the heated filament and additional anode

member, I know of no one prior to John Ambrose Fleming who disclosed its use in connection with radio signaling. The use of this type of two-electrode vacuum tube as a rectifier for low-frequency currents was, however, disclosed prior to the date of the Fleming patent.

95. Cross-question. How does the degree of vacuum employed in mercury vapor lamps compare with that employed in vacuum tubes of the type referred to in your last answer?

Answer. I would estimate that the vacuum employed in mercury vapor lamps is equal or of a somewhat lower degree than the lowest degree of vacuum which has ordinarily been employed in two-electrode vacuum tubes.

96. Cross-question. Do mercury vapor lamps operate by virtue of the electron flow?

Answer. Yes.

97. Cross-question. How important a part does ionization take in the operation of mercury vapor lamps?

Answer. Ionization in mercury vapor lamps is of considerable importance in determining the current flow in such lamps.

98. Cross-question. Are such lamps used commercially in connection with radio signaling?

Answer. Not to my knowledge.

99. Cross-question. Have you experimented with the production of high-frequency oscillations by a two-element vacuum tube?

Answer. Yes.

100. Cross-question. What proportion of the tubes with which you experimented were you able to cause to produce such oscillations?

Answer. With high-vacuum two-electrode vacuum tubes I was unable to obtain oscillations with any tubes, even [fol. 576] though I exhausted every effort in the attempt to obtain such oscillations. With low-vacuum three-electrode vacuum tubes, which were converted into two-electrode tubes by connecting the grid and plate electrodes together, I have been able to obtain more or less erratic and variable oscillations under abnormal operating conditions, with practically all of the tubes that I tested. These tubes were chosen by me because I believed that they contained sufficient gas to permit the generation of oscillations by an action similar to that of the arc.

101. Cross-question. Are the high-vacuum two-electrode vacuum tubes to which you referred in your last question the "kenotrons" to which you referred this morning?

Answer. Yes. These tubes had a tungsten filament surrounded by a cylindrical plate, and though not sold for use as radiodetectors could be used as such with perhaps as good results as any other high-vacuum two-electrode vacuum tube.

102. Cross-question. Did you actually use them as detectors?

Answer. I do not remember that I have, but I know that they could be so used.

103. Cross-question. Is it true as a general principle that any device which will generate oscillations will also amplify?

Answer. No; but I believe the converse is true. In order to know whether or not an oscillation generator will be capable of amplifying, it is necessary to know something of the mechanism of the device, but in general a device which will amplify is capable of generating oscillations.

104. Cross-question. Is it true that any vacuum tube which will oscillate will also amplify?

Answer. Not necessarily. I would expect that a vacuum tube which generates oscillations in a manner similar to the arc could possibly be made to amplify.

105. Cross-question. Are all of the three-electrode vacuum tubes which were purchased by the United States, capable of use in commercial radio signaling?

Answer. To the best of my knowledge, they were all capable of use in radio signaling, though they were not all used in connection with radio signaling.

106. Cross-question. Were they used for any purpose other than radio signaling, except for the so-called T. P. S. system of ground telegraphy?

Answer. I know of no other major use of the tubes for purposes other than radio signaling, excepting the T. P. S. system of ground telegraphy.

107. Cross-question. For what purpose were they used in that system?

Answer. They were used as audio-frequency amplifiers. The currents used in T. P. S. signaling are entirely low or audio-frequency currents. The currents picked up at the receiving station are in general too feeble to be heard when telephone receivers are used directly. Amplifiers utilizing

the three-electrode vacuum tubes were employed to multiply the power of these audio-frequency currents so that they were capable of actuating the telephone receivers.

108. Cross-question. Did the vacuum tubes used in this system operate in any different manner from tubes 5 and 6 in Miller drawing H?

[fol. 577] Answer. I would say that the operation was entirely similar.

109. Cross-question. Then the T. P. S. receiving sets were equally adapted to be used as audio-frequency amplifiers in connection with radio receiving sets?

Answer. Yes; in both cases it is a matter of amplifying audio-frequency currents, and, as I pointed out in my answer to question 30, the amplifier had three binding posts, two which were used for T. P. S. signaling, and two of which were used in connection with radio signaling. It is a matter merely of fitting the amplifier to the circuit in which it is being used.

110. Cross-question. Is it not true that in many cases it is necessary to use an audio-frequency amplifier in connection with radio-receiving apparatus in order to make the received signal detectable to the human senses?

Answer. It is true that in many cases when a signal is inaudible in the telephone receiver it can be made audible by including an audio-frequency amplifier in the circuit. I have just pointed this out in connection with the T. P. S. method of ground signaling, and it is likewise true in the case of radio signaling. One must, however, not confuse the technical meaning of the term "detection" with the ordinary meaning of the verb "to detect." In the T. P. S. method of signaling, detection and detectors are not employed, though the use of the audio-frequency amplifier makes it possible to detect a signal that would likewise be inaudible.

111. Cross-question. Using the "ordinary meaning" of the word "to detect," is not an audio-frequency amplifier necessarily employed to detect the signal when without such amplifier the signal would be too weak to be audible?

Answer. Yes; but technically one would not speak of using an audio-frequency amplifier to detect a signal. The meaning of detection is technically limited to the process of frequency conversion from the high radio-frequency, which

is transmitted, to the low or audible frequency, which is capable of actuating a telephone receiver.

112. Cross-question. The conditions referred to in the preceding question are not uncommon, are they, in practice?

Answer. I would say they are not uncommon.

(The examination by counsel being concluded, the witness, in compliance with the rule of the court requiring him to state whether he knows of any other matter relative to the claim in question, and if he does to state it, says he does not.)

(Deposition closed.)

Deposition of Robert A. Millikan, for defendants, taken at New York City on the 27th day of December, A. D. 1923

Robert A. Millikan, having been produced as a witness on behalf of the defendant, was by me sworn before any question was put to him, to tell the truth, the whole truth, and nothing but the truth relative to the said question, and [fol. 578] thereupon deposed and said that his name was Robert A. Millikan; that his occupation is physicist, California Institute of Technology, director of the Norman Bridge Laboratory of Physics, Pasadena, Calif.; that he is 55 years of age; that his residence is Pasadena, Calif.; that he has no interest, direct or indirect, in the claim in controversy; and that he is not related to plaintiff; and thereupon the said Robert A. Millikan was examined by counsel for the defendant and in answer to interrogatories testified as follows:

Direct examination.

By Mr. Edwards:

1. Question. What has been your training and experience in scientific and electrical matters, particularly your experience with electrical discharges through evacuated space or gases?

Answer. I took the doctor's degree in physics from Columbia University in 1895. For one year and one-half thereafter I was a student in Berlin and Goettingen, and then came to the University of Chicago, where I remained

from the fall of 1896 up to 1921, when I accepted the directorship of the Norman Bridge Laboratory of Physics of the California Institute of Technology at Pasadena.

My undergraduate course was taken at Oberlin College, Ohio. I have received honorary degrees for my scientific work from four or five universities, the doctor of science from Columbia University, from University of Pennsylvania, from Northwestern University, from Oberlin College, and from Amherst College.

My experience in the field of discharge of electricity through gases, perhaps, may be said to begin in 1896, when I was working in the laboratory in Goettingen with a man by the name of Potter, who was then with the Westinghouse Co., who was working on the negative resistance of the arc. We used to call it in those days the electromotive force of the arc, and I followed the literature and the development in that field, which were rapid during the next four or five years.

After becoming associated with the University of Chicago I spent a good fraction of my time from, say, 1903 up to the present on the study of the general subject of electronics, much of my experimental work having to do with the discharge through gases.

As a result of that work, I have published a large number of papers in the technical journals on discharge through gases, perhaps the most well-known contributions being the "Isolation of the ultimate electrical unit" and the actual counting of the number of electrons in small charges. This work furnished a complete demonstration of the atomic character of electricity.

The publication of it began in 1909, but there has been a whole series of publications, extending up to last year. The complete summary of all that work is contained in a book which appeared in 1917 which is entitled "The Electron, Its Isolation and the Determination of Some of Its Properties."

For some of this work I was awarded the Comstock prize of the National Academy of Sciences in 1912 or 1913.

I am past president of the American Physical Society and vice president of the American Association of the Advancement of Science, and am at present vice chairman of the National Research Council.

[fol. 579] During the war I held the commission of lieutenant colonel in the Army and the position of chief of the

science and research division of the Signal Corps, which in the spring of 1918 became the science and research division of the Department of Military Aeronautics. I have been the recipient of the Edison medal of the American Institute of Electrical Engineers, of the Hughes medal of the Royal Society of Great Britain, and of the Nobel prize, all for work in the electrical field, especially in the investigation of electronic phenomena.

In all this work I have had considerable familiarity with electron tube work, having been fairly closely associated with the development of tube amplifiers from the very inception of that development by the telephone company in 1912.

2. Question. Are you familiar with the three electrode electron tube devices of the type purchased by the Signal Corps during the war?

Answer. I am quite familiar with those devices, both because of my connection with the Signal Corps and with the Bureau of Steam Engineering of the Navy as a civilian of the antisubmarine board.

3. Question. Are these devices high-vacuum devices?

Answer. They are.

4. Question. How high is the vacuum?

Answer. Measurements which I have made on their commercial audion type bulbs have shown a pressure of, the order of 10-5 millimeters; that is, one one-hundred thousandth of a millimeter.

My own work in my own laboratory with tubes of this sort, evacuated by exactly the same methods which are used by the Western Electric Co. in their manufacture of these tubes, has shown these pressures to vary from 10^{-7} up to 10^{-5}, and sometimes higher, but that would be the order of magnitude of the pressure existing in those tubes, according to such measurements as I have myself made.

5. Question. Atmospheric pressure is about 760 millimeters of mercury, is it not?

Answer. It is under standard conditions.

6. Question. And this pressure in defendant's tubes of the range or nature of one one-hundredth thousandth of a millimeter is a pressure that would raise a column of mercury one one-hundredth thousandth of a millimeter; is that it?

Answer. That is what it means; yes.

7. Question. Does gas or vapor take any part in the operation of these devices?

Answer: It plays no appreciable role, as can be seen from the fact that the current between the filament and the negative grid is wholly negligible in comparison with the current which flows between the filament and the plate. If there were any appreciable amount of gas present, it would be ionized by the bombardment due to the negative electrons emitted by the filament, and the positive ions thus formed would produce a current to the negative grid, for the potential between the filament and the plate is normally above the ioninzing potential of any gas.

8. Question. Is what is called the electronic current a current the flow of which is not in any way associated with the presence of a gas or vapor?

Answer. It is completely independent of the presence of gas or vapor.

[fol. 580] 9. Question. Ionization related merely to an action upon the molecules of a gas or vapor, does it not?

Answer. Yes; ionization is the splitting up of molecules into positively and negatively charged parts. In gas tubes this is accomplished by electronic bombardment, and also under certain circumstances by the bombardment of positive ions.

10. Question. Why, if you know, does the Signal Corps and telephone company use the pressure that it does use in its tubes instead of having no pressure there at all?

Answer. It is not possible to have no pressure there at all in the strict sense of the word pressure, and it is uneconomical to produce a lower pressure than is sufficient for the satisfactory operation of the device. The manufacturers of tubes use as good a vacuum as they can obtain with a reasonable expenditure of money and time in producing them.

11. Question. Does the device work any differently if there is less pressure than that commonly used?

Answer. No; not at all. The pressure is reduced sufficiently so that the residual gases play no part in the phenomena going on in the tube.

12. Question. Will you explain the essential difference or differences in operation between the three electrode tubes of the type that you have been discussing and the two electrode types of electron tube such as shown, for example, in the Fleming patent No. 803684, a copy of which I show

you, assuming both types of tubes to be high-vacuum tubes and assuming both tubes to be used in wireless or wired telegraphy or telephony. By high-vacuum tube I refer to the so-called hard-vacuum tube.

Answer. For the purposes of communications, the two-electrode tube, which you refer to, is an electric valve or rectifier, pure and simple. It can detect and render signals either visible or audible solely by virtue of that rectifying action. When by virtue of the reception of high frequency waves the filament is negative with respect to the plate, a pure electron current passes from the filament to the plate and into the external circuit which joins these two electrodes and is capable of influencing a galv-ometer or telephone in that circuit.

When the impressed waves render the filament positive with respect to the plate, they can drive no current through the afore-mentioned circuit, since there are no positive carriers to pass between the electrodes in the tube. Hence, the galvanometer or telephones cases to register a current. With the high-frequency waves used in wireless, the alternations between the passages of current and the stoppages of current take place so rapidly that the inertia of a galvanometer suspension or of the telephone diaphragm prevents either of them from registering these changes. The registering instrument, in general, therefore, gives its indication during all the period during which the waves are falling upon it, and returns to its normal position when they cease to fall upon it. In this way, it renders visible or audible the presence or absence of waves whose frequency is enormously higher than could be normally detected by a galvanometer or a telephone. Thus, the rectifying or valve property of such a tube renders it useful as a detector of high frequency waves. A two-electrode tube of this kind with its electrodes connected by a circuit containing [fol. 581] a galvanometer, telephone, or other similar registering device does not and can not act as an amplifier. It met with useful application in the communications art only for the reception or detection of signals. About the fall of 1911 the telephone company set themselves the task of developing a telephone relay or amplifier, and after long experimenting developed the three-electrode tube in precisely the form used by the Government during the war as a most successful speech amplifier or telephone relay. The essential difference between the three electrode and the two

electrode tubes, for the communications art, is then that the well-exhausted two-electrode tube is simply a rectifier, and by virtue of that property can be used as detector of signals, but it is not and can not be an amplifier, whereas the three electrode tube was developed primarily for telephone amplification for the very reason that the two-electrode tube could not be so used, and the primary use of the three-electrode tube throughout the war was for the purpose of amplification and is that to-day. The essential function of the well-known telegraphic relay or amplifier in use all over the world since about 1840 is illustrated in Figure 1 of the drawing which I here insert.

Electrical energy coming in from the line to the left is passed through a transformer and by acting upon an electromagnet 2 closes through the motion of an armature 3 a second independent circuit which is supplied with a new source of energy, the battery 6. The energy value of the signal in the new circuit 5 now depends wholly upon the electrical constants of this second circuit and may therefore be as many times as is desired the energy value of the signal coming in through the line from the left. The new signal which is thus passed on to the line 8 to the right bears no necessary quantitative relation so far as its energy is concerned to that which came in to the line from the left. This same Figure 1 may be used to illustrate the essential elements of a mechanical telephone repeater or amplifier if 4 is now thought of as a carbon button or microphone, the pressure between which and the armature 3 is controlled by the currents passing through the electromagnet 2. Such a telephone relay or amplifier has actually been used in practice on telephone lines, but not very successfully, because of the impossibility of the current in 5 following accurately the relative changes of the incoming current in 1. The electron tube telephone amplifier was developed for the sake of replacing an inertialess electron stream, the inertia-laden moving part 3 of a mechanical repeater. The circuits of the electron telephone relay or amplifier are shown in Figure 2 and are essentially the same as those shown in Figure 1. The incoming electromotive forces from the line 2 are passed through the transformer to the left so as to operate between the filament and the grid of the electron tube. These changes in the electrical field surrounding the grid act upon the new circuit 12 so as to control the currents flowing in that circuit

from the battery 6 and therefore flowing between the filament and the plate in essentially the same way as the pressure between the armature and the carbon button 3 and 4 in Figure 1 control the currents delivered to circuit 5 by the battery 6 of that figure. The essential difference is merely that the distortion-full amplification by the mechanical relay of the wave form coming to it through the electromagnet 2 is replaced by a distortionless amplification by the inertialess electronic relay of Figure 2. The ampli- [fol. 582] fication factor in the device illustrated in Figure 2 may be chosen at will precisely as in the case of the mechanical relay shown in Figure 1. In actual practice it often amounts to five hundred or a thousand fold. The essential difference, then, in a word, between the two-electrode tube and the three-electrode tube, so far as the communications art is concerned, is that they were developed for entirely different purposes and actually fulfil completely different functions, the first being simply a rectifier and detector and incapable of performing either in a scientific or commercial way the function of amplification, while the second was developed for and now serves magnificently the purposes of distortless amplification.

13. Question. What is meant by amplification?

Answer. I should define it as the passing on from one circuit to another of a signal or of speech with increased energy, because of the utilization for the purposes of the signal of the energy of a new battery or other source of some kind.

(Counsel for defendant offers in evidence the sketch referred to by Doctor Millikan in his answer to question 12, and the same is marked "Defendant's Exhibit E2.")

14. Question. Can you state in a general way what commercial importance the amplification function has?

Answer. I suppose that the outstanding commercial application of amplification is in the field of wire telephony, transcontinental telephony, having been possible solely through the development of a distortionless telephone repeater or amplifier, and I suppose too that the great bulk of its use in the wireless field, small though that field be in comparison with the former, is in the distortionless amplification of speech, for every broadcasting, receiving, or transmitting set of the better type involves just this use.

15. Question. Is the distortionless repeater or amplifier

above referred to as in extended use the three-electrode tube or the two-electrode tube?

Answer. It is precisely the three-electrode tube whose functioning I have been above describing.

16. Question. In your opinion, would this extended use of electron tubes in the telephone and wireless field have been possible with the two-electrode type of tube only?

Answer. Certainly not.

17. Question. In your comparison of the two-electrode type of tube with the three-electrode type of tube, would this comparison be changed, or would the operation of the tubes be changed, whether the tube is operated at radio-frequency or audio-frequency?

Answer. The amplifying qualities of a three-electrode tube, or triode, are quite the same for radio frequencies as for audio frequencies.

18. Question. If a battery be inserted in the circuit of a two-electrode tube, still assuming a high, that is to say, hard, vacuum tube, for example, as shown in the circuit marked "Figure 3" of Miller drawing L (defendant's Exhibit D), would the tube act as an amplifier?

[fol. 583] Answer. The device shown in this diagram is equally incapable, with that which I have been discussing, of amplication in any degree whatever. The local battery in the circuit of Figure 3 is indeed continually supplying direct-current energy to that circuit, but this adds nothing to the alternating-current energy of the signal coming into the circuit with which it is coupled. In other words, for the purposes of the signal, the energy of the inserted battery is not tapped in the slightest degree. Indeed the energy available for and spent in signalling, is slightly diminished because of the ohmic resistance of the inserted battery. It is true that signals may sometimes be heard better when a local battery is inserted, as in Figure 3, than when it is absent, especially when the detector which is in series with the battery is a crystal; but this is merely due to the fact that the resistance of the crystal, or the crystal and its contact point, when it is carrying a current of some magnitude is often less than its resistance when it is carrying a very small current or no current at all. This merely means that the resistance of the whole circuit with the battery inserted may be less than its resistance with the battery absent, and therefore, at the same dissipa-

tion of energy by the signal, may give rise to a larger current, through the detector. While the battery may thus act as a sensitizer of the circuit for the signal, its own energy is not utilized at all in the alternating current of which the signal consists. A hard tube with or without a battery is equally incapable of amplification.

19. Question. In the circuit referred to, would there be any difference so far as obtaining amplification is concerned, if a crystal detector were inserted in place of the two-electrode hard vacuum tube?

Answer. In general, no. No device in a series circuit of this kind can possibly produce amplification, if it has a positive volt-ampere characteristic, that is, if an increasing potential difference applied to its terminals produces a continually increasing current passing through it. Every hard two-electrode tube has such a potential current characteristic, and must have because of its very nature. Crystal detectors also in general have such so-called positive characteristics. I think it possible however, that a freak crystal might be found which would have a negative volt-ampere characteristic, because of the existence of something like an arc at its contact point, and if this were so it would theoretically, at least, have the capacity of a certain kind of amplification, which I will designate as the negative resistance type of amplication, in order to differentiate it sharply from the relay type of amplification exhibited by any telegraph or telephone relay such, for example, as a triode tube. This relay type of amplification is that which is produced in the three electrode tube circuit described in the foregoing.

In general, triode tubes, like diode tubes, if they are well exhausted, have necessarily positive volt-ampere characteristics, that characteristic being taken between the filament and the plate.

[fol. 584] 20. Question. What would be the result of introducing or leaving in the two-electrode bulb a small amount of gas, so far as relates to the possibility of attaining amplification?

Answer. There would be no effect at all, unless the gas exceeds a certain critical amount. If, however, enough gas is present to permit the formation of an arc between the filament and the plate, or of a conducting region, which has the characteristics of an arc, it would be possible to

obtain with the two-electrode tube a certain imperfect type of amplification which I have designated in the foregoing as the negative resistance type of amplification, in order to differentiate it sharply from the relay type, for which the three-electrode tube is so well adapted. Any space between two electrodes in which it is possible to obtain a large amount of ionization of gases or vapors may under suitable conditions exhibit the peculiar property of having what is often termed a negative resistance. A negative resistance is defined as a negative value of the increment in potential causing current to flow between two points over the increment in current. If we insert such a space, which for brevity I will henceforth term an arc, in series with a circuit otherwise containing a battery and a resistance, if the arc has this negative characteristic for the impressed frequency, then the effect of the negative resistance of the arc upon the current flowing through the circuit is equivalent to the substraction of a certain amount of the resistance that is already in the circuit, so that the current which flows through it is larger than could be obtained if the arc were not there. In this case the alternating energy of the signal may be actually increased at the expense of the battery inserted in the receiving circuit. The principle here involved is the introduction into a series circuit of a negative resistance which produces amplification simply because it annuls a certain part of the resistance which the circuit already had. In this case there will be amplification in just the proportion which the substracted resistance bears to the resistance of the whole circuit. If, for example, the inserted device has a negative resistance of 1 ohm and the circuit a resistance of 500 ohms, then the alternating signal will be one five-hundredth stronger than it was before. If, on the other hand, the positive resistance of the circuit into which a negative resistance of 1 ohm is inserted, was 10 ohms, then the signaling current will have been increased or amplified 10 per cent or by a factor of one-tenth. I have measured the negative resistances of arcs, both in partially exhausted tubes and out of them, and have usually found them of the order of 1 or 2 ohms. I do not think I have ever measured one that had a negative resistance of as much as 10 ohms. This shows one of the limitations of this type of amplification. It has practically no effect at all when used in circuits of resistances larger

than a few ohms. A second more important limitation lies in the fact that these negative resistances in general represent rather unstable conditions, and hence are subject to very considerable variations so that it is practically impossible to cause one of them to have any specified amplication coeffi- [fol. 585] cient or ratio at all such as is necessary if they are used for the purposes of commercial amplification. Negative resistances have as a matter of fact never had the slightest value. This type of amplification is therefore sharply differentiable both as to method and results; indeed, I should say as to principle also, from the relay type of amplification used for years in telegraphy and now introduced into telephony through the development of the three-electrode amplifier, which makes it possible to obtain any desired amplification ratio or amplification coefficient. I may say also that the whole subject of negative resistances was one about which there was much discussion and no little confusion in thinking between 1890 and 1900. It was very beautifully cleared up by some papers which appeared in the London Electrician by Duddell in 1900 (vol. 46). Since that time there has been I think general agreement among competent students of the subject upon the essential points which I have been discussing in the preceding. The whole field is correctly analyzed and discussed in a German book written by Barkhausen about 1907 and a good many other recent books, such as Van der Bijls Thermonic Vacuum Tubes, published in 1920.

21. Question. You testified on behalf of the defendant in the case of Peter Cooper Hewitt against the American Telephone & Telegraph Co. involving the Peter Cooper Hewitt patents 781001 and 781002, did you not?

Answer. I did.

22. Question. Will you compare the kind of amplification which you have just described in your answer to question 20, with such amplification as is obtained in the operation of the devices of the two Peter Cooper Hewitt patents, just referred to?

Answer. Any amplification due to the insertion of a mercury vapor arc into a series circuit is simply a case of the negative-resistance type of amplification which I have been describing and discussing in the foregoing. This is the only type of amplification involved in the patents to which you refer.

23. Question. Will you now compare the type of amplification due to a negative resistance, such for example, as that of a gas-filled two-electrode tube of a Peter Cooper Hewitt tube, with the type of amplification obtained by the three-electrode type of tube and state wherein these types of amplification differ from each other?

Answer. They seem to me to be completely distinct in principle. A three-electrode tube such as is used in the modern tube amplifier does not have a negative resistance at all. It amplifies as I have said above, by the relay principle, that is by tapping the energy of an entirely new circuit and multiplying the energy of the signal in any desired amount, up to a thousand or even a millionfold if more than one stage is used. Its immense utility in modern life results from the fact that it is amazingly distortionless and is capable of quantitative analysis and predetermination, with definite amplification coefficients, whereas negative-resistance amplification has thus far been found to be of no commercial value because it lacks completely both these characteristics.

Cross-examination.

By Mr. Peters:

24. Cross-question. What experience have you had with two-electrode vacuum tubes such as that disclosed in the Fleming patent?

[fol. 586] Answer. I have worked with them in the laboratory but have had no commercial experience with them whatever.

25. Cross-question. Where did you obtain those that you worked with in the laboratory?

Answer. Constructed some of them myself, and have had others constructed in the laboratory by the Western Electric Co.

26. Cross-question. How much gas must there be in a two-electrode tube in order that the tube will display what you have termed negative resistance?

Answer. I think that in general any tube operating with a blue glow as it is sometimes called, may exhibit a negative characteristic, to what extent a blue glow is visible, is rather difficult to state, because it depends so largely upon the contrast between the amount of light emitted by the

tube and that coming in from other sources. One's judgment in this matter in an ordinarily lighted room is particularly subject to error. In general, however, to make as specific an answer to your question as I am able, tubes which are working at a pressure as low as 10^{-5} millimeters may be considered as pure electron discharge tubes; that is, they do not give evidence of the appreciable ionization which makes a negative resistance possible. Tubes, however, which have in them the pressure of mercury vapor at ordinary temperatures, which is about 10^{-3} millimeters, will generally show blue glow and may then exhibit the phenomena of negative resistance, when they are operated at high enough voltages. This last statement indicates that the applied voltage as well as the residual pressure as measured before the voltage is applied have to do with the appearance of the large amount of ionization which is essential for the development of a negative resistance. This answer then will perhaps give you the broad limits as to the pressure conditions under which negative resistances may be expected to appear.

27. Cross-question. What was the order of vacuum commercially possible at the date of the Fleming patent?

Answer. 10^{-6} or 10^{-7} millimeters of mercury.

28. Cross-question. Was that the vacuum of commercial electric lamps at the date of the Fleming patent?

Answer. Not at the time at which they were exhausted. I have myself made few, if any, measurements on the vacua obtained in commercial lamps. Doctor Langmuir, however, has stated that in view of the so-called clean-up effects due to the incandescence of the filament, the vacua actually existing in commercial lamps is in general very high.

28½. Cross-question. What type of pumps were available for exhausting vacuum lamps or tubes in 1904?

Answer. Mercury pumps of the Sprengel or Toepler types. These were capable of producing vacua, when used with suitable cooling traps, such as were employed in our laboratory prior to 1900, of the order of magnitude indicated above. I speak with great positiveness on this point, because I myself prior to 1904 had built a pump of this type, with which I have directly measured the vacuum produced only by methods in use prior to 1904, which showed pressures as low as 10^{-6} millimeters. I was myself entirely responsible for the development of high vacuum technic at the University of Chicago, at about this time, and know

that we could produce in 1906 or 1907 at least quite as good vacua as we can attain to-day.

[fol. 587] 29. Cross-question. My question was directed to commercial practice in 1904. Can you not state briefly what was the degree of exhaustion of tubes and lamps and vacuum tubes at that day?

Answer. I have never been very closely in touch with commercial lamp practice, but I should estimate from a knowledge of the kind of pumps that were used, that commercial lamps had been exhausted, before the clean-up effects had operated, to pressures of a thousandth of a millimeters, that is; 10^{-3}.

30. Cross-question. Can you state in a simple way how you would have ascertained a vacuum in any vacuum tube in 1904?

Answer. With a so-called McLeod gauge, which we can use to-day to measure with fair reliability, pressures of 10^{-6} millimeters.

31. Cross-question. Are you familiar with any three-electrode tubes produced prior to those which you say were developed by the Western Electric Co. beginning in the fall of 1911?

Answer. Only with the De Forest tubes.

32. Cross-question. Then your testimony was not given with the understanding that the Western Electric Co. first produced three-electrode tubes?

Answer. Not at all. They first developed the three-electrode tube for the purpose of commercial amplification for use on the telephone lines.

33. Cross-question. Can you state briefly what the development by the Western Electric Co. consisted in?

Answer. That is a question to which I could not give an authoritative answer, but I should say in general that their problem was the adaptation of the three-electrode tube as it had existed before to the entirely new problem of distortionless telephonic repetition or amplification and the modification of designs and conditions of manufacture so as to make it a thoroughly reliable and duplicable device for the purpose in hand. For example, gas in the De Forest three-electrode tube does not seriously impair it as a mere detector. It does render it quite inapplicable for the purposes of distortionless amplification.

34. Cross-question. The gas in the De Forest audion impaired it for distortionless amplification, but it still would

act as an amplifier, would it not on radio telegraph signals?

Answer. Yes; a three-electrode tube may act as an amplifier, even though there is sufficient gas present so that the amplification is not distortionless.

35. Cross-question. Do you know about how much gas there was in the De Forest tubes?

Answer. I do not think that question could be answered by anybody, for I think the De Forest tubes were at that time exceedingly variable in their gas content; some of them acting quite like well-exhausted tubes, and others not.

36. Cross-question. What experience did you have with the De Forest tubes about which you say you knew before the fall of 1911?

Answer. I had no experience with the De Forest tubes before the fall of 1911. Indeed, I think the first one that I saw was some time in 1912.

[fol. 588] 37. Cross-question. You referred in your testimony to the use of the three-electrode tube by the Government during the war as an amplifier; was not such a tube also used at the same time by the Government as a detector?

Answer. I couldn't speak with absolute certainty about that; but I presume that it was to a very considerable extent, although I should have the off-hand judgment that its use as an amplifier was very much larger.

38. Cross-question. When used as a detector a three-element valve acts as a rectifier, does it not?

Answer. Yes; in the sense that it lets through more current in one direction than in the opposite.

39. Cross-question. And it is this rectifying or valve property of the three-electrode tube which renders it useful as a detector of high-frequency waves, is it not?

Answer. Yes; at least in one kind of a detector mechanism, such a one for example, as is used when the Morse signals are being received. This of course does not mean that it could not detect signals in any other way than through this valve or rectifying action, for that would be I think quite contrary to the fact.

40. Cross-question. What other kind of detection have you in mind?

Answer. Such as is used when distortionless speech is transmitted by wire, for example.

41. Cross-question. Are you referring to radio uses or to wire uses?

Answer. Either one.

42. Cross-question. That is to say, if I understand you, that the rectifying property of a valve is not required in receiving distortionless speech transmitted by radio?

Answer. Certainly not for the audio wave, for any valve action on a given wave form necessarily distorts that form.

43. Cross-question. Is not a detector necessary when receiving both radiotelephone and radiotelegraph signals?

Answer. Certainly, if you define detecting as the receiving of a signal.

44. Cross-question. In what sense have you used the word detection in your deposition?

Answer. I defined it at the time at which I used it by explaining quite fully how an electronic valve or rectifier operated in detecting radio signalling; that is, in rendering them either visible or audible. I did not limit of course, all detecting to electronic valves, or rectifiers, nor can it be so limited, as detecting is a very broad term.

45. Cross-question. How does a three-electrode valve operate to detect signals in any other way than through its valve or rectifying action?

Answer. In the ordinary passing of speech from one circuit on to another circuit through the relaying principle, as it is used in the telephone amplifier of the three-electrode type, for example, the amplifier is of course a detector in the broad sense, but if the wave form is transmitted undistorted there is here no rectifying of valve action at all.

46. Cross-question. I understand that you consider an amplifier to be a part of a detector; is that right?

[fol. 589] Answer. Not a part of a detector; all amplifiers are, of course, detectors, in the broad use of the word detection; that is, they transmit and render audible or visible signals, but there are detectors of course which are not amplifiers, for example, the Fleming valve.

47. Cross-question. Can an amplifier be used for receiving any form of radio signals without a rectifier?

Answer. Yes; i. e., without any rectification of the signals.

48. Cross-question. Would the signals be audible without rectification?

Answer. Certainly they could be made so.

49. Cross-question. How?

Answer. By the modulating principle.

50. Cross-question. What principle do you refer to as the modulating principle?

Answer. The term is well known. I can refer you to any book on wireless telegraphy or wire telegraphy.

51. Cross-question. Do you mean that a radio telephone signal modulated to transmit music can be received by an amplifier without being rectified and made audible on the telephone?

Answer. Certainly; for if rectification of the audio wave were essential, it would be completely hopeless to attempt to transmit distortionless speech, since wherever there is rectification there is necessarily distortion of the wave form.

52. Cross-question. You are familiar in a general way with radio-telephone receivers such as are now commonly used for broadcasting reception, are you not?

Answer. Somewhat.

53. Cross-question. They all comprise a so-called detector element, do they not?

Answer. Presumably so; they certainly must detect in the broad sense of the word.

54. Cross-question. And this detector can be a crystal detector, a two-element tube, or a three-element tube, can it not?

Answer. Yes.

55. Cross-question. And without it the receiver would not operate?

Answer. In other words, it can not detect without detection; certainly not.

56. Cross-question. What does the so-called detector element do?

Answer. Receives the signal.

57. Cross-question. Receive the signal and passes it on; but what change does it bring about in the form of the signal current?

Answer. If it operates as a distortionless receiver, no change in the audio-wave form.

58. Cross-question. Why is it necessary to use it at all?

Answer. Because the ear is not adapted to receive electromagnetic waves, for one reason.

59. Cross-question. What does the detector do that enables the ear to receive the signal?

Answer. The whole receiving mechanism in the case of wireless telephony acts in some way to reproduce at the

receiving station the speech wave form sent out at the transmitting station. This wave form is actually carried upon a continuous succession of high-frequency oscillations in ordinary wireless telephony practice, the mechanism by which that wave form is imposed upon the high-frequency [fol. 590] waves at the transmitting end and brought back to the telephone at the receiving end. I do not care to go into it here, since it would be more satisfactory to simply refer to a chapter or two in books on wireless telephony, but the point with which we are here concerned, I take it, is that if the wave form of audio frequency which was impressed at the transmitting end is reproduced without distortion at the receiving end, at no point in the process will there have been rectification of such kind as is produced by a Fleming valve in that audio-wave form, for I repeat, rectification consists by its very definition, in the distortion of the wave form. The essential matter here is that the three-electrode valve when used as an amplifier is not a rectifier at all, as is the two-electrode valve. When used on the straight portion of its characteristic curve, it does not rectify, but it does transmit distortionless speech with amplification if desired. You have touched here one of the most essential distinctions between the three-electrode tube and the Fleming valve. Both of them, of course, are detectors, in the sense that they detect signals of one sort or another. The Fleming valve, however, is merely a detector, while the three-electrode tube may be in addition an amplifier. Using the three-electrode tube on the curved portion of its characteristic, it can act as a valve as does the two-electrode tube; that is, it can magnify one side of the wave and suppress more or less completely the other side. This is why I said that when a three-electrode valve was used merely as a detector, not as an amplifier, a little gas in it is not a disadvantage. I trust that this makes clear the way in which I am using throughout the terms detecting and amplifying. In a word, all receiving devices are detectors, but some types of receiving devices are much more than that, they may amplify as well as detect.

60. Cross-question. Taking a detector pure and simple without amplification, won't you state briefly how it works?

Answer. I refer you to my deposition on the action of the Fleming valve as a detector in the early part of this testimony.

61. Cross-question. And does the three element valve operate the same as a two element valve when used as a detector?

Answer. This is answered in the preceding answer, where I explained as carefully as I can the difference between the three element and two element valves.

62. Cross-question. As an example of the mode of use of the three element valve by the Government, I call your attention to Figure 2 of the drawing marked Miller drawing G, which he says shows a combination of the P–N detector circuit and a two-stage audio-frequency amplifier, are you familiar with this type of apparatus?

Answer. In a general way.

63. Cross-question. Do the three bulbs forming part of this apparatus all operate in the same way?

Answer. That depends upon the structure of the bulbs, and the precise way in which they are used in this circuit and with this last I am not sufficiently familiar to give you a categorical reply. So far as this diagram may be interpreted, the first bulb, that is the one to the left, would seem to be both an amplifier and a detector, and the last two might be said to be used simply as amplifiers if we regard [fol. 591] the detection of the incident wave as having been accomplished when that wave was brought into the receiving apparatus to the left of the line a–b.

64. Cross-question. You state that the first bulb may act both as an amplifier and as a detector, what difference do you have in mind between the two functions?

Answer. Not necessarily any difference, for as I have said a number of times, any bulb that can amplify can of course detect.

65. Cross-question. As another example of the use of these bulbs by the Government, I call your attention to Miller drawing H, inserted at page 97 of the typewritten record, and which shows a six tube apparatus in which the first three of the tubes are marked radio, the fourth tube a detector, and the remaining two tubes audio, what are the different functions of the several tubes employed in this apparatus?

Answer. I have not looked over this part of Doctor Miller's testimony, and would suggest that you can get that information more accurately therefore, from him than from me.

66. Cross-question. I understood that you were familiar with the use of these tubes by the Government?

Answer. In a general way only.

67. Cross-question. Can you refer to any specific use by the Government with which you are familiar?

Answer. I was not in the detail end of the radio work, and my main work in connection with tubes both in my laboratory and out of it has been concerned rather with the interior functioning of electronic tubes than with the details of the circuits with which they are used. I am in general familiar with the tube work which the Government did during the war, in the same way in which I am familiar with the tube development made by the Western and General Electric Cos.

68. Cross-question. I show you a sheet having on it two diagrams, which of either of these arrangements will receive radio telegraph and telephone signals?

Answer. Kindly write a description explaining what those diagrams mean.

69. Cross-question. I have indicated on the sketch the names of the several elements which enter into the apparatus, can you now answer the question?

Answer. Both of them will receive them, but what they will do with them after they receive them, I am not stating.

70. Cross-question. Will they both enable the operator to hear the signal?

Answer. B will not as it is drawn.

71. Cross-question. What does the three element bulb do which enables the circuit A to make the signals audible while the circuit B will not?

Answer. Nothing at all, for neither A nor B will receive them and render them audible as they are drawn, for the reason that, so far as I can see, they contain nothing to transform the radio-frequencies to audio-frequencies.

72. Cross-question. What would you suggest adding to the arrangement in order to make it operative?

[fol. 592] Answer. I shall not attempt to go into drawing a complete receiving system. That can be obtained if you wish it, by consulting Doctor Miller's testimony.

* * * * * * *

73. Cross-question. I call your attention to Miller drawing F, referred to in your answer to question 17, and ask

you to compare Figure 2 with that drawing of Figure A of the sketch referred to in your last preceding answers.

Answer. So far as I can see, the two diagrams are essentially alike, but both of them lack one element which is an essential in some form or other in a three electrode tube in order that it may make the transformation from radio to audio frequency and that element is a leak resistance, which so far as my observation goes it is customary to draw about the condenser which is labeled D3 in the Miller drawing F. Without that leak the grid cannot possibly follow the changes in amplitude of the carrier wave which have been impressed upon it by the audio frequency so that that audio wave form or the envelope of the carrier wave could not be reproduced by an apparatus having the precise characteristics of this diagram. The grid would simply charge up in an apparatus built precisely on these lines to the highest negative potential corresponding to the maximum positive amplitude of the impressed wave form and no lower value of the amplitude would further affect the current from the filament to the plate. This ability of the negative potential of the grid to follow on the average (by virtue of some discharging mechanism such as that which is conventially represented by shunting a high resistance around the grid condenser,) the changing amplitude of the carrier wave which represents the audio frequency, is, I think, essential to the transformation of the radio frequency to audio frequency and therefore to enabling the operator to hear the speech. With the introduction of something to represent the leak from the filament the diagram A represents a device which will enable the operator to hear audio signals. Diagram B, will not permit the operator to hear the signals, unless some more elements are added to it also.

74. Cross-question. All detectors of radio signals must operate as rectifiers, must they not?

Answer. Not in the broad sense in which I have in the foregoing been using the word detector. I was careful to state above that I had been using the word detection in its broad derivative sense i. e. to denote the receipt of a signal of any kind. In technology words often lose their derivative meaning and come to be used in a definite technical sense. It was because I was conscious of the fact that detector was used by wireless men in a very definite and specific sense that I explained from the start that I was not using the word in any such sense, as I have already indi-

cated, I am not at present working in the radio field and have made no claim to intimate familiarity with the multitude of different circuits and arrangement of parts, nor indeed with the technical terms, which are the stock in trade [fol. 593] of the radio engineer. Insofar as I have touched this field in any intimate or thorough going way, it is on the tube side rather than on the circuit side. Reference to Doctor Miller's testimony shows that he uses the word detector not in its broad sense, but in a definite narrow technological sense, and I find that the Institute of Radio Engineers in the report of their committee on standardization for 1915 has given the following technical definition to the word detector, and that Doctor Miller's use of the word appears to coincide with this definition. The definition is as follows:

"Detector: That portion of the receiving apparatus which, connected to a circuit carrying currents of radio frequency, and in conjunction with a self-contained or separate indicator, translates the radio frequency energy into a form suitable for operation of the indicator. This translation may be effected either by the conversion of the radio frequency energy, or by means of the control of local energy by the energy received."

The last sentence shows that the translation of the radio frequency energy into a form suitable for the operation of the indicator may be performed either by the conversion of the radio frequency energy after the manner of the operation of the Fleming valve or by means of the control of local energy by the energy received, after the manner of operation of the three electrode tube as I have described it above. In the sense of the foregoing definition I think I can answer your question by saying that in general under usual operating conditions of radio there must be rectification of the radio frequency energy not of the audio before there can be reception of speech or music by radio. I say, in general, for the reason that for very short distances, speech or music may be transmitted through the ether at its normal frequencies and received in quite the same way in which transmission and reception are accomplished in wire telephony.

75. Cross-question. Using the word "detector" in the sense in which it has been used in the radio art, please state

whether the three-element valve when used as a detector of radio signals acts as a rectifier?

Answer. In general, it does of the radio-frequency.

76. Cross-question. Do you know of any use by the Government where it did not so act?

Answer: I think not.

77. Cross-question. And it is this rectifying or valve property of the three-electrode tube which renders it useful as a detector of high-frequency waves, is it not?

Answer. Yes; in this technical sense, of the word detector.

78. Cross-question. It is true, is it not, that the physical principles underlying thermonic tubes having two electrodes are applicable also to three electrodes?

Answer. Only in the sense that they both utilize pure electron discharges produced by heating a filament to a high temperature in an evacuated tube. In my judgment they involve altogether distinct physical principles in the following important particulars:

The most conspicuous and important element in the three-electrode tube is the operation of changes in the potential of the grid upon what is called the space charge about the filament in such a way as to control the current furnished by a new battery or other source of electrical energy in a circuit containing the filament and the plate. This very important relay principle is the one which it seems to me has [fol. 594] made possible more than 99 per cent of developments of the last 12 years in both wire and wireless telephony and telegraphy. This principle is, in my judgment, entirely wanting in the Fleming valve, which acts as I have before said merely as a rectifier.

79. Cross-question. Is it true that the effect of applying a potential to the grid of the three-element tube is equivalent to the application of a different potential to the plate circuit?

* * * * * * *

Answer. It certainly can not be the equivalent in its result, else the grid might be dispensed with, and two electrode tubes used as distortionless amplifiers, for example.

80. Cross-question. Is it your understanding that a three-element valve never has a negative plate resistance analogous to that of which you have spoken in connection with an arc?

Answer. It never has a negative resistance when the volt-ampere characteristic is determined as in the case of the arc

by taking a volt-ampere curve between the filament and the plate, there being always, as in the case of the arc, a direct casual relation between the applied potential and the current produced by it. It is of course possible to interfere with that casual relation by some variable third agency so as to give a negative slope to a volt-ampere curve, but the space between the filament and the plate can not then properly be said, in my judgment, to possess a negative resistance. At any rate, this is something quite distinct from the negative resistance of an arc which is due to copious ionization of gas or vapor molecules.

81. Cross-question. And the third agency which you refer to may be the grid of the three-element tube, may it not?

Answer. One could introduce the third agency through the grid, but again let me say that whenever any such third agency is introduced, the whole significance of the term negative resistance disappears and we begin to confuse so it appears to one sound thinking by the indiscriminating use of words.

82. Cross-question. I call your attention to a book by Lauer & Brown entitled "Radio Engineering Principles," which book contains a "Foreword" of appreciation by Maj. Gen. George O. Squier, Chief Signal Officer of the United States Army, and to a statement on pages 177 and 178, which reads as follows:

"If now the grid potential Eg is varied so as to increase the current Ip in the plate circuit, it is seen that the resistance drop rIp in the external plate circuit will correspondingly increase. It then follows from equation (30) that, with the battery voltage Eb remaining constant, the plate potential Ep will decrease. Conversely, if the current Ip is decreased by decreasing the grid potential, the plate potential Ep will increase. Thus, on account of the external resistance of the plate circuit, the plate potential is no longer constant, but is a function of the plate current, and varies in opposite direction to the latter. In other words, the tube, operated under such conditions, has a negative plate resistance reaction as defined in connection with the oscillating arc, Chapter V. This will be taken up in greater detail in a later paragraph."

[fol. 595] Do you agree with that statement?

Answer. I couldn't answer that question without more careful study of the whole argument than I can make here.

I should wish to understand the author's terminology and his definitions before saying that he was right or wrong.

83. Cross-question. You do not deny these statements made in the quotation on any knowledge which you now have on the subject?

* * * * * * *

Answer. I am confident that the author and myself could entirely agree on this matter if we were to get together on our definitions, but it is quite impossible to take a single short paragraph which presupposes much that has gone before and refers as this paragraph does, to much that is to follow, and say that one disagrees with it or agrees with it.

84. Cross-question. As I understand you, a device displays the property which you call negative resistance when its current and voltage vary inversely?

Answer. Yes; provided the current and voltage are casually related.

85. Cross-question. Do any of the curves of Figure 75 on page 153 of the Vander Bijl book to which you have referred show this negative resistance property; and if so, which?

Answer. I should have to make the same reply as I made before, that it will be necessary for me to understand precisely what these curves represent better than I can by merely looking at the diagrams, to say whether they do or do not show a negative resistance. My off-hand impression would be that they do not, because they are labeled grid amperes and grid volts, and I suspect, therefore, that they represent volts and amperes which are not casually related. At any rate, the phenomenon is quite distinct from that found in the arc unless the negative slope is due to the copious ionization of a gas or vapor.

86. Cross-question. What would be casually related to grid currents, if not grid voltage?

Answer. The volts and amperes would be casually related if a battery were attached simply between the filament and the grid, no current at all going to the plate, and the volt ampere curve then taken. If the amperes then increase with decreasing voltage, no other causes influencing the flow of current between filament and grid except the applied potential between filament and grid, the resistance would be negative, and the properties or characteristics, by whatever

words we describe them, would then be like those of a gas filled Fleming valve, otherwise not.

87. Cross-question. According to your definition, then, the signal received by the grid and the signal given out by the plate circuit are not casually related?

Answer. This is another matter entirely; we haven't been talking about signals given out by the grid, or the plate; you have merely asked me for the definition of negative resistance, and I have attempted to give it.

88. Cross-question. And the current shown in Figure 75 is not caused by the voltage applied?

Answer. I don't know.

[fol. 596] 89. Cross-question. I call your attention to Figure 16, page 48, of the Vander Bijl book and to the last paragraph on page 49 and ask if this refers to the three-element bulb?

Answer. Figure 15 looks like a three-element bulb. I do not know what Figure 16 does represent, nor do I know what definitions Vander Bijl has here set up.

Redirect examination.

By Mr. Edwards:

90. Redirect question. If the three-electrode tube is employed in an amplifier circuit, does it act as a detector, defining detector as you have done in your answer to cross-question 74?

Answer. If the amplifier is merely producing distortionless amplification, there is none of the rectification quality present, which is necessary for the transformation of a radio frequency into an audio frequency, such as the definition requires.

Recross-examination.

By Mr. Peters:

91. Recross-question. When a three-element bulb is used on an amplifier, it is unilaterally conductive, is it not, for any grid current, which flows onto the plate current?

Answer. When it is functioning as a pure amplifier, the wave form coming in from the line is reproduced in all its phases with their relative values unchanged. This alternating wave from is superimposed upon a continuous

unidirectional current through the plate battery circuit. It is this last current alone which, as it seems to me, can be properly called unilateral. The signaling current is sent out with just the wave form with which it came in.

92. Recross-question. Is maximum amplification consistent with distortionless amplification?

Answer. I do not know quite what you mean by maximum amplification, for there is theoretically no limit to amplification, and therefore no such thing as a maximum of amplification.

93. Recross-question. My question was directed to the possibility of practical apparatus, and not to mere theories; with such practical apparatus as we have been discussing, is maximum amplification possible or consistent with distortionless amplification?

Answer. The practical limit is imposed by the bothersomeness of the extraneous noises originating in the microphone or elsewhere, which are magnified quite as much as the speech so that the distortion of the wave form is not, I think, the actual practical difficulty in amplification.

(The examination by counsel being concluded, the witness, in compliance with the rule of the court requiring him to state whether he knows of any other matter relative to the claim in question, and if he does to state it, says he does not.)

It is hereby stipulated, subject to correction should error appear, that the annexed copies of depositions of Joseph B. Baker and John Stone Stone, and the exhibits referred to therein, are true and correct copies of depositions given by the said Baker and the said Stone, and the exhibits introduced in connection with said depositions, given on the 28th and 29th days of February, 1916, in the case of the Marconi Wireless Telegraph Co. of America against Kil-[fol. 597] bourne & Clark Manufacturing Co., in the United States District Court for the Western District of Washington, Northern Division; and that said copies of said depositions and exhibits may be received in this cause as the depositions of the said Baker and the said Stone with the same force and effect as if said witnesses had been duly called, sworn, and examined on behalf of the defend-

ant in this cause, and the said depositions taken and exhibits duly introduced herein. The said exhibits which in said depositions are designated as "Defendant's Exhibits Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10," shall be marked in this case as "Defendant's Exhibits E-3 to N-3," inclusive, respectively. The exhibits offered by plaintiff in said Stone deposition and marked therein as "Plaintiff's Exhibits A, B, and C" shall be marked in this cause as "Plaintiff's Exhibits 120, 121, and 122," respectively.

It is further stipulated, subject to correction should error appear, that the said John Stone Stone and Joseph B. Baker were called as witnesses on behalf of the defendant in the suit of the Marconi Wireless Telegraph Co. against the Atlantic Communication Co. in the United States District Court for the Eastern District of New York, on or about May 14, 1915, and there identified the originals of the aforesaid Exhibits E-3, F-3, and G-3, which said originals were offered in evidence in said cause.

And it is further stipulated that if the said John Stone Stone and Joseph B. Baker were called as witnesses in this case, they would testify that the aforesaid Exhibits E-3, F-3, and G-3 are correct copies of the said original exhibits (being the said letters from Baker to Stone, dated July 22, 1899; from Stone to Baker dated June 30, 1899, and Stone to Baker dated July 18, 1899).

And it is further stipulated that the aforesaid Exhibits E-3, F-3, and G-3 may be received in this cause with the same force and effect as the originals of said letters, all objection to the competency thereof being waived.

And it is further stipulated that the annexed is a true copy of the deposition of Walter C. Dean, who testified as a witness on behalf of the defendant in the aforesaid case of the Marconi Wireless Telegraph Co. of America against the Atlantic Communication Co. in the District Court for the Eastern District of New York, and that the said copy may be received in evidence on behalf of the defendant in this case with the same force and effect as if the said Walter C. Dean had been duly called as a witness on behalf of the defendant, sworn, and testified, as stated in said deposition; and it is further stipulated that the annexed is a true copy of the defendant's Exhibits F-3, referred to in said Dean deposition, and that the same may be marked as "Defendant's Exhibit O-3" in this case, and

received with the same force and effect as the original of said exhibit.

Dated January 19, 1924.

Sheffield Betts, L. T. H. Betts, Attorneys for Claimant. Clifton V. Edwards, Attorney for Defendant, Special Assistant to the Attorney General.

Approved:

Robert H. Lovett, Assistant Attorney General.

[fol. 598] New York, February 28, 1916.

Proofs for final hearing taken on behalf of defendant at the office of George F. Scull, Esq., 149 Broadway, New York City, before Alexander Gilchrist, jr., standing examiner in the United States District Court, Southern District of New York (acting as examiner by agreement of parties in the place and stead of Thomas B. Hardin, Esq., named in said order, the latter being incapacitated by illness) pursuant to an order herein dated February 17, 1916, and to notice to plaintiff's counsel thereunder, beginning February 28, 1916, at 10:30 a. m.

Appearances: L. F. H. Betts, Esq., counsel for the plaintiff; George F. Scull, Esq., counsel for the defendant.

Joseph B. Baker, a witness called on behalf of the defendant, being duly sworn, deposes and says in answers to interrogatories as follows:

Direct examination.

By Mr. Scull:

1. Question. Where do you reside, Mr. Baker?

Answer. New York City.

2. Question. Are you acquainted with Prof. John Stone Stone?

Answer. Yes, sir.

3. Question. Please state how long you have known him and the circumstances connected with your acquaintance with him.

Answer. I met Mr. Stone in the year 1891. At that time he was employed in the mechanical department of the

American Bell Telephone Co. in Boston, and I was employed in that year in the same department. We were both engaged in experimental work, for the telephone company and Mr. Stone and I became quite intimate, especially in connection with his own inventive work both for the telephone company and later on in his own interest.

4. Question. How long did your acquaintance with Professor Stone continue, roughly? By that I mean your acquaintance with him while you were in Boston.

Answer. It continued from 1891, or some time in 1891, to the time I left Boston to go to Schenectady to take a position with General Electric Co. there, which was in the year 1904. That was my active acquaintance with Mr. Stone in Boston.

5. Question. Were you acquainted with any work which Professor Stone did in radiotelegraphy?

. . . . . .

Answer. Yes, sir.

6. Question. Were you acquainted with any ideas that he had in connection with radiotelegraphy?

Answer. Yes, sir.

7. Question. Have you previously testified in a suit in the United States District Court for the Eastern District of New York, entitled "Marconi Wireless Telegraph Co. of America *v.* Atlantic Communication Co., and others," [fol. 599] in which you testified for the defendant and were cross-examined by Mr. L. F. H. Betts?

Answer. I testified in a suit some months ago in Brooklyn, and I believe that was the suit.

Mr. Scull. It is agreed that the suit referred to was based on Marconi patent No. 763772 and Lodge patent No. 609154.

8. Question. I show you a paper and ask you if you know what that is?

Answer. I believe this is a letter that I wrote to Mr. Stone acknowledging communications from him.

9. Question. Is it an original or a reproduction?

Answer. I believe it is a reproduction.

10. Question. When you testified in the Brooklyn suit to which I referred above, were you shown the original of this letter?

Answer. Yes, sir.

Mr. Scull. I offer this in evidence and ask that it be marked "Defendant's Exhibit No. 1."

* * * * * * *

Mr. Scull. Defendant's counsel states in reference to this exhibit and others, which will be produced hereafter, that the originals thereof were introduced in evidence in the suit against the Atlantic Communication Co. above referred to, and are there part of the court records, and not available to this defendant, although they might be available to plaintiff's counsel.

(Marked "Defendant's Exhibit No. 1.")

11. Question. I show you two papers and ask you if you recognize them?

Answer. I do recognize these papers.

12. Question. Will you briefly state what they are?

Answer. I believe these papers are reproductions of letters which were written to me by Mr. Stone on the dates given at the heads of the letters, in which he disclosed to me certain ideas which he had in regard to selective wireless telegraphy.

13. Question. Are these letters the letters referred to in your letter of July 22 as you now recall?

Answer. Yes, sir, they are the letters that were acknowledged in my letter of July 22.

Mr. Scull. I offer in evidence the reproduction of the letter dated June 30, 1899.

* * * * * * *

(Marked "Defendant's Exhibit No. 2.")

Mr. Scull. I also offer in evidence the second paper referred to, being letter dated July 18, 1899.

* * * * * * *

(Marked "Defendant's Exhibit No. 3.")

14. Question. Do you now recall the receipt of these letters and your sending the acknowledging letter, defendant's Exhibit No. 1?

[fol. 600] Answer. I recall the fact of receiving them and acknowledging them. I do not recall the detail local circumstances.

15. Question. I note on defendant's Exhibit No. 1 that the date "20th" has been stricken out and "June 20," written above the same. Can you explain this?

Answer. This letter was dictated to a public stenographer in Boston. I made use of that stenographer in my own inventive work in correspondence and she wrote a good many letters and papers for me. I recall that it was my habit in reading over her work to make the corrections with a pen as I read the letter or the paper, and then to sign it afterwards, and to the best of my recollection I made this correction, noting that the date was wrong, but apparently in seeking to make the correction I made another error, but my intention was to have the dates in this acknowledgment correspond to the dates of the letters that I had received from Mr. Stone.

15. Question. In addition to the receipt of these letters, did you have any conferences or conference with Professor Stone on the subject matter referred to in these letters?

Answer. Yes, sir; there were several such conferences.

16. Question. Up to the time of these conferences what had been your training generally, and particularly in the subject of electricity?

Answer. I had been educated at the Massachusetts Institute of Technology in the course of electrical engineering, graduating in 1890 with the degree of S.B. Following that technical-school training I had been connected with an electric-light contractor for one year, which brings me up to 1891. From 1891 to 1898 approximately I was connected with the American Bell Telephone Co. and with the American Telephone & Telegraph Co. In all of these occupations I endeavored to keep abreast of the times in electrical invention and discovery, and through my association with Mr. Stone I became fairly well acquainted with the art of wireless telegraphy as it was practiced at that time.

17. Question. These conferences that you had with Professor Stone, were they prior to or subsequent to the writing of these letters, defendant's Exhibits Nos. 1, 2, and 3?

Answer. To the best of my recollection they were both prior to and subsequent to these letters.

18. Question. Please state as well as you can now recollect what Professor Stone then explained to you as his inventions.

Answer. If I may be a little discursive in this matter: Stone and I were great friends, and when he had an idea he would communicate with me about it, and when I had an idea I would communicate with him. We talked things over in a mutual helpful way. It was quite a regular thing for me to meet him by appointment for lunch or at his office and for him to sit down and make a little diagram, write a few equasions, to explain an idea that had come to him. Sometimes these conversations would last for hours, and he would bring out one idea after another, illustrating them with diagrams, working them out, largely, at that interview, I believe. In this way he disclosed to me certain ideas in regard to the improvement of wireless telegraphy, the majority of his ideas being based upon his mathematical researches. Among the ideas that he disclosed was the fact that a vertical wire had a natural period of oscillation of an electric charge impressed upon it, and [fol. 601] that it could be made the seat of a set of electrical oscillations of different frequency, which Stone called forced oscillations or forced vibrations. Another point that he mentioned was the extreme desirability of developing a continuous train of electromagnetic waves other than the spark gap, which was the means then used.

Another point that he often discussed was the great necessity for improvements in the coherer, the coherer being the only device known at that time, as far as I am aware, for receiving wireless telegraph sendings. These points are representative of a number of points that he brought up. I might add that the whole burden of his work was the desirability of selective wireless telegraphy. He realized that it was very important that messages should be secret, and that they should be as secured from interruption as wireless telegraph messages are, whereas at that state of the art they were not at all secured from interruption and not at all secret.

19. Question. Referring to this matter of selectivity to which you have referred, did Mr. Stone, as you now recall, explain what he had in mind as a means by which this selectivity would be obtained generally?

Answer. Yes, he did.

20. Question. What do you now recall that to be?

Answer. I recall very distinctly that his idea was—Mr. Stone's idea was to provide a circuit at the sending station and a circuit at the receiving station such that the electrical oscillations of a certain determined frequency would flow in the circuits at maximum strength of current, and oscillations of all frequencies would be, I might say, discouraged; they would find these circuits more or less opaque.

21. Question. What do you now recall was Professor Stone's idea as to how he expected to determine the frequency of his waves?

Answer. I recall that point distinctly also. He explained to me that the natural rate of vibration of any electric circuit was due to the elements of electrostatic capacity and inductance, and he proposed to control the periodicity of the oscillations in his circuits by regulating the value of the capacity and the value of the inductance by suitable condensers and inductance coils without iron, and he laid great stress upon the fact that inductances in wireless telegraph work would always have to be without iron on account of the high frequency of the oscillations. I might add that my memory is very vivid on the generalities of this experience, because it formed such a large part of my life. I was quite intimate with Mr. Stone, and it was a great interest in my life, and is at this time, to go into these problems.

22. Question. Referring to these various conversations which you had, what relations, if any, is there between them and these letters, defendant's Exhibits 1, 2, and 3?

Answer. I should say the relation is the letters are a written record of the spirit of many of these conversations and that they were written to me as a means of getting the facts that he had disclosed to me upon record, and securing acknowledgment from me.

23. Question. Do you understand that they are a record of all that he disclosed to you, or merely of the substance of these various conferences and disclosures?

Answer. They are not a record of all that he disclosed to me, neither are they a record of the substance, but I should say that they are a record of some of the or perhaps most of the essential points.

[fol. 602] 24. Question. You say that Mr. Stone frequently made sketches illustrating what he was describing to you. Could you visualize any of the sketches which you used at that time?

Answer. Yes, sir.

25. Question. I show you a certified copy of a photographic copy from the Patent Office records, and ask you if you recognize these sheets that are reproduced photographically?

. . . . . .

Answer. I believe that this is a copy of the affidavit that I made for the company that Mr. Stone was connected with.

26. Question. Would you recognize that signature as a photograph of your signature [indicating]?

. . . . . .

Answer. I believe that that is a reproduction of my signature.

27. Question. Do you remember that on or about the date of this paper, March 18, 1901, that you made an affidavit of that character [indicating paper]?

. . . . . .

Answer. I remember making one or two or three affidavits. I do not remember when they were made.

28. Question. Were the affidavits you just referred to in your last answer made before or after the sending of these letters, defendant's Exhibits 1, 2, and 3?

Answer. To the best of my recollection, all the affidavits were made after the letters and my acknowledgment of the letters.

29. Question. What was the subject matter of these affidavits you said you had made, generally speaking?

Answer. Speaking very generally, the subject matter was to fix the date of Mr. Stone's disclosures to me.

30. Question. And did they or did they not refer, as you now recall, to these letters, defendant's Exhibits 1, 2, and 3?

. . . . . .

Answer. I believe that they all referred to these letters.

Mr. Scull: I offer in evidence the certified copy of the affidavit, dated March 18, 1901, and ask that it be marked "Defendant's Exhibit 4."

. . . . . .

Mr. Scull: Defendant's counsel notes that this paper is shown the witness merely for the purpose of connecting his signature thereon with the matters to which he has testified, and that defendant expects to offer in evidence sub-

sequently a certain copy of the file wrapper of patent No. 714831.

(Marked "Defendant's Exhibit No. 4.")

31. Question. I note in this affidavit you state, "Also prior to the time above named I wrote and mailed to Mr. Stone a letter in which I stated that I had received his description and understood it and believed myself capable [fol. 603] of putting the same in practice." Can you now state to what sentence that letter refers?

Answer. I believe it refers to this letter which I have spoken of before.

32. Question. Referring to defendant's Exhibit 1?

Answer. Yes.

33. Question. I show you a paper purporting to be a photographic copy of an affidavit and ask you if you recognize that?

* * * * * * *

Answer. I believe it is a reproduction of an affidavit that I made.

34. Question. Do you recognize the reproduction of the signature?

Answer. Yes, sir.

35. Question. What is that?

Answer. It is a reproduction of my own signature, I believe.

36. Question. With your memory refreshed by this photographic copy, can you not state whether or not you made an affidavit on or about the date specified therein, and generally what such affidavit related thereto?

* * * * * * *

Answer. I remember making affidavits, but I do not remember the dates, nor do I remember how many there were.

37. Question. When you say "I remember making affidavits," what do you mean?

Answer. I remember being requested to come to the office of the Stone Wireless Telegraph & Telephone Co. and having them present to me affidavits drawn up ready to be executed and being requested to read them and execute them, and I remember that I did read these documents at the time, and satisfied myself that they were substantially correct, and that I was willing to swear to the truth of their contents.

38. Question. Generally what was the subject matter of these affidavits that you have referred to?

Answer. The fact of the disclosure to me of certain ideas in wireless telegraphy by Mr. Stone.

39. Question. I note in this copy which I have shown you there is this statement:

"Prior to December 15, 1899, I received from Mr. Stone two letters containing a full and complete written description with drawings of a system of selective electric signaling by simple harmonic electromagnetic waves.

"Also prior to December 15, 1899, I wrote and mailed to Mr. Stone a letter, in which I stated that I had received his description and understood it, and believed myself capable of putting the same in practice."

Can you tell me to what letters those statements refer?

• • • • • • •

[fol. 604] Answer. I believe they refer to the two letters to which I have already referred.

40. Question. Referring to defendant's Exhibits 2 and 3?

Answer. Yes, and to my acknowledgement of those letters.

41. Question. Defendant's Exhibit 1?

Answer. Yes, sir.

42. Question. Do you know of any letters, other than defendant's Exhibits 1, 2, and 3, which passed between yourself and Professor Stone relating to the subject matter in the two paragraphs which I have quoted to you from this affidavit?

Answer. No, I do not recall any other letters.

Mr. Scull. I offer in evidence the two sheets of photographs shown the witness and ask that the same be marked "Defendant's Exhibit 5."

• • • • • • •

Mr. Scull: For information of plaintiff, defendant's counsel advises plaintiff's counsel that the papers shown this witness have not been for the purposes of proving that any such affidavits ever were filed, but rather to show what was disclosed to this witness at various times, and to show furthermore that this disclosure was referred to subsequently by this witness long prior to any controversy arising over the subject matter of the patent in suit.

(Marked "Defendant's Exhibit No. 5.")

Cross-examination.

By Mr. Betts:

43. Cross-question. You state that you were connected with the Bell Telephone Co. and the American Telephone & Telegraph Co. from 1891 to 1898?

Answer. Yes, sir.

44. Cross-question. What were your duties during that time?

Answer. My duties for the American Bell Telephone Co., where I was employed from 1891 to about 1894, were to prosecute experimental work in the experiment laboratory [fol. 605] of that company, and to pass upon the inventions of outside inventors which were submitted to the company; also to make routine tests of copper wire used in stringing the lines of the telephone company; and other work ordinarily carried on in the experiment laboratory. My work for the American Telephone & Telegraph Co. was that of an inspector and of a service inspector. It consisted in the construction, care, and maintenance of switchboards, line construction work, and research work connected with traffic problems.

45. Cross-question. Then all of your work while you were connected with either the Bell Co. or the A. T. & T. Co. was in connection with wire telephony?

Answer. All of my work with those companies was in connection with wire telephony.

46. Cross-question. How old were you in 1899?

Answer. I was about 30 years of age.

47. Cross-question. You stated I believe that as far as possible you kept up with wireless telegraphy as practiced prior to 1899. What was wireless telegraphy as practiced prior to that date?

Answer. Well, to begin with, it was very meager. It was associated with the name of Mr. Marconi largely, but other inventors were coming into notice. It consisted of the sending and rece-ving of messages from untuned stations, received from untuned stations, over comparatively short distances, and the essential apparatus consisted of a spark gap connected to a vertical wire at the sending end and at the receiving end a coherer connected to the vertical wire.

48. Cross-question. What wireless stations had you personally seen prior to 1899?

Answer. I had only seen one actual working wireless station, and I do not know whether that was before or after 1899, but it was about that time. The wireless station I refer to was on the island of Nantucket, a Marconi station which was set up Siasconsett for the purpose of demonstrating that telegraphy could be carried on with ships at sea, and I was present on the island of Nantucket at the time that the *Lucania* was picked up, as it was called, as she was passing, I think on her western trip, at a point 30 or 40 miles distant from this wireless station.

49. Cross-question. How long were you at this wireless station?

Answer. I visited that wireless station once or twice and was present only a few hours.

50. Cross-question. Is that then all the practical experience you have had in wireless telegraphy prior to 1899?

Answer. I do not recall any other.

51. Cross-question. What was Mr. Stone's occupation with either the Bell Co. or the A. T. & T. Co. while you were connected with those two companies?

Answer. Mr. Stone's occupation, as I recall, consisted of experimental work in part, but very largely mathematical research and inventive work of his own for the company. He devised and recorded a number of inventions connecting the carbon battery system, as it was termed, but spent I suppose the larger part of his time in mathematical research, a comparatively small amount of time in experimental work and in inventive work. I should say the overwhelming majority of his time was spent in mathematical research.

[fol. 606] 52. Cross-question. How long were you and Mr. Stone associated with the Bell and the A. T. & T. Cos.?

Answer. We were together in the Bell laboratory, as it was called, from 1891 to approximately 1894. We were then separated, from the fact that I went with the other company, the American Telephone & Telegraph Co., and he remained with the American Bell laboratory, so that that was the period of our association, simply this three years approximately, the period of our association with the same company. Later on I think he was retained by the American Bell Telephone Co. during the time that I was employed by the American Telephone & Telegraph Co. I believe he was retained by the telephone interest, but which company I am not quite sure.

53. Cross-question. I believe you stated that Professor Stone not only disclosed to you his selective system but also ideas that he had in coherers and other devices for wireless telegraphy; is that correct?

Answer. Yes, sir.

54. Cross-question. Can you positively swear that the letters marked "Defendant's Exhibits 1, 2, and 3," are the only letters which passed between you and Stone in regard to all improvements which he made in wireless telegraphy?

Answer. No, sir, I can not.

55. Cross-question. Can you swear that these letters, defendant's Exhibits 1, 2, and 3, are the only letters which passed between you and Stone relating to what you have termed his (Stone's) selective system of wireless telegraphy?

Answer. No, sir, I can not.

56. Cross-question. When first did Mr. Stone, according to your recollection, disclose to you what you have termed Stone's selective system of wireless telegraphy?

Answer. To the best of my recollection it was some years before these letters passed that Mr. Stone commenced to talk to me about his general ideas.

57. Cross-question. Can you give any definite time or place when he disclosed his ideas to you on his so-called selective system of wireless telegraphy?

Answer. I can say this, that it was at or shortly prior to the time that Mr. Stone took an office of his own as a consulting electrical engineer. If that date could be fixed it would help.

58. Cross-question. But I am asking you if you can now place or fix any definite time when he first disclosed to you his selective system?

Answer. No, sir, I can not.

59. Cross-question. Can you fix now any definite time or place at which Mr. Stone explained his ideas to you on his selective wireless system of telegraphy?

Answer. No, sir. His ideas were given to me in fragmentary form from time to time, I believe, as they occurred to him. They were given in the course of informal conversations, many of them.

60. Cross-question. Prior to 1900, besides visiting the Marconi station at Nantucket, what knowledge had you had on wireless telegraphy?

Answer. Only the knowledge that I obtained from reading technical press, which gave rather full reports of what was being done in wireless.

[fol. 607] 61. Cross-question. How frequently did you see Mr. Stone between 1891 and 1904?

Answer. Every day—between 1891 and 1894?

62. Cross-question. No.; 1904?

Answer. Oh, I beg your pardon; between 1891 and 1894 I saw him every day, because we were in the same laboratory. For a few years after 1894 I saw him two or three times a week. It was his habit in coming to lunch, he would come up past the telephone company's building on Milk Street, and quite often stop in for me, and we would go out together. I should say two or three times a week would be a conservative statement.

63. Cross-question. During the years 1898 and 1899 you did not have the same offices with Professor Stone.?

Answer. No, sir.

64. Cross-question. How frequently during those years do you think you saw Mr. Stone?

Answer. I should say two or three times a week, on the average. There would be, as I recall, several weeks go by that I would not see him. Then I would see him every day for a while.

65. Cross-question. Principally at luncheon hour?

Answer. I think so; but I also saw him for long periods at his home or at my home. We used to spend long evenings together.

66. Cross-question. During what years?

Answer. During those years, around 1899 and 1900, as I recall it.

67. Cross-question. In this paper marked "Defendant's Exhibit 5," purporting to be photographic copy of affidavit made by you, you state that you received from Mr. Stone descriptive drawings "of a system of selective electric signaling by simple harmonic electro-magnetic waves." What do you mean by "simple harmonic electro-magnetic waves?"

Answer. I mean an alternating electromagnet wave which is governed by a simple mathematical equation. Such a wave, if plotted graphically, would take the form of a sine curve.

68. Cross-question. On what do you base your belief that defendant's Exhibits 1, 2, and 3 are the letters to which you refer in defendant's Exhibit 5?

Answer. I base my belief upon a general recollection of the contents—no, I will not say the contents—of the trend of the information conveyed, upon a recollection of the fact that such letters passed between us, and of the importance that Mr. Stone associated with getting the matter upon record, and I also base my belief upon a memory of the physical appearance of the letters. I remember perfectly that there were such letters, that I read them carefully, studied them, in fact, and in my endeavor to help Mr. Stone I pretty carefully framed my own reply. I was myself engaged in inventive work at the time, and my mind was full of getting things upon record exactly, with the proper dates.

69. Cross-question. Why did you want to help Mr. Stone?

Answer. We were friends and I was impressed by his genius and foresight in this art. I felt that the work that he was doing was exceedingly important, and I felt honored that I should be one associated with him, and wanted to help him all I could.

70. Cross-question. Referring to defendant's Exhibit 4, what letter do you refer to in that affidavit?

[fol. 608] Answer. Well, I believe I referred in this affidavit not to a letter but to the description embodied in both letters. One letter was supplemental to the other. I remember that I acknowledged both letters by one acknowledgment.

71. Cross-question. Which two letters?

Answer. The two letters that I have referred to in this testimony.

72. Cross-question. (Handing witness papers.)

Answer. I believe that those are the letters.

73. Cross-question. Referring to defendant's Exhibits 2 and 3?

Answer. Yes, sir.

74. Cross-question. On what do you base your belief that defendant's Exhibits 2 and 3 are the letters to which you referred in defendant's Exhibit 4?

Answer. Because as far as I know Mr. Stone attached great importance to those letters and to my acknowledgment of them, and considered them to be a very vital record of his inventive work, and they were considered very important by his business associates; and also to the fact that I do not recall that any other letters were sent to me or that I acknowledged any other letters. Most of the disclosures

were made informally, without a written communication, which was acknowledged. They were simply sketches made in the course of conversation.

75. Cross-question. I believe you stated that as you understood Mr. Stone's disclosure and ideas with respect to his selective system, referred to in defendant's Exhibits 1, 2, 3, 4, and 5, that it was to impress on the antennæ forced oscillations. Am I correct?

Answer. Forced oscillations were discussed, but the development of free oscillations was also discussed. The desirability of impressing upon the vertical wire the oscillations which were in its own natural period, that was discussed as well as the impressing upon the vertical wire of forced oscillations foreign to its natural period. It does not come to me now that Mr. Stone made a great point of the desirability of using forced oscillations. It does come to me according to my recollection that he considered the desirability of utilizing the natural period of the vertical wire, and associated with it a circuit which would favor those oscillations; but he did unmistakably speak of the possibility of impressing upon any vertical wire any desired periodicity; he certainly did.

76. Cross-question. That "second circuit" to which you have referred, Mr. Stone called his weeding-out circuit, did he not?

Answer. No, sir. I do not know that I quite understand your question.

(Question read.)

Answer. You used the term "second circuit"?

77. Cross-question. Yes.

Answer. In my answer I referred to a circuit associated with the circuit wire, I believe. That circuit was not the weeding-out circuit. That circuit was the circuit containing inductance and capacity designed to control the periodicity of the oscillations. The weeding-out circuit was a separate circuit.

78. Cross-question. Referring to defendant's Exhibit 1, where were you when you dictated and signed that letter [handing paper to witness]?

[fol. 699] Answer. I was in the office of the public stenographer in the Tremont Building at Boston at the time I dictated it, I believe. I dictated most of my letters in her office.

all of them as far as I recall. I do not recall where I was when I signed the letter.

79. Cross-question. How did you happen to dictate this letter to a public stenographer in the Tremont Building?

Answer. Because it was my habit to dictate a number of papers forming a record of my own inventive ideas—I was using this stenographer, and found it convenient to dictate my letters to her as well.

80. Cross-question. Was Mr. Stone present when you dictated this letter, defendant's Exhibit 1?

Answer. He was not, as far as I recall.

81. Cross-question. Was he present when you signed that letter?

Answer. He might have been, although I doubt it. I probably carried that letter home with other material that the stenographer had written for me and signed it in my home and mailed it. I do not recall.

82. Cross-question. At the time you dictated defendant's Exhibit 1, did you have before you defendant's Exhibits 2 and 3?

Answer. I believe that I did. I had studied them carefully.

83. Cross-question. You say you believe you did. I want to know definitely whether you had these two letters, defendant's Exhibits Nos. 2 and 3, at the Tremont Building when you dictated defendant's Exhibit No. 1?

Answer. I can not recall at all about that. It is possible that I made notes, in studying Mr. Stone's letters, and dictated my letter to the public stenographer in the Tremont Building from my notes rather than having the letters themselves before me. It is possible that that occurred. I remember that I framed my own acknowledgment pretty carefully.

84. Cross-question. But you do not recall whether you signed this letter, defendant's Exhibit No. 1, at the Tremont office building or at your home?

Answer. I do not recall, and yet I might have signed that in Mr. Stone's office. You see, his office was right across the street.

85. Cross-question. I want to know, please, the place, if you can recall it, where you signed this letter, defendant's Exhibit No. 1?

Answer. I do not recall that, sir.

86. Cross-question. Referring to defendant's Exhibits Nos. 2 and 3, there does not seem to be any address contained in either of them. Where were they addressed to?

Answer. I do not recall whether Mr. Stone handed them to me or whether they were mailed to me. I recall that I received them.

87. Cross-question. Did he hand these two letters to you, or did he mail these two letters to you at the same time?

Answer. No, sir.

88. Cross-question. Or were they received separately by you?

Answer. To the best of my recollection they were received separately. I firmly believe that they were received separately.

89. Cross-question. Referring to defendant's Exhibit No. 1, was the interlineation "June 20" made by you?

Answer. Yes, sir; made in my own handwriting.

90. Cross-question. Was this interlineation "June 20" made by you at the same time that you signed your name to this letter?

[fol. 610] Answer. It certainly was. I am positive on that point.

91. Cross-question. Was this interlineation made with the same pen and the same ink that you used in signing this letter?

Answer. Yes, sir. I have no reason to doubt that it was. I do not recall that.

92. Cross-question. Did you use blotting paper at the time you made this interlineation "June 20," in blotting this correction?

Answer. I do not believe I did.

93. Cross-question. Did you use blotting paper after affixing your signature to defendant's Exhibit No. 1?

Answer. Yes, sir. It was my habit to blot my signatures. They were made with a heavy stub-pen, and so much ink that they had to be blotted.

94. Cross-question. Was the interlineation "June 20" on defendant's Exhibit No. 1 made with a blunt pen?

Answer. I believe so—a stub pen. I was in the habit of using a stub pen.

95. Cross-question. How do you account for the fact that you blotted the signature on defendant's Exhibit No. 1 and did not blot the interlineation "June 20"?

Answer. That comes to my recollection pretty well. It

was my habit to read over papers and make corrections with my pen as I read. Many of the things that I dictated were long documents, memoranda of my own experimental work, and I would correct the stenographer's errors or make changes of my own as I went along, and I did so in this case. I applied what I thought was a correction, and then when I got to the end and signed the letter I blotted the signature and probably blotted the other, but the ink had already dried.

96. Cross-question. You now think, then, that you blotted both the signature and the interlineation on defendant's Exhibit No. 1?

Answer. I think that I applied the blotting paper to both, unless I may have noted that the other had already dried.

97. Cross-question. Where was the original of this letter, of which defendant's Exhibit No. 1 purports to be a copy, from the time you wrote it until you identified it in court?

Answer. I do not know. I presume in Mr. Stone's possession.

98. Cross-question. These two letters, defendant's Exhibits Nos. 2 and 3, which you received from Stone, where were the originals of those letters after you received them and until you identified the originals in court in the Atlantic Communication case in Brooklyn?

Answer. They were in my possession for a while. My recollection is that Stone asked me to return them to him, just when I do not know. It might have been a few months afterwards. I think it was not long after I received them.

99. Cross-question. What do you mean by "not long"?

Answer. A few months. My recollection is that he asked for them back again because they were pretty carefully written and contained a statement that he wanted; but I may be mistaken about the time. It may be a year or two. I know that they were in my possession for a while, because [fol. 611] I received them and I studied them, and I know that he did not ask for them back right away.

100. Cross-question. When he did ask for them back, did he ask verbally or in writing?

Answer. To the best of my recollection, verbally. I feel very sure that he did not ask for them in writing; he was not so formal as that.

101. Cross-question. But you can not now tell whether you returned the original letters to Mr. Stone within a few months or a year or two after you received them?

Answer. I am trying to recollect. I would say that a considerable time had elapsed. My impression is that, or my recollection is that Stone asked me for those letters back again and that I gave them to him unquestionably, feeling that they were part of his records and feeling that he wanted them.

102. Cross-question. But you can not fix now any definite time when you did actually hand them back or send them back to Mr. Stone?

Answer. I can not recall. I will say this, that it might have been at the instance of his business associate that I returned them. I feel sure that when Stone wrote me those letters his only object was to get the matter on record, with the date and my acknowledgment, and he was acting as an individual at the time. I feel inclined the reason he asked me to return them was that he was asked to do so by his business associates. He regarded it as very important. That is my general impression.

103. Cross-question. Did you return the originals of these letters, defendant's Exhibits Nos. 2 and 3, to Mr. Stone prior to the time you made your affidavits in defendant's Exhibits 4 and 5?

Answer. I believe so.

104. Cross-question. I am not asking for your belief. I want to know whether you can swear that you returned them prior to the time you made either one or both of those affidavits?

Answer. I am not prepared to swear that I did. I think that I did. I am almost sure that I did.

105. Cross-question. After you returned the originals of these letters to Mr. Stone, of which defendant's Exhibits Nos. 2 and 3 purport to be copies, did you ever see them again?

Answer. Yes, I think I did. I think I saw them in his office. He had an office with his business associates, the Stone Wireless Telephone & Telegraph Co.

106. Cross-question. Just give me any definite time when you saw them after you returned them?

Answer. I think I saw them at the time I was requested to make one or more of these affidavits. I think I recollect that Stone showed me the letters and asked me if I remembered about them, asked me to look them over, and then they stated that they wanted me to make these affidavits. I think they refreshed my memory by handing me the letters.

107. Cross-question. You are positive of that, are you?
Answer. All but positive.

[fol. 612] Redirect examination.

By Mr. Scull:

108. Redirect question. You said in your cross-examination that professor Stone at the time that he was engaged by the A. T. & T. Co. or the American Bell Co. was engaged principally in business or matters relating to mathematics. What sort of mathematics? In general, what did such mathematics relate to?

Answer. One subject that he devoted a good deal of time to was the subject of the attenuation of telephone currents and the subject of distortion. At that time a great deal of experimental work was being done on telephone relays, and that was considered a very important subject, to discover the causes of attenuation and distortion.

109. Redirect question. Then, generally, these mathematics related to electric currents?

Answer. Yes, sir.

110. Redirect question. Was Professor Stone considered a mathematical expert in electricity at that time?

Answer. I considered him one. I do not believe he had a very wide reputation as one.

111. Redirect question. Several times in your cross-examination you used expressions such as "I think I recollect"; just what did you mean by that phrase?

Answer. I was trying to give the best impression I could dig up in my memory.

112. Redirect question. That is to say, you were trying to give your present recollection?

Answer. My present recollection, as I look back upon the circumstances.

* * * * * * *

JOHN STONE STONE, a witness called on behalf of the defendant, being duly sworn, deposes and says in answer to interrogatories as follows:

Direct examination.

By Mr. Scull:

1. Question. Please give your present occupation and residence.

Answer. I am consulting electrical engineer, and reside at 34 Gramercy Park, New York City.

2. Question. Will you please state in general your experience with oscillation circuits, electrical radiation, electrical resonance, and wireless telegraphy and telephony prior to the year 1900?

* * * * * * *

Answer. I studied mathematics and physics at Columbia University, New York City, and Johns Hopkins University, Baltimore, Md., during the years from 1886 to 1889, inclu- [fol. 613] sive. During the latter two years of my studies at the Johns Hopkins University the subject matter of electrical radiation was attracting a great deal of attention owing to the beautiful and sensational experiments of Professor Hertz. In consequence of the general scientific interest enhanced in radiation, so called, I studied the question of electrical oscillations and read considerable literature relating to both electrical oscillations and electrical radiation.

On leaving Johns Hopkins University in 1890 I entered the employ of the American Bell Telephone Co. as experimentalist in the laboratories of the company. There I continued the study of electrical oscillations and electromagnetic radiation and waves, and particularly the work then being done and published by Prof. Elihu Thompson and Nicola Tesla.

My attention was focused still further upon these subjects owing to the fact that in the spring of 1892 the chief engineer of the company, Mr. H. V. Hayes, asked me to investigate the possibilities of transmitting speech telephonically, without wires through the use of Hertzian waves, and, if possible, to devise means for thus producing what we now call radiotelephonic transmission.

During the year 1892, or a considerable part thereof, I prosecuted experiments with a view to accomplishing radio-telephony by Hertzian waves, using the Hertz oscillator in combination with a Tesla high-frequency coil apparatus.

These experiments led me to the conclusion that in the absence of a quantitative continuously active detector it was impracticable to transmit speech by Hertzian waves over any except commercially insignificant distances, and as a result of this conclusion my experimental work with high-frequency oscillations and telephonic transmission by electromagnetic waves was directed into a somewhat new channel, namely, into the development of what is now called "wired wireless." This wired wireless differs from the ordinary wireless or radio chiefly in the fact that the stations are connected by a conducting telegraph or telephone wire which serves to guide the waves from one station to another. In fact, the wired wireless to-day is merely a system comprising transmitters and receivers identical with the radio transmitters and receivers connected to a telegraph or telephone wire.

The object of all this work was to secure multiple transmission of messages over a single wire, and this was accomplished by impressing alternating or oscillating currents on the line at the transmitter and selectively receiving these currents in a resonant circuit attuned to the frequency of the incoming oscillations at the receiving station. Several transmitters each employing different frequencies or oscillations were used, and a corresponding number of resonantly tuned receiving circuits were used at the receiving stations, each receiver being attuned to the frequency of one of the transmitters.

I filed applications for patents for some of these inventions in wired wireless in 1893, and in 1894 I got into two interferences in the United States Patent Office involving the applications of Prof. I. Pupin, of New York City, and Messrs. Hutin and Le Blanc, two well-known electrical engineers of Paris, France. These interferences, or at all events, the interference with Professor Pupin, extended over a period of some eight years, and as a result of this interference my interest in the subject was kept alive even [fol. 614] after my experimental work ceased, and it became necessary for me to closely study everything that was published on the subject of electrical resonance and electrical oscillations and allied matter.

I also undertook a rather more comprehensive mathematical investigation of the subject of electrical resonance than had theretofore been made, and so also did Professor Pupin, whose mathematical work upon the subject of resonance in coupled circuits I had occasion to study in the course of this interference.

Early in 1899, in January or February of that year, I left the laboratory of the American Bell Telephone Co. and opened an office of my own in Boston, my only remaining connection with the American Bell Telephone Co. being that I was retained as advisory expert in connection with their patent litigation.

During the progress of my work with wired wireless in the laboratory of the American Bell Telephone Co., Prof. Charles R. Cross, of the Massachusetts Institute of Technology, became interested in my results and asked me to deliver a short course of lectures each year to the graduating classes in physics and electrical engineering at the Massachusetts Institute of Technology, and I delivered a course of lectures over a period of years from approximately 1896 to 1905 or 1906.

Shortly after I opened my office at the Phillips Building in Boston I was consulted by Herman W. Ladd, who had invented a system for determining the direction of the waves in radiotelegraphic communication, who wished me to look into the possibilities of his invention and give him such expert advice as I could in the matter.

A syndicate known as Ladd Wireless Telegraph Syndicate was formed, and early in the year 1901, as nearly as I can remember, I began experiments on the Ladd invention and continued them for some time.

In 1899, shortly after leaving the American Bell Telephone Co.'s laboratory, I conceived the idea of applying the principles which I had worked out in connection with my wired wireless experiments, to the elimination of what I have considered the principal practical obstacle to successful radiotelegraphy.

At that time, and even to-day, radiotelegraphy suffers very seriously from what is known as "interference." This interference is of two kinds, one kind being due to atmospherical electrical disturbances arising from natural as well as artificial causes, and the other kind is due to the reception of messages from other stations than those with which communication is desired.

The first kind of interference is usually referred to as static, and the second kind of interference is usually called station interference.

3. Question. I would call the witness's attention to the fact that the question was simply to state his general experience.

Answer. Yes; but I am not through. The avoidance of this interference I undertook to secure through the production of pure simple harmonic electromagnetic waves at the transmitter, which should be very much less damped than was common to radio waves in those days, and at the receiver through the use of very highly selective or very accurately resonantly attuned circuits loosely coupled to each other.

[fol. 615] 4. Question. Where was the laboratory of the American Bell Telephone Co. located; I do not mean the street; simply the city?

Answer. During the first year that I was with the American Bell Telephone Co. the laboratory was in Boston, and during the latter years it was in South Boston.

5. Question. Is there a system of wireless telegraphy known as the Stone system?

Answer. There is such a system.

6. Question. I will ask you to describe that system and give the history of its development.

Answer. Do you want me to recite about the patent application, etc.?

7. Question. The question is: Please describe the system and give the history of its development.

Answer. The Stone system, broadly speaking, comprises a transmitter, means for producing electromagnetic waves of a simple harmonic character, that is to say, of a single frequency and of high persistency, and at the receiving station of means for selectively receiving the energy of the incoming waves of one frequency to the practical exclusion of the energy of in coming waves of any other frequency.

Specifically the means employed at the transmitting station is a primary oscillating circuit, comprising a spark gap, a condenser, and the primary coil of an oscillation-transformer the secondary coil of which is included in the aerial circuit.

The primary oscillating circuit may or may not comprise an auxiliary inductance coil and the secondary circuit may also comprise an auxiliary inductance coil.

The generation of waves of but a single frequency, that is to say, simple harmonic waves, is effected in this system through the extremely loose coupling of the primary oscillating circuit with the secondary or aerial circuit.

The loose coupling between the primary oscillating circuit and the aerial circuit is effected either through making the mutual induction between the primary and secondary helixes of the oscillation transformer or Tesla coil small, per se, or through the addition of inductance to the primary and secondary circuits by means of the auxiliary inductance coils therein.

At the receiver, in its simplest form, the detector and indicating devices are associated with a local resonant secondary circuit comprising a condenser, and a secondary of an oscillation transformer, this circuit being resonantly attuned and very sharply attuned to the frequency of the waves, the energy of which is to be received therein.

The primary or open aerial circuit comprises the primary coil of the oscillation transformer.

The primary and secondary circuits are very loosely coupled with each other, and this looseness of coupling may be effected either by making the initial inductance in between the primary and secondary coils of the oscillation transformer small, per se, or by the addition of auxiliary self-induction to either of these circuits through the addition of auxiliary inductance coils.

In this specific system all four of the circuits described are very accurately attuned to the same frequency, said [fol. 616] frequency being the frequency of the electromagnetic waves used in transmission between the stations.

A modification of this specific system described above is sometimes resorted to when either greater selectivity than can be obtained by the simpler system is required.

This modification consists in the addition either at the transmitter or at the receiver, or both of a circuit which I have called a "weeding-out" circuit, or sifting circuit. This "weeding-out" or sifting circuit is a closed, highly resonant electric circuit, comprising a primary and a secondary coil of the transformer, and a condenser, and it may also comprise an auxiliary induction coil.

This "weeding-out" or sifting circuit, when used, is interposed between the aerial and the primary oscillating circuit at the transformer, and between the aerial and the resonant local receiving circuit at the receiver, and when it

is used it is inductively coupled very loosely both with the aerial and with the local resonant or oscillating circuit with which it is associated. It serves the purpose at the transmitter, so to speak, of weeding out any frequencies that may be developed in the primary oscillator other than that to which the primary oscillator and aerial are attuned, and it also serves the purpose of increasing the persistency of the waves developed at the transmitter, if properly constructed.

This circuit, containing as it does nothing but the coils and the condenser, is extremely selective of one frequency to the exclusion of all others, and its function is to bar the passage of any frequency but that one frequency to which it is attuned.

At the receiver the "weeding-out" circuit is inductively and very loosely coupled with the aerial on the one hand and with the "weeding-out" circuit on the other hand, and is attuned to the common frequency of the aerial and local resonant receiving circuit.

The Stone system comprises in addition to this apparatus a host of other radio-telegraphy devices and systems, such as systems for directing space telegraph signals and relay space telegraph signals, etc., covered by some 100 or more United States patents and a corresponding number of foreign patents; but I do not understand that you are interested in that phase of the system here. I have not answered your question fully.

8. Question. Permit me to ask here before you take up the development of the Stone invention: Am I correct in understanding that the transmitting and receiving devices which you have explained including some source of power and a key by which the power is controlled at the receiving station by some form of detecting device?

Answer. Yes; the usual form of power supply connected in the usual manner to the terminal of the spark gap at the transmitter and, similarly as I believe I mentioned in my answer, detectors and indicating devices associated with the receiving circuit in the usual manner.

9. Question. Now, will you please state the development of the system you have just described as the Stone system?

Answer. I conceived this system in the late spring or very early summer of 1899. I first disclosed and discussed the system to my friend, Mr. J. B. Baker, in the summer of 1899, and shortly afterwards to my patent attorney, Mr.

[fol 617] Alexander P. Brown, of Boston, the system I disclosed to these gentlemen being the system I have just described.

I do not at the moment exactly remember when I made these disclosures to Mr. Brown, but as near as I can remember it was in the fall of 1899; but I do remember the fact that it was in the summer of 1899 and in the early summer of 1899 that I disclosed the Stone system or the invention of the Stone system to Mr. A. P. Brown, then of Boston.

Mr. Brown prepared and filed applications for patents covering the specific system I have just described and also assisted me in securing capital for the exploitation of the invention, and I remember that I went with Mr. Brown to see his cousin, James Maynadier, in an effort to secure financial support from the Delbear Wireless Telegraph Syndicate, of which Mr. Maynadier was counsel.

Finally in 1901 Mr. Brown and I secured the necessary financial arrangements to enable us to form the Stone Wireless Telegraph Syndicate, which, as near as I can remember, was formed early in 1901 This syndicate supplied $10,000 for the purpose of testing the invention in a laboratory to such a point as to warrant the expenditure of considerably larger sums in the field experiments, it being agreed that if the laboratory tests showed that the invention was operative and secured the selectivity which we sought, the syndicate would organize a company and pay into the treasury of that company $10,000 in cash.

Through the year 1901 I conducted experiments with the Stone invention that I had disclosed to Mr. Baker, and which I had described in my patent application.

10. Question. What form did your disclosure of your invention to Mr. Baker take?

Answer. My disclosures to Mr. Baker were both oral and in writing, but I here refer to the invention I disclosed to Mr. Baker in writing, in two letters, dated June 30, 1899, and July 18, 1899, photolithographic copies of which I hand you.

Mr. Scull. Witness refers to defendant's Exhibits Nos. 2 and 3.

* * * * * * *

11. Question. Did you testify in reference to the matters about which you have been questioned to-day in a suit in the eastern district of New York between the Marconi Wireless

Telegraph Co. of America, plaintiff, and the Atlantic Communication Co. and others, defendants, on Marconi patent No. 763772, some time during the year 1915?

Answer. Yes.

12. Question. At that time did you produce the originals of the letters, defendant's Exhibits Nos. 2 and 3?

Answer. I did.

13. Question. And do you know whether or not such originals were offered in evidence in that case?

Answer. They were.

14. Question. Did you also at that time produce photolithographic copies of the original letters which were offered in evidence?

Answer. Yes.

[fol. 618] 15. Question. Please examine defendant's Exhibits 2 and 3 and tell me whether or not those are duplicates of the photolithographic copies which you produced at the former trial?

Answer. They are.

16. Question. And so far as you can remember are these copies, defendant's Exhibits Nos. 2 and 3, exact reproductions of the original letters?

Answer. They are.

17. Question. Do you know who had these photographic copies made of the original letters, and if so, when was it done?

Answer. I looked that matter up at the time I testified in the other case, but I do not remember it now.

18. Question. Just your recollection.

Answer. I do not remember the date at which these photolithographic copies were made, but I do remember that they were made to be attached to an affidavit which Mr. Baker made in connection with the prosecution of one of my subsequent applications for patent in the United States Patent Office.

19. Question. I show you a copy of a patent to John Stone Stone, numbered 714756, granted December 2, 1902, the application date of which is stated on this copy to be February 8, 1900, and ask you what that patent is, and whether or not it has any relation to the matters to which you have just testified?

Answer. This patent is the first patent which discloses the Stone system to which I have referred in my previous testimony, and discloses the Stone invention to which I have

referred in previous answers in this deposition. Do you not want me to go ahead and continue the answer which we interrupted for this purpose?

20. Question. Yes; please continue your answer to question 9.

Answer. As these experiments with the Stone system in the laboratory progressed I finally attained a degree of perfection in selectivity which was satisfactory to myself, it being what is sometimes called 10 per cent selectivity. I was not, however, satisfied to rely upon my own opinion in the matter, and so I called upon my friend, Prof. Charles R. Cross, who held the chair of physics at the Massachusetts Institute of Technology, to come and witness his experiments and express his opinion as to their success.

I also called upon my former professor of electricity and magnetism at the Johns Hopkins University, Dr. Louis Duncan, to express his opinion as to my results.

Both of these gentlemen reported highly favorably upon my work, and I therefore recommended that the work be carried into the field, and this was done as near as I can remember early in 1902. I then caused two small stations with a mast only 40 feet high to be set up on the Charles River embankment at Cambridge, across the river from Boston. These stations were very small affairs, and were only about a quarter of a mile apart. One of the stations was equipped as a transmitter and receiver, and the other station purely as a receiver. The transmitter employed was the Stone transmitter, as I have described it in answer to preceding questions, and as set forth in United States patent No. 714756. The receivers used were also Stone [fol. 619] loose-coupled receivers, which I have heretofore described in answer to your questions. Though in my patents and in some of my disclosures to Mr. Baker and Mr. Brown the conductive coupling of oscillating circuits at the transmitter with the aerial, and the conductive coupling of the local receiving circuit with the aerial at the receiver, were considered as alternative arrangements; nevertheless in all my experimental work and in all the apparatus that I actually built for commercial purposes the inductive coupling both at the transmitter and at the receiver was strictly adhered to.

The experiments between these two small stations were conducted as nearly as I can remember for a period of a few months only. Then the height of the mast at the trans-

mitter was increased very considerably, being somewhat over 180 feet, as I remember it, and the power of the transmitter was correspondingly increased, and with this increased power transmitter I was able to get reports from distant wireless stations of the performances of the transmitter, and I was also enabled with the increased antennae height to receive messages from more distant stations and judge of the power of the selectivity of my receiver to exclude extraneous signals.

I do not remember exactly at what period, but I think it was in the latter part of the year 1901 or early in 1903, I constructed a third station at Lynn, Mass., and continued experiments between Cambridge station and this Lynn station. During a period of nearly three years after the organization of the Stone Telegraph & Telephone Co. the company attempted to do no commercial business, but confined its efforts to developing experimentally a host of inventions related to the Stone system, as hereinbefore described in this deposition, and in conducting research work bearing upon the perfection of the apparatus of the Stone system. A hundred or more United States patents were applied for covering the results of this work.

Finally in the latter part of the year 1904 or the early part of the year 1905 the Stone company undertook to secure contracts from the United States Navy to supply its shore stations and ships with apparatus, and I recollect that the Navy Department agreed to permit the Stone company to equip its Portsmouth and Boston radio stations with its system, if it could establish direct communication between those two points, Portsmouth and Boston.

Prior to that time the Navy wireless stations at Portsmouth and Boston had been unable to communicate with each other directly, and were obliged to make use of a relay station for repetition of the messages at Hatchs Island.

Shortly after the Stone company equipped these two stations communication was established between them; the Government abandoned its Hatch Island station and accepted the Stone company's apparatus.

Shortly after this, or at about the same time this equipment was going on, the Stone company equipped the United States collier *Lebanon*, and later the United States battleships *Minnesota* and *Georgia*.

I can not remember the dates of those equipments, but the Stone company equipped a few battleships, some naval

stations, such as Pensacola, and some auxiliary vessels for the Navy, doing a net business that I should estimate without pretending to be very accurate, at $50,000.

[fol. 620] I should also roughly estimate that the money expended by the Stone company in developing its various inventions and patenting them was about $200,000.

I was chief engineer of the company from the date of its organization until it went out of business, I believe in the latter part of 1909. I think that about answers your question.

21. Question. Who was Mr. J. B. Baker, to whom you wrote the letters, defendant's Exhibits 2 and 3, and generally what were your relations with him?

Answer. Mr. Baker was an electrical engineer whom I first met in 1892 at the laboratory of the American Bell Telephone Co. where he was engaged in experimental work. Mr. Baker and I were associated in the work of the laboratory of the American Bell Telephone Co. until he left, I believe in the year 1896.

Thereafter I saw Mr. Baker from time to time as he remained in Boston. Mr. Baker afterwards entered into the employ of the Stone Telegraph & Telephone Co. as one of my assistants, and Mr. Baker was also at one time associated with me in the offices connected with the Ladd Wireless Telegraph Syndicate.

I do not remember the exact dates at which Mr. Baker was employed with me, but I know that he assisted me in my experiments at my laboratory at 40 Lincoln Street during the year 1901.

I also remember that Mr. Baker did some work for me in connection with my Cambridge station during the early periods of that work.

Furthermore, Mr. Baker at one time, though not in the regular employ of the Stone company, conducted some research at the Boston Public Library for me in connection with the literature of radiotelegraphy.

22. Question. In the summer of 1899 when the two letters, defendant's Exhibits Nos. 2 and 3, were written, were you and Mr. Baker associated in any way?

Answer. No. Mr. Baker and I were merely friends. He used to call upon me quite frequently at my office in the Phillips Buildings, and we would go to luncheon together, and he would call at my house, and I at his. This refers to the time in 1899.

23. Question. Did you disclose to Mr. Baker, other than in the letters, defendant's Exhibits Nos. 2 and 3, the inventions which you then had in mind, and if so when and how?

Answer. Yes; I disclosed inventions to him in the course of conversations at my office, and when we were at lunch together, and when we called upon each other at our respective houses. We discussed the inventions at some length.

24. Question. I show you defendant's Exhibit 1 and ask you if you recognize it?

Answer. I do.

25. Question. Will you please state briefly what you recall as to that exhibit, defendant's Exhibit 1?

Answer. I recall that the letter, of which this is a photolithographic copy, was a letter which I received from Mr. Baker in answer to the two letters I wrote him on June 30 and July 18, respectively, of which photolithographic copies are in evidence in this case.

26. Question. Defendant's Exhibits Nos. 2 and 3?

[fol. 621] Answer. Yes; defendant's Exhibits Nos 2 and 3 in this case.

27. Question. At or about the time of these letters, or shortly thereafter, did you disclose the invention set forth in these letters, defendant's Exhibits Nos. 2 and 3, to anyone other than Mr. Baker and Mr. Brown, whom you have mentioned?

Answer. Yes; I remember specifically disclosing the invention to Mr. James Maynadier and G. W. Pickard.

I have referred to the circumstance of this meeting in a previous answer. I can add here that at the interview in question Mr. Pickard was present as Mr. Maynadier's expert and I further remember that I disclosed the patent to Mr. Pickard both orally and by exhibiting to him a draft of my application for patent which finally resulted in patent No. 714756, or a copy of the application, I forget which.

I cannot place the date of this interview very accurately, but it must have been prior to and in fact a considerable time prior to the formation of the Stone Wireless Telegraph Syndicate, as the object of the visit was to secure financial support for the exploitation of the invention, and we made no further effort to secure financial support in that way after formation of the syndicate.

28. Question. You have stated that you gave lectures at the Massachusetts Institute of Technology. Did you refer

to your inventions set forth in defendant's Exhibits Nos. 2 and 3 in any of those lectures?

Answer. The title of my lectures was "Electrical oscillations and their applications." In my lectures I referred to all the applications I had personally made, as well as the applications others had made of electrical oscillations. After I had conceived the invention which I have referred to in this deposition as the Stone system, I made it a custom to describe it in these lectures.

29. Question. Had you applied for any patents prior to the summer of 1899?

Answer. Yes; I had applied for quite a large number of patents prior to that time, as near as I can remember some 20 patents relating to telegraph and telephone systems and to so-called "wired wireless" systems and to electrical resonance per se.

30. Question. Referring now to the various Stone stations which you have described, were there any distinctive characteristics common to all of them, and if so, please describe them?

Answer. Yes. The Stone stations were all equipped with the same type of apparatus, having the characteristics I have described as characteristic of the Stone system in my former answers in this deposition.

Perhaps the most unique characteristic of all these stations was the fact that waves developed at the transmitter were simple harmonic in character; that is to say, contained but a single wave length.

The second characteristic was that the coupling of the primary oscillating circuit with the antenna circuit at the transmitter station was always inductive and always loose.

Another characteristic was that at the receiver the local resonance circuit with which the detector and indicator were associated was rendered highly resonant to the frequency of the waves, the energy of which was to be received, and this circuit was loosely coupled indictively with the aerial circuit. [fol. 622] A further characteristic of all these stations was that the primary oscillating circuit and the aerial at the transmitter were attuned to the same frequency, or perhaps, as it may be more accurately stated, the primary oscillating circuit was attuned to the fundamental of the aerial or radiating circuit, while at the receiving station the local resonant receiving circuit was accurately attuned to

the fundamental of its associated aerial or antenna circuit.

When two such stations were in communication with each other, the four circuits of the two stations were each attuned to the frequency of the waves by means of which the transmission was being effected.

31. Question. What was the special advantage, if any, of this single-wave length which you obtained?

Answer. The special advantage of the simple harmonic wave or wave of a single frequency is that if there be waves of two frequencies, part of the energy of the transmitting station is in the waves of each wave length, and if the receiver be highly selective, as is desirable in order to avoid interference, then the receiver only receives the energy of the particular waves to the frequency of which it is attuned, and the energy of the waves from the transmitter which are of a different frequency is lost so far as its useful effect at the receiver is concerned.

Again, when the energy of the transmitter is divided between two or more wave lengths it is difficult to secure as persistent trains of waves as when all the energy is concentrated in waves of a single frequency or wave length.

Finally, if one is trying to operate a considerable number of radio stations within a given area without mutual interference, it is much easier to accomplish this if each transmitter radiates waves of one frequency characteristic of itself. That is to say, if there are 10 stations in the group and each station radiates waves of two or more wave lengths, there will be waves of 20 or more wave lengths radiated, and for a given receiving station to exclude all but the waves from the particular station with which it desires to communicate it becomes necessary to employ wave lengths covering an enormous range of frequencies at the transmitters.

32. Question. You have stated that in your system the four circuits of the system were attuned. Please state what specific means of tuning were used at your various stations?

Answer. The most common means we employed in tuning the primary oscillator of the transmitter to the fundamental of the antenna was a spark gap placed across the secondary coil of the transformer.

The primary oscillating circuit was adjusted until a maximum spark could be drawn across the secondary coil in the antenna circuit, this indicating a maximum resonant rise of potential in the antenna circuit and indicating with a very

high degree of precision, under the conditions which we worked the exact attunement of the primary to the secondary.

Later, when wave meters became more common and when hot wire ammeters were more plentiful, these two means were also used by my assistants, but in all my earlier work the spark gap was used at the transmitter in the way in which I have described it.

At the receiver the attunement was usually made by varying the adjustment until a maximum certainty of response [fol. 623] was secured; and I refer to response of the detector and indicator, though in my early experiments at the laboratory at 40 Lincoln Street I not infrequently attuned the local receiver circuit by the spark method, taking it across the room to the transmitter and directly observing the resonant rises of potential at the condenser, when the period of the local circuit was the same as that of the transmitter.

In those experiments the antenna at the receiver was always made identical with the antenna at the transmitter, so that they were necessarily in tune.

33. Question. In making these adjustments in the receiving circuit, what features or parts of the circuit were changed to give the desired variation?

Answer. In the early experiments of the transmitter I varied the capacity of the large air dielectric condenser which I employed in the primary oscillating circuit, while in the later commercial apparatus the inductance of the primary circuit was the element that was varied for the purposes of tuning.

At the receiving station in the early experiments the tuning was almost accomplished by variations of the capacity of the receiving condensers in the local receiving circuit, though in that of later commercial apparatus large variations in tuning were made by cutting in and out additional amounts of inductance, and the intermediate variations of frequency were made by continued variations of the local condenser.

The tuning of the antenna, both at the receiver and the transmitter, in the early experiments, was invariably made by varying the number of turns of the helix of the oscillation transformer in that circuit, both at the transformer and the receiver, and this particularly persisted in the commercial apparatus, except that in the commercial apparatus

a condenser was sometimes included in the aerial circuit, and this was varied in the process of tuning, but the condenser used in the aerial circuit of these commercial receivers was not placed there for the purpose of tuning, but for the purpose of a subsequent invention which enabled us to give the aerial circuit an opportunity to respond to atmospheric disturbances at a frequency which would not disturb the local receiving circuit.

In other words, we gave the vertical system two natural frequencies and attuned the local receiving circuit to one of them.

34. Question. What was the result of this tuning, first with regard to the two circuits of the transmitter, then with regard to the two circuits of the receiver, and finally to all four circuits together?

Answer. The result was that two stations so adjusted were very accurately attuned to each other, and that each of the four circuits were attuned very accurately to the same frequency.

* * * * * * *

35. Question. In some of your previous answers you have referred to the fundamental of the aerial circuit. Will you please explain what you mean by that expression?

Answer. The aerial circuit or antenna has a number of natural periods to which it will respond and the lowest or gravest natural mode of vibration of the aerial is called its [fol. 624] fundamental, while the higher or more rapid natural modes of vibrations are usually referred to as harmonics, though they are not always strictly in a harmonic ratio to the fundamental.

To be a little more elementary and specific in my description of this term, as I have used it in this deposition, I will say that if you impress a vibratory or alternating electric force upon an aerial system and slowly vary the rate of vibration of the force, the aerial will practically not respond to the force; that is to say, will have negligible oscillations developed in it, except when the period of the force is the same as the natural period or fundamental of the aerial. Then, as the frequency of the force is still further raised, the aerial will again cease to respond or practically cease to respond to the force, until the period of the force equals the period of the first harmonic natural

rate of aerial, when again the aerial will respond with considerable energy.

As the period is still further increased, again the aerial will practically cease to respond to the force until the period of the force equals the second harmonic natural period of the vertical, and so on.

If the aerial conductor be excited into what is called natural oscillations, simply charging it with electricity and allowing it to discharge to earth, it will vibrate with the period of oscillation corresponding to the fundamental, and also with vibrations corresponding to each one of the harmonics; but if the aerial be excited by a simple harmonic force it will vibrate with the rate of vibration equal to that of the force, and whether or not it responds appreciably will depend upon whether the period of the force corresponds to the fundamental or to one of the harmonics.

If the period of force does not correspond to the fundamental of one of the harmonics of the aerial practically no oscillations will take place in the aerial.

36. Question. When an antenna circuit is vibrating, both in the fundamentals and in the harmonics as you have stated in this last answer, what is the resultant effect so far as the waves radiated are concerned?

* * * * * * *

Answer. Waves are radiated which have frequencies corresponding to the fundamental and all the harmonics.

37. Question. In your description of the Stone system you have repeatedly stated that the primary and secondary circuits were loosely coupled. Why did you use this "loose coupling"?

Answer. The loose coupling was used to secure a simple harmonic oscillation of the aerial and a corresponding simple harmonic radiation; that is to say, radiation of waves of a single wave length.

According to the theory of coupled oscillators it is possible to secure oscillations of a single frequency with two coupled oscillators only, when the coupling is either extremely tight or extremely loose.

In the case of an extremely tight coupling the two oscillators so coupled must be attuned to extremely different periods, while in the case of an extremely loose coupling the oscillators must be attuned to the same natural period, in order that a simple harmonic oscillation may result.

That is the reason I adopted the extremely loose coupling in my system, in order that I might get waves having but a single frequency.

[fol. 625] 38. Question. Have you any photographs or other contemporary records illustrating the various installations of the Stone system which you have previously referred to?

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Answer. I have certain photographs of some of the stations in question and of the apparatus contained in them, but I have them not in my possession at present, as they were introduced in evidence by the defendant in the suit of the Marconi Co. against the Atlantic Communication Co., which has been previously referred to.

39. Question. Were the photographs which you there produced offered in evidence in that case?

Answer. Yes.

40. Question. Have you any present recollection of what those photographs were and what they showed?

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Mr. Scull: Defendant's counsel states now, as he did in reference to previous copies offered in evidence, that the originals are part of the records in the Atlantic Communication Co.'s case and are not available for use in this case.

• • • • • • •

Answer. I described in my testimony in the Atlantic Communication Co.'s case what these photographs showed. Without having them before me I do not suppose I could describe them here so well.

41. Question. I note that at page 570 of the record in the Atlantic Communication Co.'s case, you produced and described a sheet of photographs which you then stated showed experimental stations on the Charles River embankment at Cambridge. With this to refresh your recollection can you describe now what that photograph showed?

Answer. I can if I refer to the testimony I gave in the Atlantic Communication Co.'s case to refresh my memory.

42. Question. I hand you a copy of the record in the Atlantic Communication Co.'s case and refer you particularly to pages 570 to 573, in which certain photographs are referred to, and with that testimony before you, I ask you

to briefly state what the photographs were that you then produced?

* * * * * * *

Answer. The first photograph or sheet of photographs referred to showed the experimental stations on the Charles River embankment to which I referred in this deposition, and showed the transmitting station after the 180-mast had been set up. On the reverse side of the sheet the photograph showed the interior of the transmitting station, and particularly showed the very large air condensers used in [fol. 626] the oscillating circuit of the transmitter and also the oscillation transformer, indicating the fact that these were open wire coils spaced some little distance apart, indicative of loose coupling.

The second photograph was a photograph of the interior of the Portsmouth Navy Yard station which bore a date "September, 1905." On the back of this sheet there were some photographs of stations other than the Stone stations.

The next photograph was one of the Stone Lynn, Mass., stations, which is dated "1903-04."

The next photograph showed the Stone station at the Isle of Shoals and is dated "September, 1905."

The next photograph shows the Stone apparatus, equipment on the U. S. S. *Lebanon* and is dated "September, 1905."

The next is sheet of photographs illustrating the navy yard station at Charlestown, Mass., after the Stone equipment was put in. It shows specifically the 3-kilowatt power plant, as well as the 3-kilowatt transmitting apparatus.

Another sheet of photographs here shows the Stone transmitter and receiver coils at the Charlestown Navy Yard, and from the character of these coils it is evident that the apparatus is of the loose-coupled type.

Another sheet of photographs shows the radio station on board the U. S. S. *Lebanon* and one of the photographs is interesting as showing the use of three-tune circuits at the receiver, one of these circuits being the "weeding-out" circuit to which I have referred in this testimony.

Another sheet of photographs shows the Stone receiving apparatus at the Charlestown Navy Yard, dated October and November, 1905. This photograph also shows what I recognize as the three-tune circuit, indicating that here also the "weeding out" circuit was used in the receiver.

A still further photograph shows particularly well the enormous air condenser which is used at the transmitting station at Cambridge, Mass., and also shows the oscillating circuit of the transmitter, the large sized wire indicating the primary oscillator coil, the fine wire coil being the secondary.

There is still another photograph showing the same elements.

Another photograph shows an operator using the apparatus at Charlestown Navy Yard, and the photograph shows that the weeding-out circuit was used in the receiver.

Another photograph which I offered in evidence in that case was one showing the air condensers and coils used in tuning the receiver at Lynn station.

• • • • • • •

43. Question. At the time these photographs were shown, when you testified in the Atlantic Communication Co.'s [fol. 627] case, did you recognize the apparatus and installations shown in them to be substantially what you have testified to?

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Answer. I did.

44. Question. I note from the record in the Atlantic Communication Co.'s case that when you testified you produced an old slip of paper entitled "Notes for Mr. Baker, dictated by Mr. J. S. Stone." Have you a copy of that paper?

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Answer. No; I have not that paper.

45. Question. Was that old slip of paper offered in evidence in the Atlantic Communication Co.'s case?

Answer. Yes.

46. Question. I find that when you testified in the Atlantic Communication Co.'s case you produced a letter which you described as being a letter addressed to you by Mr. Alexander Porter Brown, from Nantucket, Mass., August 14, 1900, relating to the communications which led up to the formation of the Stone Wireless Syndicate. Did you produce such a letter in this case?

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Plaintiff's counsel calls attention to the fact that Mr. Philip Farnsworth, now counsel for the present defendant,

was also of counsel for the defendant in the Atlantic Communication Co.'s case.

Mr. Scull: Defendant's counsel calls attention to the fact that the paper here inquired about, as well as all the previous papers and documents which have been referred to in this deposition, are part of the court record in the Atlantic Communication Co.'s case, and not available to this defendant for the purposes of testimony in this case.

Answer. Yes.

47. Question. Have you a copy of that letter?

* * * * * * *

Answer. No.

48. Question. Were you or the Stone Co. or any of the companies referred to by you, with whom you have been connected, ever notified by the plaintiff, the Marconi Wireless Telegraph Co. of America, or any owners of the Lodge and Marconi patents here in suit, Nos. 609154 and 763772, of infringement by you or any of those companies, of either of those patents.

* * * * * * *

Answer. I certainly was not. I never heard of the Stone Co. or of any other company with which I might have been connected, being so notified, and I am quite sure that had the Stone Co. been notified I should have heard of it.

49. Question. For how long a period were wireless telegraph sets made according to the Stone system, which you have described, operated by you or by your company?

* * * * * * *

Answer. The Stone Co. was not an operating company. It manufactured sets for commercial purposes for the United States Navy, between early in 1905, until sometime [fol. 628] in 1909, when it shut down its business entirely.

50. Question. In the art of wireless telegraphy what is meant by the term "quenched gap"?

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Answer. A quenched gap is a spark gap devised, specially designed to rapidly damp out the oscillations in any circuit in which it is included by cooling the spark.

The specific structure consists of a number of conducting plates of considerable mass, placed with their opposing surfaces in close juxtaposition, and with their edges so ar-

ranged so as to facilitate the radiation and conduction of heat away from the spark-gap device, and the connections of this series of plates is such that when used as a spark gap the spark has to jump across a succession of gaps between the plates, each one being very short, and immediate proximity of a large mass of metal.

51. Question. In the art of wireless telegraphy what is ment by the term "logarithmic decrement?"

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Answer. In the old theory of the oscillations which place in an electric circuit when a condenser is charged with electricity, and then permitted to discharge through a coil and spark gap, the resulting electric oscillations begin with a maximum initial amplitude, and then decay according to what is called an expotential or logarithmic law, so that the ratio of the amplitude of each oscillation to the next preceding oscillation bears a constant value throughout the train of decrescent oscillations.

That is to say, if the second oscillation is nine-tenths as great as the first oscillation, then the third oscillation will be nine-tenths as great as the second oscillation, the fourth oscillation would be nine-tenths as great as the third oscillation, and so on throughout the train of oscillations.

According to this theory the oscillations practically never cease in a circuit, but simply continue to become smaller and smaller.

The function known as the decrement or logarithmic decrement of the oscillations or of the circuit is the natural logarythm of the ratio of the successive amplitudes which I have just described.

This theory was first advanced by Prof. William Thomson, afterwards Lord Kelvin, in 1853, and has been pretty generally made use of in all work relating to electrical oscillations, but it is not strictly applicable to any circuit containing the spark gap, and when the damping due to the spark gap is large compared to that due to the conductoral resistance it is not strictly applicable at all.

52. Question. I show you an article entitled "The resistance of the spark and its effect on the oscillations of electric oscillators," by John Stone Stone in the proceed- [fol. 629] ings of the Institute of Radio Engineers, under date of December, 1914, and ask you whether you are the John Stone Stone who is the author of that paper?

* * * * * * *

Answer. I am.

Mr. Scull. I offer the paper referred to in evidence and ask that pages 307 to 327 therein be marked "Defendant's Exhibit 6."

(Marked "Defendant's Exhibit 6.")

Mr. Betts. Objected to as immaterial; same objection.

53. Question. In an oscillatory circuit containing a quenched gap, a relatively large capacity, a relatively small conduc-ance, and a relatively small conductor resistance, what kind of a decrement would there be?

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Answer. There would be what is known as a linear decrement, in contradistinction to a logarithmic decrement the linear decrement being the kind of decrement discussed in my paper before the Institute of Radio Engineers, defendant's Exhibit 6, illustrated in Figure 6 thereof, while the logarithmic decrement is the kind of decrement illustrated in Figure 1 of that paper.

In the case of the linear decrement there is no constant ratio between the amplitude or magnitude of the successive oscillations in an oscillation train, and there is therefore no logarithmic decrement or decrement in the sense that there is one in the logarithmic decrement theory.

54. Question. In describing the logarithmic decrement I believe you said that according to this theory the oscillations continue indefinitely. Is this true of an oscillation decaying according to the linear decrement?

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Answer. It is true that according to the logarithmic decrement theory the oscillations are supposed to continue indefinitely, while in actual fact the oscillations die out, and the spark quenches after a definite time. The linear decrement theory shows definitely the extinction of the oscillations after a definite period of time.

55. Question. In an oscillatory system, having a primary circuit and a secondary circuit inductively connected, with a 10 per cent coupling, and a quenched gap in the primary, the circuits being adapted to quench the spark at the first beat, what is the maximum number of oscillations that could occur occur in the primary circuit?

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Answer. Five and five-tenths, though in practice the spark would be more likely to quench and the oscillations cease after five complete oscillations have taken taken place.

56. Question. In your paper, defendant's Exhibit 6, there occurs the following language on page 313:

"While the question of the end of the train of oscillations is of only minor importance, since by the time the amplitude of the oscillations has reached one-fifth its initial value, [fol. 630] the energy of the remaining oscillations represents only four per cent of the total energy of the train."

What is the basis of your selection of one one-fifth of the total value of the amplitude of the oscillations for your calculation of the remaining energy in the wave train?

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Answer. My reason is primarily that stated in the paragraph you have quoted, because "the energy of the remaining oscillations represents only 4 per cent of the total energy of the train."

Now, the energy of the oscillations is the property of the oscillations which maintains the conductivity of the spark across the spark gap.

When the energy of the oscillations becomes too small to keep the gases incandescence at the spark gap, the spark quenches and the circuit opens.

It is therefore necessary, in considering when the spark gap will open through the quenching of the spark, to consider the energy of the oscillations rather than the amplitude of the current of the oscillations.

In most practical cases I should expect the spark to quench when the energy of the oscillation reached 4 per cent of the initial energy required to break down the spark gap; that is to say, 4 per cent of the total energy of the train.

57. Question. How much of the total energy of the train remains when the current has reached 1 per cent of the initial amplitude?

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Answer. One ten-thousandths part of the initial energy, or of the energy of the wave train.

Cross-examination.

By Mr. Betts:

Cross-question. I believe you stated on your direct nation that you applied for and were granted 100 or United States patents for your improvements in wire-legraphy, but that you only described one invention r direct examination, and that was the matter which ant was interested in here. Am I correct?

swer. I did refer to one other invention specifically; , the use of a condenser in the aerial circuit, which ployed by me to give the aerial circuit two natural ncies, one of which absorbed largely the energy of nterference waves, and the other of which was util- the reception of messages, this invention being the of avoiding excessive disturbance from atmospheric ity. I do not remember in this deposition of de- any of the other inventions.

Cross-question. What do you understand to be the volved in this case?

swer. I understand the suit is one brought by the i Co. under the Marconi so-called four-tuned circuit for infringement of that patent, or certain claims

Cross-question. And your deposition with respect to leged disclosures to Baker, Maynadier, Brown, , and the filing of your application for your patent No. 714756 is, as you understand it, for the pur- showing prior invention and use by you of the patent in suit.

swer. I conceive that that is the defendant's purpose g me.

Cross-question. And that is why you limited your xamination to describing in detail this invention, e possibility of such description as you have made pect to the other invention, which, as I understand s in the employment of a condenser in the aerial get two frequencies in that circuit; is that right?

swer. I simply answered the questions that were asked best of my ability. I did not see that any of the were directed toward any other of my inventions one that I described.

62. Cross-question. In what way, if at all, are you connected with the De Forest Radio Telephone & Telegraph Co.?

Answer. I am a stockholder in that company, having received a certain stock consideration in it when the bondholders of the Stone Co., of which I was one, sold some hundred of the Stone Co.'s patents to the De Forest Radio Telephone & Telegraph Co.; and, further, the De Forest Radio Telephone & Telegraph Co. made a contract with me that I should advise Doctor De Forest with respect to the possibilities of his constructing radio telephone or telegraph apparatus which should not infringe or fall within the scope of the claims of other radio telephone patents than those owned by the De Forest Co. That contract I believe has been abrogated through noncompliance on the part of the De Forest Co. with the terms of the contract. These two particulars are the only particulars in which I am in any way connected with the De Forest Radio Telephone & Telegraph Co.

63. Cross-question. And one of the patents which you were to advise the De Forest Co. on was this Marconi patent in suit No. 763772?

Answer. I was not called on to advise Doctor De Forest or the De Forest Radio Telephone & Telegraph Co. on the patent in question or any other patents. My function was purely to advise with Doctor De Forest with regard to the construction of radio transmitters and receivers which should not fall within the scope of the claims of certain patents, as they had been construed by the courts.

In other words, my function was purely that of an electrical engineer and inventor, and I was not called upon to construe the claims of the various patents which might be involved.

To make the matter clear I did advise Doctor De Forest on two circuit arrangements, one for a transmitter and the other for a receiver, some year and a half or two years ago, and since then have not had any further communication with him or the company.

64. Cross-question. Was not Marconi patent in suit No. 763772 one of the patents which you were called upon to advise the De Forest Co. on?

Answer. Yes, in the sense that I was called upon to devise apparatus which should not fall within the scope of the

claims of that patent as those claims had been construed by the several courts that had passed upon the patent in question; but I was not called upon to advise them as to the scope or validity of that patent.

[fol. 632] 65. Cross-question. One of the subject matters of this Marconi patent No. 763772 is the matter of attuning or tuning together the two transmitter circuits?

Answer. That is part of the subject matter of that patent.

66. Cross-question. And another part or subject matter of the Marconi patent No. 763772 is the matter of the tuning together of the two circuits of the receiver?

Answer. That is also a part.

67. Cross-question. And a third matter of this patent No. 763772 was the matter of tuning all four circuits together?

Answer. As I remember it, that is also a part of the subject matter of the patent, though I have not looked it up recently. It may be either that my recollection comes more from something that was said in one of the court's decisions than from what was said in the patent. I had not looked at that patent for some little time, and I might be likely to confuse some of the statements made by different courts that have considered it, with statements made in the patent specification itself.

68. Cross-question. When was it that you were called upon and did advise the De Forest Co. with respect to devising an apparatus which would not infringe or be within the scope of the claims of Marconi patent No. 763772, as construed by the Courts?

Answer. I do not remember the date. I could fix the date approximately if I knew the date upon which Judge Hough granted a preliminary injunction against the De Forest Radio Telegraph & Telephone Co. under the Marconi patent in suit.

69. Cross-question. Was it before or after that decision of Judge Hough?

Answer. It was before.

70. Cross-question. How many years ago was it?

Answer. I don't remember, but I should say that it was a year or perhaps two years ago.

71. Cross-question. How do you account for the fact that you can not remember that date when you pretend to remember the date of a disclosure to Baker more than 16 years ago?

Answer. In the first place, because the matter of the disclosure to Baker was a matter which was of very much greater importance to me, and in the second place, I had looked up and refreshed my memory upon the subject of all those early dates to which I have testified in giving depositions in several suits, and I have even before me the photolithographic copies of the letters that I wrote Baker at the time, copies of letters which I have had in my possession or which have been in the possession of my attorney ever since they were made years ago.

72. Cross-question. Did you advise the De Forest Co. or Doctor De Forest that the apparatus of the De Forest Co. which was the subject matter of the suit before Judge Hough was or was not within the scope of the claims of the Marconi patent as it had been construed by the court?

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Answer. I advised Doctor De Forest that in my opinion the apparatus I recommended to him, and which he used in part, was not within the scope of the claims of the patent as those claims had been construed by the courts, which had passed upon them up to that time.

[fol. 633] 73. Cross-question. You are aware of the fact, are you not, that the Marconi Co. brought a suit against the De Forest Co., of which you are a stockholder, upon Marconi patent No. 763772 in suit?

Answer. Yes.

74. Cross-question. How many times have you testified as an expert in wireless telegraph cases?

Answer. I do not remember. I have testified quite a few times both as an expert and as principal in patent suits and in interferences in the United States Patent Office.

I have testified as an expert for the old defunct De Forest Radio Telephone Co. in a suit brought by that company against the Collins Wireless Telephone Co. and as expert for that old De Forest Co. in suits brought against it by the National Electric Signaling Co.

I have testified as an expert for the Telefunken Co. in suits brought against it by the National Electric Signaling Co.

I have also testified for the Atlantic Communication Co. in suits brought against it by the National Electriet Signaling Co., and as a fact witness in a suit brought against it by the Marconi Co.

I have testified as expert for Professor Fessenden in an action brought by him against the National Electric Signaling Co., and I have given affidavits for the present De Forest Radio Telephone & Telegraph Co. in a suit brought against it by the Marconi Co. under the patent in suit. I possibly also have given testimony in some other radio cases which I do not remember just now.

75. Cross-question. When you testified for the defendant Telefunken Wireless Telegraph Co. in the suit brought against it by the National Electric Signaling Co., and also for the defendant Atlantic Communication Co. in the suit brought against it by the National Electric Signaling Co., you remember the subject matter of plaintiff's patents involved in those suits was the tuning of the two circuits of the transmitter and the two circuits of the receiver?

Answer. I remember that the tuning of these circuits was involved, with regard to the transmitter I believe in one suit, and with regard to the receiver I believe in another suit. I do not remember that tuning all four circuits was involved in either one of these two suits; at least that is my impression now.

76. Cross-question. Did you in testifying in either one of those two cases for the defendents testify to the conception and the disclosure and exploitation of the Stone system which you have testified to on direct examination to-day in this suit?

Answer. No.

77. Cross-question. And yet that testimony that you have given to-day was applicable as a defense to both of the patents upon which these suits are brought.

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Answer. Undoubtedly. Unfortunately I was not asking the questions which I was called upon to answer in both those cases. The questions directed to me, as I remember the case, were not such as to bring out my prior conception, invention, and use of four-time circuits. I could only conclude that the defendant's counsel did not care in those suits to bring out my prior invention, disclosure and use of the four-tune circuits.

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[fol. 634] 78. Cross-question. Who were the defendant's counsel in these two cases?

Answer. Mr. Fenton, of Philadelphia, was the counsel in both of these cases, or the principal counsel in both of these cases.

79. Cross-question. Were not Knight Bros. of counsel for the Atlantic Communication?

Answer. If they were of counsel in either of those cases I did not come in contact with them in connection with either of those cases.

80. Cross-question. Did you tell Mr. Fenton when consulting with him about the defense of these suits, of your alleged prior conception, disclosure?

Answer. I certainly pointed out to Mr. Fenton the disclosures of my early patent No. 714756 and told him that I could produce evidence of early disclosure and use.

81. Cross-question. Did you produce that evidence to Mr. Fenton?

Answer. No; at least I do not remember producing it. In fact, I do not remember producing any evidence to Mr. Fenton except what he called for. There was very little preparation made for either of these suits between Mr. Fenton and myself. A very short time was allowed for conference before I went on the stand. To the best of my recollection Mr. Fenton and I conferred for only one day in New York City before I proceeded to Philadelphia and testified in the first suit, and in the second suit, though we had a somewhat long conference, it still was very short, considering the importance of the suit and the mass of evidence we had to discuss together.

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82. Cross-question. Were you aware of the litigation brought by the National Electric Signaling Co. against the United States Wireless Telegraph Co. in the courts of the first circuit at the time it was pending?

Answer. I think I heard about that litigation, but I did not know anything about it, except now that I think of it I remember that Mr. Farnsworth I believe represented or was of counsel for the United Wireless Co., and the expert which he called was, I believe, Mr. Waterman. I remember Mr. Farnsworth asking me to come to his office and to describe to him and Mr. Waterman, his expert, certain features of the Stone patent No. 714756 and to more or less analyze the patent for him.

83. Cross-question. The subject matter of plaintiff's patent involved in that litigation was the tuning together of

transmitter and receiver circuits, was it not, as you understood it?

Answer. It was.

84. Cross-question. And did you at that time disclose to Mr. Farnsworth the evidence which you have testified to to-day in regard to your alleged early conception and disclosure?

Answer. That question was not asked me, but I believe I did mention the fact that I could produce proofs of some very early dates of disclosure. The purpose of his inquiries was——

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[fol. 635] His inquiries were not directed toward the dates of my disclosures to others, but toward the interpretation which I had placed upon the language of the patent application itself.

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85. Cross-question. In what month did you leave the employ of the American Telephone Co.?

Answer. I do not remember exactly what month. I think it was January or February of 1899.

86. Cross-question. How old were you in 1899?

Answer. I was about 30.

87. Cross-question. Your experiments in wireless telephony while you were connected with the Bell Co. were successful, were they?

Answer. No; except for the transmission of speech between rooms in the same laboratory, and even then the transmission was not loud.

88. Cross-question. How long did these experiments last?

Answer. I do not remember with any great precision how long the experiments on the purely radio line telephone lasted. I should say perhaps three months, before I became convinced that it was best to change to the wired wireless line.

89. Cross-question. Has anybody else except yourself ever used *used* the expression "wired wireless" line?

Answer. Yes; others have used it. In fact, I did not originate the expression. The only way I ever heard of it was when I wrote a paper for the Franklin Institute on a subject which I entitled "Practical aspects of the propagation of high-frequency currents in long wires," which the

Franklin Institute committee, in conferring a medal upon me for this paper, referred to as my paper on "wired wireless." I have since then adopted the shorter and more suggestive name of "wired wireless" for the art.

90. Cross-question. Well, it is popularly known as wired telegraphy or wired telephony?

Answer. No; it is popularly known as wired wireless, being distinguished in that way from the ordinary wired telegraphy and wired telephony, in which high-frequency currents, electrical oscillations, and resonance are not made use of.

91. Cross-question. In your direct examination you have used the expression "Resonant circuit." What do you mean by that expression?

Answer. The resonant circuit as I have used the expression in my patents and in this deposition is one comprising a capacity and an inductance in concentrated form, such as is obtained by the use of a condenser and an inductance coil; and so otherwise constituted that it shall have a very pronounced tendency to respond to alternating electric forces of one periodicity or frequency only. Such circuits are often spoken of as containing "lumped capacity" and "lumped inductance" in contradistinction to circuits like the open circuit of an aerial in radiotelegraphy, which has distributed capacity and distributed inductance along its whole length, though, of course, a circuit of the latter kind can, through the presence of a large inductance coil, be made to approach as nearly as desired to a pure resonance circuit.

[fol. 636] Moreover, when I speak of a resonance circuit, either in my patents or in this testimony, I imply that magnetic and dielectric hysteresis shall not be present to such an extent as to greatly militate against the resonant response of the circuit to the particular frequency to which it is tuned.

For instance, the iron core of a coil, such as the iron core in the coil of a telephone receiver, if allowed to intervene in a resonance circuit, would greatly if not completely kill the resonance phenomenon in the circuit; so such elements are assumed to be excluded when I speak of resonance circuits.

92. Cross-question. Do you or do you not use the term resonance circuit as synonymous with "oscillatory circuit"?

Answer. No. There is a nice distinction between those two classes of circuits, though, of course, an oscillating circuit when closed is necessarily a resonance circuit; but a resonance circuit is not necessarily an oscillating circuit.

Every circuit containing a lumped inductance and capacity will have a particular frequency to which it will respond, and respond fairly strongly, but only circuits having resistance less than the critical value will oscillate when their electrical equilibrium is distributed, and as I understand we now have my patent No. 714756 in evidence, and I would refer you to the definitions contained therein for the use of these two terms which I make.

The oscillating circuit I have called sonorous circuits, to distinguish them from resonance circuits.

93. Cross-question. Do I understand you to say that a closed circuit, comprising the helix of a transformer and capacity, must have additional or auxiliary lumped inductance in order to be a resonant circuit?

Answer. Not necessarily. As a rule, if the transformer contains no iron and the resistance on the circuit be not enormously high, and if the dielectric of the condenser be of suitable material, such a circuit may be very strongly resonant without any auxiliary inductance; but if it lacks resonant properties through the presence of considerable resistance, it might be made resonant by the addition of an auxiliary inductance coil.

94. Cross-question. Who was the successful party in the interference between Pupin, Stone, Hutin, and Le Blanc?

Answer. There were two interferences, one between myself and Hutin and Le Blanc, and one between myself, Professor Pupin, and Hutin and Le Blanc. I do not remember the outcome of the Hutin and Le Blanc-Stone interference, but I do remember that Professor Pupin prevailed in the three-party interference.

95. Cross-question. How did you fix the date when you left the Bell Co. in 1899?

Answer. I do not remember now exactly how I did fix that date, except that I had occasion to look up the lease of my office at the Phillip Building, the office which I took immediately after leaving the Bell Telephone Co. laboratory, and I fixed the date in that way, and by looking up everything I could find in that connection when I have testified on previous occasions in regard to my history.

96. Cross-question. When first did you begin to deliver the course of lectures at the Massachusetts Institute of Technology?

[fol. 637] Answer. I do not remember that date exactly, but I think it was 1896. It was about that time that Professor Cross, of the Institute of Technology, and Professor Trowbridge, of Harvard College, became interested in the work I was doing on electrical resonance, and I believe it was in that year that Professor Cross asked me to begin giving my course at the institute and Professor Trowbridge submitted my name for fellowship in the American Academy of Arts and Sciences.

97. Cross-question. Have you any memorandum which enables you to fix the date when you began to deliver your course of lectures at the Massachusetts Institute of Technology?

Answer. No; I do not believe I have any memorandum by which I can fix that date. Very likely Professor Cross could fix the date.

98. Cross-question. How long did you continue to deliver that course of lectures at the Massachusetts Institute of Technology?

Answer. I remember that I delivered the lectures at the Institute of Technology for some time prior to my leaving the laboratory of the American Bell Telephone Co., and for some years subsequent to that date. I think I stopped giving my lectures at the Institute of Technology about 1906.

99. Cross-question. Is that the most definite answer you can give?

Answer. Yes. I fancy that Dr. Louis Duncan, who was in charge of the electrical engineering course at Massachusetts Institute of Technology, about that period, could fix the date more exactly.

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100. Cross-question. Have you any memorandum which will enable you to fix exactly the date when you ceased to give your lectures at the Massachusetts Institute of Technology?

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Answer. I do not think that I have any memorandum by which I can fix that date.

101. Cross-question. Give the exact date when you were first consulted by Mr. Ladd?

Answer. I do not remember that date.

102. Cross-question. Give the exact date when the Ladd Syndicate was formed?

Answer. I can not fix that date purely from memory.

103. Cross-question. Give the exact date when you began experiments for the Ladd Syndicate?

Answer. I can not fix the exact date when I began from the Ladd Syndicate, purely from memory.

104. Cross-question. Give the exact date when you first conceived the idea of eliminating interference in wireless telegraphy?

Answer. I can not fix that exact date purely from memory.

105. Cross-question. Give the exact date when you first conceived the idea of producing a pure simple electromagnetic wave in a wireless telegraph transmitter?

Answer. That would be substantially the same date as the date of my conception of the invention of my patent No. 714756. I have already answered that I can not fix that date purely from memory.

[fol. 638] 106. Cross-question. Did you ever build or use a wireless apparatus such as is described in your two letters to Baker, defendant's Exhibits Nos. 2 and 3, before you wrote those letters to Baker?

Answer. No: I am quite certain that I did not build the apparatus described in those letters before writing the letters, but the elements and even some of the combinations described there, though not constituting the invention as a whole, I had caused to be constructed, and I used in my wired wireless experiments.

107. Cross-question. In your direct examination I understood you to say that the Stone system of your patent No. 714756 is used. As a matter of fact no apparatus manufactured by the Stone Co. is in use today; is not that so?

Answer. I am sure I do not know whether any of the Stone Co.'s apparatus is still in use or not. Certainly there is, or it is more than likely that apparatus embodying all the features of the invention of the disclosure of patent No. 714756 are in use in many parts of the world, though I do not mean to say by that, that such apparatus was constructed by the Stone Telegraph & Telephone Co.

108. Cross-question. What was the character of the spark gap which you actually used in your experiments, or commercial application of the Stone system?

Answer. We used a great variety of spark gaps. One of the favorite early forms was a multiple series spark gap. We also used multiple spark gaps. We used spark gaps with air blasts. We used very high-power air blasts, to quickly extinquish the spark. We used almost all the different spark gaps which have been either brought out by ourselves or others, except the so-called modern quenched gap. We never used a gap similar to that, which I have described as a quenched gap in this deposition.

109. Cross-question. Did you use rotary spark gaps?

Answer. We used rotary spark gaps in some of our experimental work, but not in our commercial sets.

110. Cross-question. What was the character of the detector used in your experiments?

Answer. I began, as practically everyone did in the early days, with the old filings coherer, and soon abandoned that for the microphone contact coherer of various types, including metal points on mercury. I at a very early date adopted for a time the bolometer. We used the thermal junction, electrolytic, crystal, and a variety of other detectors, in experimental work. In our commercial stations we used almost entirely, if not entirely, the Wallaston electrode.

111. Cross-question. When first, and where, did you use the metal filings coherer?

Answer. The metal filings coherer I first used in some experiments in the laboratory of the American Bell Telephone Co., merely as a matter of curiosity, without any attempt at working a wireless telegraph apparatus, but merely investigating the coherer principle as a matter of curiosity.

The first time I used coherers in connection with my radio telegraph experiments was in my laboratory at 40 Lincoln Street, Boston. I can not fix the date of those experiments, as I testified, though I remember I looked up and refreshed my memory for the purpose of testifying in the Atlantic Communication Co. suit, and fixed that date pretty closely. [fol. 639] 112. Cross-question. When first did you use the microphone detector in wireless telegraph work?

Answer. I can not fix that date exactly from memory.

113. Cross-question. When first did you use the bolometer as a detector in your wireless telegraph work?

Answer. I can not fix date definitely from memory, but I believe there are affidavits in some of my patents for bolometer detectors in which I made and fixed that date with certain precision.

114. Cross-question. When first did you use the electrolytic detector in your wireless telegraph work?

Answer. I can not fix that date with precision from unaided memory.

115. Cross-question. When first did you use the crystal detector in your wireless telegraph work?

Answer. I can not fix that date with precision purely from memory.

116. Cross-question. What substances did you use as crystal detectors in your wireless telegraph work?

Answer. I used the ordinary crystals, such as galena, pericon. I did not undertake an investigation of a large number of crystals for their different properties.

117. Cross-question. When first did you use the Wallaston detectors in your wireless telegraph work?

Answer. From unaided memory I can not fix that date, but I believe that date is also established in the records of some of my patents relating to that type of detector.

118. Cross-question. Can you fix now from memory the date when first and for how long, you used any of these forms of detectors in your wireless telegraph work?

Answer. Not purely from memory.

119. Cross-question. Can you not fix from memory the date when first and for how long you used the various forms *fo* spark gaps which you have described?

Answer. I can fix the date of the use of the ordinary round polished balls, with pretty fair precision, considering the lapse of time, since those balls were used in connection with my experiments on radio telephony in the laboratory of the Bell Telephone Co., the records of which show that I was doing this work in April or May, 1899.

120. Cross-question. Other than that you can not fix the dates when and for how long you used the various forms of spark gaps which you have described?

Answer. The round ball spark gap was used by me for experimental purposes as long as my experiments with radio telegraphy continued in the work of the Stone Co. I remember the first form of multiple spark gap was in use*d* by me at my Cambridge station in 1903. I can not fix very

definitely the period in 1903 purely from memory in which the multiple spark gap was used, but my memory in that connection is refreshed by some of the photographs that I have recently seen of the apparatus at that station.

121. Cross-question. What do you mean by using the expression, "very accurately attuned circuits"?

Answer. I refer to the degree of precision with which we attuned circuits to one another in the Stone Co.'s laboratory, where a precision in such measurements of one-half of 1 per cent or a quarter of 1 per cent was insisted upon. In [fol. 640] certain instances a far greater degree of precision was attained, but in ordinary research work I insisted upon a precision of one-half to a quarter of 1 per cent.

122. Cross-question. What do you mean by the expression, "extremely loose coupling"?

Answer. An extremely loose coupling is a term which I have applied as relating to the transmitter when the coupling is sufficiently loose so that with an ordinary open gap and with no cooling except such as is obtained from an ordinary air blast, the oscillations developed in the primary and secondary circuits will be at one frequency only, and the radiated waves one wave length only. At the receiver an extremely loose coupling is one in which two circuits, such as an aerial and a closed resonant circuit, each separately tuned to the same frequency and brought into inductive relation with each other, will remain practically in tune without material change in the adjustment of either.

Perhaps this statement may need a little clarification. I will point out that if two circuits, such as in the aerial and the closed resonance circuit, be each attuned exactly to the same frequency and then be brought into close inductive relation with each other, both the circuits will be found to have their periods changed, and in order to secure a maximum response in a closed circuit from any waves received by the open circuit it is necessary to readjust the closed circuit or retune it, as it is popularly expressed.

When the coupling is loose no retuning is required, or else such retuning as is required is very slight.

I think that fully answers your question.

123. Cross-question. What do you mean by "an ordinary spark gap"?

Answer. An ordinary spark gap is composed, for instance, of two juxtaposed balls, of say, brass, or two mush-

ed electrodes with their mushroomed surfaces
d, or two cylinders with their edges juxtaposed;
these forms, with a moderate air blast passing be-
juxtaposed surfaces.

oss-question. You do not include in the phrase
"spark gap" the rotary spark gap or the quenched
?

No.

oss-question. Do you include the multiple spark

. I might in some connections, where distinction is
e; for instance, between the quenched type of gap
p in which no great provision is made for quench-
ark.

oss question. What degree of coupling between
y coupled circuits do you have in mind when using
"extremely loose coupling"?

There is no definite coupling coefficient, so called,
be regarded as the dividing line between tight
coupling, because the amount of coupling at a
ng station, for instance, in a so-called loosely
stem may be greater when one kind of spark is

oss-question. Do you mean spark or spark gap?

Well, spark gap; when one kind of spark gap is
and then another kind of spark gap is employed.
speaking the greater the quenching action at the
that is to say the less hysteresis of the spark, the
coupling may be without developing the oscilla
ore than one frequency or——

128. Cross-question. Do you mean looser in-
ghter?

No; quite the other way.

ss-question. Well, tighter?

Then the tighter the coupling may be without
oscillations of more than one frequency or with
ping electro-magnetic waves from the aerial of
one wave length. After all that question is the
f what constitutes loose coupling, the practical
t the transmitter.

* * * * * *

ss-question. Can you state what degree of cou-
had in mind when using the phrase "extremely
ling"?

Answer. A degree of coupling which would insure a single frequency of oscillation at the transmitter and of resonance in the receiving circuit. In specific cases such a degree of coupling would have a definite value, but for different conditions of circuits this degree of coupling would vary. In the case of the transmitter the maximum coupling that could be called loose coupling ——

131. Cross-question. No; I am talking about extremely loose coupling, Professor?

Answer. I will go on with that, and make the distinction. The maximum coupling that could be called loose coupling would be the coupling that would produce oscillations and waves of but a single frequency with an open or ordinary gap, and an extremely loose coupling would be a coupling considerably less than this maximum coupling.

132. Cross-question. I suppose you mean other conditions being the same?

Answer. Yes; that is right; and to be still more specific I remember that with some of the open gaps we used in my experimental station at Cambridge the maximum coupling at the transmitter that would produce a single-frequency wave was of the order of 3 per cent.

In a case of this kind an extremely loose coupling would be, say, of the order of 1 per cent, or a half of a per cent. Of course, any similar coupling would still be a loose coupling.

At the receiver the maximum coupling which would insure practically a single frequency of resonance will also vary with the conditions of the circuits, but I remember that in some of the sets that I used in my early work 2 or 3 per cent was the order of the coupling which effected this result.

With such a circuit a coupling of 1 per cent, or half of 1 per cent, or anything less than that might be called extremely loose coupling. I would say that extremely loose couplings actually were used in practice, and couplings of possibly as small as one-hundredth of 1 per cent actually were used when the necessity for excluding excessive inter- [fol. 642] ference was extreme. Such couplings at the receiving station would be called extremely loose couplings.

133. Cross-question. What are the conditions of the circuits which are to be taken into account in determining the degree of coupling in order to insure the emission or reception of but a single wave?

Answer. These conditions are exremely complex. They can only be determined by careful mathematical study of the relations of coupled oscillators. The theory of coupled oscillators was investigated by Bjrknes and Drude, Bjrknes's paper being published prior to the advent of radiotelegraphy and Drude's some time subsequently; but neither of these investigators took into account competently the effect of the resistance of the circuits, and this was never done until I published the mathematical theory of the subject in a presidential address before the Society of Wireless Telegraph Engineers, which presidential address was published in the Electrical Review and Western Electrician, of New York and Chicago, as near as I can remember, in January, 1903, and was reprinted in the Jahrbuch Drachlose der Telegraphie and in the l'Eclairage Electrique in the years 1905 and 1903, respectively, I believe.

Without reexamining these papers it would be very difficult to say exactly what the effect of each one of the elements or constants of the circuits had upon the degree of coupling which would give the reception of a single frequency or the emission of waves of but a single frequency. The subject is extremely complex.

Without, therefore, pretending to give a full answer to your question, I will say that considering the transmitter one of the principal conditions affecting the maximum coupling which will insure the radiation of waves with but a single frequency is the hysteresis of the spark. When this is large the maximum coupling which may be called loose coupling is correspondingly small, and conversely as the hysteresis of the spark is diminished the maximum coupling which may be called loose coupling or which will result in the radiation of waves of single frequency is correspondingly large.

The subject of the hysteresis of the spark and its effect in quenching the spark before two wave lengths or two frequencies of oscillation are fully developed was set forth by me in a presidential address before the Institute of Radio Engineers last year.

This, again, is not so simple a subject as to be dealt with except in a very technical manner.

With regard to the conditions at the receiver which would effect its response to a single frequency to the exclusion of

other frequencies, so far as the degree of coupling is concerned, that is also quite complicated, but the mathematical expressions determining that question in the matter of the tuning of the two circuits to each other are set forth in full in my United States patent No. 714756, to which I have referred in this deposition.

If I may be permitted to look at the mathematical expressions in that patent I think I can outline the conditions to which you referred in your question. May I refer to the patent?

134. Cross-question. Certainly. (Patent produced.)

Answer. The larger the resistance of the primary and secondary resistances the tighter the coupling may be which will insure response to a single frequency to the exclusion of all others, and the larger the reactances of the two circuits; that is to say, the larger the electrical stiffness of the [fol. 643] two circuits the tighter the coupling may be that will insure the resonant reception of waves of one frequency to the exclusion of all others.

It would also appear, though I can not be quite certain of it without computation, that, other things being the same, the smaller the frequency, or the longer the wave length to which the circuits are attuned, the tighter the coupling will be, capable of causing the circuits to respond to single frequency or wave length.

135. Cross-question. What do you mean by the expression "hysteresis of the spark"?

Answer. That expression is derived from the Greek and signifies a lagging behind. It is used in several phases of electrical work to indicate the lagging of a physical result after its physical cause.

Its most common application is to the magnetization of iron, which is very familiar as magnetic hysteresis, and the electrification of dielectrics or dielectric hysteresis.

There is a lagging behind in the resistance of an arc or spark, a lagging behind the current changes in the arc or spark.

The subject is set forth perhaps most simply and certainly most explicitly on pages 319, 320, 321, and 322 of defendant's Exhibit 6 in this case.

It is a somewhat complex phenomenon, and its results upon the oscillations in an electric circuit are extremely complex. These latter I have considered in the presidential address before the Institute of Radio Engineers last year.

Perhaps the simplest way to express what is meant by the hysteresis of the spark or arc gap is to say that the resistance at the spark or arc gap in a circuit is a function, or depends upon the amount of the current that passes across the gap during the spark.

If the resistance at any moment merely depended upon the current at that moment, then the resistance of the arc or spark would be set, not to have any hysteresis or lag, but it is found by experience that the resistance of the spark or arc at any moment "depends not only on the current flowing at that instant but also upon the current which has been flowing during an appreciable interval of time preceding it."

I am quoting the last passage of defendant's Exhibit 6, at pages 321, 322.

136. Cross-question. Then the greater the resistance of the spark the greater is the hysteresis or lag of the spark?

Answer. No. Usually I should expect the opposite to be the case, because the greater the resistance of the spark the quicker I should expect it to respond to a variation of the strength of the current of the spark.

137. Cross-question. The function of all spark-gaps, whether they be plain or open gaps, multiple gaps, rotary gaps, or quenched gaps, is that they serve as a trigger in starting oscillations, and to limit the potential applied to the condensers by the transformers' secondary; is that correct?

Answer. That is one function of the spark in radiotelegraphy. The subsequent function of the spark, after it has once begun to discharge, depends upon whether the system be of the impulsive excitation character, or of the loose coupled persistently oscillating primary circuit type of excitation.

[fol. 644] 138. Cross-question. The ideal spark gap should have infinite resistance at the beginning of the spark and zero resistance during the continuation of the spark, and infinite resistance at the end of the wave train?

Answer. Such a spark would be an extremely desirable spark if it could be secured for a loose-coupled persistently oscillating primary circuit type of transmitter, and efforts were made at an early date to secure in practice just such a spark with considerable success in one type. Unfortunately, I do not believe that type of spark has ever gone into practical use.

139. Cross-question. For every different type of spark gap, plain or open gap, multiple gap, rotary gap, or quenched gap, other things being the same, there will have to be different degree of tightness or looseness of coupling required in order to emit or receive waves of a single frequency; is that correct?

Answer. So far as the receiving is concerned the problem will not be particularly affected by the particular type of spark gap used, other things being the same.

So far as the transmitters are concerned this will depend upon whether the impulsive excitation be used or whether the persistent primary oscillating system be used.

The mere use of a spark gap of a particular type will not determine upon which plan the impulsive excitation or the persistent primary oscillation excitation the transmitter will operate.

Taking the case of the persistent primary oscillation excitation, then the gaps which give rise to the least resistance hysteresis of the spark will permit of the use of the tighter coupling at the transmitter, and conversely those spark gaps giving rise to the larger resistance hysteresis of the spark will require the use of looser couplings.

Taking the case of the impulsive excitation transmitter, here the hysteresis of the spark is not the factor which determines the coupling which must be used.

The factor which determines that coupling is the production of a true or complete beat between the oscillations in the antennæ circuit and in the primary oscillating circuit.

Unlike loose-coupled persistently oscillating primary oscillator systems of excitation, in which any coupling looser than the maximum coupling will develop waves of a single wave length, the quench-gap system requires the use of some particular coupling in any given case, and that coupling, that critical coupling, is the coupling which will make the amplitude of the oscillatory current passing through the quench gap practically zero at the first beat, between the oscillations of the open and closed circuits at the transmitter.

If this critical coupling be departed from without making any other changes in the circuit to compensate for it, the spark will not quench at the first beat, and the excitation of the system will cease to be of the character of the quench gap or impulsive-excitation system.

In the case of the quench gap system therefor one operating as such, the type of the spark gap used, other things re-

maining the same, cannot be regarded as determining or materially affecting the coupling which may be used to effect the radiation of waves of but a single frequency wave length, so long as the spark gap is distinctly of the quench type: that is, of the type productive of extremely small resistance [fol. 645] hysteresis of the spark, as compared with what are often spoken of as the open spark gaps.

140. Cross-question. As I understand your last answer you have characterized the type of transmitter which you called impulse excitation as one having a quenched gap, and the transmitters which you called the loose-coupled type of transmitters as having open, rotary, or multiple gaps: is that what you mean?

Answer. No. I characterize these two different types of transmitters not by the type of spark gap used alone, because the mode of operation of the two is different, aside from the mere type of spark-gap device used.

You will note that I speak of the loose-coupled transmitters with persistently oscillating primaries as one type of practical radio transmission, in contrast to the impulsive excitation transmitters.

The distinction between the two transmitters is one of mode of operation rather than one of type of apparatus used.

It would be quite possible to use a quench gap in a transmitter and employ the mode of operation of the loose-coupled persistently oscillating primary circuit type of transmitter, and it would also be possible to use one of the older forms of spark gaps, such, for instance, as the rotary spark gap or the series open spark gap, with heavy air blast, in the impulsive excitation manner, in which the transmitter would be distinctly of the quench-spark type.

I am not sure that the efficiency of such transmitters could be as great as is commonly secured to-day by the use of quench gaps in the impulsive quench-gap devices, in impulsive excitation systems, and the open gap in the persistent primary oscillation loose-coupled transmitter system of operation.

In other words, the gap does not determine the system, but each type of gap is best adapted to one or the other of these two modes of operation.

141. Cross-question. If the gap does not determine the system what does determine the system?

Answer. The systems are the two extremely opposite modes in which a spark excited transmitter may be used for the development of waves of single frequency.

In the extreme case of the persistently oscillating primary loose-coupled transmitter, the coupling would be made very loose indeed, say a half of 1 per cent. The spark would be either so constructed or utilized that its resistance would be extremely small during the entire time of oscillation of the primary and secondary circuits, and within a wide range of from almost zero coupling up to, say, 1 per cent coupling the transmitter would operate to radiate waves of a single or substantially a single wave length.

On the other hand, in the case of the quench-gap system a certain definite coupling, other things being equal, would have to be used. This coupling would have to be sufficiently tight to produce a beat between the current through the spark gap after say five oscillations of the primary circuit, and at the same time the other constants of the two circuits, the aerial and primary circuit, would have to be so proportioned to each other and to the mutual induction that this beat in the current passing through the spark gap would be a complete beat or practically complete beat, so that in other [fol. 646] words the amplitude of the oscillatory current passing through that spark gap will become zero or practically zero at the beat.

These conditions find no parallel in the persistently oscillating primary loose-coupled transmitter systems. In these letter systems there in no critical mutual inductance, which must be used under given relations of the other constants. There is simply a maximum coupling which must not be exceeded, but which may be loosened to any desired degree without altering the mode of operation of the apparatus.

142. Cross-question. In your testimony you have used the phrase "five oscillations." Do you mean complete or half oscillations?

Answer. I mean complete oscillations.

143. Cross-question. That is, ten half oscillations?

Answer. No. The word "oscillation" implies a to and fro oscillation as a rule, when used by English speaking physicists, and certain foreign physicists have used the term "oscillation" to imply what we call half oscillations or reversals of current, yet even in European literature that use of the term is disappearing.

144. Cross-question. What do you mean by "tight coupling"? What values do you have in mind in using that phrase?

Answer. I believe I have already answered that question. Tight and loose coupling are purely relative terms, and per se I should not wish to place any specific numerical value on what is tight or what is loose coupling.

145. Cross-question. You have said in a previous answer that in what you have termed the loose-coupled persistent oscillating transmitters the maximum coupling must not be exceeded. What value do you have in mind in saying "the maximum coupling"?

Answer. That just illustrates my point, that most specific numerical value can be ascribed to the term "loose coupling" or "tight coupling," because in the loose-coupled persistently oscillating primary circuit transmitters the coupling which is properly called loose is that coupling which will result in the generation of oscillations and waves of a simple harmonic type, or have but a single frequency or wave length.

This degree of coupling will be different, dependent, as I have testified, upon a number of different considerations, and therefore what might be a tight coupling in one transmitter and therefore defeat the purpose of the device through its tightness of coupling would be loose or sufficiently loose for the successful operation of another one of the transmitters, and it would not be fair therefore to undertake to specify a given coupling as the limit of loose coupling, except for a particular station.

The term is generic as used in this connection and is characteristic of that whole class of transmitters which operate with the persistently oscillating primary circuit in which the oscillations of the primary circuit decay gradually, where the primary oscillating circuit and aerial have ample opportunity to effect each other's oscillations, so far as affects the development in each of two or more frequencies.

146. Cross-question. You have, I believe, stated that the character of the spark gap is not the factor which determines whether a transmitter be of the type which you have called impulse excitation transmitter or of the type which you [fol. 647] have called loose-coupled persistently oscillating primary transmitter, and as I understand your testimony you have said that the factor which does determine to which of these two types the transmitter belongs is the degree of

coupling between the primary and secondary circuits. Am I correct in so understanding it?

Answer. Not quite.

147. Cross-question. What, then, are the factor or factors which determine to which type of these two transmitters a given transmitter belongs?

Answer. The two types are characterized by a difference in their modes of operations, of which the general order of the coupling is only a result, and though looseness of coupling is one of the characteristics of the persistently oscillating primary transmitter capable of radiating simple harmonic waves or waves of a single wave length. While tightness of coupling, so called—that is to say, couplings of the order of 10 or 15 per cent, more or less—is one of the characteristics of the impulsive excitation transmitters capable of radiating waves of the simple harmonic type, yet the real difference is the difference in the mode of operation of these two systems.

In the first system, after the initial rush of current across the spark gap, a long persistent train of oscillations takes place in that circuit, and these oscillations in turn set up oscillations of corresponding frequency in the antenna or open circuit with which the primary oscillator is loosely coupled.

The oscillations in these two circuits react upon each other. If the coupling be sufficiently loose, the frequency of the oscillations developed into primary and secondary circuits will be substantially the same frequency or rate of vibration and no beats will occur in the oscillations of these two circuits, or if the frequencies of the oscillations developed in these two circuits be sufficiently different to produce beats they will nevertheless be sufficiently near to one another not to produce beats which will quench the spark of the primary oscillator before it has practically expended all the energy of the initial charge of the condenser, or else not sufficient to produce anything approaching a complete beat during the life of the oscillations of the primary oscillating circuit.

From this it will be seen that a considerable range or latitude exists in the amount of coupling which may be used in a given transmitter of this kind, without changing anything else.

On the other hand, in the impulsive excitation system in use the oscillations of the primary circuit after the first

rush of current across the gap are very quickly suppressed by the production of a beat in the current in the primary oscillator, owing to the reaction on the oscillations of that circuit, due to currents of a different frequency developed in the antenna circuit.

For the production of this rapid extinction of the spark in the primary circuit it is essential that the oscillations developed in the antenna or aerial radiating circuit by the oscillations and the primary circuit, be of a considerably different frequency from those of the primary circuit, and this is secured through the use of a so-called tightness of coupling between the two circuits, or through a detuning of the two circuits from each other, of say 10 or 15 per cent, as to their natural frequencies, and also through the adjustments of the circuits so that the beats between the currents, [fol. 648] due to the primary oscillator alone, and those due to the oscillations in the aerial, shall produce complete beats in the primary circuit, real or approximately real zeros of current amplitude in the spark gap.

There is, therefore, a relation between the coupling and the other constants of the circuit which determines the definite coupling for any particular circuit or combination of circuits at an impulsive excitation transmitter station.

* * * * * * *

148. Cross-question. Will you please now answer my question and say what are the factors in a given transmitter which determine whether that transmitter is of the type which you have called the impulse excitation type, or of the type which you have called the loose-coupled persistently oscillating primary type? Is it the character of the spark gap employed or the degree of coupling employed, or both?

Answer. In this and my preceding answers I have, I feel, fully answered that question. I do not see how I could make the matter clearer, by any different answers than those I have already made.

I think I have completely distinguished between the two systems and shown that the distinction between these two types of transmitters is one of mode of operation and not one of mere types of apparatus.

I have even gone so far as to show that certain types of apparatus which are generally characteristic of one of these types of transmitters might be converted to the use of the other type of transmitter, and vice versa; but that they

would merely operate less efficiently in the type of transmitter for which they were not designed.

* * * * * * *

149. Cross-question. Does the character of the spark gap employed in a given transmitter determine whether the mode of operation of that transmitter is of the impulsive excitation type, or of what you have called the loose-coupled persistently oscillating primary type? Please answer that yes or no.

Answer. Not alone.

150. Cross-question. What other factor does determine it? Is it the degree of coupling? Please answer that yes or no.

Answer. No other one factor determines it.

* * * * * * *

151. Cross-question. What other factor or factors decide the character of the spark gap?

Answer. I have already answered that the factor which determines the type of transmitter, that is to say, of the distinction of the two types of transmitters of which I have been testifying, is the mode of operation, and the fact whether or not the spark in the primary circuit is quenched after the first beat in the current passing through it.

* * * * * * *

152. Cross-question. I again ask you what factor or factors determine whether the mode of operation of a given transmitter is of the type which you have designated the impulse excitation type, or of the type which you have designated the loose-coupled persistently oscillating primary type?

Answer. The factor of whether there is developed in the primary circuit a beat, which causes the arc to extinguish [fol. 649] after the first beat in the current passing through it. The distinction between the systems is one — mode of operation and not one of apparatus, as I understand it.

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153. Cross-question. Will you be kind enough to answer the questions?

Answer. I have answered the question to the best of my ability.

154. Cross-question. Then I will put the question in another way: You have said that the character of the spark gap does not alone determine whether or not a given transmitter belongs to that class of transmitters which you have designated as impulse excitation transmitters or to that class which you have designated as loosely-coupled persistently oscillating primary transmitters. Does the degree of coupling between the two circuits determine, or is it a factor in determining, to which of these two types a given transmitter belongs? Please answer that yes or no.

Answer. It is only so far a factor as it determines whether a beat shall be produced in the primary circuit which will extinguish the spark on the first beat.

155. Cross-question. Will you please answer the question yes or no.

Answer. I do not believe the question can be answered yes or no.

156. Cross-question. What produces the beat in the primary circuit?

Answer. The beat in the primary is produced by oscillations induced in the primary circuit, from or by oscillations occurring in the secondary circuit, when said induced oscillations in the primary circuit are of equal amplitude with the principal primary oscillations at the time of said beat.

The exact relations of inductance capacity, mutual inductance, dissipation of energy in the different parts, etc., which will produce this condition, are extremely complex. They have never been completely and accurately determined mathematically. They are therefore incapable of being treated with precision.

The nearest approach that could be arrived at as to a statement of these conditions might possibly be by a study based upon Bjrken's mathematical theory which I have already referred to. I am not aware that anybody has made even this approximate study of those conditions. Once this study has been made, it would probably be possible to state exactly what the criteria are for the quenched gap mode of operation, just as it is possible to express exactly the criteria for the mode of operation of the loose coupled persistently oscillating systems; but I am quite sure that no expert could to-day offhand state the exact criteria in relation of the electrical constants of the system which would produce the mode of operation which we have

come to call the impulse excitation or quenched-spark system.

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157. Cross-question. Take the case of a transmitter provided with a plain or open spark gap on the one hand, and the case of a transmitter with a quench-spark gap on the other hand, all other conditions of the transmitter being the same, how would the degree of coupling between two such transmitters compare if both transmitters were designed and adjusted to emit a simple or pure harmonic wave, or what you call a wave of a single frequency?

[fol. 650] Answer. Practically, an engineer would, in the case of the plain or open gap, loosen the coupling between his primary oscillator and aerial or open circuit until he was able to detect but a single wave length in the radiated waves. When he had done this the order of the coupling he would have secured would be the order of say 2 per cent or less.

After reaching this value of the coupling he could further loosen it to any degree he pleased, and make still more sure of changed conditions of the spark gap not giving him two wave lengths.

In the case of the quench-gap device he would adjust his coupling, starting with a very close coupling and gradually loosening it until he secured a wave of a single frequency. The coupling he would reach in such a case would be of the order say of 10 or 15, more or less; but having secured this wave of a single frequency, any variation of the coupling, if sufficient to modify the mode of operation of the apparatus, causes the production of either two waves or at all events very inefficient operation of the apparatus.

When these two types of spark gap are used in radio transmitters the order of the difference in coupling I have indicated above, is about indicative of what occurs in practice.

I would not like to say offhand that some specially constructed, altogether experimental and special apparatus, might be gotten up for purely demonstration purposes, in which the relative magnitudes of the coupling might not be made different; but such an apparatus would not be typical, but would be extreme, and calculated to mislead rather than clarify the distinction between the two systems.

158. Cross-question. The primary function of any spark gap, whether it be an open gap or quenched gap, is to permit the condenser or condensers in the primary circuit of a wireless transmitter, to charge, and enable them to discharge?

Answer. That is its primary function.

159. Cross-question. And the object of using a quenched gap in a wireless transmitter is to prevent the retransfer of energy to the closed primary circuit after the energy has been supplied by the primary circuit to the open circuit in a requisite amount?

Answer. That is one object of using the quenched gap, another object being the securing of a persistent train of simple harmonic waves from the transmitter.

160. Cross-question. You are familiar with the so-called transmitters which were involved in the suit of Marconi against the Atlantic Communication Co.?

Answer. Yes.

161. Cross-question. They were quenched spark gap transmitters were they not?

Answer. They were.

162. Cross-question. The transmitters involved in the suit of Marconi against the De Forest Radio Co. were also quenched gap transmitters, were they not?

Answer. I believe so.

163. Cross-question. Now, referring to the crystal detectors, which you have used in the stations of the Stone Co., were these high-resistance detectors?

Answer. My recollection is that the crystal detectors used were all of the type which I had to connect across the [fol. 651] condenser to get the best results, and therefore I believe that they must have all been of the high-resistance type.

164. Cross-question. In the quenched-gap transmitters the spark is not quenched, and the primary circuit quenched to stop oscillating, until the energy has been transferred from the primary to the secondary; that is true, isn't it?

Answer. I believe that that is practically true. That is to say, such energy as remains in the primary circuit, is but a small fraction of the total energy of the discharge, and the nearer this relation is obtained, the more efficient is the operation of the apparatus.

165. Cross-question. How many complete oscillations were there in the primary of the Atlantic Co's. transmitter before the spark was quenched?

Answer. I do not remember with certainty that figure. I seem to remember that I gave that figure in an affidavit in the case of the Marconi Co. against the Atlantic Co., and without wishing to be understood as definitely remembering the number, I think it was seven oscillations.

166. Cross-question. Now, answer the same question with regard to the De Forest transmitters?

Answer. I don't remember having looked into the exact number of oscillations in the De Forest transmitters, but generally speaking the number of oscillations in quenched gap systems generally, as commonly used, is say four to seven; of that general order. This does not by any means imply that this is necessarily the number of oscillations which must be used. I am inclined to believe that the number could be, by slight circuit modifications, very much reduced.

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167. Cross-question. These defendants' transmitters which were involved in the Atlantic Communication Co. case or the De Forest Co. case were of the type which you have designated as impulse-excitation transmitters?

Answer. Yes.

168. Cross-question. Is it or is not true that with any form of spark gap whether it be a plain rotary, or quenched spark gap, that two or three wave lengths may be radiated, and that with any form of spark gap the circuit may be adjusted so that only one wave length is radiated?

Answer. Yes; though possibly with certain constants in primary and secondary oscillators, this could not be accomplished. I wish to modify my next preceding answer so far as this affects the De Forest transmitter. The exact arrangement and mode of operation of that transmitter I do not remember at the present moment. My best recollection is, however, that it was an impulse-excitation transmitter, but I can not remember absolutely that, without remembering the exact mode of operation as I do not at present.

169. Cross-question. The De Forest transmitter employed a quenched spark gap, as you remember it?

Answer. To the best of my recollection, it did, and also to the best of my recollection the excitation was impulse

excitation, but of this I am not sure. My best recollection [fol. 652] seems to me that there was an impulse excitation of a closed oscillating circuit which in turn produced forced vibrations in a radiating circuit, the period of which was very different from the period of the closed primary circuit.

170. Cross-question. What, if any, advantage is there in employing a tight coupling in a wireless transmitter as distinguished from a loose coupling?

Answer. Greater electrical efficiency and more persistent trains of waves have been secured recently by the so-called tight coupled impulse excitation transmitters than were attainable with the old loose coupled persistently oscillating primary transmitters.

171. Cross-question. Is it or is it not a fact that the employment of a quenched spark gap in a wireless transmitter, as contrasted with a plain or rotary gap, may permit tighter coupling between the primary and secondary circuits?

Answer. The coupling of any circuit transmitter may be tightened to any desired degree provided you do not care to radiate waves of a single frequency, that is to say, single harmonic waves, but if the condition of radiating simple harmonic waves be imposed then you are right, the use of a quenched gap with its much smaller hysteresis does not enable you to employ a system of impulse excitation by which waves of the simple harmonic type may be radiated at a much tighter coupling than is possible with the older system of the persistently oscillating primary. However, the contrast should not, I think, be made between the rotary gap and quenched gap, at all events not with the same force as is made between the ordinary open gap and the closed gap, for as a matter of fact the hysteresis of the rotary gap is very much less than that of the open gap, and in fact a good rotary gap I can imagine might be so constructed and used as to be almost, if not quite, as efficient in an impulse excitation system as what is conventionally called a quenched gap device.

172. Cross-question. I believe that you have used in your direct examination the phrase "resonant secondary circuit" in a wireless receiver. What do you mean by that phrase?

Answer. I mean a circuit comprising a condenser and an inductance coil or transformer coil, the inductance and capacity and other constants of the circuit being such that it responds resonantly to but a single frequency of im-

pressed force or to the waves of but a single frequency, to the exclusion or practical exclusion of waves of materially different wave length.

173. Cross-question. You have also used the expression in your direct examination of "tuned" and "attuned resonant circuits." Do you use them synonymously, or not?

Answer. Practically so. I generally use the word "attuned" to something, while using the word "tune" I often use it simply to indicate that it is adjusted to respond to a given frequency without referring to which frequency.

174. Cross-question. What do you mean by the phrase "sharply attuned" circuit?

Answer. The expression "sharply attuned" or "sharply resonant" indicates the degree of the attunement. A sharply attuned circuit responds very vigorously to waves of given frequency, and is practically opaque or nonresponsive to waves differing but slightly in wave length from this resonant wave length; while a circuit which is not [fol. 653] sharply attuned is one which, though having particular wave length to which it responds most vigorously, also responds sensibly to wave lengths in the neighborhood of that particular resonant-wave length.

175. Cross-question. What do you mean by the phrase "accurately attuned"?

Answer. I may mean in certain connections very sharply attuned, and in other connections, which I think could be distinguishable from the context, "the attunement of which is very accurately known."

176. Cross-question. And you have used the phrase in your direct examination "highly resonant circuit." What do you mean by that phrase?

Answer. A resonant circuit in which the resonant phenomenon is very pronounced. The expression in that sense is practically equivalent with sharply attuned resonant circuit.

177. Cross-question. Is it or is it not a fact that in the suit of the Marconi against the DeForest Co., to which we have referred and in which I believe you said you made one or more affidavits for the defendant, that you claimed that the DeForest transmitter was made and operated in accordance with your patent No. 714756?

Answer. I do not remember exactly the organization of the DeForest transmitter, nor do I remember having made the statement to which you refer.

178. Cross-question. I show you copy of the record in the Circuit Court of Appeals in the suit of Marconi v. DeForest Co., calling your attention to an affidavit of yours appearing on pages 339 to 344, inclusive, and ask you if this does not refresh your recollection and enable you to say whether or not you meant to contend that the DeForest transmitter's mode of operation was that set forth in your patent No. 714756; your affidavit is the one verified November 2, 1914?

Answer. I find under the last subject heading of my affidavit, namely, "Definitions," the only reference to my United States patent No. 714756. Under this caption of "Definitions" I refer to certain technical terms which I have used in the affidavit, such as "natural oscillations," "force oscillations," "natural period of oscillation," etc., "wave-ding-out circuits," etc., and then I say:

"The most complete and accurate definition of some of these terms, and the most accurate simple exposition of these subjects, particularly to radio telegraphy, is contained in my United States patent No. 714756, granted to me. I attach a copy of said patent to this affidavit and ask that the technical terms that I have herein employed be understood in the light of the explanations set up at great length in that patent."

I do not think that this would indicate that I have by this language intended to imply that the DeForest transmitter was, as to its mode of operation, necessarily disclosed in this patent specification, particularly as a very large part of the specification of that patent is given over entirely to a perfectly abstract discussion of the phenomenon of oscillations in simple oscillating and resonance circuits, and in coupled circuits, and as to the distinction between natural and forced oscillations in simple and coupled circuits and the effect on the natural periods produced in circuits by employing them together, and allied theoretical matters.

[fol. 654] The previous literature on the subject has been so entirely mathematical that I could only refer a mathematical physicist to it for definition of these terms, and an exposition of these phenomena, but I have always felt since the appearance of this patent of mine, No. 714756, that the subject is therein most clearly explained in language which can be understood by those merely skilled in the art of radio

telegraphy and not having the attainments of a mathematical physicist.

Whenever I have occasion to refer any one to a written exposition of these phenomena and a definition of these terms I refer them to this patent, where I made such an effort to get this very complicated subject clearly stated in accurate physical terms without a cloud of mathematics.

I do not mean to be understood as saying that the DeForest transmitter may not coincide with the invention of this patent, or may not be included under the terms of the claims of this patent. In fact, I believe that that transmitter should fall under the claims of the patent, though I could not make sure of it at this date without going over the subject very carefully.

I do not remember what my conclusions were on the subject at the time, even if I did reach a conclusion upon the subject.

179. Cross-question. When was it that you assisted Doctor DeForest in designing the transmitter involved in this suit?

Answer. I advised Doctor DeForest in regard to that matter, I think it was, about a year ago; I do not remember the date. I have no means of refreshing my memory as to the date just now. If I knew the date of the affidavit to which I have just referred I might be able to project backward and fix the date rather more accurately.

180. Cross-question. The affidavit is dated November 2, 1914, and in it you state:

"The object of the system designed by Doctor DeForest and myself is the same as that of all systems of radio transmission."

Can you now state when you assisted Doctor DeForest in devising this DeForest transmitter?

Answer. I think it was in the summer of 1914; the latter part of the summer of 1914 as I now remember it, that I advised Doctor DeForest as to the type of transmitter referred to in that affidavit.

181. Cross-question. Do you now say that the DeForest transmitter which you assisted Doctor Forest to design, and which was involved in this suit of Marconi against DeForest, did or did not employ the mode of operation described in the specification, excluding the claims of your patent No. 714756?

Answer. From my recollection of the transmitter I advised Doctor DeForest it was the combination of an impulse excitation and of a persistently oscillating primary circuit system of transmission. It was of a type to which I have already referred in this deposition, where a persistently oscillating primary circuit, extremely closely coupled, to an aerial or radiating conductor, tuned to a very different frequency from that of the primary oscillator, radiates substantially simple harmonic waves.

Now, if I remember correctly, my patent No. 714756 discloses only the type of transmitter employing loose coupling in which the aerial system and the primary oscillating [fol. 655] system of the transmitter are attuned to the same frequency in order to radiate waves of single frequency or simple harmonic waves.

Therefore, I do not believe, with this recollection of the transmitter Doctor DeForest used, and of my patent, that the transmitter Doctor DeForest used is the transmitter or falls within the scope of the particular transmitter specifically described in this specification; but it certainly fell under the general class of transmitters radiating simple harmonic waves, referred to in this patent, and not described as the preferred form.

182. Cross question. I next call your attention to another affidavit of yours, verified November 2, 1914, in the same suit, of the Marconi Co. against the DeForest Co., on the Lodge and Marconi patents here in suit, and ask if you did not testify in this affidavit as follows:

"I assert positively and unqualifiedly, and I base my assertion on the knowledge I have gained through a great many years of practical experience in dealing with radio or wireless apparatus, that the essential character of defendants' apparatus and the mode of its operation as well, is radically different from the apparatus, arrangement, circuit connection and the mode of operation of the Lodge and Marconi patents in suit. If in an attempt to make it appear that the circuit arrangement of defendants' apparatus is the equivalent of the Lodge and Marconi inventions, it be contended that the radiating conductor is the path A, C^2, L^2, C^3, E, of Figure 1 of the blue print attached to the affidavit of Lee DeForest and J. S. Murphy, I assert that such contention is contrary to the fact, since the natural oscillations which take place through that path are purposely

made extremely small in order that they may not waste energy, while the useful oscillations, which cause the radiation to take place, are in a circuit A, C^3, C^4, E, and are oscillations forced on that circuit from the closed 'weeding-out' circuit, C^2, L^2, C^3. This circuit is essentially a 'weeding-out' circuit since it is a tune circuit without a spark gap interposed between the primary oscillating circuit 1 and the open radiating circuit A, C^3, C^4, E. The character of such 'weeding-out' circuits, their function and mode of operation is described in my United States patent No. 714756 attached to my supplemental affidavit in this case, and I shall therefore not dwell further at great length upon this subject. I will point out that the 'weeding-out' circuit 2 takes its energy from the primary oscillator and forces these oscillations on the open radiating circuit. This open radiating circuit A, C^3, C^4, E is purposely given a very different natural rate of oscillation from that of the 'weeding-out' circuit, in order that the forced oscillations may be of a single frequency, that they shall be practically free from any second frequency, such as would result if the open radiating circuit were in tune with the 'weeding-out' circuit or were to have nearly or approximately the same natural period as that of the 'weeding-out' circuit.

"The presence of this secondary frequency is a drawback to circuits or apparatus of the Marconi type, since the energy which flows into second frequency is not only lost so far as useful effect on the tuned receiver is concerned but serves to interfere with other radio stations in the neighborhood, which may happen to be trying to use waves of this second frequency or waves of nearly this second frequency for their own intercommunication. So harmful has this feature proved in the practice of the art in the past, [fol. 656] that the Government requires that radio stations, to pass inspection, shall, in the event of the presence of such a second frequency, be so adjusted and operated that the energy of the waves of this second frequency shall not be greater than 10 per cent of the energy of the useful frequency waves."

Did you so testify?

Answer. The quotation you make appears to be correct.

183. Cross-question. And in the same case did you also give a third affidavit for the defendant, namely, that verified October 23, 1914, on a motion for a preliminary injunction, and did you not in this affidavit testify as follows:

"The opinions of Judges Parker and Veeder are in substantial accord, in fact, in close accord in their interpretation of these two patents. Considering first the earlier of these two patents, namely the patent to Lodge, both opinions agree that the invention of this early and famous patent consists essentially in using an induction coil in the open or aerial circuit at both the transmitting and receiving stations. At the transmitting station the coil was used in order to cause the transmitter to emit a persistent train of waves, of a definite frequency, that is to say, a long procession of isochronous waves, instead of a highly damped wave train, or one containing only a very few successive waves such as a wave train which is extinguished after say three or four successively diminished waves had passed. At the receiving station the coil is *sued* in the aerial to attune the receiving aerial open circuit to the periodicity of the waves emitted by the transmitter. On this point Judge Veeder, after discussing the art prior to the Lodge patent very fully, proceeds to describe the invention of Lodge and to define its scope so clearly as to leave no doubt as to the interpretation to be placed upon the claims of this patent, however they be worded.

"Of this beautiful invention of an able scientist, Judge Veeder says:"

(The witness then quoted from Judge Veeder's opinion, the quotation being found at 213 F. R., p. 843, beginning at the second paragraph and continuing through to the beginning of the second paragraph on page 844.)

"I add hereto a sketch illustrating a Lodge construction by way of assisting the court in understanding the otherwise beautiful, clear discussion of the Lodge invention by Judge Veeder. In the foregoing sketch I have shown the open or aerial circuits of the Lodge patent as grounded at their lower extremities in order to bring it into line with the modern practice, and this is justified in view of the fact that Lodge, in his patent, states that one of the capacity areas may be the earth. In this sketch V represents the capacity area, L represents an adjustible inductance coil, S represents a spark gap, and K represents a coherer or other detector of high frequency oscillations. Various means may be used to cause a spark at S, and various means may be used adjunct to K for the purpose of assisting it in its function of detecting the oscillations."

Did you so testify?

Answer. The quotation you make seems to be correct.

184. Cross-question. And did you also in this same affidavit testify as follows in regard to Marconi patent No. 763772 (p. 263):

[fol. 657] "This patent to Marconi, which is famous as the result of the decisions of Justice Parker and Judge Veeder, is generally known amongst the radio engineers, experts, and operators as Marconi's four-tuned-circuit patent. In this patent Marconi secures a radiation of persistent trains of waves in a manner different from that previously employed by Lodge. He secures a persistent train of waves by connecting his open aerial radiating circuit at the transmitter by means of a two-coil transformer, to a closed oscillating circuit, which is itself persistent, and he secures the transfer of energy from this persistent operating closed circuit to the aerial by attuning the aerial circuit by means of an adjustable inductance coil therein, so that it shall have the same natural rate of vibration as the persistent closed oscillating circuit. Marconi in this patent further secures his syntonic or resonant response at the receiving station by a different method from that employed by Lodge. He includes his detector in a closed persistently oscillating circuit connected to open aerial absorptive circuit by means of a two-coil transformer, and he secures the transfer of energy from the open aerial absorptive circuit to the closed persistently operating circuit by attuning the open aerial circuit by means of an adjustable inductance coil therein, so that it shall have the same natural period of oscillation as the closed oscillating circuit, comprising the detector K. Finally, Marconi secures the transfer of energy freely between the transmitting station and the receiving station by attuning the two circuits of each station so as to have the same natural periodicity of the two circuits of the other station. Thus the complete system comprises four circuits, each attuned to the same natural frequency by making the product of the capacity by the inductance of each circuit the same as that for each of the other circuits.

"Both Judge Veeder and Justice Parker have been quite clear in their statements of these facts, and their decisions make even the most ambiguous claims of the Marconi patent in suit easily interpretable as to their scope and real significance."

And did you not, after quoting claim 2 of the Marconi patent in suit and commenting upon it, then continue as follows:

"With the same characteristic clearness of thought and expression as were evident in the passages I have previously quoted from Judge Veeder's opinion in relation to the Lodge patent, he says of the Marconi patent in suit."

You then quoted from Judge Veeder's opinion 213 F. R. at page 844, beginning with the paragraph at the bottom of the page and continuing to the end of the second paragraph, page 845, and then beginning again at page 847 at the second paragraph and continuing to the end of the first paragraph at the top of page 848.

I have correctly quoted from your affidavit in that case, have I not?

Answer. Yes; the quotation is correct.

185. Cross-question. You also gave one or more affidavits for the defendant in the suit of the Marconi Co. against the Atlantic Communication Co. on the Lodge and Marconi patents in opposition to a motion for a preliminary injunction?

Answer. Yes; I so remember.

186. Cross-question. Did you not in an affidavit in that case verified July 10, 1914, testify as follows:

[fol. 658] "I deny that the only important difference between the aerials at the date of the application for Lodge's patent and those of to-day resided in the spark gap of the early transmitting antenna. Further, the apparatus of Figure 3 of the Lodge patent is obviously inoperative, and Figure 4 is, to say the least, highly inefficient. It is so highly inefficient that no one would for a moment consider using it practically to-day."

Answer. The quotation is correct.

187. Cross-question. Two coil transformers in wireless transmitting or receiving sets are the equivalent of one coil or autotransformers, are they not?

Answer. In general, yes.

188. Cross-question. And a condenser coupling between two circuits in a wireless transmitter or receiver is an equivalent coupling to a one-coil or a two-coil transformer coupling?

Answer. No; I think in general not. I have carried the theory of the equivalents of conductive couplings to the in-

ductive couplings further in one of my papers than it has been carried by any one else.

I refer to a paper on "The coefficient of coupling of oscillation transformers," published in the Electrical World, I should say some five or six years ago, though in the case of conductively coupled circuits where the link between the two circuits is purely and simply an inductance coil, there is a very close analogy between the conductively coupled or autotransformer and the two coil transformer, yet when the common branch of connecting link between the two circuits is a condenser, I am not certain that the equivalence can be found. The whole subject of this equivalence needs a reexamination. I am, in fact, at the present moment contemplating working out and publishing the mathematical theory of those equivalents for both the condenser conductive and inductants conductive connections, as well as the combination of these two in which the common connecting link between the two circuits is both a condenser and a coil.

189. Cross-question. At any rate, a condenser common to two circuits of a wireless transmitter does, of course, serve to transfer energy from one circuit to the other?

Answer. Yes; it is a mode of coupling the circuits and effects the transfer of energy to and fro between circuits.

190. Cross-question. Were these lectures which you gave at the Massachusetts Institute of Technology printed?

Answer. No; they were not; they were given extemporaneously.

191. Cross-question. Did you deliver a paper before the Canadian Society of Civil Engineers on the 9th of March, 1905, on the subject of "Interference in wireless telegraph," and is the printed paper which I now hand you a copy of such paper?

Answer. I read a paper before the electrical section of that society on that date and of that title, and what you hand me is a reprint of that paper, but I notice that one plate or figure or sheet of curves seems to be missing. The figure to which I refer is numbered Figure 10, and my recollection is that through some error Figure 10 was not included in the reprint, although it was included in the printed proceedings of the society and was also included in the reprint of the paper or report of the paper which appeared [fol. 659] in the local technical press shortly after I de-

livered the paper. I think I remember that the paper appeared in its complete form with that figure in the Electrical Review and Western Electrician, New York and Chicago, within a few months after I read the paper in Montreal.

192. Cross-question. Can you produce a copy of this paper which has the Figure 10 included in it?

Answer. I do not believe I have in my possession a copy of this paper, other than reprints, just like the one you have. I possibly could find it in the files of the Electrical Review or the Western Electrician.

Mr. Betts: Plaintiff's counsel offers in evidence the paper identified by the witness to be marked "Plaintiff's Exhibit A."

* * * * * * *

(Marked "Plaintiff's Exhibit A.")

193. Cross-question. Are you the John Stone Stone to whom was granted United States Letters Patent Nos. 767984 and 767999, dated August 16, 1904, copies of which I now show you?

Answer. I am.

Mr. Betts: Plaintiff's counsel offers in evidence printed Patent Office copies of the aforesaid two patents, and they are marked, respectively, "Plaintiff's Exhibits B and C."

(Marked "Plaintiff's Exhibits B and C," respectively.)

194. Cross-question. Did you testify for the defendant in a suit of the National Electric Signaling Co. against the Telefunken Co. on a patent to Fessenden, No. 928371, in September, 1911, as follows:

"Will you please give a concise statement of the principles involved in radiotelegraphy, as a practically applied art, including in your statement its genesis and evolution down to and including the date of Marconi's British patent No. 7777 of April 26, 1900, as respects its development after that date. I will ask you subsequently concerning each step thereafter.

"A. Referring first to the work of Marconi, it is safe to say that his British patent No. 12309 of June 2, 1906, was the first patent ever granted for an operative system of radiotelegraphy based upon a creation and detection of radiated 'Hertzian or electromagnetic waves.'"

Answer. I believe I made that statement.

195. Cross-question. Did you also testify in that same case as follows:

"Q. 28. Now, please state briefly the character of the apparatus constituting the next decided step in the art made by Marconi?

"A. The British patent No. 7777 of 1900 discloses the really important advances made in the art at that date. Marconi therein discloses a variable inductance coil in series in the antennae, or aerial structure, conductor, and the tuning condenser in shunt with the primary of the transformer in a tuned secondary of which is connected the detector and tuning condensers and inductance coils. Both the condenser in the primary and secondary and tuning inductance coils in the secondary, are made variable for the purpose of tuning the circuits with which they are associated."

Answer. I believe I made that statement.

[fol. 660] Cross-question. And in the same case did you not also testify as follows:

"Q. 10. Speaking generally, how do the subsequent advances in the art of radiotelegraphy, down to the present time, compare in relative importance to what was summed up in Marconi's two British patents of 1906 and 1900, to which you have referred, and others substantially cocontemporaneous with the latter?

"A. Though it is undoubtedly true that the apparatus substantially as it is clearly shown in the separate drawings of Marconi's British patent, is preserved in every efficient form of commercial apparatus, and of all systems used today, it is equally true that many of the elements in it were not of his invention."

Answer. I believe I made that statement.

197. Cross-question. And did you not also testify in that same case as follows:

"The first very clear and complete exhibition of the use of a continuously variable tuning condenser in shunt to the primary of a transformer in a wireless telegraph receiver, so far as I am aware, is contained in the specifications and drawings of the English patent to Marconi, No. 7777, of 1900."

* * * * * * *

Answer. I believe that is a correct statement of what I said.

198. Cross-question. When did you first disclose to Knight Bros., solicitors for the defendant in the suit of the Marconi Co. against the Atlantic Communication Co., the subject matter of your letters which are in evidence as defendant's Exhibits Nos. 2 and 3?

Answer. I can get you the exact date by referring to my files. I can do this because I wrote at that time to my patent attorneys, Browne & Woodworth, in Boston, in whose safe these letters were being preserved for me, and in whose safe the photolithographic copies of these letters were being preserved for me at my request, and I feel quite sure that I can find in my letter files a letter I wrote to Mr. Woodworth or to Mr. Browne or to Messrs. Browne & Woodworth asking them to send these letters on. Otherwise I cannot remember the date very specifically, except that I should say it was about a month prior to the time they were produced in court. It may have been earlier than that, but I should say it was about a month prior to the date of that production.

199. Cross-question. That is some time during 1916?

Answer. Yes; that would surely be in 1915.

200. Cross-question. In your affidavits which you filed in behalf of the defendants in opposition to the motion for preliminary injunction in the Atlantic Communication Co. case, and also in the De Forest Co. case, you did not produce or say anything about these Stone-Baker letters did you?

Answer. I do not remember having done so. I feel quite sure I did not.

201. Cross-question. Can you give the exact date when you conceived the invention described in defendant's Exhibits Nos. 2 and 3?

Answer. The exact date I cannot fix any closer than I have already in this deposition.

[fol. 661] 202. Cross-question. Can you give the exact date when you first disclosed to or discussed this invention with Baker, and the place where such disclosure was made?

Answer. I cannot state it any more closely than I have already in this deposition

203. Cross-question. Can you give the exact time when you first disclosed this matter to your attorney, Mr. Browne?

Answer. No closer than I already have in this deposition.

204. Cross-question. Where did you disclose it to Browne?

Answer. Either at his office in Boston or at his summer home in Nantucket, Mass.

205. Cross-question. You have spoken of seeing Mr. James Maynadier in regard to this matter. Can you give me the exact time and place when and where you saw him?

Answer. I cannot place the time any closer than I have in this deposition. The place was at his law offices in the Sears Building, in Boston, Mass.

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206. Cross-question. Give the exact date when the Stone Wireless Telegraph Syndicate was formed?

Answer. I cannot give the exact date from memory, purely, any closer than I already have in this deposition.

207. Cross-question. What is the date as near as you can now fix it?

Answer. Early in 1901 or late in 1900.

208. Cross-question. Can you approximate the month?

Answer. No; I don't think I can approximate the month purely from memory. The date could, however, doubtless be fixed more closely by reference to some of our old records.

209. Cross-question. When was the $10,000 paid into the Stone Wireless Telegraph Syndicate?

Answer. It was substantially at the date of its formation.

210. Cross-question. When was the Stone Telegraph & Telephone Co. organized?

Answer. I cannot fix that date any more closely than I have in this deposition, purely from memory. Of course, the date of the formation of that corporation is a matter of record and could be exactly fixed, if necessary.

211. What is your recollection, your present best recollection, as to when the Stone Telegraph & Telephone Co. was incorporated?

Answer. Very nearly the first of 1902.

212. Cross-question. Can you approximate the month, from your present recollection?

Answer. To the best of my present recollection it was December, 1901, or January, 1902.

213. Cross-question. How long did the Stone Telegraph & Telephone Co. continue in active business?

[fol. 662] Answer. The Stone Telegraph & Telephone Co. continued in active business until some time in the latter part of 1909, or early part of 1910, though its activity was not very great at that latter period, and I can not fix absolutely from memory the date at which the company actually stopped doing any further business.

214. Cross-question. Was either the Stone Wireless Telegraph Syndicate or the Stone Telegraph & Telephone Co. operating wireless companies?

Answer. The Stone Wireless Telegraph Syndicate did no business whatever. It merely financed the experimental work I was doing at the time. The Stone Telegraph & Telephone Co. was purely a manufacturing company and development company. It never, per se, was a commercial operating company. The Stone Telegraph & Telephone Co. did, however, own the small company that operated the Isle of Shoals plant.

215. Cross-question. Did the Stone Telegraph & Telephone Co. manufacture and supply wireless apparatus while it was in existence to anyone except the United States Government?

Answer. Yes. It supplied apparatus to the Isle of Shoals Operating Co., which, however, was only one station, and it supplied a considerable number of apparatus to amateurs through a subsidiary company.

216. Cross-question. What was the name of this subsidiary company owning the Isle of Shoals station?

Answer. I do not remember the name of that company. I think it was the Isle of Shoals Wireless Telegraph Co., or some such name.

217. Cross-question. When was that company organized?

Answer. That company was organized, as near as I remember, in the latter part of 1905 or the early part of 1906. I fix that date by my recollection of the installation and operation of the Stone apparatus at the Navy radio station at Portsmouth, N. H., Navy Yard, with which the Isle of Shoals station communicated.

218. Cross-question. How long did the Isle of Shoals station continue to operate?

Answer. As long as the Stone Telegraph & Telephone Co. continued its operations; and whether it continued to operate after the Stone Telegraph & Telephone Co. went out of business or not I do not know.

219. Cross-question. Will you please give me the exact length of time in months or years during which the Isle of Shoals station was operated?

Answer. I have already testified that I do not know when the Isle of Shoals station ceased to operate. For all I know, it may be in operation to-day. I have never had occasion to look into the matter of its continued operation.

220. Cross-question. When did the Stone Telegraph & Telephone Co. cease to manufacture wireless-telegraph apparatus?

Answer. At the time it went out of active business.

221. Cross-question. When was that?

Answer. As near as I can remember, that was in the latter part of 1909 or very early part of 1910.

222. Cross-question. Why did the Stone Telegraph & Telephone Co. go out of active business?

[fol. 663] Answer. On account of lack of capital with which to prosecute its business.

223. Cross-question. You have testified, I believe, that you conducted experiments financed by the Stone Wireless Telegraph Syndicate during the year 1901, with a view to attaining a degree of selectivity of your system satisfactory to yourself; is that so?

Answer. That is a fact.

224. Cross-question. What degree of selectivity did you obtain which was satisfactory to you during these experiments?

Answer. I attained a degree of selectivity of better than 10 per cent. This degree of selectivity was not what I considered as high as I ultimately hoped to secure, but it was secured with the then accepted detector, namely, the filings coherer; and for such an erratic detector, creating as it does great perturbations in the receiving resonance circuit, I regarded it as sufficient.

225. Cross-question. Will you explain now what you mean by attaining a degree of selectivity better than 10 per cent?

Answer. The tests were made at that time at a receiving station comprising a filings coherer and telegraphic relays and sounders, the transmitter during the test remaining at a fixed distance from the receiver.

In these tests the four circuits of the transmitter and receiver were first placed in resonance, all of the same fre-

quency, and the amount of power at the transmitter adjusted until the receiving telegraphic apparatus responded satisfactorily, the amount of power being used being such that any diminution of the power would cause the telegraphic apparatus to cease responding satisfactorily. Then the two circuits of the transmitter, while still using the same power, were attuned to a frequency 10 per cent different from that previously used, that to which the two circuits of the receiver were attuned, and the transmitter was again operated.

If during the course of the test the receiving apparatus failed to respond at all to the transmitter with its second adjustment the system was said to have a selectivity of 10 per cent.

In all these tests the transmitter was first used with the frequency and wave length corresponding to that of the receiver, and then used with frequencies and wave lengths 10 per cent greater and 10 per cent less than the frequency to which the receiver was attuned.

226. Cross-question. Where was the receiving station and the transmitting station?

Answer. They were at the opposite ends of a long room being about 50 feet apart.

227. Cross-question. You have stated that the Stone Telegraph & Telephone Co. was organized in December, 1901 or January, 1902. How long previous to the organization of that company did you succeed in attaining a degree of selectivity of your system satisfactory to you?

Answer. I do not remember the date definitely but it was in the latter part of 1901 that I got sufficiently consistent results at 10 per cent selectivity to suit myself, as near as I can now recollect.

228. Cross-question. Well, was it subsequent to August 1, 1901?

Answer. I can not undertake to specify the month. It was in the latter part of that year, as near as I can remember.

[fol. 664] 229. Cross-question. Well, as near as you can remember was it later than August 1, 1901?

Answer. I should think so.

230. Cross-question. When was it that Professor Cross was asked by you to make a report on your experiments?

Answer. I do not remember the date. It was in the latter part of 1901, as near as I can remember.

231. Cross-question. When was it that Dr. Louis Duncan was asked to witness or make a report on your experiments?

Answer. Doctor Duncan was asked to make several reports on my work. The first time he was asked to report upon this work, as near as I can remember, was in the latter part of 1901. Subsequently he made more extended reports on the more elaborated apparatus and system.

232. Cross-question. Did Professor Cross witness your experiments; if so, when first?

Answer. Professor Cross witnessed my experiments in my laboratory in 40 Lincoln Street prior to the formation of the Stone Co.

233. Cross-question. That is some time in the latter part of 1901?

Answer. Yes, as near as I can remember.

234. Cross-question. And when first did Doctor Duncan witness your experiments?

Answer. I do not remember Doctor Duncan's witnessing my experiments. I believe that he did make an examination of my apparatus and its working at a time when I was not in Boston. The best of my recollection in regard to Doctor Duncan's investigation of the Stone system is that the actual apparatus and its working was exhibited to him by my assistant, not Mr. Baker at the Lincoln Street laboratory, but one of my assistants at the Charles River embankment stations after the formation of the Stone Co.

235. Cross-question. What was the name of this assistant?

Answer. To the best of my recollection I was not present and I do not know who the assistant was. It might have been E. R. Cram or it might have been Mr. F. A. Kolster. I do not remember if I ever knew which one of these gentlemen showed him the apparatus. In fact, the apparatus might have been shown by him by my patent attorney, Mr. Alexander P. Browne, of Boston, 60 Congress Street, Boston.

236. Cross-question. Did either Professor Cross or Doctor Duncan make reports of your experiments in writing?

Answer. I do not remember whether Professor Cross made a report in writing or not. Doctor Duncan made at least two reports in writing, as I remember it, and published one article on the Stone system in one of the American electrical journals.

237. Cross-question. The next step as I understand it, which you took, was the erection of two experimental stations on the Charles River embankment at Cambridge, Mass.; is that right?

Answer. After the formation of the Stone Co. my recollection is that the next step was the erection of two stations on the Charles River embankment.

238. Cross-question. How far apart were those two stations?

Answer. Those two stations were about a quarter of a mile apart and had mere 40-foot telegraph poles for masts. [fol. 665] 239. Cross-question. When was the erection of those stations begun?

Answer. To the best of my recollection early in 1902.

240. Cross-question. Can you give me the month?

Answer. No, I should hesitate to try to fix it more closely.

241. Cross-question. When were those two Cambridge stations completed.

Answer. A very short time after they were started, as they merely consisted of match board frame buildings about 10 feet square, covered with waterproof paper.

242. Cross-question. How long did you or the Stone Co. continue to work those stations?

Answer. One of these stations was enlarged very shortly after it was built, I should say two or three months after it was built, so as to make it a two-room building some three times as large as it originally was, and having an 80-foot mast. Later the mast was increased to about 180 feet. This was some three months after the 80-foot mast had been erected, as near as I can remember. As soon as the high mast was erected the operations between the two stations were practically discontinued except for minor tests of detectors, etc., the plans for all other tests being arranged for the longest distances, either between the Cambridge station with its 180-foot mast and the navy yard station at Charlestown, Mass., or to the Stone station at Lynn, Mass. The enlarged Cambridge station continued in use until the Stone Co. went out of business. It was used both for test purposes and occasionally for reporting Marblehead yacht races, when interference was too great for the navy yard station at Charlestown to secure the clear reception of these messages. In a sense this might have been regarded as commercial operations of the Stone Co., except, so far as I

remember, these reports of the yacht races were not paid for, but the station was merely used to help out other stations in this connection.

243. Cross-question. Were each of these two Cambridge stations both transmitting and receiving stations?

Answer. No. Only one of them, the one that was enlarged, was ever used as a transmission station, as near as I can remember.

244. Cross-question. How long was the other, or smaller station, worked after it was completed?

Answer. It was used, as near as I can remember, for about a year, off and on.

245. Cross-question. What was the character of the spark gap at the Cambridge transmitting station?

Answer. It was very greatly varied during the course of the experiments. One type of spark gap used was large hollow brass balls filled with water.

246. Cross-question. As I understand it the Stone Telegraph & Telephone Co. did not begin to enter into commercial work, that is to say, furnishing sets of apparatus, but devoted itself to the necessary electrical tests and to research work, until some time in 1905; is that correct?

Answer. The Stone Co., as near as I can remember, did no commercial work until early in 1905.

247. Cross-question. When was it that the Stone Co. supplied apparatus to Charlestown Navy Yard?

[fol. 666] Answer. As near as I can remember it was in the early part of 1905.

248. Cross-question. Can you fix the date any more definitely?

Answer. No; I have a sort of a recollection that it was in April.

249. Cross-question. Did the Stone Co. sell its apparatus to the Government for the Charlestown station, or what was the arrangement?

Answer. As I remember the arrangement, it was the Stone Co. sold its apparatus to the Navy Department for the Charlestown station.

250. Cross-question. When was the station at Lynn erected, to which you have referred?

Answer. To the best of my recollection that was in 1903.

251. Cross-question. The purpose of the erection and operation of that Lynn station was to conduct tests of your system with the enlarged station at Cambridge?

Answer. Yes.

252. Cross-question. What was the amount of power used in the Cambridge enlarged transmitting station?

Answer. That station had various power equipments. I do not remember what the first power was. It must have been small, because with the original 40-foot mast, no very considerable power could have been radiated from the antennae, and therefore no considerable power equipment could have been used. As the height of the mast was progressively increased the power equipment was increased, and I remember supplying the power to the station was increased in capacity several times.

253. Cross-question. Why was it increased in capacity several times?

Answer. Because as we increased the height of the mast and therefore the capacity of our radiating aerial we were able to dispose of and radiate more energy, and it became necessary to use more power.

254. Cross-question. When was the Stone apparatus supplied to the Portsmouth (N. H.) station?

Answer. To the best of my recollection early in 1905. That is to say, I think that the equipment took place early in the summer of 1905. As I remember it, there was some delay in the equipment of that station after the Stone apparatus was delivered there, but I cannot remember that very distinctly.

255. Cross-question. Did the Stone wireless apparatus which was supplied to the Charlestown and Portsmouth stations comprise both transmitting and receiving apparatus or sets?

Answer. It did; also the power supply apparatus, as near as I can remember it, at both stations.

256. Cross-question. What was the rated kilowatt capacity supplied to these two stations?

Answer. I forget now whether they were 3 or 5 kilowatt. I rather think they were 3 kilowatt.

257. Cross-question. Was the Lynn station a transmitting station or a receiving station?

Answer. So far as I can remember the Lynn station was purely a receiving station.

258. Cross-question. What was the height of mast or antennae wire at this station?

Answer. I think it was about 100 feet.

[fol. 667] 259. Cross-question. Did you take part in the installation of the Stone apparatus at either the Portsmouth or the Charlestown Navy Yard stations?

Answer. No. I visited both stations to inspect the installation, as near as I can remember it, only after the installation had been made.

260. Cross-question. Did you visit either one or both of the stations more than once?

Answer. I visited them both more than once at different times.

261. Cross-question. When did the Stone Co. supply its apparatus to U. S. S. *Lebannon?*

Answer. As near as I can remember that was in the year 1905 also.

262. Cross-question. When did the Stone Co. supply its apparatus to the battleships *Georgia*, *Minnesota*, and the other battleships you referred to in your direct examination?

Answer. They were supplied with their apparatus later than the *Lebanon*. I do not remember the years in which these battleships were equipped. The *Minnesota* and *Georgia* were equipped first, as I remember it, possibly about 1906. Later other battleships were equipped. I think the *Washington* and *Tennessee* were amongst some of the ships we equipped in the Navy, but I do not remember the dates at which these equipments were made.

263. Cross-question. Am I correct in understanding you to testify that the apparatus which you used at the two Cambridge stations and also at the Lynn station, and also at the Charlestown and the Portsmouth stations, and the Stone apparatus which you supplied to the Navy Department for use on its vessels, was designed to operate in accordance with the description of your patent No. 714,756?

Answer. Yes, except, of course, that at Cambridge experimental stations, when purely research work was going on, all the varieties of circuits described in some hundred or more of the Stone Co.'s patents were set up and tested, and some of these did not necessarily involve the features and mode of operation of the Stone patent No. 714756, but for transmission purposes and reception purposes, aside from research and experimental work, the apparatus and its mode of operation was that of the disclosure of my patent No. 714756. I think this was invariably the case.

However, on occasions when the disturbance from atmospheric and other causes was practically absent, and my assistants wished to receive with the maximum degree of sensibility irrespective of freedom from interference, they would often transfer the detector and its associated indicating device from the local resonance receiving circuit and connect it directly into the aerial circuit, as in the old Marconi direct antennae arrangement, this being more sensitive than the coupled circuit arrangement, but though enormously susceptible to interference.

Again, when atmospheric and other disturbances were not present, or were practically absent, my assistants would introduce the spark gap directly in the aerial and use the aerial after the manner of the early Marconi open aerial, in order to more directly radiate the energy and secure added range to the station; but even in that latitude the times in which this could be done with advantage were very few, since both of these arrangements were inconsistent [fol. 668] with the exclusion of interference, both from atmospheric causes and from other stations.

By Mr. Seull:

264. Cross-question. You spoke of the old Marconi direct antennae. Is this arrangement to which you refer sometimes known as the "Plain antennae"?

Answer. Yes; it is the plain antennae, and in addition to that we always had it attuned to some particular frequency, so we also had a tuning coil in the antennae.

By Mr. B[illegible]ts:

265. Cross-question. In the apparatus which the Stone Co. put out what means were adopted or used to ascertain whether or not the closed primary circuit was tuned with the open secondary circuit of the transmitters and the closed secondary circuit of the receivers were tuned to the open circuit of the receivers?

Answer. I have already answered that question. With respect to the transmitter the loosely-coupled primary oscillator was tuned to the period of the fundamental of the aerial by placing a spark gap across the inductance coils, and secondary transformer of the aerial, or a portion of it, and the frequency of the oscillations of the primary adjusted until a maximum spark could be obtained across the test

spark gap in the aerial circuit. In these tests a very large number of individual sparks were taken with each adjustment of the apparatus, and it was found possible to attune these circuits to each other with the precision of one-half of one per cent or better by this method. By the use of a still greater number of individual sparks in each test we were able to attain even greater precision in the attunement of these circuits to each other, but a half of one per cent was, as I remember it, the degree of precision upon which I insisted in most of our laboratory determinations.

With respect to the receiving station the adjustment of the local resonance circuit with which the detector and indicating device were associated, the attunement of this circuit to the frequency of the waves to be received was usually accomplished merely by making the adjustments with the guide as to the precision of reception of the waves by the indicating device, that is, telegraphic relay and sounder or telephone receiver, as the case might be.

In these tests the coupling between the aerial and the receiving circuit was loosened until a certainty of response was not secured except at one particular frequency. The circuit was generally left in this condition of attunement during the test, as it was generally considered best to receive with the minimum possible coupling between the circuit that would enable an operator to read the signals easily.

In some of the early tests where a coherer of the filings type was used in the local resonance circuit, causing as it did erratic perturbations of the constants of the circuits, resort sometimes was had to tuning the local resonant receiving circuit at the transmitter by the spark method, and taking it over to the receiving station and keeping it in that condition of attunement, but that method was never quite satisfactory, in fact no resonant circuit attunement where a coherer is associated with the circuit is ever quite satis- [fol. 669] factory. The greatest precaution has to be taken to maintain anything like 10 per cent selectivity in such a circuit.

Later, when wave meters and hot wire ammeters became common, I believe my assistants tuned commercial sets, that is to say the sets with which they equipped the navy yards and battleships, by means of hot-wire ammeter readings in the transmitting antennae as is pretty generally the custom now in all wireless stations.

With the detectors which were used in commercial sets the tuning of these circuits at the receiver was always accomplished by the first method I have described with respect to the tuning of receivers.

To be specific, in this method, with the coupling quite loose, the variable condensers were manipulated and the coupling loosened until at only one position of the condensers would the incoming signals be easily legible, and that constituted the tuning of the local resonance circuit at the receiver.

The antennae circuit of the receiver was attuned as a rule by the adjustment simply of the inductance in that circuit until the maximum signals were received in the local resonant receiving circuit indicator.

In the early laboratory tests at 40 Lincoln Street the two antennae circuits, that at the transmitter and at the receiver, were maintained identical, and in that way these two antennae were always in tune.

Generally speaking, the tuning of an antennae either to transmit or receive a given wave length was a matter of careful calibration once and for all, and thereafter if any change was to be made in the antennae it was simply made by connecting in the antennae at a definite marked point on the antennae coils.

In commercial apparatus also corresponding points for such loose coupled tuning were marked on the primary coils in order that these adjustments might be quickly made without going through these tests to which I have referred.

266. Cross-question. What was the character of the detector which was supplied to the receiving sets to the Navy Department?

Answer. It was a little device first made and described by Doctor Wallston about the year 1800, as I remember it.

It was a device he got up for demonstrating that the discharge of a condenser would produce electrolysis, the discharge of a Leyden jar, not having previously been supposed to be capable of producing electrolytic action.

This is a device which consisted of a very fine platinum wire sealed in a glass tube, the end of the glass tube containing the wire sealed in it being then ground off flat, so that only the flat end of this extremely fine platinum wire would be exposed.

The wire Doctor Wallston used was so fine as to be practically invisible or almost invisible even to the naked eye

of the keenest sight, and was ingeniously made by casting a fine platinum wire in a jacket or surrounding cylinder of silver. The resultant cylinder or compound wire so formed, was then drawn down until it was itself a fine wire. The resulting end of this wire was then placed in a bath or solution which would attack and absorb off the silver, but not attack the platinum wire. In this way an extremely fine platinum wire was produced.

Doctor Wallston used this electrode in a little cell, of which the electrode was one terminal, the other terminal or [fol. 670] electrode being a flat piece of platinum and the electrolyte, I believe, as near as I can remember, was an acid solution.

We used the same structure in most of our commercial sets.

267. Cross-question. Did you use any crystal detectors in these commercial sets?

Answer. I believe some crystal detectors were used in commercial sets, but my impression is that these were not furnished by the Stone Co., and if used were used by operators who preferred that particular type of detector; and I think I am fairly clear in my recollection that the Stone Co. never put out any crystal detectors.

268. Cross-question. To what precision or degree of accuracy was the closed receiving circuit attuned to the open receiving circuit in the Stone commercial sets, after the wave meters and hot-wire ammeters came into use?

Answer. The degree of precision depended upon the operator using a set. These sets were capable, particularly when equipped with the "weeding-out" circuit, as I believe all of them were, of the most extraordinary degree of selectivity which is indicative of the degree of precision with which the tuning was accomplished.

I remember that in one of these sets a secrecy transmission test was conducted which involved the receiver, being capable of receiving Morse signals at as high a speed as 20 words a minute on one frequency, and not hearing any signals whatever which were coming in at equal strength on a wave length differing by 2 per cent from that on which he was receiving, there being two such interfering wave lengths, one 2 per cent longer and on 2 per cent shorter than the wave length upon which he was receiving.

This could only have been accomplished with an extremely loose coupling, and in fact it was accomplished

with a very extremely loose coupling, and indicates that the precision of tuning was quite as great as any of the attunements we could make in our laboratory test apparatus.

The local circuit must have been attuned to the antennae with the degree of precision far greater than one-quarter of 1 per cent in any such apparatus.

As commercially used by the Navy operators the "weeding-out" circuit was rarely ever made use of, and no such degrees of tuning were sought by them, so far as I am aware. In fact, often they made use of a provision whereby they could connect the detector and its associated apparatus directly into the aerial in order to secure greater sensitiveness at the sacrifice of almost all the selectivity resulting from the tuning of the apparatus.

269. Cross-question. When was it that wave meters and hot-wire ammeters came into use for wireless or telegraphy purposes?

Answer. The first wave meter that came into use at one of my stations was, as I remember, very late in 1905, or sometime in 1906, at the Charlestown Navy Yard station, I believe.

I do not remember whether or not I originally installed a hot-wire ammeter in the Charlestown, Mass., and Portsmouth, N. H., stations. I did not do so unless the Government's specifications call for it at that time.

270. Cross-question. Generally speaking, to what degree of accuracy or precision did operators using the Stone [fol. 671] apparatus tune the closed receiving circuit to the open aerial circuit after the wave meters and hot-wire ammeters came into use for that purpose?

Answer. Of my own knowledge I do not know. They should have attuned them to the same frequency, with a considerable degree of precision, because it was the custom of the Stone Co.'s engineers to calibrate the apparatus so that if the plugs connecting the antenna to its coils, and the primary condenser to its coils, were placed in the posts marked, and the coupling loosened to the specified extent, the attunement should be correct to within one-half of 1 per cent; but I am not personally aware whether the Government operators followed the instructions they received in this regard carefully. Of course, if they put the plugs in the specified posts and tightened the coupling too much, two frequencies of the closed and open

circuits would be forced apart, even though they were originally within one-half of 1 per cent of each other.

271. Cross-question. Can you tune the closed transmitting circuit to the open transmitting circuit, or the closed receiving circuit to the open receiving circuit of a wireless set, by merely varying the degree of coupling between the two respective circuits?

Answer. Only in a very restricted sense can you do so. If the inductances and the capacities of the circuits are such that they will be attuned to each other at a very loose coupling, while on the other hand the coupling is tight, then by loosening the coupling the necessary amount the periods of the two circuits will more and more approach each other as the coupling is loosened, until finally the periods become the same. To that extent you can attune two circuits to each other by the variation of the coupling.

In other words, assuming two circuits tightly coupled, but whose capacities and inductances are such that if they were loosely coupled with each other they would have the same frequency, but being tightly coupled have different frequencies natural to each, then if you loosen the coupling sufficiently, as you do so the natural frequencies of the two circuits will gradually approach each other until finally when the desired degree of looseness of coupling is attained, the frequencies of the two circuits will be the same or substantially the same.

It is perhaps necessary for the extreme accuracy demanded in discussing physical questions of this character, to say that theoretically, that is to say, under the old logarithmic decrement theory, two circuits which have any coupling with each other at all can not have exactly the same frequencies; but this is a matter of no particular moment, since when the coupling of circuits is made what we call loose, in practice, they are found to have so nearly the same frequency that no difference can be detected.

272. Cross-question. When did Mr. Baker enter the employ of the Stone Telegraph & Telephone Co.?

Answer. My impression is, as near as I can remember, he was my personal assistant at the time the Stone Co. was formed, and was then transferred to the payroll of the Stone Co.

He then, after a relatively short period of time, as near as I can remember, left the employ of the Stone Co., and

devoted his entire attention to the Ladd Syndicate work, and was subsequently again employed for some special work by the Stone Co.; either once or twice, as near as I can remember, Mr. Baker was reemployed by the Stone Co. [fol. 672] for some special purpose, but I do not remember the dates of his goings and comings.

273. Cross-question. Referring to defendant's Exhibit No. 2, where was the original of this letter written?

Answer. It was written, as near as I can remember, in my office in Boston. I think it was in my Phillips Building office in Boston.

274. Cross-question. Where was the original of defendant's Exhibit No. 3 written?

Answer. My impression is that that also was written at my office in the Phillips Building in Boston. At all events the letters were written in Boston and either at my office or at my home.

275. Cross-question. Were these two letters sent to Mr. Baker at the same time?

Answer. I certainly do not think they were. I think they were, I am quite certain that they were sent on the days they were written, but of course I could not be quite positive about that.

276. Cross-question. How were these two letters sent to Mr. Baker by you?

Answer. I made no particular note of how they were sent. I have no reason to suppose that they were sent any other way than through the mails, as ordinarily would be the case. That would be the best of my recollection.

277. Cross-question. When did you receive these two letters back from Mr. Baker?

Answer. The best of my recollection is that Mr. Baker produced these two letters that I wrote him some two or three years later, when my patent attorney, Mr. Browne, had occasion to make use of them in connection with the prosecution of one of the applications for one of my other patents. However, I am quite sure that I can fix the date within a day or two absolutely by papers on file. I think it quite certain I can fix that date very closely indeed.

278. Cross-question. From your present recollection can you fix the date when Mr. Baker returned the originals of defendant's Exhibits Nos. 2 and 3 to you?

Answer. I can not fix the date any closer than I have testified. He, as I remember it, returned them not to me

directly, but to the Stone Co.'s office at the time that I refer to, and under the circumstances that I refer to.

279. Cross-question. Referring to the letter marked "Defendant's Exhibit No. 2," is the original of that letter, including the date, signature and address, and contents, in your own handwriting?

Answer. Understanding by the expression "My dear Baker" you mean the address, all are in my handwriting.

280. Cross-question. And was the date "June 30, 1899," put on by you on that day?

Answer. Undoubtedly.

281. Cross-question. In writing the date, the signature, the contents of this letter, did you use the same pen and ink?

Answer. I presume so. I have no reason to doubt that I did.

282. Cross-question. Was it a stub pen or a pointed pen that you used?

Answer. I almost invariably use a stub pen, if I can get it, so it must have been a stub pen.

[fol. 673] 283. Cross-question. Did you use a blotter to blot the date or the contents or the signature on the original of defendant's Exhibit No. 2?

Answer. I have no recollection in the matter.

284. Cross-question. Did you write in your own handwriting the date, the contents, and the signature on the original of defendant's Exhibit No. 3?

Answer. Understanding "My dear Baker" to mean what you call the address, I did.

285. Cross-question. And you wrote the date "July 18, 1899" on this letter on that day?

Answer. I have no reason to doubt that I did. It is my custom to date letters the day that I write them.

286. Cross-question. After the originals of these two letters, defendant's Exhibits Nos. 2 and 3, were returned by Mr. Baker to the Stone Co. to whom were they returned?

Answer. They were returned, as I remember, to my patent attorney, Mr. Alexander P. Browne, at 31 State Street, in the company's offices, which were adjoining Mr. Browne's offices.

287. Cross-question. When did you come into the possession of the originals of these two letters again?

Answer. These letters were kept together with the photolithographic copies of them in the safe of the Stone Co., I remember, during the entire active existence of that company. After the Stone Co. went out of business, these letters and the photolithographic copies thereof, were kept, as I remember, it in the safe at my office, and at the date which I can not definitely place, they were transferred to the safe in the office of my patent attorney, Mr. Alexander P. Browne. They remained there until I called for them at the request of the counsel of the Atlantic Communication Co., when that company set up its Stone defense, in the suit brought against it by the Marconi Co., to which I have already testified.

288. Cross-question. When did you personally see the originals of defendant's Exhibits Nos. 2 and 3 after you transmitted them to Baker?

Answer. As I now remember it, I saw Mr. Baker when he came into the Stone Co.'s office to produce these letters, and I think that I inspected them at that time, but I can not be sure of that. I have no memorandum showing that I was present at the time Mr. Baker produced the letters at the Stone Co.'s office. I have simply an indefinite recollection that I was there and took part in the conference that was had with regard to them, and in regard to Mr. Baker's making any affidavit with respect to them in connection with the prosecution of one of my applications for patents in the United States Patent Office.

289. Cross-question. What was the date of that conference when Mr. Baker took the originals of these letters to your patent attorney?

Answer. I have not carried it in my mind, but I think that date can undoubtedly be fixed by some memoranda of the event, and at all events would be somewhat closely indicated by the date of the affidavit, to which photolithographic copies of these letters were attached, in the record of one of my patents in the Patent Office, as the reason for calling for these letters was the execution of that affidavit by Mr. Baker.

[fol. 674] 290. Cross-question. As I understand it, however, you are not sure that you saw the originals of these letters at that time?

Answer. At the time that they were produced I can not remember positively. I simply have a recollection that I was present and saw the letters.

291. Cross-question. After Mr. Baker produced these letters for the purpose of making this affidavit, you did not personally see the originals of these letters again, until shortly before you testified in the Atlantic Communication Co. case, which was in 1915, did you?

Answer. Yes; I have a recollection that from time to time when I had occasion to go through the safe of the Stone Co., or my own safe, I came across these letters or had occasion to move them from one place to another in the safe.

292. Cross-question. Were these letters, when kept in the safe, inclosed in an envelope?

Answer. Yes; my recollection is that they were inclosed in an envelope indorsed by the office stenographer and bookkeeper, or in her handwriting. The letters were, as I remember it, in an envelope, and the photolithographic copies were in a flat package.

293. Cross-question. Can you say that from the time that Baker returned these letters to the company's files, and until shortly before you testified in the Atlantic Communication Co. case, in 1915, that you ever actually opened the envelopes and examined the originals of these letters, defendant's Exhibits Nos. 2 and 3?

Answer. I do not think I ever did actually examine the contents more than to glance through to see what it was, to make sure that the other document or paper I was looking for was not in that envelope.

294. Cross-question. For how late a period was Mr. Baker employed by the Stone Co., or as one of your assistants?

Answer. Mr. Baker's employment by the Stone Co. was, as I remember it now, not directly as one of my assistants. It was sporadic, and as I remember, only for brief periods, for special work, and I can not place it. I should say that he was not employed by the Stone Co. after 1903.

* * * * * * *

Redirect examination.

By Mr. Scull:

295. Redirect question. During recess have you looked up any memoranda or data which you had, which would enable you to answer accurately some of the questions on cross-examination, as to when the defendant's Exhibits Nos. 2 and 3 were received by you from Mr. Baker, and as to the whereabouts of those letters after they were written?

Answer. Yes.

296. Redirect question. Will you produce any such data as you have been able to find, bearing on these subjects?

Answer. I produce the original of a letter from Mr. Joseph B. Baker to Mr. Alexander Porter Browne, dated June 3, 1902.

Mr. Scull: I offer the letter in evidence and ask that it be marked "Defendant's Exhibit 7."

(Marked "Defendant's Exhibit 7.")

[fol. 675] Answer (continuing). I also have here the envelope which contained the original of defendant's Exhibit 1, this being the envelope which I recognize as having contained this exhibit while it lay in the company's safe and in my safe. It is an official envelope of the Stone Telegraph & Telephone Co., and bears the indorsement "Baker's letter to Stone, July 22, 1899," in a handwriting which I believe I recognize as that of my patent counsel, Mr. Alexander P. Browne. This indorsement is in pencil.

Mr. Scull: The envelope referred to is offered in evidence as defendant's Exhibit 8.

(Marked "Defendant's Exhibit 8.")

Answer (continuing). I also have and produce here an envelope in very fragmentary condition, which is also I recognize an official envelope of the Stone Telegraph & Telephone Co., bearing an indorsement "Original letter, Mr. Stone to Mr. Browne, August 2, 1900." Under the word "original" is a ditto mark, followed by "Letters from Mr. Stone to Mr. Baker." This indorsement is in ink, and I recognize it to be in the handwriting of Miss Higgins, the stenographer and bookkeeper at the office of the Stone Telegraph & Telephone Co., 31 State Street, Boston.

Mr. Scull: The envelope referred to is offered in evidence and is marked "Defendant's Exhibit 9."

(Marked "Defendant's Exhibit 9.")

Answer (continuing). I recognize this envelope, defendant's Exhibit 9, as the envelope that contained the originals of defendant's Exhibits Nos. 2 and 3, as they lay in the safe of the Stone Co., and afterwards, in my safe.

I have here an attested statement by Miss G. A. Higgins, executed January 4, 1904, containing a copy of the original

of defendant's Exhibit 1. If my memory serves me correctly this attested statement was also preserved in the safe of the Stone Co. during its period of activity, and afterwards kept in my safe and finally handed over by me to my patent counsel, Mr. Alexander P. Browne, and placed in his safe.

Mr. Scull: The document referred to is offered in evidence by the defendant, and is marked "Defendant's Exhibit 10."

(Marked "Defendant's Exhibit 10.")

* * * * * * *

297. Redirect question. With this document, defendant's Exhibit 10, before you, can you now state when the photolithographic copies of which the defendant's Exhibit 1 is one, was made from the original?

Answer. It appears to have been made on January 4, 1904, or thereabouts.

298. Redirect question. Were the originals of the letters defendant's Exhibits Nos. 2 and 3 written on the dates which appear thereon?

Answer. I have no doubt in my mind whatever that they were. I have no reason for supposing that they were written on any other date, and it is my custom to date letters on the date of the day that I write them.

299. Redirect question. Was there any reason which caused you to withhold the evidence of your 1899 invention from the various attorneys in the suits in which you testified, and about which you have been questioned on your cross-examination: and if so, what were such reasons?

[fol. 676] Answer. In the first place, I did not wish to give the date of my earliest proofs of priority in this invention to any parties until I was certain that a bona fide attempt would be made to prove the priority of my invention. So long as the Stone Co. or Stone Co.'s bondholders had possession of the patent 714756, and the subsidiary patents thereto, I was disinclined to disclose the state of my earliest proofs of priority to any one else, as I wished the priority of my invention to be established by the owners of the patent, who would be truly interested in making the defense of these patents complete. I wished the patents adjudicated if possible by a suit brought under them. I did not, however, withhold from any of the attorneys who consulted me

in regard to these patents, the fact that I considered myself the prior inventor, and that this patent No. 714756 was the first disclosure of the four-tune circuit invention published and supported by my proofs of early disclosure that would anticipate anyone else. When, however, the Atlantic Communication Co.'s counsel consulted me I was convinced that that company, in the defense of the suit brought against them by the Marconi Co. under its four-tune circuit patent, was going to make a perfectly bona fide Stone defense against this patent, and I forthwith wrote to my counsel of the firm of Browne & Woodworth asking them to send me the originals and photolithographic copies of the Baker letters, and submitted them to the counsel of the Atlantic Communication Co. By that time I was satisfied that the owners of the Stone Co.'s patents, including No. 714756, were not in a financial position to bring suits for infringements under that patent, and if they did bring such suits were not in a position to make the legal fight necessary to overcome the Marconi Co.'s claims. That about sums up the chief considerations that affected me in my course in that particular.

300. Redirect question. On cross-examination you were questioned in reference to your testimony in a suit in Philadelphia in which the Telefunken Co. was the defendant, and in which the patent in suit was the Fessenden patent No. 928371. At the time you testified in that suit, did you know of anything or did you have any reason to believe that the Telefunken Co. was or was not interested in establishing the date of your 1899 invention?

Answer. I had every reason to believe that the Telefunken Co. actually has a patent agreement with the Marconi Co. in this country comparable to their patent agreement in Europe, and I felt that I had reason for grave doubt as to the Telefunken Co.'s willingness to establish the validity of my patent No. 714756, as against the Marconi four-circuit tuning patent. In fact, I felt that the patent interest in this country of the Marconi Co. and of the Telefunken Co. were very closely allied, and everything that the Telefunken Co.'s counsel said to me at the time gave color to that belief on my part. He all but said that there was some such understanding between the companies.

* * * * * * *

Mr. Scull. Attention is called to the fact that the answer is not intended to prove the truth of the statements made

therein, but rather to show the state of mind of the witness at that time.

301. Redirect question. What was the scope of the Fessenden patent No. 928371, involved in that suit, as far as it related to the tuning of the primary and secondary circuits? [fol. 677] Answer. Referring to a copy of Fessenden patent No. 928371, which I have before me, I will point out that in the first place it was restricted to the receiver circuits and in the second place that it was very distinctly limited to a structure almost if not identical with the structure of the Marconi receiver in the four-circuit patent, especially the British patent No. 7777, and covered only the variability of the different tuning elements in the two circuits at the receiver.

302. Redirect question. On cross-examination a statement was read from an affidavit made by you in a suit by the Marconi Co. against the Atlantic Communication Co. on the patents in suit herein, in which you referred to Lodge patent No. 609154 and in which you referred to the structure of Figure 4 as inefficient, etc. At the time you made that affidavit had you ever set up and tried or had any knowledge of anyone setting up and trying the structure of Figure 4 of that patent.

* * * * * * *

Answer. I do not think I ever# had any such tests made or ever knew of any such tests being made.

303. Redirect question. In your affidavit dated October 23, 1914, in the suit of Marconi against the De Forest Radio Telephone & Telegraph Co., and others, from which a long quotation beginning with "The opinions of Judges Parker and Veeder," etc., were quoted to you on this cross-examination, did you in that affidavit just prior to that quotation use the following language:

"If the two patents in suit had not been adjudicated, the interpretation to be placed upon the claims involved in this suit, would be a moot question to be determined by careful consideration of the prior art, the patents themselves, and their records in the Patent Office. But unfortunately both the Lodge and the Marconi patent in suit have been adjudicated in this country in these suits heretofore mentioned, tried before his Honor, Judge Veeder, and the corresponding patents in England, to the same inventors, have been adjudicated in a suit hereinbefore mentioned before Mr. Justice Parker. Both Justice Parker and Judge Vee-

der have given extensive opinions which leave little doubt as to the scope and significance or interpretation to be placed upon the patents to Lodge and Marconi, in suit."

Answer. I made that statement.

304. Redirect question. Also in this cross-examination, when the long quotation which I have referred to in the preceding question was placed upon the record, at a point which was omitted, about the middle of the quotation, did you make the following statement: after quoting claim 2 of the Marconi patent in suit:

"Without the benefit of the opinions of Mr. Justice Parker and Judge Veeder, the interpretation of this, as well as other of the claims of the patent, in the light of the prior art, the patent specification itself, and the explicit admissions of defendant in the record of this patent, would be extremely difficult since in terms, such a claim would be almost, if not quite the equivalent of a claim to the art."

Answer. I did.

305. Redirect question. On cross-examination you were asked whether you made this statement in answer to ques- [fol. 678] tion 16 in your deposition in the suit of the National Electric Signaling Co. against the Telefunken Wireless Co. on Fessenden patent No. 928,371:

"The first very clear and complete exhibition of the use of a continuously variable tuning condenser in shunt to the primary of a transformer in a wireless telegraph receiver, so far as I am aware, is contained in the specifications and drawings of the English patent to Marconi No. 7777 of 1900."

Please state whether that was in answer to the following question:

"Question 16. Prior to the patent in suit, and of the application therefore, was it new or old to use, in the primary and secondary circuits, or either, of a receiver system, a condenser shunted in either or both the primary or secondary circuits? Cite any instances, if you can, of any such published prior knowledge or use, either by a patent or a published book?"

Answer. It was.

306. Redirect question. Question 5 in this suit calls for a statement of the principles involved in radio telegraphy "as a practically applied art, down to and including Marconi's British patent No. 7777 of April 26, 1900." Was

your own invention at that time, April 26, 1900, a practically applied art?

Answer. No.

307. Redirect question. In that same suit you said in answer to question 107 as follows:

"All the best modern systems of modern telegraphy effect the tuning of a receiver to wave frequency by various methods, by involving electrical tuning produced by combinations of inductances of coils and capacities of condensers involving various arrangement of circuits."

Did you or not intend to include the Stone system as one of the best modern systems here referred to?

Answer. I did.

308. Redirect question. When you testified in the Atlantic Communication Co. case in Brooklyn, the record shows that you produced a document entitled "Stone Wireless Telegraph Syndicate agreement and declaration of trust," dated December 31, 1900. Have you that document?

Answer. No.

309. Redirect question. Do you know of its whereabouts?

Answer. It is in evidence in that case, presumed to be in the possession of the court.

Recross-examination.

By Mr. Betts:

310. Recross-question. Is it not your understanding that the same interests which controlled the Telefunken Wireless Telegraph Co. also controlled the Atlantic Communication Co.?

Answer. No. My impression is that it is not the same interests, but this is a mere impression. I do not know who controls the Atlantic Communication Co., and I never knew where the control lay in the old American Telefunken Co. I understood that it was partly owned by the German Telefunken Co. and partly owned by two brothers, Philadelphia merchants, but what the proportion of shares of these three interests was I never knew. At all events, I knew that the [fol. 679] two Americans seemed to have a good deal to say about the management of the affairs of that company.

311. Recross-question. You do understand, do you not, that the German Telefunken Co. is financially interested in the Atlantic Communication Co.?

Answer. I do not that for a fact, but I assume that the German Telefunken Co. has an interest in the Atlantic Communication Co.

312. Recross-question. Both the Telefunken Wireless Co. of America and the Atlantic Communication Co. marketed and used exclusively so-called Telefunken apparatus, so far as you know?

Answer. I am sure that most of their apparatus was German Telefunken apparatus, but I know that a certain amount of apparatus or at least I am quite certain that a certain amount of their apparatus was constructed here. Just what amount, or what parts, I do not know. I merely have it from hearsay that certain parts were manufactured here.

313. Recross-question. You do not wish to be understood as testifying that there was a matter of fact an agreement between the Marconi Co. and the Telefunken Co. of America?

Answer. No; I do not know anything about it. I had every reason to suspect that there was at one time, at the time of the Philadelphia suit under the Fessenden patents.

314. Recross-question. Where is that letter dated June 23, 1899, which you wrote to Baker, and which is referred to in defendant's Exhibit No. 7?

Answer. I do not know. I believe that letter had no particular reference to the invention of my United States patent No. 714756.

* * * * * * *

315. Recross-question. Can you produce the letter dated June 23, 1899, referred to in defendant's Exhibit No. 7?

Answer. I do not know whether I can or not. I do not know where the letter is at present. It may be in Mr. Browne's safe or the safe of the firm of Browne & Woodworth in Boston.

316. Recross-question. Where is the letter dated August 2, 1900, from you to Mr. Browne, referred to on the envelope which is marked "Defendant's Exhibit No. 9?"

Answer. I do not remember where that letter is, but I believe that I have recently seen a photolithographic copy of that letter or the letter itself, and that I found it to be a letter describing to Mr. Browne my system of automatically relaying wireless telegraph messages, the letter being directed to Mr. Browne at his home in Nantucket. That is

the only recollection I have of it. I think I can secure the letter or a photolithographic copy of it, by writing to Messrs. Browne & Woodworth for it; or I may even have the letter or a photolithographic copy of it amongst some papers that were sent to me by Browne & Woodworth for use in the Marconi versus Atlantic Communication Co. suit.

Redirect examination.

By Mr. Scull:

317. Redirect question. When did you give this testimony in Philadelphia on the Fessenden patent No. 928371?

Answer. In September, 1911.

[fol. 680] (It is stipulated and agreed that the exhibits produced in connection with the depositions of the witnesses Baker and Stone may be retained in the possession of respective counsel producing them until the trial of this cause.)

Walter C. Dean, called as a witness on behalf of the defendants, being sworn, testified as follows:

Direct examination.

By Mr. Knight:

1. Question. Will you state your occupation, Mr. Dean?

Answer. I am electrical expert aide at the Bureau of Construction and Repair, Navy Department, Washington.

2. Question. State briefly your technical experience?

Answer. I was a graduate in the department of electrical engineering at the Massachusetts Institute of Technology, class of 1900, and received the degrees of bachelor of science and electrical engineer.

3. Question. And since then what have you done, if anything, in connection with wireless telegraphy and similar studies?

Answer. Subsequently I was employed by the Navy Department, beginning in the fall of 1900, as a laboratorian. In 1901 I was appointed under the civil service as electrical draughtsman at the Norfolk Navy Yard. In 1903 I became interested in wireless telegraphy and assisted in the installations of land stations in the fifth naval district. I also had

charge or technical supervision of ship installations at that navy yard until about 1907, when my time was more fully occupied with other electrical matters.

4. Question. State what your course at the Massachusetts Institute of Technology covered, under what professors you studied, and what the courses were.

Answer. Those courses which related to wireless telegraphy began with a course in physics under Prof. Charles R. Cross, head of the electrical department, in which we considered the early development, beginning with the Hertz experiments and the Lodge experiments. Paralleling this course, Prof. Harry Clifford gave us a course on theoretical electricity.

* * * * * * *

Following the completion of the course in theoretical electricity at the end of the first semester of the senior year, January, 1900, we listened to a course on high frequency currents and their applications by Prof. John Stone Stone, which consisted of two lectures, in January, 1900.

5. Question. Please recount, referring to such notes as you may have, what those lectures of Professor Stone were on that subject.

Answer (referring to memoranda). I have nine pages of my original notes in my own handwriting which I took dur- [fol. 681] ing the course of lectures by Professor Stone. He first covered the analogy between electrical and mechanical vibrations, giving mathematical expressions, on the one hand, involving mass and elasticity, and in the other, namely, electrical conditions, the quantities of induction and capacity. He showed the mathematical expressions for a mechanical horizontal pendulum, showing the condition for free vibrations, three conditions, one of which was when friction squared equals four times the mass divided by the elasticity gave a harmonic vibration. He told us that the vibrations died away, due to damping, expressed by the logarithmic decrement.

He next considered oscillatory electrical circuits with variable induction and variable capacity, in which likewise he showed the condition for free or natural vibrations, and gave an equation for the current in such a circuit, when there was no electrical friction or resistance. He gave an expression for the frequency, in terms of capacity and inductance.

Vol. II

TRANSCRIPT OF RECORD

Supreme Court of the United States

OCTOBER TERM, 1942

No. 369

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA, PETITIONER,

vs.

THE UNITED STATES

No. 373

THE UNITED STATES, PETITIONER

vs.

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA

ON WRITS OF CERTIORARI TO THE COURT OF CLAIMS

PETITIONS FOR CERTIORARI FILED { SEPTEMBER 2, 1942.
SEPTEMBER 3, 1942.

CERTIORARI GRANTED DECEMBER 14, 1942.

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ON PETITIONS FOR WRITS OF CERTIORARI TO THE COURT OF CLAIMS

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Direct	1100	1407
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Direct	1153	1478
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Direct	979	1230
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Cross	889	1126
Frederick M. Sammis—		
Direct	952	1200
John Stone Stone—		
Direct	612	754
Cross	630	778
Redirect	674	839
	679	847
Recross	678	845

SURREBUTTAL

Edward H. Loftin—		
Direct	1693	2184
	1786	2307
Cross	1779	2298
	1786	2307
Joseph Maubergne—		
Direct	1641	2116
Cross	1651	2127
John M. Mi.		
Direct	1655	2131
Cross	1672	2155

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George H. Clark—		
Direct	1798	2313
	1991	2422
	2095	2484
	2152	2516
Cross	2091	2482
Greenleaf W. Pickard—		
Direct	1821	2326
Cross	1851	2344
Redirect	1863	2350
Clarence D. Tuska—		
Direct	2097	2485
	2154	2518
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Direct	1876	2357
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Direct	2157	2519
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Direct	1996	2425
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He next showed that by impressing on this system a simple harmonic force, the mathematical expression for the current consisted of two components, one of which corresponded to the harmonic force impressed, and the second was the free or natural vibration, which he stated was soon suppressed or could be easily removed, and therefore we had to consider merely the first. He showed that by making the angular velocity equal to one over the square root of CL, capacity and inductance, a condition of resonance resulted which was first noted by Grove in 1868, who supplied an alternating current to a Ruhmkorff coil and noticed sparks in the secondary circuit, which he considered of sufficient importance to communicate to Maxwell.

He then related what he had accomplished, and stated that he impressed an alternating current on a resonant circuit, and showed what the apparent resistance was and the apparent impedance of that secondary circuit. He stated that two frequencies actually resulted which were in proximity as to frequency, but that the higher one was made still higher and the lower one made still lower. He again pointed out that this was analogous to acoustical arrangements and that the vibratory condition was known as the linear theory; that inductance and capacity are really independent of the frequency, that the resistance was independent of the current and that they were constant.

He pointed out also that the wave form was distorted by the presence of iron, and in this connection referred us to the Physical Review, about 1898, he said we should use coils without iron and condensers without dielectric capacity.

The second lecture——

Question. Before you go to that, Mr. Dean, I will ask you to just refer to those parts of your notes in regard to Mr. Stone talking of his own work to you before you leave that first lecture. Speak of the parts that referred to those different elements of his talk, so that we can identify them in the notes themselves. When you take up those different notes, starting with Stone's description of his own work, point out what part of the notes refer to those different things you speak of, and then follow that same thing when you get down to the second lecture. It occurs to me that we will be going over this thing twice unless you do that.

[fol. 682] Answer. I stated with respect to the first lecture that Professor Stone said, "I impress an alternating current," etc., which I believe is what you wish.

Mr. Knight: If you have notes that enable you to refer to any one of these things, I want you to point out the part of the notes you are speaking of.

Answer (continuing). Yes. In the second lecture we considered again two resonant circuits in proximity, inductively coupled, each having variable capacity and variable inductance. Mathematical expressions were given to show that the summation of the inductive voltage, resistance voltage, capacity voltage, and mutual induction voltage must be equal to zero.

Then follows a lengthy mathematical discourse, showing the properties of resonant circuits.

He then showed us how to obtain oscillatory vibrations of very small wave lengths and drew two diagrams of such circuits inductively coupled to secondary circuits. He showed how Hertz got continuous vibrations with a rotary gap or interrupter in the primary, and a condenser and an oscillation transformer, which transferred the energy to the oscillatory circuit. He stated that Hertz got several hundred million vibrations per second by using very low inductance and capacity, and drew a diagram showing the Hertz oscillator.

He also referred to Tesla's experiments along this line and drew two diagrams showing the three-circuit arrangement employed by Tesla.

He next referred to Marconi's experiments, the diagram of which appears to be similar to that of Hertz, with one oscillator in the air, and assuming the earth to connect to the spark gap which was in the aerial circuit.

He showed what had been accomplished by the post-office experiments in England, by transmission of signals between parallel wires and with horizontal loops, which depended upon induction.

He showed us Marconi's receiving circuits, with the coherer shunted around the spark gap in the aerial circuit. He then described the coherer and its inherent limitations.

The remainder of this lecture appears to be the practical applications, and he first showed us how multiplex line telegraphy could be accomplished, making use of electrical resonance, and drew diagrams showing several sending stations, or circuits, each containing a key, variable capacity and inductance, and each operating at a different known frequency. The corresponding receiving stations were similar, except that a relay was used in place of the key. Each

receiving circuit was tuned respectively to its sending circuit. He again called our attention to the necessity for these resonant circuits to have simple wave forms, although of different frequency.

He then proceeded to show that in place of the telegraph a modification of this application would be to use telephones in closed circuits, also with variable capacity and inductance, but inductively connected to the line. Similar arrangements were used at the receiving end. In this case also the sending circuit and its respective receiving circuit were tuned to the same wave lengths.

The hour period being nearly up, he briefly referred to the next logical application, namely, to wireless. He then [fol. 683] called our attention to an article in the proceedings of the American Institute of Electrical Engineers, about 1899, relative to the question of tuning wireless circuits, and referred in particular to Pupin's articles on condenser-coupled circuits. That is the end of the course.

* * * * * * *

8. Question. Please state whether you afterwards constructed or put into operation a wireless telegraph system.

Answer. Yes, sir; at the Norfolk Navy Yard.

9. Question. Please state whether preliminary thereto you had any instruction to enable you to do so, other than that gained from this lecture by Professor Stone and the other lectures preliminary thereto, referred to?

Answer. I installed one of the first wireless telegraph sets of the Navy Department, namely, a Ducretet set of instruments, I believe in 1903, at the Norfolk station, in which I had for guidance merely the catalogue which accompanied these instruments, and which was written in French, and which was in itself hardly sufficient to make a complete installation. I believe that my instruction obtained at the Massachusetts Institute made it possible for me to put that station into successful operation.

Mr. Knight: I would like to offer these notes in evidence.

(Marked "Defendant's Exhibit F-3A.")

10. Question. You made these notes yourself at the time of these lectures in January, 1900?

Answer. Yes, sir; 1900, in my own handwriting.

11. Question. While the lecture was being given?

Answer. Yes, sir.

Cross-examination.

By Mr. Betts:

12. Cross-question. The notes that you have produced are not themselves dated, are they?

Answer. No, sir. It was a very easy — to establish the date, however, for the reason that these lectures followed immediately after Professor Clifford's lectures in thoretical electricity, and they invariably occupied the first semester of the senior year.

13. Cross-question. Have you been detailed by the Navy Department to appear here and testify in this case?

Answer. No, sir.

14. Cross-question. Is there any illustration in the notes which you have produced of an open circuit coupled to a closed circuit as used in radio telegraphy?

[fol. 684] Answer. Yes.

15. Cross-question. Where?

Answer. I have two diagrams, adjoining the words "For oscillatory vibrations for a very small length of time," in which power appears to be taken from a battery, the conventional way of showing power, and a key and an inductance and capacity loosely coupled to what appears to be an open circuit. This is on the fourth page from the last.

The Court: Draw a line with a blue pencil there alongside of the passage, from beginning to end of the passage. This will identify it.

(So indicated.)

16. Cross-question. Now, will you point out where there is any ground connection or antenna shown in those two diagrams that you have just marked with a blue pencil?

Answer. I did not indicate it, presumably for the reason that it is pretty hard to take notes from a fast lecturer. He covered a large subject in two lectures.

17. Cross-question. On the last page of these notes which you have produced I see the words "Pupin. Condenser coupled." Were those words put on at the time you made these notes in 1901?

Answer. I do not recall that they were put on them.

18. Cross-question. Is that your handwriting?

Answer. Yes, sir.

19. Cross-question. Were they put on at the same time that the other handwriting on that page was put on?

Answer. I do not recall. It may be that they were not, because I read the article after he made reference to it. He finished the lecture at that time, and subsequently I read the article.

20. Cross-question. These words look to me as if they were put on with a different pencil, either softer or harder than the other pencil notes on the same page; isn't that true?

Answer. It may be; it looks that way. I had no difficulty in identifying the article to which he referred us.

Mr. Betts: Your honor, I want to call attention to this, that in the copy that has been offered in evidence in the book, I find in pencil under the words I have called the witness's attention to, the following: "This note added 3/16/1915."

Mr. Knight: I just noted that myself, and I would like to ask the witness what he knows about that.

The Court: Who put that there? This is in pencil.

21. Cross-question. I show you the photolithographic copy which has been offered in evidence, and call your attention to the fact that the words "This note added 3/16/1915" have been written on this photolithographic copy under the words "Pupin. Condenser coupled." Do you know anything about these added words in pencil on this photolithographic copy?

Answer. I believe that that is my handwriting and it must have been that I wrote that there on that page.

22. Cross-question. So that, as I understand it, the words "Pupin. Condenser coupled" on the last page of your original notes were put onto these original notes on the 16th day of March, 1915?

Answer. Apparently.

[fol. 685] 23. Cross-question. On the third page of your original notes, defendants' Exhibit F-3a, I find the words "Use coils without iron. Use condenser without dielectric of capacity." Is that right?

Answer. Yes; I think so.

24. Cross-question. Why did Mr. Stone want to use condensers without dielectric of capacity?

Answer. I do not recall.

25. Cross-question. What is such a condenser?

Answer. Well, every condenser must have some dielectric capacity, but I presume he meant to say with a minimum amount of dielectric capacity. That is probably what was meant.

26. Cross-question. Will you now please describe the Ducretet apparatus which you say you installed in the Norfolk Navy Yard?

Answer. That has been about 12 years ago, and for the last 7 or 8 years I have not been concerned with wireless telegraphy, so it may be that I can not recall all the special arrangements of that particular set. I remember that some of the principal points are the reciprocating mechanism for producing the make and break primary circuit, by means of a motor, and that the coherer was a wood tube with adjustable terminals for varying its adjustment, and that the detector was shielded in an iron box from stray signals.

27. Cross-question. Is that all you can now remember about that installation?

Answer. That is all that occurs to me.

28. Cross-question. On page 5 of defendants' Exhibit F.3a I see the words "For oscillatory vibrations for a very small length of time"; what do you mean by "small length of time"?

Answer. I do not recall what that means.

Redirect examination.

By Mr. Knight:

29. Redirect question. In which lecture was it that this remark occurred, which you have noted as "Condensers without dielectric of capacity," and what was being described at that time?

Answer. That was in the first lecture, and it was in connection with the harmonic wave, simple wave, without complex wave form; a pure wave, in other words.

30. Redirect question. Had Mr. Stone taken up his own idea in wireless, any development he had of his own at that time, or was that general discussion?

Answer. I believe this was general.

31. Redirect question. Now, referring to the mark on page 5, I think it was called, "Oscillatory vibrations for a very small length of time"; what was the subject under discussion then, and at which lecture was this?

Answer. This was at the beginning of the second lecture, and appears to relate to the efficient transmission or interchange of energy between two circuits.

32. Redirect question. Your attention was called to a pencil note which you added to this photolithographic copy which forms a part of Exhibit F-3a. Had you forgotten that you had made this note?

Answer. Yes; as to the exact time when I made it.

33. Redirect question. Does this mean that the particular words, "Pupin. Condenser coupled" were written on that date, the 16th day of March, 1915?

[fol. 686] Answer. I think so.

34. Redirect question. Does that apply to any other part of this article?

Answer. I am afraid I do not understand your question.

35. Redirect question. Was any other part of this article as here copied written then for the first time?

Answer. The article in the book?

36. Redirect question. By "article" I mean these notes?

Answer. That is the only thing; yes, sir.

37. Redirect question. Do you now remember how you came to make this addition to the notes?

Answer. After having reread the article referred to in the lecture, I probably jotted that down to indicate the particular bearing on the subject in question.

[fol. 687] *Deposition of Edward H. Loftin, for defendants, taken at New York City, commencing on the 21st day of January, A. D. 1924*

Edward H. Loftin, having been produced as a witness on behalf of the defendant, was by me sworn, before any question was put to him, to tell the truth, the whole truth, and nothing but the truth, relative to the said question, and thereupon deposed and said that his name is Edward H. Loftin; that his occupation is lieutenant commander in the United States Navy; that he is 38 years of age; that his residence is Washington, D. C.; that he has no interest, direct or indirect, in the claim in controversy; and that he is not related to plaintiff; and thereupon the said Edward H. Loftin was examined by counsel for the defendant and in answer to interrogatories testified as follows:

Direct examination.

By Mr. Edwards:

1. Question. What has been your training and experience in scientific and electrical matter, and particularly your experience in the field of wireless telegraphy and telephony?

Answer. I graduated from the United States Naval Academy in 1908, after the usual four-year academic course given in the creation of officer material for the United States Navy, which course includes almost all of the applied sciences, including electricity and radio. In 1910, while an officer aboard the U. S. S. *Marietta*, then on duty in Central American waters, in connection with guarding American interests during insurrections and radio communication was the only form of communication with the United States, [fol. 688] I was detailed to duty by the commanding officer to supervise the radio equipment in order to be assured communication, this being my first practical association with radio apparatus, and this duty lasting for a period of six months. In 1912 I was assigned to duty as commanding officer of the U. S. S. *Baltic*, which vessel was at that time [fol. 689] engaged in special radio experimental work involving many forms of investigation of radio communication, and which vessel was at that time equipped with the then latest transmitting and receiving apparatus and other special devices, and I remained on this duty trying out various experiments for one year. In 1913 I was ordered to a post-graduate course in engineering, consisting of one year at the post-graduate school at Annapolis, Md., followed by one year at Columbia University, New York City. In this course I specialized in electrical and radio engineering and as a result, was awarded the degree of master of arts at Columbia University, this being in 1915.

In 1916 I was detailed by the Navy Department to undertake the development of radio apparatus suitable for aircraft, no practical apparatus for this purpose being then developed by this Government. While performing this duty I was also assigned to additional duty as district communication superintendent of the eighth naval district, which includes all of the Gulf coast of the United States, having radio stations at Pensacola, New Orleans, and Point Isabel, Tex., which duty involved not only the direction of radio traffic in the district, but the maintenance of the radio

material. In connection with these duties I was further assigned special experimental work investigating the use to which the Navy could make of buried wires as antennae for radio systems, and supervised elaborate experiments at New Orleans in this connection.

In 1917 I was detailed to duty as the radio officer of the fifth division of battleships of the United States Atlantic Fleet and after three months of this duty was, during the war, ordered to Europe as radio officer for the United States Naval Aviation Forces then being established in France and Ireland, and had as additional duty the negotiations for and arrangements with the French Government for a higher-power radio station for communications with the United States, which station was constructed and is still in existence, being known as the Lafayette radio station. While in France, I had addi'onal duties as member of the Inter-Allied Technical Radio Committee, involving numerous conferences with the techni.ists of the Allies involving radio subjects of all kinds. Later I was also assigned to duty as communication officer for the naval forces in France, which included the establishment of means of communication by wire, and before the end of the war I had supervised the building of 1,000 miles of telephone and telegraph lines.

In 1918, immediately after the signing of the armistice, I was ordered to the Bureau of Engineering, Navy Department, Washington, and was assigned duty as officer in charge of radio research and development, involving the supervision of all the new radio work undertaken by the naval forces.

In 1919, I was assigned additional duty as a member of a board which became known as the Inter-Departmental Radio Board, and had for its purpose the hearing of a large number of claims against the Government for the use of radio patents, and I was elected chairman of that board. During two years and a half this board considered hundreds of patents which were brought before it, in support of the claims against the Government, and a consideration of these claims involved a complete study of the radio art since its inception. Although the board completed its work and made definite recommendations for the settlement of [fol. 690] claims, the purpose of the board failed due to failure of Congress to make the necessary appropriations to cover the recommendations of the board for settlement,

with the result that most of the claims now stand in the form of suits against the United States, and since the completion of the board's work I have been retained on duty in Washington as a constant technical adviser to the officers of the Department of Justice charged with the defense of these suits. In 1921 I was one of the delegates of the United States to a meeting of the provisional technical committee of the International Communication Congress, which committee met in Paris, France.

2. Question. Will you state, in a general way, the early development of wireless telegraphy prior to December, 1896?

Answer. Wireless telegraphy generally refers to the transmission of intelligence over distance without the use of wires as the medium of conducting the necessary energy manifestations which are employed to operate the receivers. Probably the first disclosure of the transmission of electrical energy without the use of wires was contained in the theory of Clerk Maxwell, known as the Maxwellian theory, which was divulged about 70 years ago. Maxwell did not accompany his theory with any proposed apparatus for usefully employing it. The German scientist Hertz, between the years 1879 and 1890, carried out many practical demonstrations of the Maxwellian theory. Hertz demonstrated that by the use of very high frequency electrical oscillations disturbances could be produced in space which could be detected at a distance. He proved that these disturbances had many of the properties of light waves, including reflection, refraction, polarization, and the velocity of light waves. His means for detecting these energy-bearing waves was simple, consisting of a small loop of wire, having its two ends almost but not quite closed. When the loop was inserted in the field of waves generated, it intercepted some of their energy, causing electrical oscillations, which manifested itself in the form of sparks across the slight gap left in the loop.

In the Fortnightly Review of February, 1892, in an article entitled "Some possibilities of electricity," commencing on page 173, Prof. William Crooks very definitely suggests the use of the waves investigated by Hertz for wireless telegraphy, commenting that telegraphing without wires was even then possible within a restricted radius of a few hundred yards, and that with the discovery of a sufficiently sensitive receiver and powerful transmitter this

use would be brought within the grasp of daily life. He also pointed out that by tuning both sending and receiving instruments, electrically, to one and the same length of electric wave, the desired secrecy could be obtained in a message passed between any one pair of stations. He did not suggest any definite form of apparatus, except that it should produce Hertzian waves under the control of a sending operator's key to make ordinary dots and dashes of the Morse code.

The suggestion of Crooks was very quickly followed by one of Nikola Tesla, more definite in its proposal of practical apparatus. Tesla delivered before the Franklin Institute, Philadelphia, February, 1893, a lecture on "Light and other high frequency phenomenon," as reported in a book entitled "Inventions, Researches, and Writings of Nikola Tesla," by Martin, published in 1894. Investigations of Hertz discharged that in order to create energy-bearing waves it was necessary to produce high-frequency [fol. 691] currents or rapid electrical oscillations. The Tesla book of Martin, beginning at page 302, and taken particularly in connection with Figure 165, shows how to produce such currents or oscillations using ordinary dynamo machines. Referring particularly to the system illustrated as the second from the left in Figure 165, the circuit containing the inductive winding P, the condenser C, and including the two spark gaps *d d*, which circuit is supplied with energy from the dynamo G through the step-up transformer T, is particularly suitable for producing high-frequency currents or electrical oscillations of large energy, and also adjustable in frequency or period of vibration. The Tesla book describes various applications to which the high-frequency currents produced by the system illustrated in Figure 165 may be put and on page 346 definitely proposes the production of electric waves by such currents for the transmission of telegraph messages without wires. On page 348, in connection with Figure 185, he suggests an electric-wave-producing system for association with a source of high-frequency currents, a system comprising an elevated conducting surface P connected to one of the terminals of the source, the other terminal of the source being connected to the earth or water mains presumably buried in the earth. It is reasonable to associate the system in Figure 185 with any one of the numerous systems illustrated in Figure 165 for producing high-frequency currents.

I have made such an association in a sketch marked "Loftin Sketch A-Tesla Transmitter," inserted opposite. Referring to Figure 165, the second system from the left, G is a generator clearly illustrated as generating alternating currents, and reasonable to assume that these currents had at that period a frequency of 60 cycles per second. These currents are delivered to a transformer T through a switch S, having two blades. A transformer is clearly indicated as one suitable for raising the voltage of the generator to a high voltage, the number of turns of the secondary winding S being illustrated as greater than the number of turns of the unmarked primary winding. The currents raised to high voltage by the transformer T are delivered to the condenser C, which stores the energy in the current until a potential sufficiently high to break down the resistance of the two spark gaps *d d* is had. When the spark gap resistance is broken down current flows across the gap ionizing the air path, reducing the resistance from a very — value to a very low value. There then exists a circuit containing the condenser C and the inductance of the primary winding P having sufficiently low resistance to be an oscillatory circuit and the current will continue to oscillate in this circuit until the energy is sufficiently expended to reduce the ionization in the gap *d d* to a point where the resistance becomes too high to permit further flow of current. This oscillating current flowing through the winding P will set up a magnetic field linking with the winding S', thus creating an electromotive force in the system containing the elevated conductor T and the wire grounded to the earth at E, and in response [fol. 692] to this electromotive force, high frequency currents will flow in the system. These high frequency currents will create disturbances in the surrounding ether which can be detected at great distances with suitable apparatus. The operation described takes place for each half cycle or half alternation of the generator G.

The oscillations can be made as powerful as desired by a proper selection of the generator G and the accompanying apparatus, and the frequency of the oscillations controlled by the selection of proper values for the condenser C, and inductive winding P, this controlled frequency or tuning having been understood by Hertz, is also referred to by Crooks, and is thoroughly dealt with by Tesla in the Tesla book.

In the article by Sir William Crooks, at the bottom of page 174, he states:

"What, therefore, remains to be discovered is, firstly, simpler and more certain means of generating electrical rays of any desired wave length."

In the Tesla transmitter, which I have illustrated, there was disclosed a means so simple and so certain of generating the rays referred to by Crooks that it was universally adopted and still remains the basic arrangement in radio transmitters.

While Tesla did not specifically illustrate a switch generally known as an operator's key, for making dots and dashes in the Morse code, I consider that the insertion of such a key in a system was decidedly obvious to those skilled in the art at that time. It was certainly obvious that by closing one blade of the switch S and then operating the other blade of the switch to open and close the circuit A for long and short intervals, to make dots and dashes of the code, was well within the possibility of his device, and it would have required no more than mere mechanical skill to put the ordinary operator's knob on top of the blade and a spring device under the blade to arrive at a quick acting operator's key, or to insert in place of the blade well known commercial designs of such keys available at the time of Tesla.

The lectures of Tesla in 1893 and 1894 and the Tesla book of 1894 attracted widespread attention, some of which is indicated by the following expressions from persons skilled in the art:

Swinton in the Electrician, of London, October 22, 1897, page 869, calls attention to Tesla's book of 1894, pages 346 and 349, and accords to Tesla credit for a share in the work of bringing about practicable and commercial wireless telegraphy. Prof. S. E. Thompson in his paper on "Telegraphy across space," printed in the Journal of the Society of Arts, London, 1898, and reprinted in the Smithsonian Institute Report for 1898, shows on page 243 how Lodge had demonstrated the possibility of transmitting telegraph signals wirelessly by Hertzian waves at Oxford, in 1894, to a distance of 100 or 150 yards. He then goes on to state of Tesla's work as follows:

"Even before this, Mr. Nickola Tesla, in a lecture delivered at St. Louis in 1893, had made a further suggestion of great importance. He proposed to transmit electric energy by oscillations to any distance, without communicating wires, by erecting at each end of the stretch a vertical conductor joined at its lower part to the earth, and at its upper to a conducting body of large surface. This [fol. 693] constitutes a vertical base line from which to disseminate the oscillating disturbances."

Taking up now the second requirement set up by Prof. William Crooks to bring wireless telegraphy within the grasp of daily life, that of a sensitive detector or receiver of the energy set off into space by the transmitter or generator or electrical energy disturbances in space, at the close of Hertz's work, the only detector for making electric waves apparent to the senses was the loop of wire including a little spark gap at the two ends brought to a near closure. In 1891, Branly discovered that very thin layers of metal deposited upon glass sheets had their electrical conducting powers affected when an electric wave disturbance reached them. He also discovered that metallic powders acted in the same way. Lodge repeated the experimental work of Hertz, and the Electrician, June 15, 1894, page 189, Figure 18, described an account of Lodge's lecture before the royal institution covering his repetition of Hertz's work, and brings out that Lodge substituted for the minute spark gap of Hertz the detector of Branly used in the form of a tube filled with coarse iron filings, which device Lodge termed a "coherer." Lodge showed that when such a coherer was placed in a conducting path, subjected to electric waves, the filings conducted electricity very poorly until the passing wave struck the apparatus, when the electric impulse passing along the tube through the filings caused them in some manner to cohere; thereupon the filings conducted electricity much better. In order to restore the coherer to its original nonconducting condition after the passage of the invisible waves, it was necessary to shake the *the* tube so as to break up the cohesion between the filings.

Professor Popoff, of Russia, followed up the work of Branly and Lodge and improved the coherer. His work is covered in a paper to the coherer. His work is covered in a paper to the Russian Physical Chemical Society's

Journal at the Imperial St. Petersburg University in 1896, entitled (according to the translation) "Apparatus for detection and registration of electrical vibrations." The paper is dated Cronstadt, December, 1895. It refers to the work of Branly and Lodge. It describes an improved form of coherer which he, Popoff, had developed, and to which he accredits great sensitiveness.

Answer to question 2 continued. Popoff illustrated his coherer in Figure 1 of the paper, and in Figure 2 associated with it the necessary apparatus for making the coherer effective. Commencing in the last paragraph of page 15 of the translation of the Popoff paper there is a description of the manner in which Figure 2 was connected to an elevated conductor and to ground for the purpose of detecting atmospheric disturbances, and I have reproduced Figure 2 and applied the connections described for the purpose of atmospheric disturbance detection in a sketch marked "Loftin Sketch B—Popoff Receiver," and for the purpose of description I have added reference letters not found in Figure 2 of the paper. L represents the coherer which is connected to an elevated conductor C at the point A, the conductor being described by Popoff as approximately 28 feet high. The coherer is also connected to ground from [fol. 694] the opposite side B, the ground connection being described as through a water-net system illustrated at E. Around the coherer there is connected to a battery Q whose current when it flows passes through the coils R1, R2, and the magnetic winding M1 as well as through a coherer. When current flows, the contact C1 is closed by the action of the electromagnet M1, and this allows some of the battery current to flow through the electromagnet M2 through the contact C2. The current through the electromagnet M2 will cause the tapper T to be drawn upward striking the bell Y and opening the contacts C2. The contacts C2 being thus opened, there will be no further pull on the tapper T and it will drop back striking the coherer L, giving it a jar. Normally, the metallic filings in the coherer L will not permit sufficient current to flow through the electromagnet M1 to cause it to operate. When an electrical disturbance strikes the elevated conductor C, there will result a very large reduction in the resistance in the metallic filings path, and sufficient current will flow from the battery Q to actuate the electromagnet M1, and, as before described, result in a ringing of the bell Y, and

tapping of the coherer L restoring the filing to a non-conductive state. This operation will continue as long as the electrical disturbance acts upon the elevated conductor C.

The paper fully describes how atmospheric disturbances were observed from day to day at times when meterological observations reported the existense of electrical storms. In addition the paper tells how electrical disturbances were set up by electrical apparatus in the vicinity in actuating meterological instrameats.

In concluding his paper, Popoff showed that he appreciated the application of his coherer to wireless telegraphy. He states:

"In conclusion, I can express the hope that my apparatus, with further improvements of the same, may be adapted to the transmission of signals at a distance by the aid of quick electric vibrations, as soon as the source of such vibration possessing sufficient energy will be found."

That work was fully appreciated is reflected in such articles as that of the Scientific American supplements for 1898, volume 46, page 18874, in which is found the following paragraph:

"In 1889 W. E. Branly invented the radio conductor, which he has himself described in these pages. This apparatus is a very sensitive revealer of waves emitted, even at a great distance. It is through the use of such apparatus and of the principles of which we have just spoken that the Russian Professor Popoff in 1895 made his experiments in wireless telegraphy. To this effect he devised an apparatus for registering the electric wave produced by atmospheric disturbances and for transmitting to a distance signals registered in the North Pole. These experiments were resumed by Mr. Marconi in 1896."

Also the well-known French scientist Ducretet in a lecture before the International Society of Electricians of Paris, June 1, 1898, and reported in L'Electricien of October 8, 1898, page 235, et seq., takes full cognizance of Popoff's work, and I find a paragraph on page 237 which is particularly significant and which I translate as follows:

"Since 1895 M. Popoff has shown in his publications and in his contributions to scientific societies in Russia that his apparatus could be practically employed in the navy for the reception of long-distance signals transmitted through space."

[fol. 695] In the paper of Sir William Crookes, which I have heretofore mentioned, he stated at the top of page 175, as second requirement for bringing wireless telegraphy within the grasp of daily life as "more delicate receivers which will respond to wave lengths between certain defined limits and be silent to all others."

While the Popoff paper did not touch upon the responsiveness to wave lengths between certain defined limits, it fulfilled the requirements as to delicacy or sensitiveness, and, furthermore, provided a receiver which was automatically self-restoring. I have referred to the work of Hertz without any definite reference to its publication, because his work is so well known to those practicing the art of radiotelegraphy, but for the purpose of definitely including in the record references to publications bearing upon the subject a rather full account is found in the series of articles by G. W. de Tunzelmann in the Electrician, London, between September 14 and November 16, 1888. Also the published accounts by Prof. Oliver Lodge in the Electrician, London, in a series of articles entitled "The Work of Hertz" between June 8 and July 20, 1894.

I have referred to a translation of an article by Professor Popoff from the journal of the Russian Physical Chemical Society at the Imperial St. Petersburg University. Translations in abstract are given from the original Russian article by Popoff in the Electrician, London, December 10, 1897, page 235, volume 40, purporting to be signed by professor Popoff in Cronstadt, Russia, November 26, 1897.

Mr. Edwards. Counsel for defendant offers in evidence the following exhibits in connection with the Stone defense:

United States patent to Stone No. 714756, dated December 2, 1902, marked "Defendant's Exhibit P3."

United States patent to Stone No. 714831, dated December 2, 1902, marked "Defendant's Exhibit Q3."

Certified copy of file wrapper and contents of United States patent to Stone No. 714756, dated December 2, 1902, marked "Defendant's Exhibit R3."

Certified copy of file wrapper and contents of United States patent to Stone No. 714831, dated December 2, 1902, marked "Defendant's Exhibit S3."

United States patent to Stone No. 577214, dated February 16, 1897, marked "Defendant's Exhibit T3."

United States patent to Stone No. 638152, November 28, 1899, marked "Defendant's Exhibit U3."

United States patent to Stone No. 726476, dated April 28, 1903, marked "Defendant's Exhibit V3."

United States patent to Stone No. 767990, dated August 16, 1904, marked "Defendant's Exhibit W3."

United States patent to Stone No. 726368, dated April 28, 1903, marked "Defendant's Exhibit X3."

Certified copy of file wrapper of United States patent to Stone No. 726368, granted April 28, 1903, marked "Defendant's Exhibit Y3."

Certified copy of file wrapper of United States patent to Stone No. 767975, dated August 16, 1904, marked "Defendant's Exhibit Z3."

Defendant's counsel also offers in evidence the following exhibits referred to in the deposition of the present witness, Commander Loftin:

[fols. 696-697] The Fortnightly Review, published in February, 1892, pages 173 to 181, inclusive, containing article by Crookes entitled "Some Possibilities of Electricity," marked "Defendant's Exhibit A4."

Pages 165, 169, 174, 188 to 193, inclusive, 202, 203, 207, 208, 210 to 213, inclusive, 225, 226, 231, 234, 303 to 313, inclusive, 317, 332 33, 337, 40 to 49, inclusive, 381 to 384, 488, and 489 of a book entitled "Inventions, Researches, and Writings of Nikola Tesla," by Martin published in 1894, marked "Defendant's Exhibit B4."

Page 869 of the Electrician, published at London, England, October 22, 1897, marked "Defendant's Exhibit C4."

Pages 235 to 247, inclusive, of the Journal of the Society of Arts, published at London, England, 1898, marked "Defendant's Exhibit D4."

Pages 153, 154, and 155 of the London Electrician, published June 8, 1894; pages 186 to 190, inclusive, of the same publication, published June 15, 1894, pages 204 and 205, of the same publication, published June 22, 1894; pages 271 to 274, inclusive, of the same publication, published July 6, 1894; page 299 of the same publication, published

July 13, 1894; and pages 332 to 335, inclusive, of the same publication, published July 20, 1894. All of these articles are offered as one exhibit and marked "Defendant's Exhibit E4."

Translation of an article published in the Journal of the Russian Physico-Chemical Society at the Imperial St. Petersburg University, Russia, in 1896, by A. S. Popoff, marked "Defendant's Exhibit F4."

Page 18874 of the Scientific American Supplement, published at New York, 1898, volume 46, marked "Defendant's Exhibit G4."

Pages 235 to 237, inclusive, of L'Electricien, published at Paris, France, October 8, 1898, marked "Defendant's Exhibit H4."

Page 235 of the Electrician, published at London, England, December 10, 1897, marked "Defendant's Exhibit 14."

* * * * * * *

[fol. 698] 5. Question. In your opinion, if an electrical engineer were given the work of Hertz, Tesla, Lodge, and Popoff and the forecast of Crookes, could he produce a system of transmitting and receiving intelligible signals without the use of wires without being compelled to devise anything especially new, and if so, what, in your opinion, would be the essentials of the system which he would naturally produce in view of such prior disclosures?

Answer. I have already pointed out in my answer to question 2 that the prediction of Crookes was predicated on the laboratory experiments of Hertz, Crookes suggesting that all the Hertz experiments needed to bring wireless telegraphy within the grasp of daily life was a more simple and certain means of generating high-frequency oscillations and a more sensitive detector of these oscillations. When this apparatus became available messages could be sent employing dots and dashes of the Morse code as was then the practice in wire telegraphy. I have also shown that immediately following the prediction and suggestion of Crookes, Tesla came forward with numerous forms of apparatus for producing high-frequency oscillations, and of these forms I have selected one and illustrated it in my sketch marked "Loftin Sketch A—Tesla Transmitter," my selection of this particular form having been [fol. 699] due to the fact that it is basically the organization

of apparatus which had been universally adopted as a radio or wireless transmitter, there being tens of thousands of transmitters of this type in use to-day. I have pointed out that it required no special knowledge to apply an ordinary telegraphy switch to the Tesla transmitter in place of the knife-blade switch shown in the Tesla sketch, thus making his system fulfill all the requirements set up by Crookes.

I have also illustrated in the sketch marked "Loftin Sketch B—Popoff Receiver" a sensitive receiver developed by Professor Popoff, whose work was specifically recognized by Marconi in the last paragraph but one of his reissue patent, the sketch also including the way in which Popoff connected his receiver to a grounded elevated conductor and successfully received electrical disturbances through space originating in distant electrical storms, together with electrical disturbances artificially created in electrical circuits operating meterological instruments which happened to be in the vicinity of the location Popoff chose for setting up his receiver of atmospheric electrical disturbances.

So complete and full were the disclosures of Tesla and Popoff that all that was required of one skilled in the art to produce a successful system of wireless communication was to set up the devices of Tesla and Popoff, operating the Tesla transmitter to make dots and dashes of the Morse code as suggested by Crookes. It would not have been necessary to even refer to the very complete considerations of the subject by Lodge.

6. Question. How does the character of wave, oscillations, or radiations of the patent in suit compare with those used by Lodge in 1894, by Popoff in 1895, and by Tesla during the early nineties.

Answer. The Marconi patent in suit, the articles by Lodge in 1894, and by Popoff in 1895 all refer to the character of the transmission of energy through space with which they were dealing as Hertzian waves. Tesla did not so characterize his mode of space energy transmission, but from the apparatus and structures used it was essentially the same as the others.

[fol. 700] (Defendant's counsel offers in evidence the following publications, patents, and sketches referred to by the witness, Loftin:)

Defendant's Exhibits—

J-4. Pages 183 and 184 of Electric Waves by Hertz, published at London in 1893.

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[fol. 701] R-4. Loftin sketch A.
S-4. Loftin sketch B.

• • • • • • •

[fol. 702] "*Resonance phenomena.*—In order to determine whether, as some minor phenomena had led the author to suppose, the oscillations were of the nature of a regular vibration, he availed himself of the principle of resonance. According to this principle, an oscillatory current of definite period would, other conditions being the same, exert a much greater inductiv effect upon one of equal period than upon one differing even slightly from it.

"If, then, two circuits are taken having as nearly as possible equal vibration periods, the effect of one upon the other will be diminished by altering either the capacity or the coefficient of self-induction of one of them, as a change in either of them would alter the period of vibration of the circuit."

It is thus apparent that Hertz appreciated that the best transfer of energy would take place when the transmitting and receiving circuits were tuned one to the other, and arrived at this conclusion through the application of the ordinary principles of resonance phenomena. Also that he fully appreciated the manner in which such tuning could be accomplished, namely, by adjusting either the capacity or the self-induction.

That Hertz appreciated the mathematical relation existing between the frequency or period of electrical circuits and the values of the capacity and inductance, is shown in the De Tunzelmann article appearing in the Electrician, September 14, 1888, for at page 588 it states:

"These periods are determined by the products of the coefficients of self-induction of these conductors even to the capacity of their terminals, and are practically independent of their resistances."

This statement of the mathematical relation is the practical foundation for the mathematical formula in common use to-day expressing the relation between the frequency and the inductance and capacity of electrical circuits.

In confirmation of the above-quoted conclusions as to the relation of these elements, the article states at the bottom of page 588 and the top of page 589, as follows:

"In confirmation of this it is found that if, when the point of contact is at c and the sparks have been made to reappear by connecting a conductor with one of the knobs, this conductor is replaced by one of greater capacity, sparking is greatly increased.

"The conclusions were further confirmed by the results when coils of copper wire were inserted into one or other and then into both of the branches of the micrometer circuit."

This is evidence that Hertz not only appreciated the relation of capacity to inductance but devised a practical means of obtaining self-induction in a circuit, namely, a coil of wire, which is precisely the same means covered by the claim in suit of the Lodge patent.

That the practical application of the Hertz disclosures to wireless telegraphy was apparent is shown by defendant's Exhibit A-4, Crookes' article of February, 1892. The article states on page 175:

[fol. 703] "If, however, the sender and receiver were moving about, so that the lens device could not be adopted, the correspondents must attune their instruments to a definite wave length, say, for example, 50 yards. I assume here that the progress of discovery would give instruments capable of adjustment by turning a screw or altering the length of a wire, so as to become receptive of wave lengths of any preconcerted length. Thus, when adjusted to 50 yards, the transmitter might emit, and the receiver respond to, rays varying between 45 and 55 yards, and be silent to all others."

This adjustment of instruments by the mere turning of a screw predicted by Crookes is exactly what happens in practical apparatus in radio communication. As soon as radio apparatus came into commercial use, the designers immediately arranged to vary the capacity and the inductance by the mere turning of convenient knobs. Also the limits of selectivity suggested by Crookes compare very favorably with what is obtained in actual practice. Crookes expressed the wave length in yards, while in the radio art as practiced the wave lengths are expressed in meters. In

a modern receiver tuned, for instance, to 300 meters one does not expect to hear only transmitting stations also tuned to 300 meters but finds that station tuned to 275 meters and 325 meters are also heard, while stations tuned to 200 meters or 400 meters become very faint or not heard at all, depending upon a number of considerations.

That Tesla understood in 1893 and 1894 how to construct electrical oscillation producers or transmitters having tuned circuits is apparent from reference to defendant's Exhibit B-4, Tesla book. He takes up at considerable length the methods of tuning the various circuits of the oscillation producers illustrated in Figure 165 (p. 303). The book states at page 305 that the frequency may be adjusted "by the determination of the capacity, self-induction, and resistance of the circuit." At page 315 of the book it is explained that tuning may be accomplished by means of an adjustable condenser C, Figure IIa, and also through an adjustable self-induction coil in series with the circuit. On page 317, in considering the arrangement of Figure IIIb, the secondary circuit is provided with an adjustable condenser for the purpose of tuning it to the primary.

I have shown in "Loftin Sketch A—Tesla Transmitter," inserted opposite page 427 of the typewritten record, that when Tesla connected an elevated conductor as provided for in Figure 185, page 348, to one of the oscillation producers illustrated in Figure 165, there is a coil of wire included in the elevated conductor between the elevated capacity area P and the earth E, which is the arrangement provided for in claims 1, 2, and 5 in suit of the Lodge patent. In fact, it is impossible to use any of the oscillation producers illustrated by Tesla without introducing an inductance coil in the elevated conductor circuit provided for in Figure 185.

In a book by Prof. Oliver Lodge entitled "Lightning Conductors and Lightning Guards," printed in London in 1892, there is discussed at great length the oscillatory paths, consisting of any one of short wires, long wires, and spiral wires. Lodge shows in Figure 47, page 352, a jar discharging either through a very short wire or through a spiral wire of half a dozen turns, and on page 354, states as follows:

"14. The noteworthy circumstance in all these experiments is the remarkable action of a long, thick, and good

[fol. 704] conductor in causing the jar to overflow, especially if it be insulated, the most powerful conductor for this purpose being one with suitable self-induction and capacity but very little resistance. Evidently such a conductor assists the formation of an electric surging, whose accumulated momentum charges the jar momentarily up to bursting point. Resistance damps the vibrations down, and short wires have insufficient electric inertia and capacity to get them up."

This shows that Lodge appreciated that large capacity and self-inductance was necessary in order for oscillation to build up and be prolonged or sustained, and that the proper inductance is obtainable through the use of a spiral or coil of wire.

Lodge, after referring to the work of Hertz, in a book entitled "Modern Views of Electricity," published in London, 1889, states on page 373:

"One immediate consequence and easy proof of the oscillatory character of a Leyden jar discharge is the occurrence of phenomena of sympathetic resonance.

"Everyone knows that one tuning fork can excite another at a reasonable distance if both are tuned to the same note. Everyone knows, also, that a fork can throw a stretched string attached to it into sympathetic vibration if the two are tuned to unison or to some simple harmonical. Both these effects have their electrical analogue. I have not time to go fully into the matter to-night, but I may just mention the two cases which I have myself specially noticed.

"A Leyden jar discharge can so excite a similarly timed neighboring Leyden jar circuit as to cause the latter to burst its dielectric if thin and weak enough. The well-timed impulses accumulate in the neighboring circuit until they break through a quite perceptible thickness of air.

"Put the circuits out of unison by varying the capacity or by including a longer wire in one of them, then, although the added wire be a coil of several turns, well adapted to assist neutral induction as ordinarily understood, the effect will no longer occur. It can be obtained again by diminishing the static capacity."

This shows that Lodge considered the resonance phenomena between electrical circuits to be the same as that between tuning forks, stretched strings, or other well-known

forms of vibrators, and that the tuning could be controlled by varying capacity or inductance, and one way of controlling inductance was the use of a coil of wire.

A paper entitled "d'Arsonval's Modification of Current of Great Frequency," published in a book entitled "Transactions of the American Therapeutic Association," New York, 1894, there is stated in reference to apparatus for producing rapid operations by the discharge of a condenser as follows:

"This is the method employed by Doctor Hertz to produce extremely rapid electrical undulations. * * * The duration and number of oscillations may be measured by examining the discharge by means of a turning mirror."

The article then states the formula for determining the frequency of oscillations of an electrical circuit depending upon the inductance and capacity, and further states:

"We may consequently give to T values more definite by modifying L and C. Doctor Hertz has obtained one-billionth [fols. 705-706] of a second; and my friend, Mr. Potier, has been able to lower the oscillating period so as to give to the Leyden jar a musical sound perceptible to the ear. In my first experiments I employed a Hertz vibrator. Later, I employed the more powerful arrangement suggested by M. Elihu Thomson and by Tesla. In my recent researches I found great advantage in the exclusive employment of the following apparatus for which the experiments of M. Lodge has given me many suggestions. * * *"

The article then describes apparatus including an oscillatory circuit having two capacity areas with an inductance coil inserted between them comprising a winding of 15 or 20 turns of coarse copper wire.

This article shows that the author had no difficulty in linking up the apparatus of Hertz, Tesla, Lodge, and his own as the same manner of apparatus, and fully realized the matter of varying the period of such electrical circuits, and using a coil of wire as the inductance element of the circuit.

* * * * * * *

[fol. 707] 21. Question. Please explain the nature and operation of the device described in the Marconi patent No. 763772 here in suit having particular reference to *to* the

subject-matter set forth in claims 1, 2, 3, 6, 8, and 10, to 20, inclusive.

* * * * * * *

Answer. The specification of Marconi patent 763772 in suit, briefly states in opening, lines 10 to 19, inclusive, page 1, the nature and purpose of the apparatus as follows:

"My invention relates to apparatus for communicating electrical signals without wires and by means of Hertz oscillations or electric waves; and the object of the invention is to increase the efficiency of the system and to provide new and simple means whereby oscillations or electric waves from a transmitting-station may be localized when desired at any one selected receiving station or stations out of a group of several receiving stations."

The general procedure of communicating electric signals without wires and by means of Hertz oscillations or electric waves has been freely discussed in connection with the Marconi reissue patent and the Lodge patent in suit, and is thought to need no further comments in connection with the consideration of this patent. The quotation gives two objects for the invention, namely, "to increase the efficiency of the system" and localizing the electric waves at a selected receiving station.

The first object is rather indefinite, as there is no indication of the kind of efficiency Marconi proposes to increase. For instance, it could refer to efficiency from the point of view of economy of electrical energy, or it may have in mind efficiency from the point of view of signalling to great distances without regard to the saving or waste of energy in accomplishing the long distance results. The second object, that of localizing signals at a particular receiving station is most definite, and subject to only one interpretation. Marconi desired to carry on communication between a given transmitting and receiving station without having the sig- [fol. 708] nals made unintelligible by interference from signals of other transmitting stations designed or adjusted to communicate on a different frequency.

The specification next refers to Marconi's prior patent, reissue No. 11913, here in suit, and describes the arrangement therein for communicating electrical signals. Having described the earlier apparatus, the specification then proceeds to state in general terms the outstanding features of

the new apparatus. The statement as to the transmitter, lines 33 to 47, page 1, is as follows:

"According to the present invention the system includes at the transmitting station the combination, with an oscillation transformer of a kind suitable for the transformation of very rapidly alternating currents of a persistent oscillator, and a good radiator, one coil of said transformer being connected between the aerial wire or plate and the connection thereof to earth, while the other coil of the transformer is connected in circuit with a condenser, a producer of Hertzian oscillations or electric waves shown in the form of a spark producer, and an induction coil (constituting the persistent oscillator) controlled by a signaling instrument."

Referring to Figure 1 of the drawing, this quotation states in effect that the oscillation transformer *d d'* interlinks the elevated conductor A to a lateral circuit containing a condenser *c* and a spark gap or spark producer (unmarked), and that the elevated conductor is a good radiator, while the lateral circuit linked to it through the oscillation transformer must be a "persistent oscillator." The quotation refers to the spark producer as "a producer of Hertzian oscillations or electric waves." This statement, of course, is not exactly correct, a spark gap not being capable of itself to produce oscillations. It must be associated with a circuit having proper inductance, capacity, and resistance values, the capacity and inductance determining the frequency of the oscillations and the resistance determining whether or not oscillations are produced at all. If the resistance is too high no oscillations can be produced. The function of the spark gap is to provide a high resistance in the circuit intended to oscillate while the condenser, such as *c* in Figure 1, is being charged with electrical energy, and by adjustment of the length of the gap it can be caused to break down when a certain pressure or potential has been obtained in the condenser *c*, and thereafter remain a very low resistance path, while oscillations of electrical current in the oscillating circuit take place. The gap is therefore a trigger device and not of itself a generator or producer of electrical oscillations or alternating current.

The specification states further in generalizing the system, lines 56 to 66 inclusive, page 1, as follows:

"The system also requires as essential elements thereof the inclusion in the lines (at both stations) from the aerial

conductor to the earth of variable inductances and the use at both stations of means for varying or adjusting the inductance of the two circuits at each station to accord with each other. By this arrangement of apparatus I am able to secure a perfect 'tuning' of the apparatus at a transmitting station and at one or more of a number of receiving stations."

This quotation shows that Marconi, having associated a good radiator with a persistent oscillator, proposed as a second step toward obtaining his object the adjustment of the [fol. 709] several circuits included in his system so as to obtain "a perfect 'tuning'." That is, having associated a good radiator with a persistent oscillator, perfect tuning would then be possible.

The quotation taken by itself would indicate that Marconi proposed to accomplish his adjustment by the manipulation of inductance values only, but this is not in keeping with later statements in his specifications and with his drawings and descriptions of the elements illustrated in the drawings. For instance, the description of the condenser *c* at the transmitting station, Figure 1, and the description of the condensers *h* and *h'*, at the receiving station, Figure 2, make these devices variable. Marconi, of course, appreciated that circuits could be adjusted in time periods or frequency by varying either inductance or capacity, or both. For instance, at lines 123 to 126, inclusive, page 2, he states "are each and all to be so independently adjusted as to make the product of the self-induction multiplied by the capacity the same in each case."

Here he does not require the adjustment of inductance alone, as the product of inductance and capacity may be varied through varying capacity value.

Also referring to the table of tunes on page 4 of his specification, it will be noted that at the transmitting station he varied the value of the capacity of the condenser *c* more often than he varied the inductance.

The specification next sets forth in detail, lines 76 to 97, inclusive, the elements comprising the transmitting station illustrated in Figure 1. Following this statement of the elements it is stated that the induction coil C, may be replaced by other proper means, for instance, a generator of alternating electric current. The generator form of supply

of energy to a radio transmitting system is a common form encountered in practice.

The specification then specifically states, lines 6 to 24, inclusive, page 2, what this organization of apparatus at the transmitting station must do, as follows:

"The illustrated arrangement of parts at a transmitting station enables much more energy to be imparted to the radiator *f*, the approximately closed circuit of the primary being a good conserver and the open circuit of the secondary being a good radiator of wave energy. My experiments have demonstrated that the best results are obtained at the transmitting-station when I use a persistent oscillator—an electrical circuit of such a character that if electromotive force is suddenly applied to it and the current then cut off electrical oscillations are set up in the circuit which persist or are maintained for a long time—in the primary circuit and use a good radiator—i. e., an electrical circuit which very quickly imparts the energy of electrical oscillations to the surrounding ether in the form of waves—in the secondary circuit."

That is, in effect the lateral circuit must be capable of taking a large quantity of electrical energy from a source of supply, must be able to convert this energy into high frequency electrical currents or oscillations, must conserve the energy so as to spread the oscillations out over a long period of time, and must deliver energy to a good or rapid radiator in such a way that it will not be radiated too quickly by a good radiator, but drawn out over a long period of time. The lateral circuit must act as a reservoir for the [fol. 710] rapid radiator, always having a little more energy in store to replace that rapidly radiated. This quotation makes clear that providing the storage system of energy for a rapid radiator, such as the elevated conductor, much more energy can be radiated in the long run by holding back the energy from the radiator in a manner forcing the radiator to convert it into electric waves at the pace or rate set by the persistently oscillating lateral circuit.

The following paragraph of the specification, lines 25 to 38, inclusive, page 2, relates the operation of the transmitting system to obtain the requirements set for it by Marconi in the paragraph I have just quoted. The operation is stated as follows:

"In operation the signaling-key *b* is pressed, and this closes the primary of the induction-coil. Current then rushes through the transformer-circuit and the condenser *c* is charged and subsequently discharges through the spark-gap. If the capacity, the inductance, and the resistance of the circuit are of suitable values, the discharge is oscillatory with the result that alternating currents of high frequency pass through the primary of the transformer and induce similar oscillations in the secondary, these oscillations being rapidly radiated in the form of electric waves by the elevated conductor."

This quotation describes the manner in which the condenser *c* of the lateral circuit receives a quantity of electrical energy from a source of supply to be converted into high frequency electrical currents or oscillations. It makes clear that the spark gap is a trigger device which holds back the electrical energy from flowing in the circuit until the condenser has been supplied with a quantity of energy, and also makes clear that the spark gap is not in itself the producer or generator of the desired oscillations, for it states that whether or not the discharge is oscillatory depends upon the capacity, the inductance, and the resistance of the circuit having suitable values. Marconi points out that with suitable values for these characteristics the discharge is oscillatory resulting in high frequency alternating currents passing through the primary of the transformer. He points out that the passage of these high frequency oscillations of the lateral circuit through the primary of the transformer induce similar oscillations in the secondary circuit or elevated conductor, where they result in radiation in the form of electric waves. That is, Marconi used the lateral circuit as a generator or source of oscillations of definite characteristics, and having produced these oscillations of definite characteristics, he impressed them without change in characteristics ("similar oscillations") upon a circuit designed or arranged to well impart the energy of these oscillations definite in characteristics to surrounding space.

Having provided for a source of oscillation of definite characteristics, Marconi then gives some instructions for obtaining best results from these oscillations. The paragraph immediately following the one just quoted, that is, lines 39 to 49, inclusive, page 2, reads as follows:

"For the best results and in order to effect the selection of the station or stations whereat the transmitted oscilla- [fol. 711] tions are to be localized I include in the open secondary circuit of the transformer, and preferably between the radiator *f* and the secondary coil *d'*, an inductance-coil *g*, Figure 1, having numerous coils, and the connection is such that a greater or less number of turns of the coil can be put in use, the proper number being ascertained by experiment."

That is, for best results it is not sufficient to impress the oscillations which he generated upon any elevated conductor that happened to be available, but upon one including a variable inductance coil, so that a greater or lesser number of turns of the coil could be put in use, the proper number of turns being ascertained by experiment. This, of course, simply means that Marconi varied the inductance in the elevated conductor until the product of the inductance and the capacity inherent in the structure of the elevated conductor was of such value as to give the elevated conductor system a natural period of electrical oscillation in resonance with the frequency of the oscillations produced in the lateral circuit. Having arrived at such adjustment there would be a better and more efficient absorption by the elevated conductor circuit of the energy in the magnetic field produced by the oscillations or currents passing through the primary winding of the oscillation transformer *d d'*. This would be manifested by currents of larger amplitude or greater intensity flowing in the elevated conductor circuit. Again, if the elevated conductor circuit were not adjusted in its natural period to be the same as that of the frequency of the oscillations in Marconi's generator, the lateral circuit, there would be oscillations of two frequencies in the elevated conductor. One of these oscillations would have the frequency of the oscillations in the lateral circuit. The other set of oscillations would result from some of the energy absorbed by the elevated conductor circuit changing its frequency of movement to the natural period of the elevated conductor. Another good reason for adjusting the natural period of the elevated conductor circuit to resonance with the generated oscillations is that the generated oscillations are rapidly expending their energy in various ways, some of them a total loss. If the elevated conductor circuit where the energy is to be usefully utilized

is not made as receptive or as good an absorber as possible by the time the oscillations in the lateral circuit have ceased, the elevated conductor will have received a portion only of its maximam possible share of the available energy.

The specification next proceeds to a consideration of the receiving stations, and offers for selection as preferred forms a number of receivers described by Marconi in several United States patents, patents Nos. 586193, 627650, 647007, 647008, 647009, and 668315 being specifically mentioned. The specification also suggests as a responder to electric waves, or detector, the use of the coherer described in Reissue patent No. 11913 (original No. 586193), here in suit, which has been fully described in connection with the consideration of the reissue patent; or the specification states that other well known devices may be used, naming a number developed subsequent to the early Marconi patent.

The specification next proceeds with a number of suggestions for varying the capacity or the inductance, or both, in the two circuits at the receiving station for placing the receiving system in resonant accord with the transmitting system, describing the various variable elements for accomplishing these adjustments, the detailed description [fol. 712] being concluded with the following general statement, lines 12 to 17, inclusive, page 3:

"The adjustment of the self-induction and capacity of any or all of the four circuits can be made in any convenient manner and employing various arrangements of apparatus, those shown and described herein being preferred."

That is, the art had already devised convenient ways of adjusting the inductance and capacity of electrical circuits, and Marconi was not insistent upon the use of any particular manner or way of accomplishing this adjustment.

The specification is then given over to a detailed description of the maner in which Marconi built a number of the elements of his system, and on page 4 includes tables for six different tunes of his transmitting and receiving stations, the tables specifying which of the elements he has previously described in detail are to be used for each one of the tunes.

The following paragraph in the specification, lines 118 to 129, inclusive, page 2, refers to the system as a whole, including both the transmitting and receiving stations. It reads:

"The capacity and self-induction of the four circuits—i. e., the primary and secondary circuits at the transmitting station and the primary and secondary circuits at any one of the receiving stations in a communicating system—are each and all to be so independently adjusted as to make the product of the self-induction multiplied by the capacity the same in each case or multiples of each other; that is to say, the electrical time periods of the four circuits are to be the same or octaves of each other."

That is, having provided a system capable of resonance, one having a single frequency generated in and set by the first circuit into which energy is introduced at the transmitting station for conversion into high frequency electrical oscillations, namely, the lateral, energy-conserving, persistently oscillating circuit at the transmitting stations, the proper thing to do is to adjust the time period of all of the other circuits in the system to that of the pace setting or frequency determining circuit.

Referring to the use of the system for localizing the transmission of intelligence, the specification states, lines 5 to 11, inclusive, page 3, the following:

"If the time periods of the circuits of the transmitting station are varied until they are in resonance with those of one of the receiving stations, that one alone of all of the receiving stations will respond, provided that the distance between the transmitting and receiving stations is not too small."

This points out that the time periods of the circuits of the transmitting station are to be varied until in resonance with but one of the receiving stations. This does not merely mean adjusting the product of inductance and capacity, but includes adjusting the transmitting station so that it is capable of producing resonance in but one of the receiving stations. This requires producing waves of but a single frequency which are sufficiently drawn out to permit of a receiving station being resonantly affected thereby. When waves having such characteristics are produced, then advantage may be taken of adjusting the individual time [fol. 713] periods of the circuits to this one-frequency, long drawn out wave, and it is only by such provision that one receiver can be affected to the exclusion of others.

* * * * * * *

In the foregoing I have considered the various statements of Marconi as to the objects of his invention, its differences from prior radio systems, his discussion of how the system should function, his statements of operation, and some of the details of construction of the various elements. With these matters in mind, it is most clear to me that Marconi provided a particular and most definite system for radio communication, founded on the basis of creating in the lateral circuit at his transmitting station electrical currents or oscillations of a fixed and unchanging frequency, backed up by a sufficient initial supply of energy and conserved through a proper coordination of the elements of the lateral circuit, and delivered to an associated radiating circuit, all such that the oscillation while maintaining their constancy of frequency would be persistent or maintained for a long time in order that all of the mediums between the lateral circuit, the first circuit of the system, and the lateral circuit at the receiving station, the last circuit of the system responsible for transferring the electrical energy from one stage to another in the system could be caused to accomplish this transfer through what might be termed "cumulative resonance." The mediums of transfer of the high frequency energy from the beginning to the end of the system are, first, the magnetic field created by the currents flowing in the primary winding *d* of the oscillation transformer *d d'*; second, the currents flowing in the elevated conductor A, which currents are created by the action of the magnetic field on the secondary winding *d'*; third, the electrical pressure variations or waves in space, which variations are created by the currents flowing in the elevated conductor A; fourth, the currents flowing in the elevated conductor A at the receiving station, which currents are created by this conductor absorbing or having impressed upon it some of the energy in the space waves or electrical pressure variations; fifth, the magnetic field created by the received currents flowing through the primary winding *j'* of the oscillation transformer *j' j²* at the receiver; sixth, the currents flowing in the lateral circuit at the receiver due to the effect of the magnetic field created by the currents in the primary winding *j'* upon the secondary winding *j²*. Unless the frequency of all of these high frequency currents, magnetic fields, and electrical space pressures or waves is one and the same throughout the entire system, and sufficiently long

drawn out or enduring, there can be no real cumulative resonance, or as Marconi terms it, localizing of electric waves from a transmitting station at any one selected receiving station.

It is well known that in transferring alternating-current energy from one circuit to another through any form of interlinkage of the two circuits there results a conversion of the one frequency of the alternations which exists with- [fol. 714] out any interlinkage with another circuit into alternations of two frequencies, one higher than the frequency existing with no interlinkage and one lower than this frequency, and that the no-interlinkage frequency no longer exists unless the two circuits are so loosely interlinked that the affect of the second circuit drawing energy from the first circuit is very small. This interlinkage of two circuits is commonly termed "coupling," and the two frequencies resulting from the interlinkage or coupling are termed generally "coupling frequencies." It is common to say that if the two circuits are so loosely interlinked as to create no apparent two frequencies from a practical point of view, that the circuits are "loosely coupled." If the interlinkage is such as to create two frequencies sufficiently widely separated as to be detectable with practical radio receiving apparatus the circuits are said to be "tightly coupled."

This formation or development of two coupling frequencies is not and can not be controlled by adjusting the product of the capacity and self-inductance of each of the two circuits considered independently to the same value. The control in this respect is entirely through the degree of interlinkage, or, as commonly expressed, "degree of coupling" between the circuits. It has been frequently stated in this case that the frequency with which electrical energy will oscillate in an oscillatory circuit when the circuit is charged with electrical energy which is set free to move, depends upon the values of capacity and inductance in the circuit. This means that this is true only when the circuit is considered independently and uninfluenced or unhampered by an interlinkage with another circuit. It is apparent that the moment another circuit is brought to bear upon an oscillating electrical circuit so that it absorbs energy therefrom, the moving energy no longer can deal only with the capacity and inductance of the first circuit but has to encounter and take into consideration the ca-

pacity and inductance of the second circuit, the extent of the affect of the second circuit upon the first circuit being dependent upon how closely the two circuits are interlined or coupled. The bringing to bear of the second circuit on the first circuit will first have the effect of drawing energy from the first circuit or placing a load on it, and the electrical energy under such load will tend to slow down in its rate of motion. The second circuit having drawn some energy from the first circuit will then, through the interlinkage or coupling, try to give back some of the energy with the result that the movement of the energy is accelerated. This is a condition not limited to electrical circuits alone or high-frequency circuits, but is commonly encountered in electrical machines. For instance, a generator driven by a turbine or engine will deliver energy to a motor connected in the line which put a load on the turbine or engine, and the turbine or engine will tend to slow down unless there is provided a governor to open the throttle wider and admit more steam under such conditions to maintain the speed constant. The motor having received energy from the generator will increase its speed an under this increase generate a higher back electromotive force, which will tend to return some of the energy taken by the motor back to the generator and permit the generator to speed up above normal speed, unless the governor again comes into play, and closes the throttle to admit less steam to the driving element. Likewise, this holds true in the case of two oscillatory bodies, such as stretched strings or pendulums. [fol. 715] We know that a pendulum by itself will oscillate at one frequency. However, if we attach it to another pendulum as through a rubber band, it will change from its normal or natural frequency of oscillation to two frequencies, and these two frequencies will be close together or widely separated, depending upon how closely the two pendulums are interlinked, as by whether or not the rubber band is large and stretches with difficulty or is small and stretches easily. In the case of a large rubber band, the two pendulums would be tightly interlinked or coupled, the effect of the first pendulum on the second pendulum would be large, and the frequencies of oscillations would be widely separated. In the case of the small rubber band, the effect of the first pendulum on the second pendulum would be small, the two pendulums being under such circumstances

loosely interlinked or coupled, and the two frequencies would be very little separated, and if the rubber band is made sufficiently elastic, it would be quite difficult to note any difference between the two frequencies, or between either one of the two frequencies and the uninfluenced frequency oscillation of the first pendulum.

Still considering the pendulum analogy, if the rubber band is large and does not stretch easily, it is easy to visualize that the tugging of the second pendulum on the first pendulum will very soon absorb the energy from the first pendulum to the benefit of the second pendulum, and then the second pendulum having all of the energy proceeds to reverse the situation and the tugs on the first pendulum until finally the first pendulum has all of the energy that remains, some of it being dissipated of course in mechanical and air friction and in molecular displacement friction in the rubber band, and this transfer of energy from the one element to the other goes on alternately until all of the energy is expended and the two pendulums are at rest.

If the two pendulums tightly coupled through the large rubber band are not of the same size—that is, one large and the other small, so that they do not have the same natural frequency of vibration—it is still easy to see that the tugging of one on the other will tend to transfer the energy back and forth between the two elements just as would happen if they were exactly the same. However, it would take the small one a long time to get all of the energy away from the big one, and the big one would have all of the energy of the small one in a very short time. This merely results in an irregularity in the instances in which the energy is first all in one, and second, all in the other, and it would naturally be difficult to determine just when these instances would occur, the determination depending upon a number of complicated considerations, such as the relative masses of the two pendulums and the elasticity of the rubber bands connecting them. If the two pendulums are exactly the same, it will take the same length of time for each one to extract the energy from the other, so that under such circumstances the instances when the energy being all in one and entirely absent in the other are more easily predicted and more readily under control.

(Recess.)

[fol. 716] The larger the rubber band, or the less the elasticity, the greater will be the effect of the tug or pull of one pendulum on the other; that is, the greater will be the transfer of the energy of the one pendulum into the other for each oscillation, and therefore it will require fewer oscillations to have all the energy passed from one to the other, thus increasing the frequency of the instances when the energy is all in one and entirely absent from the other, and vice versa. This means that the frequency of these instances is entirely under the control of the interlinkage or degree of coupling between the two pendulums, or any other analogous system, such as oscillatory electrical circuits.

If we make the rubber band small, that is, of large elasticity, it is easy to visualize one pendulum completing practically its entire swing without imparting much energy to the second pendulum and without having its motion greatly disturbed either as to frequency or extent. Under such circumstances, it would take a great many swings of the first pendulum to set the second pendulum into large motion, so much so that the energy derived from the motion of the first pendulum may be entirely expended in friction and otherwise in both pendulums before the second pendulum can ever accomplish acquiring all of the energy common to the coupled system, and there will not occur instances in which the energy is first all in one pendulum and then in the other. Under this condition of loose coupling the oscillations or swings of the pendulum endure longer than under a condition of tight interlinkage or coupling. The energy wasted or expended depends upon the extent or amplitude of oscillation of the two pendulums. If the energy is quickly transferred in large amounts from one to the other, both move through greater distances or amplitudes and expend energy rapidly. If only one moves through great distance and the other through small distance, as in the case in loose coupling, only one is rapidly expending energy and therefore the oscillations can endure for a much longer period of time. In the loose coupling when the first pendulum starts its action on the second pendulum there is at first a building up of the extent of swing of the first pendulum starting from no motion at all. Having little motion to begin with, the second pendulum does not expend much energy and the energy derived from the first pendulum can mostly all be employed in

building up the swing until finally the swing reaches such extent that the energy expended is just made up by that derived from the first pendulum. At this point the extent of swing ceases to increase, and since the first pendulum has expended a fair portion of its energy in arriving at this point it can no longer supply the same amount of energy to the second pendulum, and from this point on the extent of oscillation begins to decrease. If the first pendulum is so constructed as to originally receive and store a large amount of energy, is designed to conserve this energy, and is interlinked with the second pendulum so that it slowly transfers energy, then the oscillations endure or are maintained for a long time. These same considerations apply in interlinking electrical oscillatory circuits to cause the oscillations to endure or be maintained for a long period of time.

With the two pendulums interlinked through the small rubber band, if one is larger than the other, it is readily [fol. 717] apparent that the second pendulum having received some energy from the first pendulum will endeavor to oscillate at its own natural frequency, or period of vibration. At the same time, it is always being pulled or tugged at by the first pendulum through the rubber band at the frequency of the first pendulum. There will result a complex motion having two frequencies, one, that of the first pendulum, and, second, that of the natural period of the second pendulum. Under such circumstances, there will not be the same extent of motion of the second pendulum, part of the energy received being bent upon one purpose and part of the energy upon another purpose. If the second pendulum is made to have exactly the same natural period as that of the first, then these two energies are brought together to a common purpose, that of creating swings of one frequency, with the result that the extent or amplitude of swing is substantially increased.

This discussion, I think, makes clear that energy to be usefully utilized must be directed in one path toward one purpose, and not spread out over a number of paths of effort having conflicting purposes. In the language of Marconi, this is merely "localizing" effort. It also makes clear that if it is impossible to localize effort through quick action, then much can be gained by taking a little more time to acquire practically perfect localizing of effort, and though the action of each localized effort may be small,

when added together over a long period of time, a better result may be obtained than through two strong, non-localized efforts acting to different purposes.

This discussion has shown that a prime factor toward localizing of effort in transferring energy from one system to another, whether the system be electrical or mechanical, is small interlinkage or loose coupling. The Marconi specification does not go directly into the matter of loose coupling between his circuits, but I think, taking together all that he says, it is impliedly contained in the language of the specification. He positively states conditions that must obtain for the success of his system, and these conditions can not be obtained without due consideration for the laws governing coupled energy transfer systems.

His main object is the localizing of the energy effort of his system, and I have shown that this can not be accomplished in a coupled system without making the coupling loose. He states that the oscillations must be long drawn out or maintained for a long time. The laws of coupling make this impossible without loose coupling. He states at the transmitting station the oscillations transferred into the elevated conductor or good radiator must be "similar" to those in the lateral circuit. I have shown that the laws governing coupled systems make this impossible without loose coupling. There is therefore language in the Marconi specification which to one skilled in the art beyond all doubt implies a proper degree of loose coupling.

Aside from the language, this is very definitely indicated in the drawing to one capable of interpreting the ordinary conventional way of indicating or illustrating electrical circuits. In Figure 1 there is shown a single turn of wire representing the primary *d* of the oscillation transformer *d d'*, and only two turns of wire representing the secondary, *d'* of this transformer. The turn *d* is turned away [fol. 718] from the two turns *d'*, indicating a separation of the two elements of the transformer, separation or special relation being one way of reducing the degree of coupling in such a device. Also, where there are only one or two turns of wire, it is very difficult to get a tight coupling because the magnetic field is most intense immediately around the surface of the wire, and if the wire is insulated or separated from the turns of the other coil to prevent sparking the magnetic field escapes in the path represented by this insulation without linking with the wire of the other

circuit. The figure shows part of the turns of the inductance in the elevated conductor A located in the coil *g* so far removed from the primary *d* that the magnetic field originating in the primary *d* would not to any practical extent act upon the turns of the coil *g*. Since the degree of coupling depends upon the percentage of the to-al inductance of a circuit that interlinks with the magnetic field of the other circuit of the system, and since the drawing indicates four t*ru*ns in the coil *g* only two turns in the coil *d'*, there is indicated only a small percentage of the inductance of the elevated conductor A in a position capable of being at all effectively interlinked with the lateral circuit. An analysis of the tunes listed on page 4 of the specification with reference to the devices listed for accomplishing the tunes and described also in the specification shows that in practically all cases there was provided arrangements for a degree of coupling which in the practice of the radio art would be considered effectively loose for good localizing of energy effort.

The Marconi specification requires at the transmitting station a device which he terms a "spark producer" in several places and on page 2, line 30, a "spark gap." On page 1, lines 83 and 84, he describes this device as having "spherical terminals or other contacts." In the drawing, Figure 1, the device is unmarked, bat is shown immediately to the left of the letter C as being two small balls separated by an airgap. In several places in the specification, I find language bearing upon the requirements for this device. Page 2, lines 9 and 10, Marconi states "circuit of the primary being a good conserver." Since the spark gap is one of the elements of the primary of the lateral circuit of the transmitter, it must be so designed as to aid or do its share in this circuit towards conserving the energy; that is, it must not be unreasonably wasteful.

Page 2, lines 12 to 20, as follows:

"My experiments have demonstrated that the best results are obtained at the transmitting station when I use a persistent oscillator an electrical circuit of such a character that if electromotive force is suddenly applied to it and the current then cut off electrical oscillations are set up in the circuit which pr*o*sist or are maintained for a long time."

The spark gap being an element of the circuit which Marconi specified as a persistent oscillator, the gap must do its part in permitting persistency; that is, broken down from the high resistance which it had before the condenser c was fully charged, the gap must remain low in conductivity for a long time and not close too soon to stop the flow of oscillations. It must permit the oscillations in the primary circuit to "persist" or be "maintained for a long time."

Page 2, lines 30 to 36, inclusive, reads as follows:

"If the capacity, the inductance, and the resistance of the circuit are of suitable values, the discharge is oscilla- [fol. 719] tory, with the result that alternating currents of high frequency pass through the primary of the transformer and induce similar oscillations in the secondary."

The resistance of the spark gap after it is broken down and becomes of low conductivity is part of the resistance of the circuit which it is desired to have oscillatory, and the resistance in the gap together with the resistance of the rest of the circuit must be such that oscillatory discharging of the condenser will be permitted.

With the above instructions from Marconi, it is easy to determine the character of the spark gap or spark producer required by his system. The first function of the spark gap is to retain the intended oscillatory lateral circuit open while the condenser c is receiving a quantity or charge of electrical energy from the source. The air gap between the balls or other electrode of the gap with a separation of only a fraction of an inch will prevent current from flowing across this gap with pressures as high as ten to twenty-five thousand volts, the voltage at which the gap will break down depending upon the separation between the balls or electrodes and upon their shapes. The separation of the electrodes therefore determines how much energy is put into the condenser c. The higher the voltage to which the condenser c is charged, the greater the quantity of electricity that is stored therein for a given capacity of condenser. In practice, it is usual to make the separation between the two electrodes of the gap adjustable, so that varying powers of transmission are obtainable. Air under ordinary conditions is a very good insulator or obstructor to the flow of electrical current, so that a spacing of a small fraction of

an inch between such electrodes ordinarily holds back the flow of current under voltages of the order of several thousand. Electrical sparks will more readily jump from pointed electrodes than flat or rounded ones, such as the balls, shown in Figure 1, and the jumping or sparking from pointed electrodes is more irregular as to voltage required than in the case of flat or round electrodes. Pointed electrodes also deteriorate more readily under the heat produced in the gap than electrodes of larger surface, and with pointed electrodes it would be necessary to adjust the gap length more frequently to take care of the burning away of the points. For this reason the ball or cylindrical rod types of electrode were very common in general practice.

The condenser c having received a charge of electricity up to a voltage or pressure predetermined by the separation of the electrodes of the spark gap, a spark jumps across the gap and in so doing changes the electrical characteristics of the atmosphere in the space so that instead of having a resistance of thousands of ohms, the resistance immediately falls to a very low value, allowing the condenser c to discharge causing a current to flow in the oscillatory circuit, finally charging the condenser to a high voltage in the opposite sense. This opposite sense charge causes a current to flow in the opposite direction, and since the rapidity of the change is such that the spark gap is not given opportunity to regain its normal state of high resistance, the current in the opposite sense also encounters a low resistance in the gap and so on until the oscillating energy reaches such a low value that the gap is allowed to recover itself from the effects of the passing current in the interval when no current is flowing at one of the reversals.

[fol. 720] Spark-gap action may be visualized by the common happenings in handling electrical switches, the difference of action between opening and closing electrical switches being undoubtedly familiar to everyone. In ordinary house lighting, the voltage on the line is about 110 volts. A switch on such a line can be closed without drawing the slightest sign of a spark. In starting to close the switch, the air separating the switch and the switch blade is normal and of high conductivity, and the switch can approach the blades to a very minute fraction of an inch without causing a spark to jump under the low pressure of 110 volts. On the other hand, if the switch is closed, and the

circuit carrying current, on opening the switch a current follows the switch as it is drawn away from the contacts ionizing or changing the character of the atmosphere separating the contacts and the blades with the result that a very long and intensive spark can be drawn. This means simply that the current flowing in the path is given opportunity to change the character of the atmosphere separating the two conducting elements, and changes this character from a very high resistance to a very low resistance. If the atmosphere having undergone this change can be swept aside or dispersed, the spark can be broken up. A strong magnetic field acting on such a gap will disperse this atmosphere, or a strong blast of air is to a degree effective. In general electrical power transmission it is customary to provide switches with a device which creates a strong magnetic field across the gap between the contacts when a switch is opened, this device being known as a "magnetic blowout." Often switches in circuits carrying heavy currents are arranged to open in a body of oil rather than in air, oil being a good insulator and yet not having its character as to resistance changed so readily as air when a current or spark takes place.

This effect on the air or atmosphere in the space separating two electrodes when a current flows across the path is termed "ionization." This means that the electrical character of the atoms forming the atmosphere in the space is changed. Normally, the atoms of a gas are in a state of equilibrium or neutral in the matter of electrical characteristics. An atom is comprised of a definite number of electrons, and an electron may be said to be an infinitely small unit of negative electricity, but not so small that it does not have mass, and therefore bump into something else and leave its effect. If an atom comprised of a definite number of electrons is in some way robbed of one or more of its electrons or units of negative electricity, then this atom becomes positive with respect to both the negative electrons it has lost and to other atoms of the atmosphere, and since electrical bodies which are differently electrified or charged attract each other, the atom which, under its new electrical condition, is termed an "ion," commences moving toward some other atom, which has not been ionized, at the same time the atom moving toward the "ion," with the result that the two collide, and when this collision takes place addi-

tional electrons are knocked out of the ion, and some electrons are knocked out of the atom which collided with the ion. The result of this is that there is created another ion to go running about bumping into other atoms, and in about one-millionth of a second or less the whole space is a turmoil of ions and electrons bumping about.

[fol. 721] Every time an ion bumps an atom more electrons are set free or knocked out of the atom, and every time an electron collides with an atom or an ion additional electrons are set free. The electrodes of the spark gap are oppositely charged or have positive and negative potentials with respect to one another and with respect to the electrons and ions. The positive electrode attracts the negative electron. These electrons rush toward the positive electrodes at an extremely high velocity, encounter atoms and ions on the way and colliding with them set free additional electrons to be drawn toward the positive electrode. The additional electrons also collide with atoms and ions on the way and further increase the effect. The ions, being positive, are drawn in an opposite direction to the movement of the electrons toward the negative electrode of the gap. The ions being of greater mass than the electrons do not travel so fast, but their motion is opposite to that of the electrons, and aids in increasing the collision effect with the electrons. The ions on reaching the negative electrodes have considerable velocity and colliding with the negative electrodes suffer the loss of additional electrons through this collision, at the same time knocking electrons free from the atoms comprising the electrode structure. It will thus be seen that the space becomes a very active neighborhood, and this is manifested in the form of a spark which gives off light, noise and heat, a phenomenon familiar to every one who has seen a spark drawn in any form of electrical circuit, or a spark jumping from clouds to earth in the familiar form of lightning.

Electrical current is merely the movement of electrons, the amount of the current being a measure of the number of electrons in motion. Electrons can move through solid bodies such as wires, and in fact moves very readily and with the least resistance in certain solid bodies such as copper and silver. They can also move through gases, such as air, but do not start to move so readily as in solid bodies until a few of them are set at a high speed motion to knock

other electrons out of the atoms of the gas to establish a flow of electrons. It takes a very high voltage to start this collision effect, but once started, the voltage to maintain it need be but very small. For instance, in the spark gap, they may remain inactive up to voltages of ten to twenty-five thousand depending upon the length of the gap, but once a sufficiently high voltage is reached to start a few collisions, or movement of electrons and ions, the voltage immediately falls. This is the same as saying that the inactive gap has a high resistance, and in fact the resistance is the order of thousands of ohms. Immediately the collision effect takes place the resistance falls to a very small value, a mere fraction of an ohm.

It is this resistance of the gap in its broken down or active state that Marconi is interested in from the point of view of one of the requirements of his lateral circuit, the one stated at line 10, page 2 of the specification, which is that the lateral circuit must be "a good conserver" of energy. If the active or broken-down resistance of the gap is unnecessarily high, an unnecessary amount of energy will be wasted [fol. 722] in the gap detrimental to conservation of energy. There are arrangements of gap lengths, shape of gap electrodes and material of electrodes, as well as atmosphere between the electrodes which determine whether or not resistance of the gap during the active state will be unnecessarily high or desirably low. As to gap length, the greater the energy which can be stowed in the charging condenser, the greater the current that will flow in the circuit when the gap breaks down. The longer the gap length, the greater will be the energy storage in the condenser. The larger the current flowing in the gap the more intensive is the resulting ionization, which means lower gap resistance. Therefore, one suitable requirement for the Marconi gap is long gap length. As to gap electrode shapes, the more the electrodes depart from the sharp or pointed form the less the gap resistance. Spherical balls or flat-shaped disks are better than sharp-pointed electrodes. Balls of large radius are better than small balls. This is readily apparent from the consideration that the ionization between pointed electrodes would be restricted to a path of small area of cross section. If the electrodes are spread out there will be a path for ionization of large cross section. This follows the general law of movement of all kinds of matter. The bigger the path in which anything has to flow the less the

resistance to the flow. As to material, there are certain materials which do not substantially aid in the ionization effect, such as copper and silver, while there are others which play quite an important part in the ionization, such as tin and zinc. These latter named materials readily vaporize under heat, and since there is considerable heat generated in a spark gap, electrodes of tin and zinc furnish metallic vapors to the atmosphere in the path. Metallic vapors more readily and more intensively ionize than do ordinary gases. There are therefore added two other suitable arrangements for meeting Marconi's requirement for good conservation, namely, electrodes for the gap having lateral extent such as balls or disks, and electrodes of vaporizing material. A very common form of spark gap was one having disks of zinc for the electrode. As to the atmosphere of the gap, I have pointed out that atmosphere of metallic vapors originating from electrodes of suitable material assisted in reducing gap resistance. Air is better than hydrogen or other gases having less atomic weight than air, and the general practice has been to operate the gap in air.

On account of the head generated in the gap aiding in the vaporization of the metallic electrodes, it is not desirable for low resistance to make any special provision for cooling the gap provided the heat generated is not so intensive as to destroy the gap at such a rate as to make frequent renewals necessary. In handling extremely large powers the consumption of the gap electrodes would be rather rapid without some arrangement for cooling, and under such circumstances a compromise has to be made with the matter of obtaining the best possible low resistance. I have also previously stated that ionization could be affected by dispersing or diffusing the ionized atmosphere between the electrodes, such as the use of a magnetic blow-out, common to switches in power lines. Such a device would act against obtaining low resistance in a spark gap and has never been used to my knowledge in a spark-gap radio transmitting system.

[fol. 723] The second requirement by Marconi for the lateral circuit at the teransmitting station is stated page 2, lines 18 to 20, inclusive, as follows:

"Electrical oscillations are set up in the circuit which persist or are maintained for a long time in the primary circuit."

This in effect states that there must not be permitted any too early unnecessary stopping or interference with the oscillations in the primary circuit; they must persist or be maintained for a long time. This has bearing upon what the spark gap must be, for if it is not correctly or properly designed, it will return to the inactive high resistance state too early and stop all oscillations in the primary circuit, leaving a residual unexpended charge of electricity in the condenser c, and there will be no real benefit gained by giving this condenser an initial high charge. In addition to the oscillations not being maintained for a long time, the circuit would not be the desired reservoir of energy for the radiating circuit, for with an early cut-off of the gap, the residual charge of electricity stowed in the condenser c could not be made available to the radiating circuit. It only is made available through the motion of the electrical energy, as when in motion it passes through the primary coil of the oscillation transformer to create a magnetic field, and it is from this magnetic field that the secondary circuit gathers its energy for radiation.

Some of the features of construction determining whether the spark gaps will close or become inactive early, or remain active for a long time, are (1) length of the gap, (2) nature of the materials forming the gap electrodes, (3) shape of the gap electrodes, (4) atmosphere between the electrodes, and (5) cooling the electrodes.

As to gap length, this is best understood by considering the nature of the oscillations, and the current magnitude accompanying the oscillations. First, the current flows in one direction, gradually building up until it becomes a maximum. Then the current begins to subside until it reaches a zero, or no value, there being no current at all. Then the current proceeds to flow in the opposite direction building up to a maximum, followed by a subsiding to no value, and this cycle of events repeats itself, the maximum amplitude of the current always being a little less for each successive oscillation on account of the energy given to the radiating circuit and the energy expended in losses. The oscillations are extremely rapid, the ordinary spark radio transmission being of the order of half a million per second. There are two periods of no current value for each cycle of events, so that for one-half million cycles per second, there will be one million instances of no current value. The instances

of no current value of course are a very small part of the duration of a cycle of events, so that in one-half million cycles per second the duration of the instant of no current value would be figured in the order of one-billionth of a second. If the gap is going to be deionized and become inactive it must do so during the time that no current is flowing, and of course must be extremely quick in accomplishing this in the very short interval of time that it has. When the current reaches its zero value some of the electrons and ions are left near the center of the gap space, and if these ions and electrons can get to the electrode before the current commences in the opposite direction there will be no ionized path for the new current to start on and the gap will remain inactive. If the gap length is short the electrons and [fol. 724] ions may succeed in accomplishing this, but if the gap length is long they cannot travel the distance in the very short interval of time available. Therefore, persistency or maintenance of oscillations for a long time depends upon length of gap.

As to nature of material forming the gap electrode, I have pointed out that certain materials such as tin and zinc vaporize and furnish metallic vapor to the atmosphere in the gap. The atoms of these metallic vapors are much heavier than the atoms of gases such as hydrogen and air, and therefore under the same moving force travel at a much lower rate. Ionized atoms of such vapors left near the center of the gap have much less chance of reaching the gap electrodes during the minutely small interval of no current than have ionized atoms of light gases. The material of electrodes therefore plays an important part in maintaining the oscillations for a long time, and zinc has been a very common material for the electrodes.

As to the shape of the gap electrodes, the greater the extent of the surface of the electrode the better the opportunity the ionized atoms in the path have for reaching the electrodes, as there will be many paths of entrance towards the electrodes instead of all trying to crowd into one point of entrance as would be the case in pointed electrodes. While electrodes of large extent are desirable for low resistance, they aid in causing an early opening of the gap, and for this reason the early art adapted a sort of compromise in this particular arrangement. The gap electrodes were neither pointed or of very large extent.

As to atmosphere between the electrodes, I have already stated the beneficial effects of metallic vapors over lighter gases, and have pointed out the use of vaporizing material for the electrodes. Light gases like hydrogen or helium have atoms of small mass or weight which would travel very rapidly to the electrodes as compared to air, the atomic weight of air being some sixteen times that of hydrogen and a number of times that of helium. It has been common in the practice to use these gaps in air, from which use they derived the name of "open gap," so generally applied to them.

As to cooling of the electrodes, I have pointed out that heat is necessary for generating the metallic vapors, which are beneficial for maintaining the gap active for a long time. In the use of these open gaps, the art has not resorted to cooling means, except where very large power is used, resulting in too rapid a consumption of the gap electrodes. The heat is also beneficial from another point of view. Heated bodies throw off electrons, and with electrodes heated during the period of no current flow, the heated electrodes continue to throw electrons out into the gap space, leaving some electrons available to start the new current flowing.

I neglected to include in the list above deionization by artificial diffusion, such as a magnetic blow-out. A magnetic blow-out will greatly aid in clearing the path between the electrodes of ionized atoms during the interval of no current, and such deionization would aid in rendering the gap inactive and stopping oscillation. No such devices have been adopted by the art.

[fol. 725] I have prepared a number of sketches in which I explain the manner in which coupling between two oscillatory electrical circuits may be obtained, the effect of various types of coupling upon the frequency of the oscillations and also the effect of making the time period of each of the two circuits considered independently the same—that is, making the product of the capacity and self-inductance of each of the two circuits the same. In these sketches I have used colors to represent in the various figures different frequencies. I have selected purple to represent the desired frequency for localizing radio signals at a receiving station. I have selected red and green to represent the two coupling frequencies obtained when the coupling is close, red rep-

resenting the coupling frequency which is greater than that of the desired frequency and green representing the coupling frequency which is less than that of the desired frequency.

In the practical application of radio to communication both for short distances and long distances it is necessary to assign different frequencies to different types of communication in order to minimize interference and in order that receiving stations may know how to adjust their receivers when expecting a communication from a transmitting station required by the rules to transmit on a particular frequency.

Until the last year or so it was common to state these assignments in terms of wave length rather than frequency, but the tendency now is to state the assignment in terms of frequency, the unit being kilocycles, which is 1,000 cycles per second. The range of frequencies employed in modern radio is very wide; for instance, amateurs are restricted to a frequency in the neighborhood of one and a half million cycles per second, or 1,500 kilocycles, which in the old way of stating the assignment was a wave length of 200 meters, while the Lafayette radio station in France, the highest powered radio station in the world and the one employing the lowest frequency, has a frequency of about 15,000 per second, or 15 kilocycles, which in the old way of stating the assignment, was a wave length of about 20,000 meters. The intermediate frequencies between these two extremes are assigned for various purposes such as the popular broadcasting of to-day, communication between ships and shore stations, communications for the operation of radiocompass stations, giving bearings to ships at sea, the transmission of time and weather reports, communication between land stations and air craft, naval and military communications, short-distance point to point traffic between stations on land, and transoceanic communication for international use.

It is therefore seen that frequency is a *vital* characteristic in radio communication, and the great problem of the world to-day is that there are not sufficient frequencies to meet all of the requirements. International conferences have been held and future ones planned in the hope that through common understanding and agreement the frequencies so far made available through the development of the art up to date may be the most efficiently utilized.

[fol. 726] It has always been particularly important in the practice of the art that a station when assigned a particular frequency should be able to create that frequency and should minimize to the greatest extent interferences with other frequencies due to impure wave forms and the like.

In my sketch marked "Loftin Sketch F" I have shown in Figure 1 a generator of high-frequency electrical currents or oscillations, the same as that described by the Marconi patent in suit, it being the lateral circuit of the Marconi transmitter illustrated in Figure 1 of the drawing of the patent. The generator A, which is the source of energy supply for the transmitter, is shown as an alternating current dynamo, and in ordinary practice would generate alternating current of from 60 to 500 cycles per second at a voltage of from 110 to 220 volts. The transformer C is an ordinary type suitable for stepping up the voltage from a comparatively low-frequency source to 10,000 to 25,000 volts, providing a high-voltage low-frequency source of supply for charging the condenser *e* with a quantity of electricity. The spark gap G is adjusted in length such that when the condenser E obtains a charge of electricity that will raise the pressure to 10,000 to 25,000 volts the gap will break down and allow high-frequency electrical currents or oscillations to take place in the circuit comprising the condenser *e*, the inductance coil *d*, and the spark gap G. Since this oscillatory circuit is not associated with any other circuit, the oscillations therein will be on one frequency, this frequency being determined by the product of the capacity of the condenser *e*, and the inductance of the coil of wire *d*. The mathematical formula for this relation between frequency and product of capacity and inductance is old, having been developed considerably prior to Marconi's work in radio, as I have pointed out in my discussion of the Lodge patent here in suit, and is as follows:

$$N = \frac{1}{2\pi\sqrt{LC}}$$

where N represents frequency, L inductance, C capacity, and π has the numerical value 3.1416. This formula is known to every worker in the radio art, but I refer to Wireless Telegraphy, by Zenneck, as translated by Seelig, 1915 edition, published by McGraw-Hill Book Co. (Inc.), New

York, in which on page 5 this formula is stated. Professor Zanneck, of Germany, the author of the publication, is accepted internationally as one of the leading authorities on the subject.

The oscillations of one frequency in the circuit of Figure 1 of my sketch F, passing through the coil *d* will create a magnetic field surrounding the coil of the same frequency of oscillation, and I have indicated such a magnetic field by a series of lines in purple, as representative of the so-called magnetic lines of force existing in such a field. I have illustrated these lines in purple because the circuit being uninfluenced by association with any other circuit, adjustment can be obtained such that there will be but one frequency, and this can be made the desired frequency or frequency assigned to the transmitting station. In Figure 1*a* I have made a view looking down through the coil *d* to illustrate how the lines of force of the magnetic field originate within the coil and extend radially in all directions.
[fol. 727] In Figure 2 of sketch F I have shown the effect of associating an oscillatory circuit such as illustrated in Figure 1 with another circuit through an interlinkage of coil *d* with a coil *d'* in the second circuit. The second circuit is illustrated as including an elevated conductor *f*, grounded to earth at E, as in Figure 1 of the Marconi patent. The two coils are shown in very close relation, the turns of one coil interleaving with the turns of the other coil, which would result in a very close or tight coupling, and would be the same as the two-pendulum system I have heretofore described when the two pendulums are interlinked through a large rubber band. I have explained that any two systems interlinked through a tight coupling will not result in oscillations of one frequency, but there will be oscillations of two frequencies, one being higher than the desired frequency and one being lower than the desired frequency. The magnetic field produced by the oscillations with two frequencies will also have two frequencies, and I have illustrated this by the red and green lines representative of the so-called lines of force of the magnetic field in the coils *d* and *d'*. Since the energy of the oscillations is divided between two frequencies, it can not be as strong in either one as it would be in the case of a single frequency as obtained in Figure 1, and I have indicated this roughly by making the extent of the red and green magnetic field

in Figure 2 less than the one-frequency purple magnetic field in Figure 1.

In Figure 3*a* I have shown a view looking through or down upon the coils D and D'. This view shows that practically all of the magnetic lines of force interlink both coils, and since the degree of coupling or tightness depends upon how many of the lines of force originating in one coil interlink with the other coil, this figure illustrates a very tight coupling.

Figure 3 is a modification of Figure 2, showing the coil *d'* somewhat separated from the coil *d*. Under such circumstances there could still be what in practice may be considered a tight coupling, as a great many of the lines of force originating in the coil *d* interlink or cut the coil *d'*. There would still result two decided frequencies of oscillation, and therefore two frequencies in the magnetic field, and I have illustrated this by coloring the lines of force of the magnetic field with red and green.

Figure 3*a* is a view looking through or down upon the coils *d* and *d'* of Figure 3, and shows how many of the lines of force of the coil *d* do not pass through or cut the coil *d'*, resulting in a much weaker coupling than that illustrated in Figure 2. The two frequencies resulting from the arrangement shown in Figure 3, would not be so widely separated in frequency as in the case of Figure 2.

The production of these two coupling frequencies is also subject to mathematical expression thus:

$$N^1 = \frac{N}{\sqrt{1 - K}}$$

$$N^2 = \frac{N}{\sqrt{1 + K}}$$

where N^1 is the frequency above the desired frequency, which I have indicated by red lines in my figures, N^2 is the [fol. 728] frequency below the desired frequency, which I have indicated by green lines in my figures, N is the desired frequency, or frequency that would be had by one circuit uninfluenced by the other, which I have indicated by purple lines in my figures, and K is a quantity representing the degree of coupling or interlinkage between the two circuits. K is the percentage of the total number of lines of force produced interlinking with the second circuit, and is expressed in percentage such as 20 per cent, 50 per cent,

3 per cent, and so on. In Figure 2 the interlinkage is large, so that the percentage representing K would be large. Perfect or 100 per cent coupling between electrical circuits is impossible, no matter what precautions are taken, as many of the lines of force concentrate close to the surface of the wire making up a coil, and since the turns of the wire must be somewhat separated to provide for insulation to prevent sparking, many of the lines of force escape in this insulating space without cutting the other coil. Couplings up in the 90 per cent are obtained in low-frequency transformers where iron cores are used to concentrate the magnetic field to one path, but in high-frequency circuits having no iron cores this high order of couplings is never obtained. Figure 3 well illustrates that the percentage value of K is fairly small, only a small percentage of the lines of force originating in the coils D, cutting the coil *d'*.

The two formulae in the mathematical expression above show that there will be two frequencies under conditions of coupling which will vary from the desired or no coupling frequency by an amount depending upon the square root of 1 plus or minus the percentage of the coupling. As an example, let it be assumed that the desired frequency is 1,000 kilocycles per second, then these formulæ state that if the coupling is 20 per cent, instead of having a frequency of 1,000 kilocycles per second, there will be two frequencies, one of 1,112 kilocycles per second and the other of 913 kilocycles per second, which is a separation of 200 cycles. On the other hand, if the coupling is loose, say 3 per cent, there will result two frequencies very close together—1,015 kilocycles per second and 986 kilocycles per second, a total difference of 29 kilocycles. In the case of the 20 per cent coupling, a practical radio receiver will differentiate between the two coupling frequencies. In the case of the 3 per cent coupling, it will require an unusual receiver to differentiate between these two frequencies. The result is that for a coupling of 3 per cent there could for all practical purposes be considered to exist but one frequency, the average of the two frequencies, namely, 1,000 kilocycles per second. For the 20 per cent coupling practical apparatus would require dealing with two frequencies.

The formulæ I have stated above are also found in the Zenneck book I have just previously referred to, being the formulæ stated at page 88, article 59.

In Figure 4 of my sketch F, I have illustrated the coils *d d'* of the two circuits as widely separated, so that only a very few of the magnetic lines of force originating in the coil *d* interlink with the link *d'*, resulting in a very loose coupling, so that for all practical purposes there may be [fol. 729] considered to be but one frequency, which I have illustrated by indicating the magnetic lines of force in purple. In the actual example above I have shown that if the interlinkage is such as to result in a coupling of 3 per cent, for all practical purposes there may be considered to be but one frequency.

In Figure 4*a* I have shown a view of coils *d* and *d'* of Figure 4, looking through the coils. The figure shows how, with the wide separation of the coils, there results a very small interlinkage of the two circuits as compared to Figure 3*a*, in which the coils are located close together.

In Figure 5 I have shown how loose couplings may be obtained by means other than separation of the coils of the oscillation transformer. In this figure the inductance of the two circuits is divided into two parts, part of the inductance in the lateral circuit being included in coil *d* and part in the coil *g'*. In the elevated conductor circuit part of the inductance is located in the coil *d'* and part in the coil *g*. In an arrangement of this kind the energy of the magnetic field is distributed over the several inductances in proportion to the inductance value of each of the coils. The only interlinkage between the two circuits is through the magnetic field of the coil *d*, and since this field is only a fraction of the total field, a large part of it being in the field of coil *g'*, the interlinkage between the two circuits is small. With this arrangement there may result such a loose coupling that for all practical purposes there may be considered to be but one frequency, and I have illustrated this by representing the magnetic lines of force of the several fields in purple.

In my sketch marked "Loftin Sketch G" I have illustrated some of the effects of coupling, using as before purple to represent the desired frequency, red to represent the coupling frequency above the desired frequency, and green to represent the coupling frequency below the desired frequency. I have also numbered the figures to correspond to the conditions illustrated in my sketch F.

Figure 1 represents the alternating current curve of the low-frequency dynamo in Figure 1 of sketch F, and I have

illustrated this curve in blue to differentiate from the colors I have already used for the high frequencies. As the current from the dynamo *a* reaches a maximum, such as near the point *x* on the blue curve, the condenser *e* is fully charged, and the spark gap *g* breaks down. There results oscillations of one frequency in the lateral oscillating circuit of Figure 1 of my sketch F, which I have illustrated as a train of oscillations in Figure 1*a* of sketch G. The strength of the oscillation is represented by the purple wave lines above and below the horizontal line, the portions above the horizontal line showing that the current first flows in one direction, and the portions below the horizontal line showing that the current next flows in the opposite direction, and so on. The train is shown as having strong oscillations to begin with, the oscillations gradually decreasing in strength as the energy is expended.

I have shown the blue curve representing the dynamo current in broken line from the point *x* to *y*, this on account of this current not following this line after the spark gap *g* breaks down. When the spark gap *g* breaks down, the current from the dynamo *a* immediately falls in value, and does not return to its normal form until the spark gap be- [fol. 730] comes inactive. I have shown the train of oscillations in Figure 1*a* as extending beyond the point *y* on the blue curve merely on account of space conditions on the drawing sheet. In actual practice, the train of oscillations ceases before the point *y* is reached, but to have illustrated this would have made it necessary to have crowded the oscillations into small space, making it difficult to illustrate them.

The current of the dynamo *a* is shown to commence building up in the opposite direction at the point *y* and to increase to a maximum to the point *z*, where the condenser *e* is fully charged in the opposite sense. The spark gap again breaks down and another train of high-frequency oscillations is created, this time the oscillations starting in the opposite direction from that illustrated in the first train, this on account of the condenser being charged in an opposite sense by the reversal of the current from the dynamo *a*. The blue curve illustrates the two maxima reached by the dynamo current during one cycle of events, and Figure 1*q* shows that there are two trains of oscillation created for each cycle of the dynamo *a*. That is, if the

dynamo *a* has 500 cycles per second, there will be generated or created 1,000 trains of oscillation per second.

I have illustrated the trains of oscillation in Figure 1*a* in purple, or of the desired frequency, as Figure 1 of sketch F shows a single circuit uninfluenced through association with any other circuit, and therefore a generator of but one frequency.

Figures 2, 2*a*, and 2*b* of my sketch G illustrate the conditions encountered under tight coupling as illustrated in Figures 2 and 3 of my sketch F. Figure 2 represents the oscillations in the lateral circuit and Figure 2*a* the oscillations in the antenna or elevated conductor circuit derived from the interlinkage of the two circuits. The figures also include the assumption that the products of capacity and self-inductance of the two circuits is the same. I have described how, under conditions of tight coupling, there results two frequencies, and so have illustrated the oscillations in both circuits in red and green. I have not shown the oscillations as extending as far above and below the line in these figures as in the case of Figure 1*a*, this on account of the energy being distributed between the two frequencies with the result that it will not be as strong in either one as it will be when there is but one frequency.

I have explained in connection with two pendulums connected by a large rubber band—that is, tightly coupled—that the energy of the first pendulum is gradually absorbed by the second pendulum, is given back to the first pendulum by the second pendulum, and so on. I have also explained that this action takes place in all coupled systems including electrical circuits. Examining Figure 2 it will be seen that the oscillations start strong but soon die down to practically zero at the point I have marked *p*. Examining Figure 2*a* it will be seen that the oscillations at first are weak, and gradually build up to a maximum at the point *p'* opposite the point *p*, or point of minimum energy in the lateral circuit. The antenna circuit having all of the energy at the point *p'* then gives back energy to the lateral circuit until at the point *q'* there is little or no energy in the antenna circuit and there is a maximum at the point *q* in the lateral circuit. This process continues on with the energy shifting from one circuit to the other, but always with two frequencies of oscillation, until all of the energy is ex- [fol. 731] pended, both by losses in both of the circuits and by radiation for signalling from the antenna circuit. At

some point in Figure 2 the spark gap *g* will become inactive, there being no longer sufficient energy to support ionization. There remains a small quantity of energy in the antenna circuit which will continue to oscillate, but since the lateral circuit is open and can not take energy from the antenna circuit to create two frequencies, the rest of the energy in the antenna circuit will oscillate at the natural frequency of the antenna circuit, which is the desired frequency under the conditions I have assume- of the product of capacity and induction being the same in both circuits. I have represented in purple at the end of Figure 2*a* the continuation of the oscillations at the desired frequency.

In Figure 2*b* I have plotted roughly the results on the energy radiated into space of coupling conditions creating oscillations of the type represented by Figures 2 and 2*a*. Horizontal dimensions represent frequency and vertical dimensions represent signal strength. The curve in green represents the signal strength radiated due to the coupling frequency less than the desired frequency. The curve in red represents the signal strength radiated by the coupling frequency greater than the desired frequency. The little curve between the red and green represents the signal strength radiated by the small amount of energy remaining in the antenna circuit when the spark gap becomes inactive, and this being of the desired frequency, is shown in purple. The figure shows that under conditions of tight coupling the energy radiated on the desired frequency is so small as to be of no practical value, while energy is radiated on two coupling frequencies quite strong.

The summary of this figure is that a receiver expecting to receive this transmitting station on a definite frequency and so adjusted would not hear the signal while receivers adjusted to hear transmitting stations assigned frequencies corresponding to the two coupling frequencies would hear the transmitter so strong as to be greatly interfered with in the matter of receiving their own communications. This, of course, is not localizing communication and making it possible to receive signals to the exclusion of other communications.

Neither does this arrangement involving tight coupling provide for efficiency from any point of view that efficiency can be considered. The figure shows that the energy of the waves radiated into space is distributed

among three different frequencies, and under such distribution there can be no efficient use of the energy.

I have quoted the statement of objects of the Marconi invention from the specification of the patent in suit as being obtaining efficiency and localizing communication. From my discussion above as to the effects of tight coupling it is quite apparent that the Marconi system did not include tight coupling—that tight coupling actually prevents obtaining the stated object.

[fol. 732] I have pointed out that the Marconi reference to efficiency did not make clear the specific form of efficiency sought, but after a consideration of the effects of coupling as I have discussed them, it begins to become clear that Marconi had in mind a particular kind of efficiency obtainable through concentrating the energy in the transmitting waves into one frequency.

I have mathematically shown that with a 20 per cent coupling between the two circuits the desired frequency of 1,000 kilocycles is not obtained, but that two coupling frequencies, one having the frequency of 1,112 kilocycles and another having a frequency of 913 kilocycles, are obtained. It may be well to consider here the practical effect of such communication upon radio practice. I have shown how different frequencies are assigned for different uses, and let it be supposed that the 1,000 kilocycle frequency is assigned for communication between ships and shore, 900 cycles for communication between seaplanes and coastal stations, and 1,100 cycles for communication between ships and radiocompass stations on shore. Under such circumstances it is apparent that if the ship to shore station instead of transmitting a frequency of 1,000 kilocycles as assigned, actually produces two coupling frequencies, one of 913 kilocycles and the other of 1,112 kilocycles, instead of successfully carrying on its own communications, it will amount merely to a double interfering agency annoying both the seaplanes and the radiocompass stations.

I will next endeavor to make clear the particular manner in which it is evident to me Marconi proposed to obtain efficiency and localizing of communication, employing a number of figures embodied in a sketch which I have made, marked "Loftin Sketch H." I have given the figures in this sketch, numbers corresponding to the figure numbers in my sketch F for the circuits, making it possible for

Marconi to secure the desired result, and these are the loosely coupled circuits of Figures 4 and 5 of my sketch F.

Figure 4 of my sketch H represents the long-drawn-out train of oscillations in the lateral circuit of Figure 4 of sketch F, which it is possible to obtain when the coupling with the elevated conductor circuit or antenna is loose, and when the spark gap is designed as I have previously described to permit of conserving the energy and drawing it out for a long time. I have shown these oscillations in purple because the coupling is so loose as to have the two coupling waves so close together in frequency as to result for all practical purposes in but a single frequency. The oscillations are shown as commencing quite strong with a large supply of energy available in the condenser c and gradually reducing in strength as the energy is transferred to the elevated conductor circuit or is wasted through unavoidable losses. The figure shows that the train of oscillations is uninterrupted by periods of no energy in the lateral circuit as was the case with tight coupling, the energy never being entirely transferred to the lateral circuit.

Figure 4*a* shows the oscillations in the antenna circuit resulting from the energy derived from the oscillations in the lateral circuit. I have assumed for the purpose of discussion and illustration that the capacity and self-inductance of the antenna have such values as to give them a product different from the product of the inductance and capacity of the lateral circuit, and I have assumed that the [fol. 733] product in the antenna circuit is less than the product of the lateral circuit—that is, that the natural frequency of electrical vibration of the antenna circuit is greater than the natural frequency of the lateral circuit.

Under such conditions, the oscillations of the lateral circuit will transfer energy to the elevated conductor circuit so that the energy will oscillate at the same frequency that it is received in part only, for some of the energy will take up another frequency, that of the natural frequency of the antenna circuit. The oscillations having the same frequency as that of the lateral circuit are termed "forced oscillations." This means that there are no conditions in the antenna circuit supporting oscillations at this frequency, but since the energy is fed into the elevated conductor circuit a little at a time at a definite frequency, some of the energy is forced to maintain or act at the frequency from

which it is derived. I have illustrated this energy in purple, because it is of the desired frequency or pace set by the lateral circuit, which is adjusted to give the desired frequency. Examination of Figure 4*a* shows that the energy of the desired frequency in the antenna circuit is first small, but gradually builds up in strength as more energy is received from the lateral circuit, the rate of transfer being such that the energy received more than makes up for the energy radiated or unavoidably wasted. The figure shows after reaching a maximum the strength of the oscillations begin a decrease; this meaning that the lateral circuit can no longer supply energy in excess of that radiated and lost.

I have also shown in Figure 4*a* a train of oscillations in red, this representing that part of the energy in the antenna circuit takes up oscillating at the natural frequency of the circuit. These oscillations are shown to be less in strength than the desired oscillations in purple. The relation between the strength of the two oscillations will depend largely upon the resistance of the antenna circuit. At the point *x* opposite the point of Figure 4 illustrating the oscillations in the lateral circuit where the oscillations cease I have shown that the red and purple oscillations combine and continue on as red oscillations; that is, at the frequency of the antenna circuit. This means that the spark gap in the lateral circuit having become inactive and the lateral circuit no longer supplies the energy to the antenna circuit to force the oscillations to be largely maintained at the frequency of the lateral circuit, the energy then is left free to take up the natural period of vibration of the antenna circuit.

In Figure 4*b* of sketch H I have plotted the results of an arrangement of the kind of Figure 4 of sketch F, where I have assumed that the antenna circuit has a product of capacity and inductance different from that of the lateral circuit, giving oscillations of the kind illustrated in Figures 4 and 4*a* of sketch H. In Figure 4*b* the vertical dimensions represent signal strength and horizontal dimensions represent frequency. This figure shows that the oscillations in the antenna circuit of Figure 4*a* give a fairly strong signal of the desired frequency, the curve representing this being in purple. The small curve to the right in red shows that [fol. 734] the energy in the antenna circuit which takes up the natural frequency of the antenna circuit gives a signal of less intensity than that of the desired frequency.

This Figure 4*b* shows that with loose coupling the object of Marconi of localizing communication and of obtaining efficiency is better realized than under the conditions of tight coupling, most of the energy being concentrated in a frequency which is the desired one. It shows, however, that with the two circuits not carefully adjusted to have their products of capacity and self-inductance the same, there will result a second frequency which will require useless expenditure of some energy. In the discussion of the Lodge patent in suit it was pointed out that Lodge laid great stress on obtaining two conditions for a good resonant transfer of energy between two circuits; (1) obtaining a train of oscillations of long duration; (2) tuning the two circuits together; that is, making their products of self-induction and capacity the same. It is not to be expected that Marconi, after the teachings of Lodge, was satisfied with merely getting a long-drawn-out train of waves. We find in the Marconi specification that having prescribed persistent oscillation or maintenance of oscillation for a long time, he then sets forth the second step of Lodge, that of tuning, and thus avoided obtaining a second frequency as illustrated in Figures 4*a* and 4*b* of sketch H.

In the next group of figures of sketch H, Figures 5, 5*a*, and 5*b*, I show the results obtained by using both the loose coupling and making the products of self-inductance and capacity the same, as described by Marconi. Figure 5 shows the oscillations in the lateral circuit the same in character as Figure 4, the circuits being loosely coupled, permitting the lateral circuit oscillations to be substantially of one frequency character, this being illustrated by making the oscillations in purple. Figure 5*a* illustrates the oscillations in the antenna or elevated conductor circuit, and since the elevated conductor circuit has the same natural period or frequency as the oscillations in the lateral circuit, there is no tendency for another group of oscillations to build up, as in Figure 4*a*. The forced oscillations and the natural frequency oscillations are the same and they therefore join to give a one frequency oscillation of greater strength than either one of the oscillations in Figure 4*a*. This I have roughly illustrated by making the extent of the oscillations above the horizontal line in Figure 5*a* greater than in Figure 4*a*.

In Figure 5*b* the result of the one-frequency waves radiated from the antenna or elevated conductor circuit is

shown. As before, signal strength is represented by vertical dimensions and frequency by horizontal dimensions. The one curve in purple shows that signals of but one frequency are radiated. Since all of the energy of radiation is concentrated in this one frequency, it is quite natural that the signals on this one frequency should be stronger than when the energy is divided among several frequencies. I have roughly indicated this by making the curve in Figure 5*b* somewhat higher than the curves in Figure 2*b* and in Figure 4*b*.

Here, then, is the system of Marconi obtaining his two objects; first, localizing signals by concentrating the energy in one long-drawn-out train of oscillations of but one and the desired frequency, and, second, efficiency by concentrating all of the radiated energy into oscillations of but a single frequency.

[fol. 735] The desired result is obtained, first, by creating oscillations in a lateral circuit; second, by making the lateral circuit a good conserver of energy—not unreasonably wasteful; third, causing the oscillations in the lateral circuit to persist or be maintained for a long time—that is, having provided for conserving its energy not to cease slowly feeding energy to the antenna circuit unnecessarily early; fourth, slowly feeding energy into the antenna through a coupling sufficiently loose as not to disturb the frequency of the oscillations in the lateral pace-setting circuit to any practical extent; and, fifth, to adjust the antenna or good radiating circuit to have a natural period the same as the frequency period of the oscillations in the lateral circuit—that is, to get the resonant transfer of energy described by Lodge.

I find that the effect of closely coupled oscillating circuits on each other is well discussed by Zenneck in the 1915 edition of the book I have previously referred to from pages 87 to 93, inclusive. On page 89, Figure 124, Zenneck shows actual oscillograms of the current in coupled circuits corresponding to Figures 2 and 2*a* of my sketch G. The figure does not make clear that there are two oscillations of different frequency corresponding to the red and green oscillations of my figure. The oscillations are so rapid that there is no known instrument which would differentiate between the two for photographic purposes. The Zenneck figure does show very clearly that the energy is alternately transferred from one circuit to the other, being a maximum in one

circuit when practically nil in the other circuit. Examination of the figure shows that the lobes of maximum energy in one circuit are opposite the blanks or no energy spaces in the other circuit. Figure 125 on page 89 of the Zenneck book shows the same information obtained by photographing the sparks passing through spark gaps in the circuit. This figure clearly shows that energy is transferred from one circuit to the other, the gaps of no energy in one circuit being opposite those of maximum energy in the other circuit.

On page 94 of the Zenneck book, Figure 130, there is illustrated diagrammatically the alternate transfer of the energy between the two circuits similar to my Figures 2 and 2*a* of sketch G. Zenneck has made no effort to show that there are two frequencies in each of the circuits corresponding to my red and green, the purpose of the figure being merely to show that the energy is first all in one circuit and then in the other circuit, as represented by the high and low points in the two figures of the diagram marked "Primary circuit" and "Secondary circuit."

Pages 84 to 87 of the Zenneck book consider the matter of loose coupling between two oscillatory circuits. At the middle of page 85 Zenneck states:

"In our conception of very loose coupling, the oscillations in the primary circuit remain practically unaffected by the coupling with the secondary circuit. In the secondary there are produced in general, two distinct oscillations:

"1. One having the same frequency and damping as the oscillation of the primary—the so-called "forced" or "impressed oscillation."

"2. The other having the characteristic frequency and damping of the secondary circuit—the "free" or "natural oscillation."

[fol. 736] This quotation is a statement of what I have illstrated in Figures 4, 4*a*, and 4*b* of my sketch H. Zenneck states that under conditions of very loose coupling the oscillations in the primary circuit (the circuit which I have termed "lateral") are practically unaffected by the coupling with the secondary or elevated conductor circuit. I have illustrated this by making the oscillations in purple to represent one frequency. Zenneck then says that there are two distinct oscillations in the secondary or elevated

conductor circuit, one having the same frequency as the oscillations in the lateral circuit and one having the characteristic frequency of the elevated conductor circuit, which I have illustrated in Figure 4*a* by the purple and red oscillations.

At the bottom of page 85 Zenneck further states:

"*b*. The amplitudes of both the forced and natural oscillations become a maximum when the natural frequency of both primary and secondary circuits is the same, i. e., when the two circuits are "tuned" or "in resonance". Then the forced and natural oscillations have the same frequency and may be considered as constituting a single oscillation."

This last quotation is in language exactly what I have illustrated in my Figures 5, 5*a*, and 5*b* of sketch H. Figure 5*a* shows that when the secondary circuit has its natural frequency the same as that of the oscillations of the primary circuit; that is, has its product of inductance and capacity so adjusted as to be the same as the primary circuit, the forced and natural oscillations then combine to form a single frequency of oscillations of maximum intensity.

Having considered the Marconi invention from the point of view of the statement thereof in the specification, I will next proceed with particular reference to the subject matter set forth in the claims enumerated in the question. I find that claims 1, 3, 6, 8, 11, and 12 relate to the transmitting station. That claims 2, 13, 14, 16, 17, 18, and 19 to the receiving station, and claims 10 and 20 relate to both stations. I will take up these claims in the three groups, claim by claim, in each group, commencing first with the transmitting station claims. Claim 1 reads as follows:

"1. At a station employed in a wireless-telegraph system, a signaling instrument comprising an induction-coil, the secondary circuit of which includes a condenser discharging through a means which automatically causes oscillations of the desired frequency; an open circuit electrically connected with the oscillation-producer aforesaid and a variable inductance included in the open circuit, substantially as and for the purpose described."

This claim specifies the combination of a number of the elements found in Figure 1 of the patent and requires par-

ticular discussion as to one feature, being that part of the claim which reads "discharging through a means which automatically causes oscillations of the desired frequency." This, of course, to an engineer does not mean the spark producer, or spark gap taken by itself, for by itself it is not capable of producing oscillations of any nature. This expression necessarily includes the circuit connected with the spark gap, and requires that the circuit not only be capable of oscillating but must be capable of producing the oscillations at the frequency desired as the signaling frequency for the system in which the transmitter is used. I have shown that a circuit associated with another circuit such as the elevated conductor or antenna of Figure 1 is not capable [fol. 737] of producing oscillations of the desired frequency unless loosely coupled to the second circuit. It is therefore clear that the "means" referred to in claim 1 requires that the lateral circuit and the elevated conductor or open circuit shall be loosely coupled. The claim also provides for a variable inductance in the open circuit. This is for the purpose of adjusting the natural time period of the open circuit to the frequency of the oscillations in the primary circuit.

"Claim 3. At a station employed in a wireless-telegraph system, a signaling instrument comprising an induction-coil, the secondary circuit of which includes a condenser discharging through a means which automatically causes oscillations of the desired frequency, and the primary circuit of which includes a generator; means for varying the primary circuit; an open circuit electrically connected, and a variable inductance included in the open circuit, substantially as and for the purpose described."

This claim also specifies the combination of a number of the elements shown in Figure 1, together with "a means which automatically causes oscillations of the desired frequency," and is therefore clear that this "means," like claim 1, requires loose coupling between the circuits. It differs from claim 1 in the detail of claiming "means for varying the primary circuit." This addition is merely for any well known means to make it possible to vary the frequency of the "desired frequency" in order that the transmitting station should not be limited to a one frequency device. It simply provides for making possible through a well known means for transmitting at different frequencies from time to time as operating circumstances would require.

"Claim 6. At a transmitting station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating-conductor at one end and capacity at the other end, and whose primary is connected to a condenser-circuit discharging through a means which automatically causes oscillations of the desired frequency, and means for adjusting the oscillation period of each of the two circuits connected with the transformer to bring them into accord with each other, substantially as described."

This claim, like claims 1 and 3, includes with the combination of a number of the elements of Figure 1, "a means which automatically causes oscillations of the desired frequency," which therefore makes it clear that this claim includes in the "means" loose coupling between the lateral and elevated conductor circuits. It broadly includes "means for adjusting the oscillation period of each of the two circuits," being any of the then well-known means for varying either capacity or inductance, specifically shown in Figure 1 as a variable condenser c in the lateral circuit and a variable inductance g in the elevated conductor circuit. In this way Marconi provided for a resonant transfer of energy between the two loosely coupled circuits.

"Claim 8. At a transmitting station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating-conductor at one end and capacity at the other end, a variable inductance being included in said circuit, and whose primary is connected to a condenser-circuit dis- [fol. 738] charging through a means which automatically causes oscillations of the desired frequency, substantially as described."

This claim like the foregoing claims specifies the combination of a number of the elements of Figure 1 together with "a means which automatically causes oscillations of the desired frequency," and like the foregoing claims clearly includes in the "means" loose coupling.

"Claim 11. An apparatus for communicating electrical signals, the combination, with an oscillation-transformer, at a transmitting-station, of an induction-coil; an electric circuit containing the secondary of said coil, a condenser and the primary coil of the oscillation-transformer; a pro-

ducer of electric waves of high frequency electrically connected with the secondary of the induction-coil; a signaling instrument in circuit with the primary of the induction-coil; the secondary coil of the oscillation-transformer electrically connected, at one end to capacity and, at the other end, to an inductance, and an aerial conductor connected to the inductance, substantially as and for the purpose described."

This claim requires practically the same combination of the elements of Figure 1 as the foregoing claims, but changes the former language "a means which automatically causes oscillations of the desired frequency" to "a producer of electric waves of high-frequency electrically connected with the secondary of the industance coil." Clearly this expression loosely employs the term "electric waves" for "electric oscillations." The expression requires that the producer be connected with the secondary of the induction coil, and therefore clearly means the primary or lateral circuit. Marconi has carefully explained in his specification that the lateral closed circuit is a poor radiator, and therefore does not effectively produce "electric waves," this being the function ascribed to the elevated conductor or open circuit. The expression "electric wave" generally means the form the energy takes after leaving the radiator and is traveling in space. "Electric oscillations" generally refers to the form of the energy while flowing as alternating current in a circuit. Undoubtedly the expression refers to the electric oscillations of high frequency in the lateral circuit, and undoubtedly has the same meaning as the expression used in the foregoing claims; that is, I understand the expression to mean that the lateral circuit is the producer of the electric oscillations of high frequency for the purpose of exciting the elevated conductor or antenna circuit with oscillations of the desired frequency for communicating electric waves.

Claim 11 makes no reference to adjustment of capacity and inductance of the two circuits. It is a broad claim on the association of two circuits at a transmitting station through an oscillation transformer where a number of specific elements are included in each of the circuits.

"*Claim 12.*—In apparatus for communicating electrical signals, the combination, with an oscillation-transformer,

at a transmitting station, of an induction-coil; an electric circuit containing the secondary of the said coil, a con- [fol. 739] denser and the primary coil of the oscillation transformer; a producer of electric waves of high frequency connected with the secondary of the induction coil; a signaling instrument in circuit with the primary of the induction coil; the secondary coil of the oscillation-transformer electrically connected, at one end to capacity and, at the other end, to a variable inductance, and an aerial conductor connected to the variable inductance, substantially as and for the purpose described."

The only difference between claim 12 and claim 11 is that the former specifies that the inductance in the elevated conductor circuit is "variable." The claim is subject to the same comment as claim 11.

Summarizing the group of transmitting claims above listed, it is to be noted that in no one of the claims does Marconi claim the two circuits actually in resonance. The claims include "means" for adjusting the time periods of the circuit, in some cases naming the specific devices; that is, Marconi only included in his claims the instrumentality for accomplishing the result. Adjusting the time period of circuits was old at the time of the Marconi application, and these claims clearly show that Marconi fully appreciated this and made no claim to two circuits having time periods in accord with each other. He merely included in his claims an enumeration of instrumentalities adapted to conveniently adjust the circuits to secure this relation.

"Receiving Claims

"*Claim 2.*—At a station employed in a wireless-telegraph system, an oscillation-receiving conductor, a variable inductance connected with said conductor; a wave-responsive device electrically connected with said conductor and in circuit with a condenser, substantially as and for the purpose described."

This claim sets forth the combination of a number of the elements of Figure 2 of the patent and in no way makes any suggestion towards the adjustment of time periods of the two circuits at the receiving station or considers the matter of resonance. It amounts to a mere combination of physical elements.

"*Claim 13.*—At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a variable inductance being included in said circuit, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and a condenser in circuit with the wave-responsive device, substantially as described."

Claim 13, like claim 2, merely sets up a combination of a number of elements in Figure 2 of the patent. It adds to the combination of claim 2 the oscillation transformer. Like claim 2, there is no suggestion of adjustment of the time period of the two circuits or reference to the matter of resonance.

"*Claim 14.*—At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and means [fol. 740] for adjusting the two transformer-circuits in electrical resonance with each other, substantially as described."

Claim 14 includes with a combination of the elements of figure 2 of the patent "means for adjusting the two transformer circuits in electrical resonance with each other." It does not claim two circuits "being in resonance," but merely includes a generic way of stating some adjustable means in either one of the circuits, or in both, for adjusting to resonance, if desired. It clearly shows that Marconi appreciated that the art prior to him provided for resonance between two circuits at a receiving station, and made no claim to this condition. The claim here is for the "means" or instrumentality for adjustment in combination with other elements.

"*Claim 16.*—At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-

receiving conductor at one end and capacity at the other end, an adjustable condenser in a shunt connected with the open circuit and around said transformer-coil, a wave-responsive device electrically connected with the other coil of the oscillation-transformer, and means for adjusting the two transformer-circuits in electrical resonance with each other, substantially as described."

This claim is substantially the same as claim 14, being a combination of a number of the elements shown in Figure 2 with "means for adjusting the two transformer-circuits in electrical resonance with each other." There is no requirement that the two circuits shall be in resonance, but merely states generally a "means" or instrumentality for obtaining an adjustment for resonance, if desired, in combination with other elements. The claim differs from claim 14 particularly in including "an adjustable condenser in a shunt connected with the open circuit and around said transformer-coil." This is merely one of numerous ways for obtaining an adjustment of the product of capacity and inductance of a circuit, in this case the adjustment being obtainable through varying the capacity.

"*Claim 17.*—At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a wave-response device electrically connected with the other winding of the oscillation-transformer, and means included in each of said transformer-circuits, for adjusting said circuits in electrical resonance with each other, substantially as described."

This claim, like claims 14 and 16, is for a combination of the elements shown in Figure 2 with "means included in each of said transformer-circuits, for adjusting said circuits in electrical resonance with each other." Like claims 14 and 16, it does not require that the two circuits be in resonance, but merely claims "means" or instrumentalities for accomplishing the result, if desired, in combination with other elements. Its specifically requires that there be means in both circuits.

"*Claim 18.*—At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-

transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end, and capacity at the other end, a vari- [fol. 741] able inductance being included in said open circuit, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and a variable inductance included in circuit with the wave-responsive device, substantially as described."

This claim is merely for a combination of a number of the elements of Figure 2 of the patent and makes no reference whatever to adjustment of the time period of the two circuits or resonance. It merely requires a variable inductance in each of the two circuits in combination with other elements.

"*Claim 19.*—In a system of wireless telegraphy, the combination of a receiving-station, of an oscillation-transformer; an open circuit comprising, in part, an aerial conductor connected with one end of the primary coil of the oscillation-transformer; a connection from the other end of said coil to capacity; a variable inductance in said open circuit; and electrical connections from the secondary coil of the oscillation-transformer to a receiving instrument, battery, condenser, wave-responsive device and a variable inductance, substantially as and for the purpose described."

This claim, like claim 18, is merely for a combination of a number of the elements of Figure 2 of the patent, simply having a few more elements in claim 18. It makes no reference to or suggestion of adjustment of time periods of the two circuits or adjusting the two circuits to resonance.

Summarizing this group of receiver claims, I do not find any requirement by Marconi that the two circuits at the receiving station shall be adjusted to accord in time periods or adjusted to resonance. This clearly shows that Marconi fully appreciated that the art prior to him had disclosed this feature and Marconi made no claim thereto. His claims are for the means or instrumentalities for adjustment in combination with other specific elements.

"Claims Covering Both Stations

"*Claim 10.*—A system of wireless telegraphy, in which the transmitting-station and the receiving station each contains an oscillation transformer, one circuit of which is an open circuit and the other a closed circuit, the two circuits

at each station being in electrical resonance with each other and in electrical resonance with the circuits at the other station, substantially as described."

In this claim Marconi for the first time broadly claims electrical resonance between circuits, the claim requiring that all of the circuits of the system from beginning to end be in resonance. This clearly shows that while Marconi admitted that the prior art included tuning or resonance between the two circuits at a transmitting station and at a receiving station, he considered that he was the first to specify this condition for all four circuits making up two stations and was entitled to broadly claim it in a combination claim.

"*Claim 20.*—In a system of wireless telegraphy, a transmitting-station containing an oscillation-transformer, the primary of which is connected to a condenser-circuit discharging through a spark-gap which automatically causes electric waves of the desired frequency, the secondary of said transformer connected to an open circuit including a radiating-conductor, and with a capacity and a coil for [fol. 742] charging the condenser aforesaid; a receiving-station containing an oscillation-transformer, the primary of which is connected with an oscillation-receiving conductor and with a capacity, a wave-responsive device connected with the secondary of said transformer, and a receiving instrument connected with the wave-responsive device, all in combination with means for bringing the four transformer-circuits, two at each station, into electrical resonance with each other, substantially as described."

This claim is for a combination of the elements shown in both Figures 1 and 2 of the patent together with "means for bringing the four transformer-circuits, two at each station, into electrical, resonance with each other." Like the receiver and transmitter claims, this claim does not require electrical resonance throughout the four circuits, being merely for the "means" or instrumentalities for producing the result, if desired, in combination with other elements.

Summarizing the three groups of claims, it is clear to me that in the transmitter and receiver claims taken by themselves Marconi laid no claim to originality in adjusting the time period of the two circuits at each of the stations to accord or to obtain resonance. In these claims he very clearly shows that he merely considered that he was entitled to

claim the instrumentalities for accomplishing the result in combination with other elements. That when he came to the complete system involving four circuits he had a different view. He clearly considered that in the complete system he was entitled to broadly claim the condition of resonance throughout the system as a whole in spite of the prior are having disclosed transmitting stations having two circuits in accord and receiving stations having two circuits in accord.

* * * * * * *

22. Question. Claimant's witness, Waterman, in his discussion under the title "The characteristics and properties of the oscillatory circuits," commencing at page 145 of his deposition, states as he understands the Marconi specification, it does not say or imply that when the two circuits are associated as shown, the oscillations in the primary or closed circuit persist for a long time or for any particular time. Do you agree with this understanding?

Answer. I do not agree with the understanding of Mr. Waterman that the Marconi specification does not say or imply that when the two circuits are associated as shown, the oscillations in the primary or closed circuit persist for a long time.

At page 145 of the Waterman deposition he quotes from page 2, lines 6 to 24 of the specification, as follows:

"The illustrated arrangement of parts at a transmitting station enables much more energy to be imparted to the radiator *f*, the aproximately closed circuit of the primary being a good conserver and the open circuit of the secondary being a good radiator of wave energy. My experiments have demonstrated that the best results are obtained at the transmitting station when I use a persistent oscillator—an electrical circuit of such a character that if electromotive [fol. 743] force is suddenly applied to it and the current then cut off electrical oscillations are set up in the circuit which persist or are maintained for a long time—in the primary circuit, and use a good radiator—i. e., an electrical circuit which very quickly imparts the energy of electrical oscillations to the surrounding ether in the form of waves—in the secondary circuit."

The first point brought out by this quotation is that the arrangement of two circuits allows much more energy to

be imparted to the radiator *f*, the elevated conductor circuit.

Mr. Waterman in his deposition points out that the ordinary structure of an antenna or elevated conductor circuit prevents obtaining a large capacity, a capacity not nearly so large as is obtainable in a closed lateral circuit where the capacity can be determined by the choice of a condenser rather than upon the structure of the system. Mr. Waterman states that the capacity determines the amount of energy which a circuit can take without reaching excessive voltages or pressures. At the top of page 149 of his deposition, he sums up this matter as follows:

"Hence the amount of energy, and consequently the distance that could be reached with a given wave length by the original Marconi arrangement having the spark gap in the antenna, was limited by the small capacity of the antenna and the low charging pressure that could be applied to it on account of the presence of the spark gap."

The quotation from the specification states that a large amount of energy can be transferred from the lateral circuit to the elevated conductor circuit, but since Mr. Waterman points out that the capacity of the elevated conductor circuit for taking energy is limited, there necessarily results the conclusion that the large amount of energy transferred is not due to a quick or sudden transfer, but results from transferring little energy at a time over a long period of time.

The second requirement of the quoted paragraph of the specification is "the approximately closed circuit of the primary being a good conserver." This requirement has no meaning unless the energy remains long enough in the primary or lateral circuit for conservation. It would make no particular difference if the primary circuit were unreasonably wasteful if the energy only remained for a short time to give the wasteful characteristics an opportunity to act.

The third requirement of the quotation is that the primary or lateral circuit be a "persistent oscillator." This, of course, is very definite language and can only be construed to mean sustaining oscillations that persist or endure for a long time.

The fourth statement is "electrical oscillations are set up in the circuit which persist or are maintained for a long

time—in the primary circuit." I do not see that there can be any doubt as to the meaning of language of this kind, especially when considered in connection with Marconi's stated object of localizing communication. In discussing both the Lodge patent in suit and this Marconi patent in suit, Mr. Waterman and I have pointed out that better localizing, which is better selectivity, is obtainable through a long drawn out train of oscillations rather than through one which quickly dies out.

At page 146 of his deposition Mr. Waterman has quoted, from page 2 of the Marconi specifications, as follows:

[fol. 744] "If the capacity, the inductance and the resistance of the circuit are of suitable values, the discharge is oscillatory, with the result that alternating currents of high frequency pass through the primary of the transformer and induct similar oscillations in the secondary, these oscillations being rapidly radiated in the form of electric waves by the elevated conductor."

The duration of oscillations in a circuit depends upon the relation of the capacity, inductance, and resistance of the circuit, this being expressed mathematically by the well-known formula

$$d = \pi R \sqrt{\frac{C}{L}}$$

in which d is the decrement or measure of the duration of the oscillation, R is the resistance of the circuit, C the capacity of the circuit, and L the inductance of the circuit.

The quotation requires proper adjustment of these values so that there will be high frequency oscillations to induct "similar oscillations" in the secondary. In my sketch G, Figure 2 and Figure 2*a*, I have shown that if the transfer of energy is too quick there will be two frequencies of oscillation not of the desired frequency and therefore there can be no "similar oscillations" of the desired frequency transferred to the secondary circuit.

At the middle of page 147 of his deposition, Mr. Waterman states:

"Marconi says, in the last-quoted paragraph, that the oscillatory character of the circuit is determined by the inductance, capacity, and resistance and the relation is such that a large capacity and small inductance means a very few oscillations."

I do not find that Mr. Marconi said anything about "a very few oscillations" as covered by the latter part of the quotation from Mr. Waterman. I have mathematically shown this relation in the formula immediately preceding.

In the same paragraph from which I have above quoted Mr. Waterman, he states that he has calculated the duration of the oscillations for tune 1 of the table on page 4 of the Marconi specification, and find that there will result only three complete oscillations. I have also calculated the duration of the oscillations, assuming the same conditions as Mr. Waterman; that is, that the wave length is 200 m'ters, stated by Mr. Waterman to have been determined by him, which I assume to be through physical construction of the apparatus, and also assuming a resistance in the spark gap of 1 ohm. My calculation results in a decrement of 0.2 approximately, which gives 24 complete oscillations before falling to 1 per cent of the original value, and I have illustrated this in a sketch marked "Loftin Sketch J."

This decrement of 0.2 is the same as that prescribed by Congress in its act of August 13, 1912, which I have quoted at page 460 of my deposition. The paragraph of the act covering this matter of decrement is entitled "Use of a sharp wave." This means that the use of a decrement of 0.2 will give a wave sufficiently long drawn out or persistent to meet the requirement for selectivity set by Congress.

I have no objection to make to the assumption by Mr. Waterman of a wave length of 200 meters, as this is a matter which can be determined only by construction of the [fol. 745] apparatus following the dimensions given by the Marconi specification. I do object to Mr. Waterman's assumption of a resistance of 1 ohm for the spark gap resistance. This assumption I consider rather excessive, and I refer to the Zenneck book, translated by Selig, previously referred to, page 19, Figure 21, in which there are shown three curves of spark-gap resistance. Reference to these curves show that the spark gap resistances vary from one-tenth of an ohm to 1 ohm, making average conditions in the neighborhood of one-half ohm. If in calculating for the decrement I had used a value of one-half ohm, instead of the 1 ohm assumed by Mr. Waterman, the calculated decrement would be 0.1, instead of 0.2, resulting in a much more prolonged train of oscillations than that shown in my Sketch J. I consider the assumption of 0.5 ohms a much fairer as-

sumption than 1 ohm, and that a decrement of 0.1 more nearly approximates the decrement obtainable in tune 1 of the Marconi table on page 4 of the specification.

At the top of page 148 of the Waterman deposition Mr. Waterman points out that the conditions in the spark gap are also a factor in determining how long the oscillations will persist, a matter in which I have previously explained in great detail. Mr. Waterman summarizes these remarks as follows:

"And hence it quickly results that there is no longer a sufficient pressure in the circuit to cause the spark to jump the gap, and the oscillation of current in the circuit therefore ceases as soon as this condition is reached."

Just previous to making the above-quoted summary Mr. Waterman explained that as the current in the spark gap decreases the voltage required to start current for the next succeeding oscillation is increased, and his statement that there "quickly" results a cessation of oscillations would make it appear that he is setting forth this condition as a very critical one preventing obtaining persistent or maintained oscillations in the lateral circuit of Marconi when using a plain gap. I have explained that once the gap breaks down and becomes active the resistance becomes very low, so that the voltage can fall to a very small value and yet keep an active current flowing across the gap, with the result that the train of oscillations can be long drawn out before the voltage becomes too low to start the current flowing for the next oscillation. While it is true that the smaller the current across the gap, the greater the voltage required for the next succeeding oscillation, this is not a critical condition because the gap resistance becomes so low once the gap is active, that the voltage required to cause current to flow is very small. With the plain or open type of gap the voltage required to maintain oscillations with decreasing current can be made quite small with proper designed gap to prevent unreasonably early deionization of the gap, as I have previously explained in detail. I have pointed out that the roughly described gap of Marconi provided some of the essential elements for maintaining ionization of the gap for a long time, and thereby provide a train of persistent oscillations for slowly feeding energy to the elevated conductor circuit.

In the second paragraph of page 148 of the Waterman deposition Mr. Waterman states at the end of the paragraph as follows:

[fol. 746] "And upon how closely the two circuits are associated, and therefore how rapidly the energy is transferred from one circuit to the other."

This quotation implies that if the two circuits are closely associated there will be a rapid transfer of the energy from the primary or lateral circuit to the elevated conductor circuit, but does not explain that if the circuits are so closely associated as to have a rapid transfer of energy from the lateral circuit to the elevated conductor circuit, that such close association will result in a retransfer of energy from the elevated conductor circuit back to the lateral circuit, resulting in a long drawn out series of oscillations, impure and badly disturbed by this close association, as I have illustrated in Figures 2 and 2*a* of my sketch G.

I am, therefore, of the opinion that Marconi definitely provided for a long drawn out train of oscillations in his lateral circuit to slowly feed energy through loose coupling to an elevated conductor circuit so that the oscillations in the elevated conductor circuit would, through being undisturbed by tight coupling, have the same frequency as the oscillations in the lateral circuit, and would be long drawn out through obtaining a constant feeding of energy from the persistently oscillating lateral circuit.

23. Question. Mr. Waterman, under the title "Current oscillation and energy transfer," at page 151 of his deposition, introduces the sketch marked "Waterman's Sketch 2," illustrating the oscillation of current in the two circuits of a transmitter properly adjusted as described in the specification. Do you agree that the Waterman sketch 2 correctly illustrates the oscillation of current in the two circuits of a transmitter adjusted as described in the specification of the Marconi patent 763772 here in suit?

Answer. I do not consider that the Waterman sketch referred to properly illustrates the oscillations of current in the two circuits of a transmitter adjusted as described in the specification of the Marconi patent 763772 here in suit. The upper set of oscillations of the figure representing the "oscillations of primary circuit" only illustrates four complete oscillations which I consider to be far too few to repre-

sent the condition of persistently or maintained oscillations as required by the Marconi specification. In my sketch J I have illustrated the result of my calculations as to tune 1 on page 4 of the Marconi specification using Mr. Waterman's assumption as to the resistance of the spark gap, which I explained was unnecessarily high. My sketch J shows that even with a high resistance a train of oscillations much longer than that illustrated by Mr. Waterman in his sketch No. 2 is obtained. The oscillations would not be as long drawn out as shown in my sketch J when the primary circuit is feeding energy into the elevated conductor circuit, but as this feeding is slow, the duration of the train would be but slightly reduced, and would be like the arrangement I have shown in Figure 5 of my sketch H.

In the lower half of the sketch marked "Oscillations of secondary circuit," Mr. Waterman shows the oscillations to rapidly build up to an intensity practically the same as that illustrated as the initial intensity of the oscillations of the primary circuit.

Such a condition could only be obtained through the use of a very tight coupling, which would result in the condition [fol. 747] of affairs illustrated in Figures 2 and 2*a* of my sketch G, where the red and green curves show that there are two decided oscillations of widely different frequencies resulting from tight coupling. With tight coupling to get such a rapid transfer of energy into the secondary circuit as illustrated by Mr. Waterman, the oscillations in the primary circuit would not cease at the point *q* as illustrated by Mr. Waterman, but would commence to build up again on energy retransferred from the elevated conductor as illustrated in Figure 2 of my sketch G. This retransfer of energy from the secondary circuit would not permit the gradual fall of intensity of oscillation as shown in the lower half of the sketch, but would result in the oscillation immediately falling to a very low value as shown at the point *q'* in Figure 2*a* of my sketch G, and so on as the energy is shifted from one circuit to the other.

The real conditions in accordance with the Marconi specification in my opinion are illustrated in Figures 5 and 5*a* of my sketch H, in which it will be noted that the oscillations in the lateral circuit continue for a long time after the oscillations in the antenna circuit have reached the maximum; that the maximum values of the oscillations in the antenna circuit are small as compared to the value of the oscillations

at the beginning of oscillations in the lateral circuit, because the coupling is loose and the energy is transferred slowly.

In my sketch marked "Loftin Sketch K," I reproduce in Figure 1 approximately Mr. Waterman's sketch No. 2, and in Figure 2 I illustrate my conception of the oscillations in the two circuits when adjusted as described by the specifications, using approximately the same proportions as illustrated by Mr. Waterman for the oscillations of the primary circuit.

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Referring to Figure 1 of my sketch K, the total area covered by the oscillation of the primary circuit as illustrated by Mr. Waterman represents the total energy in the primary circuit available for transfer to the secondary circuit. The total area covered by the oscillations illustrated by Mr. Waterman in the secondary circuit represents the total energy in that circuit. A casual inspection of the two groups of oscillation shows that Mr. Waterman illustrated energy in the secondary circuit two or three times as great as that available in the primary circuit, which of course is impossible. Only a fraction of the energy can be taken up by the secondary circuit as much is lost in the primary circuit, and this I have illustrated in Figure 2 of my sketch by showing the area of the total oscillations in the secondary circuit considerably less than the area of the total oscillations in the primary circuit.

Mr. Waterman also illustrates the intensity or height of oscillation in the secondary circuit the same as that in the primary circuit. This is a condition which could not even be obtained with 100 per cent coupling between the circuits. Both Mr. Waterman and I have stated that 100 per cent coupling between electrical circuits is an impossibility, and I have pointed out that in the use of high frequencies [fol. 748] where iron core transformers can not be used, that couplings are generally below 50 per cent.

The Waterman illustration is absolutely inconsistent with the Marconi specification. It shows a very short duration of the oscillations in the primary circuit, contrary to the Marconi insistent instructions to have persistent oscillations, maintained for a long time. With the oscillations cut off so early, it would be impossible for the primary circuit to act as a reservoir circuit, conserving energy as specified by Marconi, and slowly feeding it into the secondary circuit at the required frequency.

My illustration in Figure 2 shows a persistent train of oscillations in the primary slowly feeding energy into the secondary circuit. There is no quick transfer of energy with a quick cut-off in the primary circuit as illustrated by Mr. Waterman, nor would any such quick cut-off be possible, as a large amount of energy in the secondary circuit would force a return to the primary circuit causing the oscillations to again build up in the primary, and so on.

The illustration of Mr. Waterman is typical of that usually found in text books illustrative of the action of the "quenched gap" type of transmitter that became known to the radio world a decade after the Marconi invention.

Commencing at the bottom of page 151 of his deposition, Mr. Waterman states as to his sketch No. 2 as follows:

"In this manner, as a result of the resonant relation of the two circuits, energy is first taken in the primary circuit which can not radiate it, and is transferred from that circuit in the form of resonant oscillations set up in the secondary circuit. If the circuits are properly adjusted and also properly associated with one another, this transfer takes place as indicated in the sketch No. 2, the antenna circuit gradually taking over the energy from the primary circuit and then radiating it in this space."

This statement is absolutely unjustified by the conditions illustrated in Mr. Waterman's sketch No. 2. He has shown a transfer of energy so quick that a very tight coupling would be necessary to accomplish the transfer at the rate shown, and there would result two coupling frequencies very widely separated from each other and from the natural frequency of the two circuits. There is and can be no resonant relation between things which differ in frequency, and there are no resonant oscillations transferred to the secondary circuit. The condition would be that illustrated in Figures 2 and 2*a* of my sketch G, which is totally devoid of resonant relation or effects.

24. Question. Mr. Waterman under the heading "Degree of coupling or association of circuits;" at page 152, discusses the effect of looseness of coupling and applies this to his sketch No. 2. Does Mr. Waterman's Figure 2 correctly illustrate his remarks concerning loose coupling?

Answer. Under the heading quoted in the question, Mr. Waterman states that the coupling can not be too close if the results indicated in the sketch No. 2 are to be obtained, and he goes on to show how the Marconi specification pro-

vided for a sufficiently loose coupling. He does not, however, properly indicate a result that would be obtained with loose coupling, his transfer of energy being illustrated as so quick as to be obtainable only through tight coupling. [fol. 749] Mr. Waterman then goes on to explain very much in the same manner as I have already done the ill effects of tight coupling; he mentions the two coupling frequencies and the repeated transfer of energy from one circuit to the other, and the radiation from the antenna circuit of waves of two frequencies instead of the desired frequency. In spite of this, his Figure 2 represents a tight coupling quick transfer of energy, but fails to illustrate any of the ill effects that he says will accompany such transfer.

After enumerating the ill effects which result from tight coupling, Mr. Waterman states at the middle of page 153 of his deposition the following:

"It is important, therefore, in order that the efficient radiation to which the patent refers may be secured that the association between the two circuits should not be so close as to permit the secondary circuit to break down the spark gap by reaction upon it. When the association is a proper one the oscillation of the primary circuit will cease, as shown in Waterman sketch No. 2, as soon as the primary circuit has transferred its energy to the secondary and the more quickly this can be done the better, because the smaller will be the energy consumed in the primary circuit itself and the greater will be the amount remaining to be radiated."

This quotation very properly advises the use of loose coupling in accordance with the Marconi specification, and no order of loose coupling suitable for obtaining the condition set up in the Marconi specification will result in the type of oscillations illustrated in the Waterman sketch No. 2 referred to by Mr. Waterman in the quotation. Mr. Waterman states that when the association is a proper one the oscillations in the primary circuit will cease early as shown in this sketch, but Mr. Waterman neglects to say what this association is. As a matter of fact, the cessation of oscillations in the primary circuit is not determined by the association of the two circuits, but upon spark gap conditions opposed to those which are necessary to secure the long drawn out persistent oscillations in the primary circuit of

the Marconi invention. No open or plain gap of the Marconi type will give the early cut off of energy illustrated by Mr. Waterman in his sketch 2, and there is no foundation for the figure either in the Marconi specification, or in the way that the Marconi apparatus will function under any form of adjustment or association of circuits. The figure is practically the counterpart of that shown in most textbooks as typical of the action of the quenched gap type of radio transmitter which became known to the radio world about 10 years subsequent to the Marconi invention.

The quick transfer of energy and early cut off illustrated by Mr. Waterman takes away from the primary circuit all ability to create oscillations of desired frequency. This creation of oscillations of the desired frequency in the primary circuit of the Marconi arrangement is of extreme importance. It is only through having the oscillations to so originate that the benefit of having all four circuits of the system in resonance is obtained. This feature is so important that it is one of the outstanding elements in the [fol. 750] transmitter claims of the patent, being covered in these claims as "a means which automatically causes oscillations of the desired frequency." As Mr. Waterman has illustrated the oscillations, the desired frequency is not created in the primary circuit, but in the secondary circuit, an idea entirely foreign to the Marconi specification and claims. During the short interval of time in which Mr. Waterman has illustrated oscillations as going on in the primary circuit, there are two widely separated frequencies, neither of them of the desired frequency. He, however, neglects to illustrate this fact.

Mr. Waterman makes the following observation as to the requirement in the Marconi specification that the product of inductance and capacity be adjusted to the same value near the bottom of page 153 of his deposition:

"It will be observed that the resonant relation between the two circuits, as set forth in the patent, is stated in somewhat mathematical terms—that is, as equality of the products of the capacity and the self-inductance in the two circuits. It must not be understood from this that effective operation requires a rigidly or mathematically exact adjustment of the two circuits, nor that the mathematical statement expresses the way of doing it, for neither of these things is true. No mathematically exact or precise equality

between the circuits is realizable in practice, but it is important to the efficient transfer of energy that this equality should be approximately or substantially attained."

I do not agree with Mr. Waterman that this adjustment is not a precise one. For the efficiency and localization of communication desired by Marconi this adjustment is extremely vital and should be made with all the precision that practical apparatus will permit. Referring to my sketch H, Figures 4 and 4*a*, I have shown that unless the two circuits are so adjusted there will result two oscillations, one of the desired frequency termed a "forced oscillation," and one of an undesired frequency which is the "natural oscillation" of the secondary circuit. In addition to the out of adjustment arrangement preventing the best transfer of energy, it also acts to divide the energy which is transferred into two components, one of which is not of the desired frequency and therefore deprives the desired frequency of a part of the total available energy. The apparatus illustrated by Marconi is capable of the desired precision of adjustment, he having shown both variable condensers and inductances, and in order to get the stated object of Marconi he must so adjust the circuits.

25. Question. Mr. Waterman in his answer to question 8, has given his understanding of the meaning of the expressions "tuning," "resonance," "syntony" and "selectivity." Will you state your understanding of these terms as employed in connection with the Marconi patent in suit?

Answer. Mr. Waterman points out that both Marconi in his reissue patent in suit and Lodge in his patent in suit, both refer to "syntony" or "tuning" between stations: that is, between transmitting and receiving stations. This means that they both had the idea of transmitting electrical waves of a definite frequency and by providing a receiver having its natural period adjusted to oscillate at this same frequency it would be better adapted for absorbing the [fol. 751] energy of the waves, just as I have explained in connection with stretched strings or other vibrating bodies. Mr. Waterman points out that the early Marconi patent was not capable of using syntony, tuning or resonance to obtain selectivity to any appreciable extent, because the Marconi radiator radiated its energy too quickly to permit of a resonant building up at the desired frequency to the exclusion of

other frequencies; that Lodge improved upon Marconi's early showing by prolonging the duration of the radiation of electric wave of the desired frequency so that a receiver having its frequency of natural oscillations adjusted to be the same as the radiated wave frequency, would reasonantly absorb the energy from space; that is, it would syntonize with the radiated frequency or be in tune therewith. When good syntony or tuning is had, the system is said to be "selective," being able to distinguish radiations of one frequency from radiations of another frequency through more readily absorbing one as compared to the other. This may be termed "resonance," because there is a resonant building up in the absorbing circuit of energy through gradually absorbing energy from the impressing source of the desired frequency.

Resonance, tuning, or syntony, the terms being practically synonimous, is not obtained merely through the adjustment of the product of inductance and capacity, but requires an interlinkage relation of the circuits such that there will not result two frequencies, and also requires that the oscillations be sufficiently long drawn out to result in a resonant building up of energy. It is readily apparent that a transmitting station and a receiving station, being widely separated, have the desired degree of loose coupling to prevent the transmitting circuit and receiving circuit from interacting so as to cause two frequencies. This is a case of extremely loose coupling. When it comes to a case of a primary circuit feeding energy into a secondary or antenna circuit as in the Marconi patent at the transmitter, there can be no syntony, tuning, or resonance between the two circuits unless the coupling is so chosen as to avoid the development of noticeable coupling frequencies. There must be but one frequency in order that the secondary circuit may adjust its capacity and inductance so as to give the secondary circuit a natural period of oscillation the same as that of the desired one frequency of oscillation in the primary circuit. The oscillations in the primary circuit must endure for a long time, as, with loose coupling to avoid two frequencies, energy is fed very slowly into the secondary circuit, and unless it can be fed over a long period of time no considerable quantity of energy will be acquired by the secondary circuit. Under such condition of a single frequency and a long drawn out feeding of energy, excellent resonance between the two circuits is ob-

tained by adjusting the product of capacity and inductance of the two circuits to be the same.

Marconi having provided for his initial circuit originating long drawn out oscillations of one frequency can very successfully use resonance throughout his entire system of four circuits.

At the middle of page 163 of his deposition, Mr. Waterman makes the following statement as to the Marconi four circuit tuning or resonance:

"Thus this idea of resonance between local circuits in the Marconi second or tuning patent is an entirely different thing from the interstation tuning referred to in the first [fol. 752] Marconi patent and the Lodge patent, but it is a means which, while increasing the energy and the distance of signaling, possible with antennae of give dimensions, also improves and facilitates interstation tuning."

Here he does not give the Marconi patent 763772 any credit for interstation tuning, this being attributed to the first Marconi patent and the Lodge patent, but does give Marconi credit for making it possible to transfer energy from a local circuit to a radiating circuit in such a way as to preserve the interstation tuning of these earlier patents, and says this is accomplished by the "idea of resonance between local circuits in the Marconi second or tuning patent," to which I agree, but this statement here by Mr. Waterman of the Marconi invention is not in keeping with the illustration in his sketch No. 2, in which there is no semblance of a resonant relation between the two circuits. The sketch shows a quick dumping of energy from the primary to the secondary circuit without in any way having the aid of resonance or using the idea which he in the above quotation attributes to the Marconi tuning patent.

26. Question. Please look at Waterman's sketch No. 3, opposite page 155 of the record, and say if you agree with Mr. Waterman that that sketch correctly illustrates the apparatus of Figure 2 of the Marconi patent 763772?

Answer. I note that Mr. Waterman has removed the condenser i^3 from the position it occupied in Figure 2 of the Marconi patent, namely, interposed between the two parts of the coil j^2 and placed it in parallel with the variable condenser k' and in series with the detector T. There is no justification in the Marconi figure or in the Marconi speci-

fication which I have been able to find for this change. In the position shown in the Marconi figure the condenser j^3 acts in series with the condenser h' and in series with the inductances of the coils j^2 and g^2, and has its share in affecting the product of inductance and capacity of the circuit. In the position shown by Mr. Waterman in his sketch No. 3, the condenser j^3 is placed in series with the high resistance of the detector T, effectively removing it from the circuit in which it was originally placed by Marconi and depriving it of any function or effect upon the adjustment of that circuit, or upon the division of the electromotive force between the capacity elements of the circuit. When a circuit is resonant to the received frequency the counter electromotive force across all of the capacity of the circuit is a maximum and equ to the counter electromotive force across all of the inductance of the circuit, but the two are opposed. The counter elec omotive force across either one of these characteristics is a maximum at resonance and this is why a detector connected across one of these elements so as to be influenced by the total counter electromotive force gives the maximum response at resonance. It is readily apparent that if the total capacity to obtain resonance is divided over several elements, such as the condensers j^3 and h' in Figure 2 of the Marconi patent, the detector if connected across only one of these will be influenced by only a part of the total available electromotive force. The effect on the detector in shunt with only one element will be in proportion to the relative values of the two elements, and in the arrangement of Marconi Figure 2 with his detector T across only the condenser h', conditions of adjustment could arise where a very small effect on the detector T would be had and thus make it difficult to deter- [fol. 753] mine whether or not the circuit is in resonance. The Waterman sketch 3 removes this defect in the Marconi Figure 2 by taking the condenser j^3 out of the tunable circuit so that all of the electromotive force due to capacity will fall across the condenser h' giving the maximum effect upon the detector T not provided for by Marconi.

* * * * * * *

27. Question. Will you refer to the prior art in connection with the claims in suit of the Marconi patent 763772 and state whether, in your opinion, one skilled in the art at the date of the application for the Marconi patent would have

possessed the requisite knowledge to make and use such devices without reference to the Marconi patent?

Answer. In my opinion the prior art clearly and precisely provided for the devices covered by the claims in suit of the Marconi patent 763772 at the time of the filing of the application for the patent.

The claims, which I have heretofore discussed and divided into three groups, nearly all cover means or instrumentalities for bringing circuits into resonance or for bringing them into time period accord, and one of the claims, No. 10, broadly requires that four circuits of the system be in resonance.

Before considering the claims individually, it may be well to first appreciate the relation of wireless telegraphy or radio, as it is now called, to the general electrical art, and particularly with wire telegraphy and wire telephony, and then to point out specifically some of the art in electricity applied to both forms of applications; that is, wire systems and wireless systems.

There has been considerable effort among workers in radio to create the impression that radio is a separate and distinct art from electricity in general, even including its applications to wire communication, and that radio involves numerous complicated and abstruse principles not encountered in the general application of electricity; and there has been a particular effort to differentiate radio from other applications of electricity on the grounds that radio because of employing high frequency electrical oscillations, is different from other applications of electricity. These efforts on the part of some of the workers in radio have succeeded in creating some rather false impressions as to what radio actually is. In my study of electricity, including radio and applying the principles, I have not encountered a single principle or formula that does not apply to electricity in general if it truly applies to radio, and in employing the formulae it is merely a matter of inserting the proper value of frequency to obtain the correct answer. Furthermore, it is not true that high-frequency oscillations originated with or are peculiar to radio. Before Mr. Marconi filed his first application for a patent in 1895 or 1896 several workers in the electrical art filed applications covering systems of wire telegraphy and telephony using high-frequency electrical oscillations conveyed along wires for transmitting proper signals. One of these applications was

that of Hutin and LeBlanc, filed May 9, 1894, and now being [fol. 754] United States Patent 838545 of December 18, 1906. The high-frequency system for wire communication has been as successful as the high-frequency system for wireless communication, both being in extensive commercial use to-day, and both employing practically identical apparatus at the transmitting and receiving stations, the only difference being that one employs wires for directing the energy to a particular receiving station and therefore is much more economical and requires less power at the receiving station than the other, which dumps its energy into space with the hope that some of it will reach the desired receiving station, but in order to make the hope more certain employs a large amount of power.

Resonance, including resonant transfer of energy and resonant absorbing of energy by proper adjustments of frequencies through adjustment of capacity and inductance of electrical circuits, was thoroughly appreciated before either the suggestion for high-frequency wire communication or high-frequency wireless communication was suggested, as I have more specifically pointed out in my discussion of the Lodge patent here in suit, showing that even Hertz, the very first investigator, employed resonance. It is therefore quite natural that the workers in both wire high-frequency telegraphy and telephony and wireless telegraphy should immediately adopt the principles of resonance for transfer of energy and absorption of energy. For instance, in United States Patent 519347, of May 8, 1894, to Pupin, resonance is a vital part of a system of wire telephony, as may be readily seen from a reading of claim 1 of the patent as follows:

"1. A transformer having one of the coils divided into sections, the said sections being connected in series and in electrostatic inductive relation and each section being tuned to a certain predetermined periodicity."

In another Pupin patent, 640516, filed May 28, 1895, and resulting in a patent January 2, 1900, the title is "Electrical transmission by resonance circuits." In the body of the specification, of the same patent, lines 68 to 74, page 1, there is the following "resonance" language:

"By a 'resonance-circuit' is meant one which has self-induction and capacity and therefore a natural period.

When the self-induction and capacity are properly adjusted so as to give it the period of the impressed electromotive force, the resonance-circuit becomes resonant to this electromotive force."

And lines 62 to 67, page 1:

"In multiple telegraphy by resonance-circuit it is necessary to employ selective circuits at the receiving end of the line. The employment of resonance shunt-circuits for selective receiving-circuits offers many important advantages."

Certainly, there could be no more definite appreciation of resonance and how to obtain it than that stated in the first quotation, and no more definite appreciation of its value than that stated in the second quotation. The matter of multiple telegraphy over wires employing a series of different frequencies with selective generators of these frequencies, and selective receivers for the generated frequencies, is identical with the matter of multiple telegraphy in radio employing a series of frequencies with selective generators of these frequencies, and selective absorbers at the receiving station.

[fol. 755] In the matter of the use of high-frequency electrical oscillations for wire communication, taking advantage of resonance and selectivity, and the proper construction of the circuits and devices for getting the best result, nothing could be more definite than the instructions and specifications laid down in United States Patent 638152 of November 28, 1899, to Stone, the application for which was filed December 15, 1896. For instance, lines 13 to 28, page 1, we find the following:

"When a telephone-receiver is subjected to a uniform vibratory current whose frequency of vibration corresponds to a tone of a pitch above the limit of audibility or corresponds to a tone of a pitch higher than the highest tone to which the moving parts of the receiver are capable of responding, the telephone remains silent. When, however, the intensity or amplitude of the high-frequency current to which the receiver is subjected is not uniform, but is subjected to slower periodic vibrations whose frequency corresponds to the pitch of an audible tone or combination of tones to which the moving parts of the receiver are capable

of responding, the receiver reproduces the tone or combination of tones."

In this quotation we have precisely the statement of the fundamental requirements for both radio telephony and wire telephony, sometimes termed "wired radio," both of which systems I have explained are in common use today using the same apparatus in both transmitting and receiving stations.

The manner of obtaining the high-frequency oscillations, or "carrier currents," as they are sometimes termed, because they carry the low-frequency variations characteristic of the voice or signal, is described, lines 29 to 35, page 1, as follows:

"In the present invention the high-frequency currents is developed by the disruptive discharge of a condenser in a sonorous circuit, and the required variations in the amplitude of the high-frequency current are obtained by varying the length of the spark tap at which the disruptive discharge takes place."

The manner of creating the high-frequency oscillations for delivery to the telephone line, as described in this paragraph, is precisely the same as the manner described by Marconi in the patent in suit, being merely "the disruptive discharge of a condenser in a sonorous circuit," "sonorous" in this case meaning the same as "persistent" in the Marconi description.

Page 2, lines 2 to 5, Stone provides for selective resonance between the transmitter and receiver, permitting the use of a plurality of noninterferring communications as follows:

"For this purpose, the sonorous resonanting-circuit at 1*a* and the resonator-circuit at 1*b* are attuned to the same frequency, while those at 2*a* and 2*b* are attuned to some other frequency."

It will be noted that Stone does not provide for tuning the line connecting the transmitting and receiving circuits, as in the system described he is transmitting a plurality of frequencies over the same line, and nothing would be accomplished by tuning the line to one of these frequencies and neglecting tuning of the line for the other frequency.

This is precisely the same arrangement adopted by Stone in a patent application filed prior to the Marconi application covering radio communication which I will discuss in detail later, where he desired to employ the same antenna or radiating circuit to transmit a plurality of signal carry-[fol. 756] ing frequencies delivered to the circuit by a plurality of oscillation generators. The same application covers an arrangement for communicating with but one frequency or with a plurality of frequencies from the same antenna, and the Stone application provided for the antenna being tuned or not, depending upon whether he was using the multiple system or the single system.

Page 2, lines 39 to 47 inclusive, Stone describes the operation of the primary or oscillation-producing circuit, as follows:

"In this way a uniform oscillatory current of inaudible frequency is developed in the primary circuit, including the primary helix P, which oscillatory current is impressed upon the main circuit by means of the induction-coil I. The frequency of this oscillatory current is determined by the electromagnetic, electrostatic, and dissipative resistance of the primary circuit."

Technically, this is precisely the same language as that found in the Marconi specification. Stone states that the oscillatory current is of "inaudible frequency," meaning too high frequency to be directly detected by the human ear, which is the high frequency referred to by Marconi. Stone says the "oscillatory current is impressed upon the main circuit by means of the induction-coil I." This induction-coil I is the same as the oscillation transformer of Marconi to impress the oscillations on the antenna circuit. Stone then says that the oscillations have their frequency determined by the capacity, inductance, and resistance of the circuit, which is precisely the same statement made by Marconi. In other words, Stone, prior to Marconi, generated through the aid of the disruptive discharge of a condenser through a spark gap oscillations of one frequency determined by the product of capacity and inductance of the circuit, and impressed these one frequency oscillations upon a second circuit where they conveyed to a distance the desired electrical communications.

As to the manner of adjusting the circuits to accord or for resonance, Stone states, lines 107-120, page 2, as follows:

"The frequency of the current developed by the transmitting sonorous circuits is determined by the self-induction and capacity of the circuit including the primary of the induction-coil, the induction-coil, the condenser, and the spark-gap, and by properly proportioning this self-induction and capacity any desired frequency between very wide limits may be obtained. The attuning of the receiving-circuits is likewise accomplished by proportioning the inductance of the secondary circuit to the capacity of the condenser located in the secondary circuit."

No more definite instructions than these can be given for the bringing of the time periods of circuits into accord, and technically it is the precise language of the Marconi patent. The last paragraph of the Stone specification, lines 121 to 130, inclusive, is extremely pertinent and valuable, and should have taught much to those workers in the art who were pleased to draw a great difference between high frequency and low frequency electrical effects:

"For the proper operation of sonorous circuits and of resonant circuits generally it is of the greatest importance that the inductance, and electrostatic capacity of the circuit be of the elastic type, and for this purpose dielectric and magnetic hystersis, Foucault currents, and closed second- [fol. 757] ary reactions generally should be avoided or minimized by any means best adapted for the purpose."

In this quotation Stone broadcasts the warning that in dealing with high-frequency currents structures should be avoided which would permit of large dielectric and magnetic hystersis, or Foucault currents. These hystersis and Foucault current effects merely amount to losses produced by alternating current, and increase with the frequency of the alternations. Stone warned that since the frequency was high these losses would be large unless special provision was made to keep them low. In the construction of high-frequency apparatus in all of its uses, such as wired radio and wireless good design has followed the instructions of Stone, the quality of the apparatus depending upon how low the losses are. Even the amateur of to-day buying a condenser of the variable capacity type for building his radio receiving set knows enough to seek one that has low losses, for he has been told that such a condenser makes his receiver more selective.

The last part of the quotation has a particular bearing on the Marconi arrangement, for it directs the use of "loose coupling" to which I have freely referred. The statement is "closed secondary reactions generally should be avoided." This means that the association of the two circuits should be such as not to create the two coupling frequencies which will result from a tight coupling. Stone appreciated that such reaction could be created and would destroy the purpose of the system if permitted, and carefully warned against it.

In discussing the Marconi reissue patent in suit and the Lodge patent in suit, both prior to the application for the Marconi patent now in discussion, it was pointed out that Marconi and Lodge directed the use of resonance between the transmitting and receiving stations by adjusting the circuits to have the same time periods, or same products of self induction and capacity. This fact, taken together with the prior art I have just cited, which is an extremely small part of the art available, clearly establishes that the Marconi patent now under discussion was in no way responsible for the principles of resonance, and I find that my view in this respect is in accord with that of Mr. Waterman, plaintiff's expert, as clearly stated by him at pages 162 and 163 of his deposition. At the middle of page 163 Mr. Waterman summarizes the difference between the Marconi patent under discussion and the prior Marconi and Lodge patents as follows:

"Thus this idea of reasonance between local circuits in the Marconi second or tuning patent is an entirely different thing from the inter-station tuning, referred to in the first Marconi patent and the Lodge patent, but it is a means which, while increasing the energy and the distance of signaling, possible with antennae of given dimensions, also improves and facilitates interestation tuning.

"In the first Marconi patent and in the Lodge patent there is one circuit at the transmitting station and one circuit at the receiving station tuned to agree with the transmitter. In the arrangement of the second Marconi patent there are two circuits tuned to resonance with one another at the transmitting station and two circuits tuned to one another at the receiving sation, these circuits being also tuned to the wave length emitted by the transmitting station."

[fol. 758] There appears then to be no contention that Mr. Marconi put resonance in radio, but I understand Mr. Waterman's summary to mean that it is merely contended that Mr. Marconi added to existing resonance systems a couple of steps that would work better under resonant conditions. I also understand his summary to include a comparison between the later Marconi patent and the earlier Lodge and Marconi patents, and not other art. I understand the two steps pointed to with emphasis by Mr. Waterman to be the adding of a lateral circuit at the transmitting station tuned to the antenna circuit and the adding of a lateral circuit at the receiving station, tuned to the antenna circuit, but I do not find that Mr. Waterman points to any coupling condition between the circuits that will permit in practice of usefully employing resonance between the circuits, which I have pointed out is vital as there can be no resonance without a coupling condition that will permit of but one frequency to which the circuits can be resonated. My view in this respect is in accord with the authorities in the art and with Mr. Marconi's own view, as expressed by him in an address before the New York Electrical Society, April 17, 1912, as reported in the transactions of that society, Nov. 15, 1912, pages 4 to 29, inclusive. At the bottom of page 8, I find that Mr. Marconi in his address stated as follows:

"These two circuits are tuned so as to have approximately the same natural period of electrical oscillation. They then—like tuning forks—have been adjusted in syntony. It is well known that when using an ordinary spark discharge in the primary circuit, unless weak coupling is employed, the oscillations set up in one circuit create oscillations of two frequencies in both circuits. This has the disadvantage that the radiated energy becomes divided between two waves of different length, and if the receiver is tuned to only one of these wave lengths, it will utilize or absorb only part of the energy reaching the receiver—the energy of the other wave being lost."

* * * * * * *

This statement relieves any doubt that Mr. Marconi appreciated that his system required loose coupling between the primary and secondary circuits at the transmitter, in order to obtain one frequency for the proper utilization of resonance. It brings out that Mr. Marconi knew

that resonance was not obtained through merely adjusting the two circuits to have the same natural period of oscillations. He points out that unless the coupling is loose there is no natural period of oscillation, but two frequencies result.

My consideration up to this point shows that the publications prior to the filing of the application for the Marconi patent now under consideration made it necessary for the workers in radio to do little or no guessing as to resonance effects or how to obtain and employ them, and I will not proceed to show how workers prior to the filing of the Marconi application did employ resonance, even including all that is disclosed in the Marconi patent under consideration. [fol. 759] Taking up first Lodge patent 609154 of August 16, 1898, I have shown in a sketch marked "Loftin Sketch L," the radio transmitter and the radio receiver provided by Lodge, the transmitter being based on Figure 4 of the Lodge patent and descriptive matter in the specification, and the receiver being based on Figure 13 of the Lodge patent and descriptive matter in the specification.

I have used the same reference letters as employed in the Lodge patent to facilitate following the Lodge description of operation. At page 2 of the specification, lines 72 to 95, inclusive, Lodge says as to the transmitter:

"The arrangement described with reference to Figure 4 illustrates most completely the method of charging the capacity areas h h' with an impulsive rush. The action is as follows: The Ruhmkorff machine *a* charges the jars j, whose outer coats are connected, and discharges them at the starting gap h^{10}. This spark precipitates a discharge at the supply-gaps h^6 h^7 and suddenly supplies the capacity areas h h' with electric charges, which then surge through the connecting coil h' (divided into two parts in this figure) and spark into each other at the discharge-gap between the knobs h^2 h^3. This last discharge is the chief agent to starting the oscillations which are missible in the arrangements of Figures 3 and 4 to close this last gap when desired, and so leave the oscillations to be started by the sparks at the supply gaps only, whose knobs must in that case be polished and protected from ultra-violet light, so as to supply the electric charge in as sudden a manner as possible."

This statement shows that Lodge, unlike Marconi, did not desire to have oscillations maintained for a long time in the primary circuit. That the purpose of the primary cir-

cuit is merely to provide a place for spark gaps and condensers in which the electrical energy from the source is stored until a sufficient quantity is obtained to be of use for radiation; that the purpose of the spark gaps is to offer a high resistance to hold back energy flow while the condensers are being charged by the source, and when the source is fully charged to let the energy rush into the secondary or antenna circuit. Lodge terms the action as "charging the capacity areas *h h'* with an impulsive rush." Lodge desired that as soon as the energy was all in the antenna, to have the spark gap open up to prevent energy returning to the primary circuit, for he states "whose knobs must in that case be polished and protected from ultraviolet light, so as to supply the electric charge in as sudden a manner as possible." This shows that Lodge appreciated that ionization in the gap space must be reduced to a minimum in order to have the gap become inactive, for ultraviolet light if permitted to act upon gap electrodes will cause electrons to be emitted by the electrodes. He realized that unless the gaps could be opened up immediately to prevent the return of energy to the primary circuit there would be no sudden effective charging of the antenna, as the charge would immediately return to the primary circuit. The reason for wanting the energy to remain in the antenna after a quick charging is well stated by Lodge at page 2 of the specification, lines 57 to 67, inclusive:

"By both of the means described with reference to Figures 3 and 4, I charge the two capacity areas *h h'* (which, together with the inductance-coil between them, constitute the radiator) by aerial disruption or impulsive rush. The [fol. 760] advantage of this is that charges so communicated are left to oscillate free from any disturbance due to maintained connection iwth the source of electricity, and therefore oscillate longer and more simply than when supplied by wires in the usual way."

This makes it clear that Lodge well knew that with two coupled circuits the energy would transfer back and forth preventing free oscillations unless the first circuit, the primary, could be effectively removed from the system once the energy it contained had been delivered to the secondary. Therefore, unlike Marconi, he proposed to make his antenna or secondary circuit the seat of oscillations of the desired frequency for transmitting energy to the distant

stations with the primary merely acting to supply the energy without regard to frequency, but only in as quick a manner as possible and then to get out of the way of future action. Marconi made his primary the seat of the oscillations of the desired frequency with the requirement that it remain in action for a long time slowly feeding energy at the desired frequency to the antenna or secondary circuit. Lodge did not have and did not necessarily require adjusting the time periods of the two circuits to be the same. With Marconi's slow feeding he was compelled from the point of view of the efficiency set up as one of his objects to adjust the periods to be the same. Since Lodge only had one circuit, the elevated conductor circuit, involved in the matter of determining the frequency of the oscillations at his transmitter, it was only necessary to tune the receiver to *this one circuit*, and as to this receiver he states, page 3 of the specification, lines 92 to 101, as follows:

"A receiver or resonator consists of a similar pair of capacity areas connected by a similarly-shaped conductor or self-inductance coil, the whole constituting an absorber arranged so as to have precisely the same natural frequency of electrical vibration as the radiator in use at the corresponding emitting-station, so that it can accumulate the received impulses; that is to say, can act cumulatively."

Thus, having provided for the creation of long drawn-out oscillations of one frequency utilizing the natural period of oscillation of but one circuit at the transmitter, it sufficed to provide a circuit adjusted to the same natural period at the receiver to absorb these long drawn-out one frequency energy bearing waves in a cumulative manner. Referring to my sketch L, Lodge provided variable inductance coils *h*' at both the transmitting and receiving stations for adjusting the natural period of the two circuits to be the same.

As to the particular way of collecting the energy from the receiving antenna for use to affect a detector of this energy, Lodge states, page 4, lines 49 to 61, inclusive:

"In some cases I may, as shown in Figure 13, surround the syntonizing-coil of the resonator with another or secondary coil *u* (constituting a species of transformer) and make this latter coil part of the coherer-circuit, so that it shall be secondarily affected by the alternating currents excited in the conductor of the resonator, and thus the coherer be stimulated by the current in this secondary coil

rather than primarily by the currents in the syntonizing-coil itself, the idea bieng thus tol eave the resonator freer to vibrate electrically without disturbance from attached wires."

Lodge appreciated, as clearly shown by this quotation, that a coherer or other form of detector was a high resist- [fol. 761] ance device, and if directly included in the elevated conductor circuit that there would be no particular advantage in trying to adjust the natural period of the circuit. When a circuit includes a high resistance element, it is impossible to obtain any sharpness or selectivity of response, so Lodge directed that the resistance detector be removed from the resonating circuit to a mere association with it through a coupling coil, and thus to be secondarily affected instead of directly, and he gives directions for the coupling relation between the two circuits which requires loose coupling, for he states "the idea being thus to leave the resonator freer to vibrate electrically without disturbance from attached wires." In Figure 12 he shows the detector directly connected to the coil h^4, and in the quotation just given points out that with an inductive form of connection, as is shown in Figure 13, there is less disturbance or reaction on the elevated conductor resonating circuit—that is, that the coupling is loose. I have indicated this in my sketch L by marking the coupling between the coil h^4 and the coil u at the receiver as loose.

He states further in the matter of making the receiver more effective, page 4, lines 62 and 68, inclusive, as follows:

"In all cases it is permissible and sometimes desirable to shunt the coils of the telegraphic instrument by means of a resistance or a capacity, as shown at w in Figure 12, in order to connect the coherer more effectively and closely to the capacity areas or receiving arrangement whereby it is to be stimulated."

The condenser provided for in this quotation I have shown at w in my sketch L of the Lodge receiver. Lodge does not definitely direct that the detector circuit be tuned, but this provision of the condenser w provides an element for tuning it, and Lodge's statement that it more effectively connects the detector with the capacity areas, which are the energy collecting means in the primary circuit, indicates that he was directing tuning.

* * * * * * *

Whatever gap of doubt that may have been left by Lodge as to the tuning of the secondary circuit of the receiver illustrated in my sketch L was very soon filled by Marconi himself, in his patent 627650 of June 27, 1899, prior to the filing of the application for the Marconi patent now under consideration. This 627650 patent of 1899 covers a receiver having two circuits, and is one of the receivers named in the Marconi specification now under consideration as suitable for use in his four-circuit system. I have illustrated this receiver in a sketch marked "Loftin Sketch M," this sketch being based on Figure 1 of the patent and the descriptive matter in the specification. Marconi states at page 1, lines 14 to 19, inclusive:

"According to this invention the conductor is no longer insulated, but is connected to a capacity, which may be the earth, through the primary of an induction-coil, while the ends of the imperfect contact are connected to the ends of the secondary one of the connections, being through a condenser."

Marconi explains immediately preceding this quotation that an earlier patent of his required the detector to be directly in the antenna circuit. The quotation explains [fol. 762] that his new form of receiver has two circuits—an antenna circuit and a detector circuit. Page 1 of the specification, lines 31 to 37, further states:

"It is desirable that the induction-coil should be in tune or syntony with the electrical oscillation transmitted, the most appropriate number of turns and most appropriate thickness of wire varying with the length of wave of the oscillation transmitted."

Thus Marconi provides for adjusting the number of turns of the induction coil to suit the wave length (or frequency) transmitted, and since he says "for best effects" it means that the adjustment is such that the time period or natural frequency of the antenna is the same as the frequency of the transmitted wave. No other adjustment will give best effects, a matter which has been fully covered by Lodge. Marconi states that the adjustment is attained through choosing an appropriate number of turns of wire on the induction coil. This, of course, does not mean that Marconi intended that each time the wave length is varied a new coil having a new number of turns is to be wound, but that a variably acting coil, such as the coil h^4 of Lodge, disclosed before Marconi, satisfied the requirement. In view of

Lodge's variably acting coil, and the Marconi instructions, I have shown the coil j^1 in my sketch M as variable in the conventional way in present day use, that is, by an arrow. Marconi further says, page 1, lines 38 to 42, inclusive, as follows:

"The capacity of the condenser on the connection between the imperfect contact and the secondary of the coil should be varied (in order to obtain best effects) if the length of wave is varied."

This quotation contains definite instructions to vary the time or natural period of the secondary circuit if the wave length or frequency of the transmitted wave is varied, this time the instructions being to vary the time period through varying the capacity of a condenser, which is the condenser *K* of Figure 1 and of my sketch M. The quotation states that this adjustment is "in order to obtain best effects," and since best effects are obtainable only through resonance, the instructions clearly are for tuning to the frequency of the transmitted wave. In view of the instructions to vary the condenser *K*, I have shown this condenser as variable in my sketch M in the conventional way in present day use, that of an arrow drawn through the two condenser plates.

We have therefore in this Marconi patent 627650 a definite receiver tuned to the frequency of a transmitted wave through adjusting the natural time periods of the two circuits to accord with the transmitted frequency, and therefore to each other, and the instructions provide for tuning both through varying inductance and varying capacity. In analyzing what Marconi has done in this earlier patent, it is appreciated that it amounts to no more than following the knowledge of the art in the matter of resonance effects which I have previously referred to.

Up to this point we find that the art is supplied with a system having three circuits, all having their natural periods of oscillation the same as the frequency of the transmitted wave. The first circuit is that supplied in the Lodge patent at the transmitter of my sketch L, in which the antenna or elevated conductor circuit is the seat of oscillations of one frequency, this being the frequency resulting from the natural period of the antenna circuit. The second circuit is that supplied by Lodge at the receiving [fol. 763] station, as illustrated in my sketch L, in which

the antenna or elevated conductor circuit is adjusted to have the same natural period as the elevated conductor circuit at the transmitting station. The third circuit is that supplied by Marconi in 1899, as illustrated in my sketch M, in which the secondary circuit associated with the antenna circuit is tuned to have the same natural period of oscillation as that of the first and second circuits of the system and therefore with the frequency of the transmitted wave. It is also shown that adjustment is attained through varying both inductance and capacity, and that Lodge provided loose coupling at the receiver to prevent unnecessarily large reaction of the secondary circuit on the antenna circuit. There is therefore so far not covered the fourth circuit in the Marconi patent under consideration, namely, the primary circuit at the transmitting station, which is required by Marconi to have the same natural period of oscillation as the three circuits already covered, and which, according to the Marconi specification, is the seat of the oscillations of one frequency maintained for a long time, and therefore is the circuit that sets the pace for the entire system.

This fourth step, however, was provided for in the art prior to the filing of the application for the Marconi patent under consideration. For this next step, I first refer to Tesla patent 645576, of March 20, 1900, issued prior to the filing of the Marconi application. It covers a "system of transmission of electrical energy," and illustrates and describes means for communicating such energy without the use of wire. It is a wireless system. The patent has been severely criticised because it contains suggestions for the transmission of large amounts of energy to great distances through the use of extremely high elevated conductors, when the purpose is large energy transmission, because the suggestions have never been realized in practice. The patent is in no way limited to the transmission of large amounts of energy and employing extremely high elevated conductors, and in its own terms adequately disposes of the criticism to which it has been subjected. For instance, at page 5, of the specification, in lines 24 to 32, inclusive, Tesla said:

"While the description here given contemplates chiefly a method and system of energy transmission to a distance

through the natural media for industrial purposes, the principles which I have herein disclosed and the apparatus which I have shown will obviously have many other valuable uses—as, for instance, when it is desired to transmit intelligible messages to great distances."

Thus Tesla, while admitting that he is extremely ambitious for his system, yet he does not permit his ambition to deprive it of its usefulness for purposes other than the one he set up as his ideal, and specifically mentions "to transmit intelligible messages to great distances"—wireless telegraphy.

As to the criticism of the extremely high elevated conductors mentioned by Tesla in a number of places when discussing the problem of transmitting large amounts of energy to great distances, he adequately disposes of this when it comes to the transmission of the small amount of energy necessary for transmitting intelligible messages—wireless telegraphy. Page 4 of the specification, lines 105 to 116, inclusive, he says:

"In some cases when small amounts of energy are required the high elevation of the terminals, and more particularly of the receiving-terminal D', may not be necessary, since, especially when the frequency of the currents is very high, a sufficient amount of energy may be collected at that terminal by electrostatic induction from the upper air strata, which are rendered conducting by the active terminal of the transmitter or through which the currents from the same are conveyed."

Therefore the matter of the height of the elevated conductors was a matter of degree with Tesla, depending upon the amount of energy he wished to transmit. When he thought in terms of transmission of large horsepower for operating motors and lighting cities, he considered elevated conductors of thousands of feet. It is quite natural, therefore, that when thinking of fractions of an erg for operating a sensitive wireless detector, he considered elevated conductors of the order of a hundred feet. While Tesla has been severely criticized, yet every practical worker in the art to-day knows that the higher the elevated conductor the better is distance covered. This is the consideration that led to building towers, eight in number, each 850 feet high, for the Lafayette radio station in France, when, during the war, there was a possibility of the cables being cut

[fol. 764]

by the German submarines, leaving radio communication as the only communication with the United States, To make communication over this great distance more certain night or day, winter or summer, the designers of the station undertook steel tower construction of unprecedented height in order to get the benefits of great height.

This quotation has also been criticised because of Tesla's theory of the manner of transfer of the energy between the transmitting and receiving stations. After all, it is merely theory, and since the authorities in this art are still grouping and guessing at the real manner of transfer, there can be no objection to Tesla and other early workers in the art having different theories.

The figure of the drawing shows a transmitting and a receiving station, each having an elevated conductor circuit associated with a lateral circuit through an oscillation transformer. At the transmitting station, the source of supply of the high frequency oscillation in the lateral circuit is merely indicated, but in the specification, page 3, lines 118 to 125, the indicated generator G of the drawing is described as a spark gap discharging through a condenser just as described in the Marconi patent under consideration.

Also, page 3, lines 113 to 116, read as follows:

"The transmitting apparatus was in this case one of my electrical oscillators, which are transformers of a special type, now well known and characterized by the passage of oscillatory discharges of a condenser through the primary."

In my sketch A, inserted opposite page 427 of the typewritten record of my deposition, I have illustrated the Tesla electrical oscillator referred to in the quotation, and reference to that sketch shows apparatus identical with that of the Marconi patent. In order that it may be appreciated what Tesla means when he says, in that portion of the specification which I have just quoted, that the transmitting apparatus was one of his electrical oscillators of a special type and now well known, I refer to a prior Tesla patent which gives some of the details of construction and adjustment of these Tesla coils, such as the Tesla coil shown in his patent 645576. This prior patent is his British patent [fol. 765] No. 20981 of 1896, and in Figure 13 there is shown a Tesla coil organization adapted for handling large energy.

In this figure the device L L is a rotating break or spark gap. This reference makes clear what is meant by Tesla in his United States Patent 645576, by the term on page 3, line 124, "mechanical operated break." This rotary gap or break is shown in Figure 12. It will be seen in Figure 12 (British patent No. 20981) there is a rotating portion E E-1, consisting of several rotating posts on a central shaft which is driven, as shown in Figure 11, by a suitable motor. Electrodes L L shown in Figure 12 and Figure 13 are held near the rotating spoke arrangement E-1. The object is simply to provide a spark gap device which will give a clean cut discharge where large powers are used. This British patent goes into complete detail as to the organization of apparatus necessary for producing high-frequency oscillations through the discharge of a spark gap in circuit with a condenser and inductance.

Returning to the transmitter illustrated in the figure of Tesla patent 645,576, the specification states, page 3, lines 126-127, that the primary coil C consists of "a single turn of stout stranded cable of inappreciable resistance." This is the same as shown in the single turn of Figure 1 of the Marconi patent under consideration The secondary winding is described on page 4, lines 3 to 7, as "a flat spiral composed of 50 turns of heavily insulated cable No. 8 wound in one single layer, the turns beginning close to the primary loop and ending near its center."

The Marconi patent also shows the number of turns in the secondary winding to be greater than the number of turns in the primary winding. These descriptions of the coils provide for adequate insulation and for wires of sufficient size to handle large current.

On page 4, referring to the transmitter, the Tesla patent states, commencing line 27:

"The primary and secondary circuits in the transmitting apparatus being carefully synchronized, an electromotive force from two to four million volts and more was obtainable at the terminals of the secondary coil A."

The word "synchronized" used in this quotation has the same meaning as tuning or resonance. There are therefore instructions to tune the primary and secondary circuits together as found in the Marconi specification. It also points out that when in tune a large voltage is obtained in the secondary.

On page 3, commencing line 133, the frequency obtained with the particular apparatus is given:

"That the primary circuit vibrated generally according to adjustment, from two hundred and thirty thousand to two hundred and fifty thousand times per second."

This is a frequency in most general use in radio practice of to-day, particularly for naval ships.

Tesla further states as to proportion for obtaining resonance effects, page 3, lines 58 to 85, inclusive:

"The length of the thin wire coil in each transformer should be approximately one-quarter of the wave length of the electric disturbance in the circuit, this estimate being based on the velocity of propagation of the disturbance through the coil itself and the circuit with which it is designed to be used, by way of illustration if the rate at which [fol. 766] the current traverses the circuit, including the coil, be one hundred and eighty-five thousand miles per second then a frequency of 925 per second would maintain 925 stationary waves in a circuit one hundred and eighty-five thousand miles long and each wave would be two hundred miles in length. For such slow frequency, to which I shall resort only when it is indispensible to operate motors of the ordinary kind under the conditions above assumed, I would use a secondary of fifty miles in length. By such an adjustment or proportioning of the length of wire in the secondary coil or coils the points of highest potential are made to coincide with the elevated terminals D D, and it should be understood that whatever length be given to the wires this condition should be complied with in order to obtain the best results."

Adjusting the length of wire to one-quarter of a wave length, as set forth in the first part of the quotation, is a very common rough or thumb rule used among practical radio workers for obtaining approximate resonance in wire conductors. When the result mentioned in the last part of the quotation is obtained: that is, when the highest potential exists at the elevated terminal, resonance is actually obtained, and Tesla points out that this is the final test irrespective of the thumb rule as to length of wire, and points out that "best results" are obtained when this adjustment is attained: that is, that there is resonance between the elevated conductor circuit and the primary oscillating circuit feeding energy into the elevated conductor circuit.

These considerations of the Tesla patent, issued prior to the filing of the application for the Marconi patent under consideration, clearly shows that Tesla appreciated the necessity for best results of adjusting the time period of the primary and secondary circuits to accord at the transmitter in a wireless or other system of communicating electrical energy through space.

In British patent No. 1862 of 1899 to Braun, there is shown in Figure 4 a two-circuit transmitter. The primary circuit of this transmitter consists of two condensers F F connected in series with a spark gap U and the primary winding of a coil P. There is a secondary winding S inductively associated with the primary T, and the winding S is connected to a radiating circuit M and to either a ground or other capacity area.

British patent 12420 of 1899, in Figure 9, shows a two-circuit receiver, the two circuits being inductively associated through a transformer. These two patents to Braun therefore cover a four-circuit system of wireless telegraphy, two circuits at the transmitter and two at the receiver.

My next reference is to the work of John Stone Stone, commencing in his letter of June 30, 1899, to Baker, defendant's Exhibit F.3, recited in a second letter of July 18, 1899, to Baker, defendant's Exhibit G.3, and covered in United States Patent 714756 of December 2, 1902, the application for which was filed on February 8, 1900. This work of Stone completely covers the four-circuit system of the Marconi patent under consideration from beginning to end, including the tuning of the two circuits at each of the stations, tuning of all four circuits of the system, and the loose coupling necessary to make the Marconi system effective.

[fol. 767] In the Stone letter of June 30, 1899, the opening paragraph generally sets forth why in previous systems, selectivity has not been obtained. The second paragraph of the letter states that the difficulty may be overcome by the use of a system generating simple harmonic waves and capable of receiving simple harmonic waves. The third paragraph reads as follows:

"In the existing vertical wire stations, the waves sent out and the waves received are complex harmonic waves owing to the fact that the vertical wires are not simple resonators, but are capable, upon having their electrical equilibrium abruptly disturbed, of developing oscillations

of a considerable number of different frequencies and also are capable of responding more or less powerfully to a correspondingly large number of different frequencies."

This is the same objection raised by Lodge in his patent 609154 to the single circuit vertical wire system of Marconi. I have already pointed out how Lodge proposed to remedy the defects, particularly in connection with my sketch L.

The fourth paragraph of the Stone letter of June 30, 1899, sets forth the manner in which Stone remedied the defect. He states:

"Instead of utilizing the vertical wire itself at the transmitting station as the oscillator, I propose to impress upon this vertical wire, oscillations from an oscillator, which oscillations shall be of a frequency corresponding to the fundamental of the wire. Similarly at the receiving station, I shall draw from the vertical wire, only that component of the complex wave which is of lowest frequency."

Paragraph 5 then states:

"If now the fundamental of the wire at the receiving station be the same as that wire at the transmitting station, then the receiving station may receive signals from the transmitting station, but if it be different from that of the transmitting station, it may not receive those signals."

Here there are definite instructions to create oscillations of the desired frequency separately and to impress these oscillations upon the vertical wire or antenna, having the antenna's fundamental or natural period of oscillation the same as that of the separately generated oscillations. These are precisely the instructions given by Marconi for his transmitting stations. There are no definite instructions to use loose coupling in order to avoid producing two frequencies, but the very object of Stone was to produce simple harmonic waves, or waves of one frequency, so that loose coupling is necessarily implied, just as in the case of Marconi where he gave no instructions for loose coupling but so stated his object and conditions as to require loose coupling.

The instructions also require adjusting the fundamental or natural period of the vertical wire or antenna at the receiving station to be the same as the vertical wire at the

transmitting station, and directs drawing from the vertical wire only that component of the complex wave which is of lowest frequency. The component of lowest frequency is the fundamental or natural period, and to draw it from the vertical wire requires a lateral circuit of the same natural period as the vertical wire.

* * * * * * *

[fol. 768] If a circuit is tuned to the frequency of oscillations in another circuit, it will "draw" energy from that circuit by reason of resonance. On the other hand, if the circuit if not tuned to the frequency of the circuit in which there are oscillations, it will only receive energy through the action of forcing.

The sixth paragraph in the Stone letter of June 30, 1899, states an object the same as that found in the Marconi specification; that is, localization of communication, which means being able to receive communications from one transmitting station without interference from others on different frequencies.

The letter then shows diagrammatically the organization of circuits and apparatus making up the circuit of the Stone system, showing two transmitting stations and two receiving stations. In a sketch marked "Loftin Sketch N." I have reproduced the first transmitting and receiving station shown with the slight exceptions that I have followed the suggestion in Stone letter of July 18, 1899, Figure 2 of the last page, for the location of the spark gap S, this being the preferred location according to the second Stone letter, and is the same location given in the Marconi patent. At the receiving station I insert a condenser C' in the secondary circuit, which is in accordance with Stone patent 714756, in numerous figures of that patent such as Figure 6 and Figure 8, and marked in the patent "stopping condenser,' and having the same purpose as the condenser j^3 in Figure 2 of the Marconi patent, that of preventing the battery D from being short circuited. I have also marked the coupling relation between the primary and secondary circuits at both the transmitting and receiving stations as "loose couplings, and will show in my consideration of the second Stone letter and the Stone patent that he definitely provided for loose couplings. My sketch N is therefore primarily based upon the Stone letter of June 30, 1899, but contains slight modifications in no way effect-

ing the fundamental operation of the system, but being merely preferred forms brought out by Stone in the second letter and the patent.

Reference to my sketch X shows that Stone had organizations at both the transmitting and receiving stations of the Marconi patent under consideration. At the transmitting station he uses a spark gap discharging through a condenser and the primary of an oscillation transformer to create the oscillation of the desired frequency, the frequency being determined by the capacity and the inductance of the circuit. The organization being the same as that of Marconi, the oscillations are persistent or drawn out for a long time. These one-frequency oscillations are impressed upon an elevated conductor circuit, or vertical wire as termed by Stone, though an oscillation transformer. At the receiving station the energy from the space waves is collected on an elevated conductor, or vertical wire as termed by Stone, and through an oscillation transformer impressed upon a second circuit containing inductance and capacity, and having a detector in shunt to a condenser as shown in Figure 2 of the Marconi patent.

[fol. 769] In the paragraph following the diagram, Stone names the devices represented by the reference letters in his diagram, and there can be no dispute that these devices are the same as those shown in the Marconi figures.

The last paragraph but one of the June 30 letter then states:

"The tuning of these circuits one to another and all to the same frequency will probably be best accomplished empirically, though the best general proportions may be determined mathematically."

Such language as this leaves no doubt that the Stone system comprised four circuits all of which had their time or natural periods adjusted to be the same, or, as stated by Marconi, the product of capacity and inductance of all of the circuits was the same. And there can be no doubt that he provided the necessary apparatus for accomplishing this purpose. He clearly shows inductance coils and condensers in all of the circuits, and the art is thoroughly familiar with the manners in which the values of these elements could be changed at will.

The quotation states that it "will probably be best accomplished empirically, which is the method in practical

use and which is the method shown by Lodge in his variably acting inductance coil and by Marconi in the patent under consideration. In general practice, coils for inductance and condensers for capacity are constructed to be capable of having a wide range of value, and when these are inserted in radio circuits the proper values for tuning is determined empirically by turning knobs or moving switches. The operator does not know what value of capacity and inductance he is using, but from the result obtained is satisfied that he has adjusted so as to make the product of capacity and inductance the same throughout. Stone says that the best general proportions may be determined "mathematically. This is done by good designers in determining the necessary inductance and capacity to cover a given range of frequencies at which the set under design is to operate, but once the set is in use in the hands of an operator the tuning for the particular frequency of a particular communication is done empirically by the operator by turning knobs or moving switches.

The second letter of Stone to Baker, July 18, 1899, defendants Exhibit G-3, begins by going somewhat into detail into the manner of operation of radio systems and develops more specifically than the earlier letter the theory on which Stone based his new system. Having discussed the former system Stone states, commencing bottom of page 4, as follows:

"In my arrangement the vibratory current developed in the vertical wire is not due to the oscillatory discharge of the wire, but is due to a simple harmonic electromotive force impressed upon it which electromotive force produces forced current vibrations in the wire which forced vibrations as is well known depend for their period and form only upon the period and form of the impressed forces, and not upon the electromagnetic constants of the circuit in which they are developed as is the case with free or natural vibrations of a system."

This is a positive statement that Stone intended the primary circuit of his transmitter to be the seat of the oscillations of one frequency, and, having created such oscillations, they would be impressed upon the vertical wire which would be "forced" to accept them at the frequency at which generated by the primary circuit. The action de-

[fol. 770] scribed by Stone in this quoted paragraph is the same as that I have illustrated in my sketch H, the first group of figures in that sketch illustrating the condition obtained when the vertical wire has a natural frequency different from that of the general oscillations, and the lower group of figures representing the condition obtained when the vertical wire has a natural frequency the same as that of the generated oscillations.

Stone then states:

"If the period of the impressed force be the same as that of the fundamental of the vertical wire, then it (referring to the simple harmonic current in the wire) may be represented by $A_0 \sin pt$." [Parentheses mine.]

This equation by Stone is the typical equation of a simple harmonic wave form such as I have illustrated in Figure 5*a* of my sketch H. The quotation provides for tuning the two circuits together to obtain the result Figure 5*a* of my sketch H illustrates.

The letter then goes on to state that having obtained a simple harmonic current in the vertical wire of a definite frequency there would result radiation of energy into space at this same frequency, which frequency Stone represents by the letter *p*.

Beginning at the top of page 6, the letter states:

"I place the coherer at the receiving station in a resonant circuit tuned to the periodicity *p*. Under these circumstances, the coherer will be operated by the signals sent from the sending station described, but if a second sending station develop radiations or periodicity *f*, materially different from *p*, then the receiving apparatus will not be affected by these radiations since the circuit in which the coherer is located is practically opaque to these radiations, or, more properly speaking, to the current which these radiations are capable of exciting."

Here Stone required very careful tuning at the receiver, more particularly in the secondary circuit. Very much sharper tuning is obtainable in the closed type of secondary circuit illustrated by Stone and the Marconi patent than is obtainable through the open type of circuit represented by vertical wire, and this is why Stone at this point lays stress on the tuning of the secondary circuit.

In the letter of June 30 and in his patent he provides for tuning all circuits together.

The next paragraph of the Stone letter is extremely important as it clearly brings out the necessity for loose coupling and his method of obtaining it. It also brings out that as far as the apparatus at the transmitter is concerned, in its general aspects he does not differ from the prior arrangement of Tesla which I have discussed, Stone merely contending that his particular arrangement for obtaining loose couplings which permits him to obtain simple harmonics oscillations differs him from Tesla. The paragraph beginning bottom page 6 of the letter is as follows:

"The first transmitting circuit shown in my letter to you of June 30, is practically the same as that employed by Tesla for high-frequency current, except that I place an inductance coil L in the circuit to give additional means of tuning and to swamp by its greater inductance the reaction from the induction coil *t*, which would tend to make the oscillations multiperiodic, instead of simple harmonic. The inductance of this coil should be made large compared [fol. 771] to the inductance of the primary *t*. The use of an auxiliary induction coil for the purpose of rendering the oscillations simple harmonic in the case of circuits connected with other circuits as described above was first made by me and I have elsewhere given a mathematical demonstration of the fact that it accomplishes that purpose."

The quotation lays particular emphasis upon the inductance coil L at the transmitter as shown in my sketch X. It says first that this coil "gives additional means of tuning." It is not shown in the present-day conventional way as variable; that is, with an arrow pointing to a place on the coil, but at the time of Stone's letter and patent no definite conventions were in vogue. He does state that it is for tuning, and in view of the variably acting coil of Lodge before Stone there would be no novelty in making the coil variable in number of turns.

The most important feature of this quotation, however, is that of obtaining loose couplings between the two circuits. Stone states it in the following language:

"The purpose of rendering the oscillations simple harmonic in the case of circuits connected with other circuits."

In my sketch F, Figure 5, I have shown how an auxiliary inductance of this kind provides for loose coupling. In my Figure 5 the coil g' is the same as the coil L in the Stone transmitter. My figure shows that the magnetic field is distributed between the several inductance elements of the circuit, and that it is only the field linking with the second circuit that has effect upon the coupling. Stone states that the inductance L in his circuit is large compared to the inductance of the primary of his transformer, which means that the magnetic field of his coil L will be much the larger, and since this field does not effectively link with his vertical wire circuit, the coupling will depend upon the linkage of the small field in the primary of his transformer. The result will be a very loose coupling and a simple harmonic or one-frequency oscillation for all practical purposes instead of a double frequency. Stone says that the large inductance of the coil L "swamps" the small inductance of the primary of the oscillation transformer, meaning simply that the inductance of L being large, the coupling effect of the primary of the oscillation transformer is necessarily small. Stone states that he has elsewhere given a mathematical demonstration of this obtaining of loose coupling through the use of the swamping inductance. This is mathematically demonstrated at page 6 of his patent 714756. There he shows mathematically that the larger the inductance of the auxiliary coils in the circuits, the smaller will be the mutual inductance or coupling between the two circuits.

The letter then, page 7, describes the action in producing the high-frequency oscillations as the discharge of a condenser through a spark gap and inductance just as described in the Marconi specification.

As to the receiving station, the letter states, commencing bottom of page 7:

"At the receiving station the coil L and condenser K form a resonant circuit which is attuned to the frequency [fol. 772] of the current developed at the transmitting station. Again, the inductance of the coil L should be made large compared to the inductance of the secondary of the induction coil t at the receiving station in order to obtain well-defined resonance to a single frequency.

"I believe that I was the first to discover that it was desirable to place an auxiliary induction coil of large in-

ductance in a secondary circuit in order to make it resonant to a definite frequency. I have elsewhere shown that it accomplishes this purpose."

Here Stone provides for inductance coils and condensers for tuning purposes, and necessarily implies that they be variably acting, as tuning can not be accomplished without varying either capacity or inductance to get the desired effect. More important, however, is his provision for loose coupling, using the same large inductance L as at the transmitter to "swamp" the inductance of the winding in the transmitter to "swamp" the inductance of the winding in the oscillation transformer. It is just as important for selectivity to have a loose coupling at the receiver as at the transmitter. If the antenna or elevated conductor at the receiver is set into oscillation by absorbing energy from space and transfers this energy to a second circuit, two frequencies will be set up as heretofore explained for the transmitter, and it will be impossible to obtain resonance in the secondary circuit. Stone is definite in his requirement of loose couplings, while Marconi is totally silent as to the receiver, not even setting up any objects or conditions as to the receiver that imply loose coupling.

The letter then points out that the second set of transmitting and receiving stations shown in the first letter amounts to a refinement of the system through the use of an additional circuit interposed between the two circuits at the two stations. This second system is one of extreme selectivity but requiring the adjustment of the additional circuit, making it difficult for practical operators to handle an account of the extreme selectivity. In other words, it is too selective for ordinary practice and therefore has not come into any extensive practical use. It does, however, well demonstrate the correctness of the theory on which Stone based his system.

The letter then takes up the matter of a preferred location of the spark gap in a primary circuit at the transmitter, but this is not a mater which *affects* the fundamental principle of the system.

* * * * * * *

Next for consideration is patent 714756 to J. S. Stone, dated December 2, 1902, the application for which was filed February 8, 1900. In its fundamentals this patent covers

the same information as the two Stone letters just considered. It is much more elaborate in detail, fully covering the subject of the Stone system from almost every possible angle. The patent concerns a radio system, for it states, page 1, lines 9 to 13:

"My invention relates to the art of transmitting intelligence from one station to another by means of electromagnetic waves without the use of wires to guide the waves to their destination."

[fol. 773] Figures 5 and 6 show the fundamental system in its simplest form and is the same as the system I have illustrated in my sketch N. Figure 5 is the transmitting station and Figure 6 is the receiving station. Figure 5, like Figure 1 of the Marconi patent under consideration, has a source of supply *a* indicated as an alternating current generator, a key *k* for interrupting the source of supply to make telegraphic signals, an induction coil M′ having primary winding I'_1 and secondary winding I'_2 for stepping up the low voltage of the alternating current generator *a* to a high voltage for charging with a supply of energy a condenser C. There is a spark gap S which acts to hold back current from the source of supply while the condenser C is being charged, and which gap breaks down when the condenser is charged to a high potential and allows oscillations to take place, flowing through the primary of an oscillation transformer M having the primary winding I_1 and a secondary winding I_2 to transfer energy to the vertical conductor or antenna *c* which is connected to earth at E. Unlike the Marconi Figure 1, it has a large inductance coil L for tuning the primary circuit and for providing for loose coupling between the two circuits, definitely stated by Stone to be for the purpose of securing loose coupling. Marconi, however, has similar provision for loose coupling through the effect of a separate inductance by means of a coil *q* in his antenna circuit. Like Marconi, the frequency of the desired oscillations is determined by the capacity of the condenser C and the inductance of the primary of the windings I_1 taken with the inductance of the coils L. All through the discussion of the Marconi patents under consideration it has been shown that he laid great stress upon making these oscillations in the primary circuit persistent or drawing them out for a long time. In connection with

the discussion of the Lodge patent in suit it was shown that Lodge provided for making oscillations persistent by adding inductance to his circuit. This additional coil L in the Stone patent in the primary circuit, not found in the Marconi patent, makes the Stone arrangement a more certain persistent oscillator than the Marconi arrangement. Like the Marconi Figure 1, the vertical wire c of Stone is an open circuit and therefore a good radiator, as required by Marconi. Like Marconi, the good radiator receives the persistent oscillations of the desired frequency from the primary circuit through slow feeding and also through resonant feeding, as Stone provides for making the fundamental or natural period of the good radiator the same as the frequency of the oscillations generated in the primary circuit. Stone provides an inductance coil I_2 in the good radiator circuit, and since he states that the circuit may be tuned empirically, he had available for empirical tuning the variably acting coil shown in the Lodge patent, which is the same as the variably acting coil shown at g in the Marconi Figure 1.

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In Figure 6 of the Stone patent, the receiving station, there is a vertical wire b which is an open circuit termed by Marconi a "good absorber" of the electromagnetic waves. There is in this circuit an inductance coil I_2, and since Stone provided for tuning this circuit empirically there is no novelty in making the coil I_2 variably acting as provided for in the Lodge patent in suit. There is an oscillation transformer M comprising a primary winding I_2 and a secondary winding I_1 for transferring energy of the oscillation to the secondary circuit, as shown in Fig- [fol. 774] ure 2 of the Marconi patent. There is a stopping condenser C" corresponding to the stopping condenser $f3$ in Figure 2 of the Marconi patent. There is an inductance coil L corresponding to the inductance coil $g2$ in the Marconi Figure 2, and this inductance coil L is variable as is the coil $g2$ in Marconi, as provided for in the Stone specification, page 6, lines 76 to 81. There is a condenser C' around which a detector K is shunted corresponding to the condenser h' with the detector T in shunt in Marconi. There is a battery B corresponding to the battery B in Marconi and a receiver R corresponding to the receiver R in Marconi.

Therefore, Figures 5 and 6 of the Stone patent, comprising his complete four-circuit system, are the same as Figures 1 and 2 of the Marconi patent comprising the complete Marconi four-circuit system, and the Stone figures include all of the elements shown in the Marconi figures, all coordinated to function in precisely the same manner as in Marconi, Stone making it somewhat clearer, however, particularly in the matter of avoiding the production of two frequencies through the use of loose couplings. Each of the two circuits at each of the stations in Stone are tuned to have the same time period and all four circuits of the system have the same time period. Stone provides for generating persistent oscillations in the primary circuit of the transmitter and making this circuit the seat of the one-frequency oscillations upon which the system depends.

I have before stated that the inductance coils L at both the transmitting and receiving stations in Stone were provided for the purpose of tuning, and therefore necessarily implied making them variable acting. In the Stone patent this matter is specifically taken care of, page 6, lines 76 to 81, inclusive, as follows:

"In both the organizations illustrated in Figures 5 and 6, the inductance-coils L may be made adjustable and serve as a means whereby the operators may adjust the apparatus to the particular frequency which it is intended to employ."

In addition to the single fundamental system Stone shows in Figures 13 and 14 an extension of his system permitting the use of a single vertical wire at both the transmitting and receiving stations on which to impress a plurality of oscillations of different frequencies, commonly known as a system of multiple transmission and reception. It is obvious that in such a system the vertical wire can not be tuned simultaneously to the plurality of frequencies being transmitted and received. Stone says that under such circumstances the vertical wire should be made a periodic—this meaning merely not to attempt to tune it to any one of the frequencies being impressed upon it. In such case the oscillations of the desired frequency in each one of the primary circuits generating oscillations are forced upon the vertical wire, and each one of these forced

oscillations would affect the vertical wire in the manner shown in Figure 4a of my sketch II.

In one part of the Stone specification he states that the "frequency impressed upon the elevated conductor may or may not be the same as the natural period or fundamental of such conductor."

Thereafter he explained that in using a system of multiple transmission and multiple reception with but one vertical wire at each of the stations the vertical wire is not tuned to the oscillations, and this is what I understand him to mean by saying the vertical wire may not be tuned. His specification clearly shows that when his system involves [fol. 775] but a single transmission, all of the benefits of tuning the vertical wire to the lateral circuit should be taken advantage of.

From the point of view of taking every possible advantage of resonance there is a step brought out in the Stone specification, and shown in the figures of his letter of June 30, 1899, which is of extreme importance. Page 8, lines 30 to 32, he states:

"In Figures 6 and 8, the coherers K are shown connected in shunt-circuit to the condensers C and C', respectively."

As previously stated by me, a coherer or other form of detecting device has high resistance, and when inserted directly in a circuit intended for oscillations becomes the controlling factor in that circuit and spoils all attempts to tune through adjustment of capacity and inductance. Stone appears to have been the first to appreciate this fact in the matter of the detector associated with a lateral circuit and took his detector K out of a direct connection in the circuit and placed it in shunt relation to a condenser. This shunt relation allows the capacity and inductance to themselves act upon received current, giving sharp tuning, and the energy is merely transferred to the detector through its connection to one of these elements. This is the arrangement that is in universal use in tuned receiving circuits, and it is shown in all of the figures of the Stone patent. In the Marconi patent the arrangement is illustrated in Figure 2, but an examination of the table of tunes on page 4 shows that Marconi employed it in but one out of the six tunes given.

Reviewing this prior art and the Marconi patent under consideration, I do not find any disclosure in the Marconi patent that was not already available to the art at the time of filing the Marconi application unless it be the single exception of the idea that the primary circuit at the transmitting station should store a very large amount of energy, so much so that it would be impossible to immediately deliver it to the antenna circuit on account of the structure of that circuit preventing it from having sufficient capacity to take all of the energy it was possible to store in the primary circuit. This idea can very well flow out of the language at page 2, lines 6 to 8 of the Marconi specification, as follows:

"The illustrated arrangement of parts at a transmitting station enables much more energy to be imparted to the radiator *f*,"

and also to the structure shown in Figure 1 of Marconi and in his table of tunes on page 4. The structures invariably show that Marconi used fairly small inductance and large capacity in the primary circuit, and since the amount of energy that can be stored depends upon the capacity, the Marconi structures permitted the storing of larger quantities of energy than did the Stone arrangment, for Stone included a large "swamping" inductance in his primary circuit which necessarily reduced the amount of capacity he could use for a given frequency and therefore the amount of energy that could be stored.

There certainly can be no novelty in the Marconi patent in the matter of tuning, resonance, or syntony, because there was no lack of information in the art on this subject. The art cited shows that the time periods of circuits could be adjusted by varying either capacity or inductance, or by varying both, and knew the mathematical relation governing such variation. The art knew from the references I have cited that energy was more effectively transferred [fol. 776] when circuits were in tune through such adjustments. It knew that oscillations had to persist or endure for a long time instead of dying out quickly in order to secure an effective transfer of energy through cumulative resonance. There was information that if two circuits were closely associated one could not oscillate without being materially affected by the other, resulting in reactions, changing the frequency from that which would ordinarily be de-

termined by the constants of the single oscillating circuit to two entirely different frequencies, and under such circumstances there could be no resonant transfer of energy.

The art cited shows that resonance effects were put into use from the very beginning of the investigations of the transfer of energy through space and without the use of wires. That simultaneously with the development of the use of high-frequency oscillation without wire, high frequencies employing wires as the transmitting medium was developed, and in this development resonance effects were freely and intelligently employed.

The wireless publications before the filing of the Marconi application covering the patent under consideration show that Lodge employed resonance between a transmitting station and a receiving station; that Lodge cut off the oscillations in the primary circuit of his transmitter to avoid production of two frequencies resulting from interaction between two circuits; that Lodge at his receiver removed the detector from the antenna circuit to prevent the detector from interferring with the tuning of the antenna circuit, and coupled the antenna and detector through an oscillation transformer in such a way as to minimize the reaction of the detector circuit on the tuned antenna circuit, and placed a condenser in the secondary circuit to get a more effective relation between the antenna circuit and the detector, undoubtedly through tuning; that Marconi in 1899 added to the Lodge receiver positive instructions to vary the capacity in the secondary circuit to get best results as the wave length was changed or tuning; that Tesla in 1897 provided a transmitter having "synchronism" or tuning between the primary and secondary circuits; and that Stone in 1899 disclosed a complete four-circuit system, resonant throughout, through having the time periods of all of the circuits the same, through creating the oscillations of the desired frequency in a persistently oscillating primary circuit at the transmitter, and made the preservation of resonance throughout the system possible by employing loose coupling between the two circuits at both the transmitter and the receiver; and further by removing the detector from a direct connection in the secondary resonant circuit at the receiver. The Stone apparatus was identical throughout with that of Marconi, including the use of adjustable or variable tuning elements, the only possible difference being the value of one

of the elements, namely, the condenser in the primary circuit at the transmitter, the Marconi condenser being impliedly larger and permitting the storing of more energy.

Applying the prior art to the claims, considering first the group of transmitting claims of the patent under consideration, I do not find that these claims specifically bring out the possible difference I have pointed out that may exist between Stone and Marconi. So far as the specific elements are concerned, they are found in both the Tesla patent and the Stone letters and patent.

[fol. 777] In discussing the Tesla patent I pointed out that Tesla referred in his patent to a generator of oscillations based on prior patents which illustrated an organization of apparatus, such as I have shown in my sketch A, inserted opposite page 427 of the typewritten record. The Stone transmitter I have shown in my sketch N opposite page 715 of the typewritten record.

Claim 1. This claim requires (1) a signaling instrument comprising an induction coil, shown in my Tesla sketch A as the device T, and in my Stone sketch N as the device T: (2) the secondary circuit of which includes a condenser discharging, shown in my Tesla sketch A as the condenser C connected to the secondary S_1 of the induction coil T, and shown in my sketch N as the condenser K connected to the secondary of the induction coil T: (3) a means which automatically causes oscillations of the desired frequency, shown in my Tesla sketch A as the condenser C discharging through the spark gaps *dd*, and the primary winding P of the oscillation transformer, and shown in my Stone sketch N as the condenser K discharging through the spark gap S and the inductance of coil L and primary winding of the oscillation transformer *t*: (4) an open-circuit electrically connected with the oscillation producer aforesaid, shown in my Tesla sketch A as the vertical wire P S_1 E, and in my Stone sketch N as the vertical wire connected to the ground G through the secondary winding of the oscillation transformer *t*: (5) a variable inductance included in the open circuit, shown in my Tesla sketch A as the winding S_1 of the oscillation transformer, Tesla having provided in his patent for varying the number of turns in his winding to bring the two circuits in "synchronism," and shown in my Stone sketch N as the secondary winding of the transformer

t, Stone having provided in his letter of June 30, 1899, and in his patent, for tuning this circuit, the letter having stated "empirically," and the usual empirical method being through the use of the Lodge variably acting coil given to the art prior to Stone.

Claim 3. This claim is the same as claim 1 with the addition of two elements: (1) the primary circuit of which includes a generator, shown in my Tesla sketch A as the generator *g*, and shown in my Stone sketch N as an unmarked conventional way of indicating an alternating current dynamo or generator; and (2) means for varying the primary circuit, shown in my Tesla sketch A as either the condenser C or the winding P of the oscillation transformer or both, these both being elements well known to the art as means for varying circuits and shown in my Stone sketch N as the condenser K, the inductance coil L or the primary winding of the oscillation transformer, these all being well-known elements for varying circuits, Stone having mentioned particularly the adjustability of the coil L.

Claim 6. This claim is practically the same as claims 1 and 3, merely describing two of the elements in a different way: (1) a transformer, shown in my Tesla sketch A as the oscillation transformer having primary winding P and secondary winding S_1, and shewn in my Stone sketch N as the oscillation transformer *t*; (2) and means for adjusting the oscillation period of each of the two circuits connected with the transformer, shown in my Tesla Sketch A as the condenser C, connected with the primary P of the transformer, a condenser being a suitable element for adjusting the oscil- [fol. 778] lation period of the circuit, and Tesla having referred to changing the period of his circuit through quite a wide range by such adjustment, and by the winding S_1, which is a part of and therefore connected to the transformer, the adjustment being obtainable through adjusting the number of turns in the transformer as well as by a coil separate from the transformer, and shown in my Stone sketch N as the coil L or the condenser K, both connected to the transformer *t*, and both being suitable elements for adjustment, Stone having specifically mentioned adjustability of the coil L; and by the secondary winding of the transformer *t*, this winding being a part of and therefore connected to the transformer, Stone having provided for adjusting this circuit "empirically," and having available

to him the Lodge variably acting coil, the usual device for empirical adjustment.

* * * * * * *

Claim 8. This claim is the same as claim 6, except that instead of broadly claiming as in claim 6 "means for adjusting the oscillation period of each of the two circuits" it specifies definitely means in but one circuit, namely, (1) "a variable inductance being included in said circuit," the circuit referred to being the open circuit. This variable inductance is shown in my Tesla sketch A as the secondary winding S_1, Tesla having provided for varying the number of turns, and shown in my Stone sketch N as the secondary winding of the transformer *t*, Stone having provided for tuning the vertical wire "empirically," the Lodge variable coil prior to Stone being the usual method of empirical tuning.

Claim 11. This claim is substantially the same as claim 1, except that it adds (1) a signaling instrument in circuit with the primary of the induction coil, shown in my Tesla sketch A as a switch S, which when Tesla suggested a transmission of intelligible messages would be understood by one skilled in the art to be a telegrapher's key switch; and shown in my Stone sketch N as a telegrapher's key or signaling instrument in circuit with the alternating current dynamo. And instead of broadly claiming merely an electrical connection between the two circuits as in claim 1, the claim specifies (2) an oscillation transformer, shown in my Tesla sketch A as the oscillation transformer comprising primary winding P and secondary winding S_1, and shown in my Stone sketch N as the oscillation transformer *t;* and (3) the oscillation transformer electrically connected, at one end to capacity, and at the other end to an inductance, shown in my Tesla sketch A as the secondary S_1 connected to the capacity of earth at E, and since the inductance of the secondary S_1 is a part of the transformer, it is electrically connected thereto; and shown in my Stone sketch N as the secondary winding of the transformer *t*, one end of which is connected to capacity of earth at G, and since the inductance of the secondary is a part of the transformer, it is electrically connected thereto. Also the Stone sketch shows the provision for dividing the inductance of a circuit into a plurality of parts, for in the sketch N the inductance of the [fol. 779] primary circuit is divided or distributed over two

coils, part being in the primary winding of the oscillation transformer *t* and part being in the coil L.

Claim 12: This claim is the same as claim 11, except that it specifies that the inductance in the secondary or open circuit be "variable." Tesla instructed varying the number of turns of the secondary winding S_1, thereby providing a variable inductance. Stone provided for tuning the open circuit "empirically" and the Lodge variable-acting inductance coil prior to Stone provided a suitable means for empirical tuning.

Receiving claims: The receiving claims, as in the case of the transmitting claims, do not broadly claim resonance between the two circuits at the receiver, or having the two circuits adjusted to be in accord in time periods; some of the claims include the means or instrumentalities for adjusting the circuits to accord, and some of them are silent as to these instrumentalities.

Claim 2: This claim includes (1) an oscillation receiving conductor shown in my Lodge sketch L opposite page 694 of the typewritten record as the elevated conductor *h*, in my Marconi sketch M as the elevated conductor A, and my Stone sketch N as the vertical wire grounded at G; (2) a variable inductance connected with said conductor, shown in my Lodge sketch L as the variable inductance h^4, in my Marconi 1899 sketch M, opposite page 701 of the typewritten record, as the variable coil j^1, Marconi having provided in his specification for varying the number of turns of this coil, and in my Stone sketch N, opposite page 715 of the typewritten record, as the primary winding of the oscillation transformer *t*, Stone having provided for varying the tuning of the vertical wire "empirically," and having the Lodge and Marconi variable coil prior to him as suitable means for empirical tuning; (3) a wave-responsive device electrically connected with said conductor and in circuit with a condenser, shown in my Lodge sketch L as the wave-responsive device *r* electrically connected to the conductor *h* through the oscillation transformer having primary winding h^4 and secondary winding *u*, the same as in the Marconi patent under consideration, and in circuit with the condenser *w*, shown in my Marconi 1899 sketch M as the detector T electrically connected to the conductor A through the transformer j^1 j^2 and in circuit with the condenser K, and shown in my Stone sketch N as the detector C electri-

cally connected to the vertical wire through the transformer *t* and in circuit with the condenser C'.

Claim 13: This claim combines (1) an oscillation transformer, shown in my Lodge sketch L as the windings h^4 and *a*, in my Marconi 1899 sketch M as the windings j^1 and j^2, and in my Stone sketch N as the oscillation transformer *t*; (2) an open circuit connected with one coil of said transformer, said circuit including an oscillation receiving conductor at one end and capacity at the other end, shown in my Lodge sketch L as the elevated conductor *h*, which is the oscillation receiving conductor and is open because insulated, and is connected with one coil of the transformer, the coil being connected to the capacity of the earth h^1 at the other end; shown in my Marconi 1899 sketch M as the elevated conductor A connected to the coil at one end and the earth E at the other end; and shown in my Stone sketch N as the vertical wire connected to the transformer *t* at one [fol. 780] end and the earth G at the other end; (3) a variable inductance being included in said circuit, shown in my Lodge sketch L as the variable coil h^4, shown in my Marconi 1899 sketch M as the variable coil j^1, Marconi having provided for varying the number of turns, and shown in my Stone sketch N as the primary of the oscillation transformer *t*, Stone having provided for tuning the circuit "empirically," and Lodge having provided a variable-acting coil suitable for empirical tuning; the rest of the claim provides for a wave-responsive device in circuit with a condenser as in claim 1, the arrangement being also found in Lodge, Marconi, and Stone as pointed out in claim 1.

Claim 14: This claim is like claims 2 and 13, except instead of specifically including a variable inductance in the open circuit it more broadly specifies (1) means for adjusting the two transformer circuits in electrical resonance with each other, shown in my Lodge sketch L as the variable coil h^4, one adjustment being all that is required to bring the two circuits into resonance; shown in my Marconi 1899 sketch as either the variable coil j^1 or the variable condenser K, or both, only one adjustment being necessary to bring the two circuits into resonance, but Marconi having provided for varying the number of turns in the coil j^1 and for varying the capacity of the condenser K; and shown in my Stone sketch N as the primary winding of the transformer *t* or the inductance coil L, or both, only one adjust-

ment being necessary, Stone having particularly mentioned adjustment of the coil L and having provided for tuning all of the circuits "empirically," which necessarily implies varying either the inductance or capacity.

Claim 16: This claim is the same as claim 14, except it includes (1) an adjustable condenser in a shunt connected with the open circuit and around said transformer coil, which is an arrangement rarely used in tuning the antenna or open circuit through varying the effect of the coil of the winding which it shunts, and is merely one of the "empirical" methods employed by the art.

Claim 17: This claim is the same as claim 14, except that instead of broadly claiming means for adjusting the two transformer circuits, it includes (1) means included in each of said transformer circuits for adjusting said circuits in electrical resonance with each other. In my Lodge sketch L, Lodge definitely provides the variable coil h' in one circuit and implies varying the condenser w in the other circuit, as he states that this condenser is for the purpose of obtaining a better connection to the primary circuit, which is obtainable through tuning the two circuits to resonance; shown in my Marconi 1899 sketch M as the variable coil j' in the primary circuit, Marconi having provided for varying the number of turns in this coil, and as the variable condenser K in the secondary circuit, Marconi having provided for varying this element; and shown in my Stone sketch N, Stone having provided for varying the open circuit "empirically" and having prior to him a variable coil for the primary of the oscillation transformer t of Lodge as a suitable means for empirical variation, and Stone having specifically mentioned varying the coil L in the secondary circuit.

Claim 18: This claim is the same as claim 17, except instead of broadly claiming means for adjusting each of the circuits, it specifically includes a variable inductance as the means in each of the circuits, shown in my Stone sketch N as the primary winding of the oscillation transformer t, Stone having provided for empirical tuning and having the [fol. 781] Lodge coil as a suitable means, and Stone having provided specifically for varying the inductance of the coil L in the secondary circuit. Also, once it was made known to those skilled in the art the desirability of adjusting two circuits to resonance, it was within the knowledge of the

art to accomplish it through either varying capacity or varying inductance or varying both.

Claim 19: This claim is the same as claim 18, adding (1) a receiving instrument, battery, shown in my Lodge sketch L as a receiving instrument *g* and battery *f;* in my Marconi 1899 sketch M as a receiving instrument R and battery B, and in my Stone sketch N as a receiving instrument *r* and battery B.

Claims covering both stations: There are two of these claims in suit and, as heretofore noted, one of them is the only claim out of all of those in suit that broadly claims having the circuits in resonance. This claim specifies that all four circuits of the system are in resonance. The other claim limits itself to the means or instrumentalities for bringing the circuits into resonance.

Claim 10: This claim includes (1) a transmitting station and a receiving station each containing an oscillation transformer, shown in my Tesla sketch A as a transmitting station having an oscillation transformer, and my Marconi 1899 sketch M as a receiving station having an oscillation transformer, or in my Stone sketch N as a complete system in one showing, at both of which stations there are oscillation transformers; (2) one circuit of which is an open circuit and the other a closed circuit, shown in my Tesla sketch A as an open and closed circuit at the transmitter and in my Marconi sketch M as an open and closed circuit at the receiving station, or in my Stone sketch N as a complete system each station having an open and a closed circuit; (3) the two circuits at each station being in electrical resonance with each other and in electrical resonance with the circuits at the other stations, shown in my Tesla sketch A as two circuits at a transmitting station in electrical resonance with each other and in my Marconi sketch M as two circuits at a receiving station in electrical resonance with each other, making a complete system in which it follows that all four circuits are necessarily in resonance; or in my Stone sketch N, which is a complete four-circuit system having two circuits at the transmitting station in electrical resonance and two circuits at the receiving station in electrical resonance, and four circuits of the system in electrical resonance as stated by Stone in his June 30, 1899, letter as follows:

"The tuning of these circuits one to another and all to the same frequency will probably be best accomplished em-

pirically, though the best general proportions may be determined mathematically."

Claim 20: This claim is the same as claim 10, except that instead of broadly claiming that the circuits are in electrical resonance it merely claims the means or instrumentalities for adjusting the circuits, but does not add anything not included in the transmitting and receiving claims I have already discussed and have shown to have existed in Tesla, Lodge, and Marconi in 1899, or which is not included in the complete four-circuit system of Stone illustrated in my sketch M, and there is no necessity for pointing out these various devices in repetition over my discussion of the transmitting and receiving claims.

* * * * * * *

[fol. 782] 28. Question. Does the file wrapper and contents of the Marconi patent No. 763772 indicate whether or not the prior art to which you have referred was considered by the Patent Office, and if so, does such file wrapper indicate the reasons upon which the allowance of the application was predicated?

Answer. I have examined the file wrapper and contents of the Marconi patent 763772, and find that the Patent Office considered the prior art to which I have referred with one exception, namely, the letters of Stone to Baker of June 30, 1899, and July 18, 1899, and that the examiner who first handled the case and continued to handle it for more than three years repeatedly and consistently rejected it on this art.

The application was filed on November 10, 1900, and on July 1, 1901, the entire original specification and all of the claims were canceled and a new specification and set of claims substituted following a rejection of the *the* original claims by *th6* examiner.

Following the filing of the new specification the claims were repeatedly rejected on early art not referred to by me. Commencing in its office letter of February 11, 1902, the Patent Office began to reject on the art which I have referred to, citing on page 4 of the letter the British patent to Braun, the Lodge patent 609154 in suit, and the Marconi patent 627650 of 1889. In reply to an amendment by Marconi the Patent Office then rejected on June 3, 1902, all of the claims on Tesla 645576 of March 20, 1900, referred to

by me, the examiner stating on the last page of the letter of June 3, 1902, as follows:

"Claims 4, 13, 14, and 16, which specify a variable inductance and means for adjusting the inductance, are not patentable over Tesla because Lodge, of record, has shown that it is old to adjust the period of a circuit by a variable inductance; and claims 3 and 5, which specify an adjustable condenser, are not patentable over Tesla because applicant has shown in his prior patent 627650, that this adjustment may be produced by a variable condenser."

In other words, the examiner contended that there could be no novelty in merely providing two circuits having their time periods adjustable to be the same as Tesla had shown these circuits and provided for their adjustment in general language, and there could be no novelty in specifically claiming the adjustable elements as Lodge and Marconi himself had supplied these. The examiner on the same page of the letter of June 3, 1902, gives the practical reason for crediting to the Tesla system the use of the adjustable inductance of Lodge or the adjustable condenser of Marconi as follows:

"Since it is impossible to exactly calculate the values of the electro-magnetic constants of two circuits for the purpose of making their time period agree, it is fair to assume that the electrical oscillator of Tesla must necessarily be made with an adjustable inductance or condenser, or both."

This statement of the examiner is quite the same as that in the Stone letter of June 30, 1899, last page, as follows:

[fol. 783] "The tuning of these circuits one to another and all to the same frequency will probably be best accomplished empirically, though the best general proportions may be determined mathematically."

Thus Stone and the examiner at practically the same period of the development of the art agreed that it would be foolish to try to determine the exact proportions for adjustment mathematically; that for practice the general proportions could be so determined, leaving the specific adjustment within the general proportions to be determined by some empirical means such as the variable coil of Lodge and the variable condenser of Marconi.

This office action of June 3, 1902, resulted in Marconi letting his application become abandoned, for no reply was made within the year required under the Patent Office rules.

On October 6, 1903, 16 months after the office letter rejecting the case, Marconi filed a petition to the Commissioner of Patents for revival of the case, together with a proposed amendment and a reply to the examiner's arguments on rejection. On October 15, 1903, the examiner in a statement to the Commissioner of Patents recommended that the petition for revival be denied. Additional affidavits were filed by Marconi subsequent to the examiner's statement, and these were also considered by the examiner, and in a statement to the commissioner his recommendation for denial of the petition was persisted in. On December 3, 1903, the Commissioner of Patents formally denied the petition for revival.

In the examiner's statement to the commissioner of October 15, 1903, he persists in his contention that the claims are not patentable over Tesla, and further adds prior art considered by me in the way of the paper of Pupin presented before the American Institute, December, 1899, and the Stone patent No. 714756.

In the Marconi amendment accompanying the petition he contended that the Tesla oscillator was not the same as Marconi's oscillator consisting of a spark gap, condenser, and inductance in circuit. The examiner on page 5 of his statement comments on this as follows:

"Many of the claims are not patentable over Tesla 645576 and 649621, of record, the amendment designed to overcome said references as well as Marconi's pretended ignorance of the nature of a 'Tesla oscillator' being little short of absurd. Ever since Tesla's famous lecture on alternating current of high frequency delivered before the American Institute of Electrical Engineers in 1891, and repeated in 1892 before the Institute of Electrical Engineers and the Royal Institution, London, the Societe Internationale des Electriciens, and the Societe Francaise de Physique, Paris, which lectures have been widely published in all languages, the term 'Tesla oscillator' has become a household word on both continents."

The examiner then points out that this Tesla oscillator was found in all elementary textbooks used in the ordinary

high schools, and that Marconi evidently knew of it in 1897, because he is quoted by Della Rictia in a publication in 1898 as having used it.

In concluding the Examiner said:

"It is true that said British patent (referring to Marconi British patent No. 7777 of 1900 corresponding to the application then under discussion) as well as other foreign patents so operates and it is true that this is a valuable invention, but, in the opinion of the examiner, the references above cited and also numerous other references, some of [fol. 784] which are hereinafter set forth, effectually dispose of the idea that this is a valuable application, however valuable may be the invention disclosed therein, because any patentable claims which this application will support in view of the state of the art must necessarily be of the most limited character." [Parentheses mine.]

This statement of the examiner of October 15, 1903, having included reference to both the Pupin paper and the Stone patent, brings in all of the prior art that I have referred to; that is, prior art relating to radio communication per se, except the two Stone letters.

Following the denial of the petition for revival on December 2, 1903, by the Commissioner of Patents, Marconi, on February 19, 1904, requested a reconsideration of the petition, which petition was granted on March 28, 1904, by the Commissioner of Patents, there being no evidence in the file wrapper that the petition for reconsideration was submitted to the examiner, and there is no statement from the examiner to the commissioner included in the file wrapper.

Following the revival of the application by the commissioner, the case was immediately acted upon by a new examiner, and all of the claims formerly rejected by the old examiner allowed, except four, which were rejected on the patent to Stone 714756, which I have referred to.

The new examiner said as to these rejected claims:

"Stone shows in Figure 5 a transformer M whose secondary I^2 is connected to an open circuit including a radiating conductor V at one end and a capacity E at the other and whose primary I^1 is connected to a condenser circuit discharging through a spark gap, viz, a circuit, C, s, I^1, L. These circuits are in 'electrical resonance with each other'. See lines 16-20, page 2. It is not stated how the elevated

conductor is given a natural period equal to that of the oscillations impressed upon it but it is well known by all skilled in this art that this may be accomplished by adjusting the length of the elevated conductor, thereby adjusting the distributed capacity and the distributed conductors of the same until the natural period of such conductor is equal to the natural period of the condenser circuit C, s, I^1, L. When this is done 'the frequency impressed upon the elevated conductor' is 'the same as the natural period or fundamental of such conductor', to quote from the Stone patent."

Thus, the new examiner limited the tuning in the vertical wire or elevated conductor circuit through an adjustment of the physical length of the wire, though there is no statement in Stone which so limits it, and is a view contrary to that expressed by the former examiner who said that in view of the prior Lodge patent, there was no invention in employing for the purpose of tuning the vertical wire of Stone the variable-acting coil of Lodge in the manner shown by Marconi.

As I have heretofore stated, the Stone to Baker letters were not considered by the Patent Office. Had the Stone letter of June 30, 1899, been before the examiner, it is my opinion that his contention that Stone was limited to varying the physical length of the vertical wire would have in no wise been tenable in view of Stone's statement on the last page, as follows:

"The tuning of these circuits one to another and all to the same frequency will probably be best accomplished empirically, though the best general proportion may be determined mathematically."

[fol. 785] This very complete statement of Stone certainly invites the attention of the art to the empirical variable acting coil of Lodge or the empirical variable condenser of Marconi referred to by the former examiner.

Having interpreted this limitation into the showing of the Stone patent, the new examiner said:

"Applicant discloses another means whereby the same result may be effected, viz, by including a 'variable inductance' in the elevated conductor. All claims which include this element are considered allowable over the Stone patent."

It therefore appears that the only difference the new examiner could find between Marconi and the prior art I have referred to was the placing of the Lodge variable acting coil in the elevated conductor circuit of Tesla and Stone, and it is my opinion that even disregarding the fact that the examiner did not have before him the Stone letter of June 30, 1899, that this is an extremely narrow difference particularly in view of the examiner's statement in the paragraph immediately following, as follows:

"In regard to claim 7, it may be said that Stone states that the operator at each station may at will adjust his apparatus in such a way as to place himself in communication with any other station (page 4, lines 28-36), and that he also states that this result may be effected by making the coil L of the condenser circuit adjustable (page 6, lines 76-81). Inasmuch as the period of an oscillating circuit depends upon the capacity of the condenser in the same way that it depends upon the inductance of the coil, it is held that it is not patentable to make the condenser c of applicant's oscillating circuit adjustable for the same purpose as Stone makes the coil L of his oscillating circuit adjustable."

Here the examiner held, in considering one circuit only, there would be no invention in shifting from a variable inductance to a variable condenser, which does not seem to be in keeping with the very narrow view taken as to the latitude of the manner of adjustability of the vertical wire circuit of Stone.

Summarizing the question, I find that all of the radio art I have referred to was considered by the Patent Office except the Stone-Baker letters of June 30, 1899, and July 18, 1899, and that the file wrapper indicates as the sole reason upon which the allowance of the application was predicated was the contention of the second examiner that Stone probably intended turning his vertical wire through varying its length, and Marconi having shown the Lodge variable acting coil as a tuning means for his vertical wire he was entitled to claim it.

Disregarding the Stone to Baker letters, there could be, in my opinion in view of the state of the art, no inventive novelty on the part of Marconi in using the variable-acting tuning coil of Lodge in Marconi's antenna. Lodge had

shown the coil in an antenna circuit or vertical wire for tuning, and Stone specifically states in his patent that the vertical wire may be tuned, and I can see no reason for the examiner contending that Stone should be limited to the awkward and unpractical method of trying to add or subtract wire at the top of an elevated wire instead of employing the practical method of a variable-acting coil provided by Lodge easily placed within reach of the operator. The Lodge method was certainly obvious to one skilled in the [fol. 786] art reading the Stone specification. However, it is clear to me that the entire matter was settled by the Stone to Baker letter of June 30, 1899, not before the examiner, in view of Stone's most specific instruction for empirical tuning.

* * * * * * *

29. Question. Compare the apparatus illustrated in plaintiff's Exhibit No. 87, Wireless Specialty Apparatus type, and described in the testimony of plaintiff's witnesses, with the apparatus of the Marconi patent 763772 to which you have referred, and explain wherein the function and mode of operation of the two types of apparatus are similar or dissimilar.

Answer. I have examined plaintiff's Exhibit No. 87, Wireless Specialty Apparatus type, and the description of this apparatus in the testimony of plaintiff's witnesses together with plaintiff's Exhibits No. 60, Navy contract No. 133; Exhibit No. 62 and Exhibit No. 87A referred to by the witnesses in their testimony concerning this type. Considering first the transmitting station of the Wireless Specialty Apparatus type, I find that the apparatus illustrated in plaintiff's Exhibit 87 and described by the witnesses and the exhibits is an apparatus which functions and has a mode of operation entirely different from the transmitter of the Marconi patent 763772.

I note that plaintiff's witness Langley describes the spark gap G at the transmitting station as of the type now known as "quenched" type, and that plaintiff's witness Waterman at page 165 of his deposition quotes from plaintiff's Exhibit No. 60 as to the gap as follows:

"Quenched spark gap, new design, perfect cooling by special central drafts. (We reserve right to furnish our new type tubular gap.) This latter having new feature

of cooling and perfect sparking alignment with ease of dismantling."

Also on the same page Mr. Waterman quotes from plaintiff's Exhibit No. 60, Navy contract of September 21, 1912, as follows:

"Wireless Specialty Apparatus Co. proposes to furnish apparatus as per the following details: * * * transmitting inductances will be supplied giving continuously variable wave length of 600 to 2,000 meters with no switches, exciting and radiating circuits, always in resonance and with maximum coupling."

The first quotation very definitely describes a type of gap, and the second quotation the kind of circuits forming the two circuits at the transmitting station and the manner of their association so as to make it clear and beyond all doubt that the transmitting station is the system described in United States patent 1216615 to G. Seibt, for "Apparatus for producing powerful electrical oscillation," granted February 20, 1917, on an application filed December 27, 1909. The system disclosed in the Seibt patent has since its introduction by Seibt and others become universally known as the "quenched gap" system, as well as having been universally adopted to take the place of all other types of damped wave or "spark" radio transmission. Fundamentally, it is based on the system disclosed by Lodge in his patent 609154 of 1898, particularly the transmitter [fol. 787] illustrated in Figure 4 of the Lodge patent, and broadly stated at page 2 of the Lodge specification, lines 57 to 67, inclusive, as follows:

"By both of the means described with reference to Figures 3 and 4, I charge the two capacity areas *h h'* (which, together with the inductance-coil between them, constitute the radiator) by aerial disruption or impulsive rush. The advantage of this is that charges so communicated are left to oscillate free from any disturbance due to maintained connection with the source of electricity, and therefore oscillate longer and more simply than when supplied by wires in the usual way."

Thus Lodge laid down the principle of quickly imparting a large amount of energy to the antenna or radiating circuit and then removing or electrically disconnecting the

source of supply of the energy from the radiating circuit so that the energy could oscillate at the natural period of the radiating circuit unhampered through any maintained connection or association with the supply circuit. In the Lodge system the radiating circuit is the seat of the oscillations and determines the frequency for the entire system, and is entirely unlike the later system of Marconi in which the primary circuit is the seat of oscillations and determines the frequency, the radiating circuit merely being a stepping-stone in the Marconi system slowly taking energy from the primary circuit in small quantities to prevent interaction between the circuits, and having the amount of energy given it by the primary circuit and the duration of the giving dependent upon the characteristics of the primary as a reservoir and a good conserver. In the Lodge system, the primary circuit has nothing to do with the frequency and the duration of the oscillations, this being the function of the secondary or radiating circuit, the function of the primary circuit being merely to collect a considerable quantity of energy, deliver it to the radiator circuit in the least possible time, and finally to entirely get out of the way the radiating circuit when the latter goes into action. On the other hand, in the Marconi system, the primary circuit is entirely responsible for setting the frequency of the system and for the duration of the oscillations, and can never forsake the secondary circuit, as the secondary circuit's function in the system is entirely dependent upon the primary circuit.

The quenched gap system described by Seibt is an improvement upon the Lodge system, predicted, first, upon recognizing certain principles in connection with the action of spark gaps in the matter of ionization and, second, upon utilizing to advantage the production of two frequencies between two closely coupled circuits, which two frequencies were entirely destructive to the Marconi system.

In my two quotations from Mr. Waterman's deposition on page 165 I showed that in the first quotation Mr. Waterman pointed out that the Wireless Specialty Apparatus type of apparatus, plaintiff's Exhibit 87, contains, first, a quenched gap, which is the first improvement in the Seibt system over Lodge, and from the second quotation contains, second, "maximum" or tight coupling, together with means for bringing the two circuits in what was termed in the quotation "resonance," which coupling and so-called

"resonance" relation constitutes the second basis of Seibt for improvement over Lodge. I will point out in connection with my discussion of the operation of the Seibt and Wireless Apparatus Co. type that there is no such thing [fol. 788] as "resonance" between the primary and secondary circuits of the quenched gap type. That the adjusting of the time period of the two circuits is for a purpose having nothing whatever to do with a resonant transfer of energy between circuits as was necessary to the success of the Marconi system.

In my sketch G, Figures 2 and 2*a*, I have shown the two frequencies resulting from tightly coupling two oscillatory circuits together, and have illustrated the two oscillations in red and green to show that there are two, and I have pointed out that neither of the frequencies of the two oscillations is the same as that of the natural time period of the circuit, but entirely different, one being of a frequency higher and one of a frequency lower than the natural period. I have also shown that under such conditions of association the energy is transferred back and forth between the two circuits, being alternately all in one circuit, and all in the other circuit, giving beats of no energy in the two circuits from time to time. In the Seibt patent I have referred to this effect is also clearly shown in Figures 2 and 3, except that Seibt makes no effort to show by colors or otherwise that there are two frequencies in each circuit, the patent being principally concerned with the point at which the first beat is obtained. In the specification Seibt describes this action, page 1, lines 62 and 70 as follows:

"In the arrangement shown in Figure 1 two separate oscillations are produced, as is well known, even though the natural periods of the two circuits, I and II, are the same. In the case where these two circuits are in resonance with respect to their natural periods, the two wave lengths of the system are given by the following formulae, neglecting resistance—".

Seibt then states the two formulae for the two wave lengths or frequencies which I have previously given. I wish to point out that Seibt's reference in this quotation to "resonance" between the two circuits carefully avoids any interpretation of a resonant transfer of energy, for

he states "resonance with respect to their natural periods," meaning merely that as far as adjustment of capacity and inductance is concerned, the products are such as to make the natural periods of the circuits, if acting alone, the same. There is no resonance, and can be none, with respect to the frequencies of the two oscillations set up.

Seibt then describes the production of beats, or alternate periods of no energy in the two circuits, illustrated by me in my sketch G and by Seibt in his Figures 2 and 3, as follows:

"In Figure 2 I have shown the form of the oscillations set up in the primary Circuit I, and in Figure 3 I have shown the form of oscillation induced or set up in the coupled secondary Circuit II. An examination of these diagrams reveals the fact that in the beginning when a spark discharge takes place in circuit I there is no energy in Circuit II, and consequently the oscillations in Circuit I commence with maximum amplitude, while the amplitude of the oscillations in Circuit II commence with zero value. The energy in the primary oscillating Circuit I, however, sets up oscillations in Circuit II, so that, commencing with zero value at the beginning, the amplitude of the two oscillations in Circuit II increase, as the corresponding amplitudes of the oscillations in Circuit I decrease, thereby producing beats, the energy in Circuit II influencing the Cir- [fol. 789] cuit I and again setting up oscillations therein, but of diminished value to the extent of the damping that takes place in the transformation from the one circuit to the other. These resulting oscillations of diminished energy commence at zero value of amplitude and built up again in amplitude, in Circuit I as the oscillations in Circuit II diminish in amplitude, but the maximum value of the oscillations of the second beat in Circuit I is less than the maximum value of oscillations in said circuit at the commencement of the operation; that is, at the time of the discharge at the spark gap. In turn these oscillations of diminished maximum amplitude in Circuit I again set up oscillations in Circuit II, but also correspondingly reduce maximum amplitude, and so on, till the oscillations in both circuits are finally reduced to an infinitesimal value."

* * * * * * *

Thus Seibt describes the transfer of energy from one circuit to another alternately in a tightly coupled system

in the same manner as I have previously explained both in connection with electrical circuits and coupled oscillating bodies such as pendulums.

By reference to Figures 5 and 5*a* of my sketch H, it will be seen that in a loosely coupled, persistently oscillating primary circuit system of the Marconi type, there is no production of beats or instances of no energy in the two circuits as is had with a tightly coupled system.

Now, it is this beat phenomenon that attracted the attention of Seibt and other workers in the radio art in the years just prior to the filing of the Seibt application. It occurred to them that this point of no energy in the primary circuit could be put to a useful purpose, namely, giving the spark gap sufficient time to become adequately deionized to permit the gap to open or become inactive, thereby disconnecting the primary circuit electrically from the radiating circuit, so that no retransfer of energy could take place, and the energy all being transferred to the radiating circuit would remain there and continue to oscillate at the frequency natural to the radiating circuit until expended. Seibt describes this result at page 2, lines 74 to 87, as follows:

"From the moment of this snapping off of the current at the spark gap, or the resulting opening of the primary circuit, the secondary circuit takes up an independent oscillation, uninfluenced to any appreciable degree by the coupling thereof to the primary circuit, the character of the oscillations therein being changed so that the two coupled waves ν_1 and ν_2 disappear and the free oscillation ν_0 alone, of the secondary circuit takes place, this free oscillation being of slowly damped form and depending on the natural period of the secondary circuit."

Thus, while energy is being transferred from the primary to the secondary circuit there exists no useful frequency for radiating one frequency waves, but two arbitrary coupling frequencies which, through being different, act to create [fol. 790] a beat or point of no energy in the primary circuit. The real frequency useful to the system does not commence until all of the energy is transferred to the radiating circuit and the primary circuit then electrically disconnected from the radiating circuit through an opening of the spark gap, termed by the art "quenching," from

which the name of the system is derived. Seibt illustrates the oscillations resulting in the radiating circuit from a quenching of the spark gap at the first beat in the primary circuit in Figure 4 of his patent. In a sketch marked "Loftin Sketch O—Quenched Gap System," inserted opposite, I have illustrated the effect described by Seibt in the quotation above, and have shown the two coupling frequencies in red and green as in previous sketches, and the desired one frequency of the system obtained in the radiating circuit in purple. The Seibt quoted description above clearly brings out that there are two frequencies up to the point of quenching, but no effort has been made to show this in his Figure 4 as I have done in my Figures 6 and 6*a* of my sketch O. In my Figure 6 I show the oscillations in the primary circuit, and by carefully examining this sketch, it will be seen that the red and green oscillations commence at about the same time, or what the art terms "in phase," but being of different frequencies, they gradually pull apart until they become opposed, termed by the art "opposite in phase," which ossurs at the beat or point of minimum current, and by examining my Figure 6, it will be seen that at this point, the red oscillation is below the line and the green oscillation above the line. If the strength of the two oscillations at this point is exactly equal, one will cancel the other and there will be a period of absolute zero current having the duration of one-half cycle of the high frequency. This, of course, is a very short time when calculated in seconds, but with a spark gap properly designed so that electrons traveling at the rate of 185,000 miles per second can all, or practically all, escape from the space separating the electrode, it will be appreciated that this very short period of no current can be very usefully employed in bringing about "quenching," so vital to the quenched gap system. I will explain later the requirement for a gap suitable to operate in such a system.

In my Figure 6*a* the oscillations in the secondary or radiating circuit are illustrated, and I have drawn the oscillation directly below those in the primary circuit to indicate what happens in the secondary at instances corresponding to the primary. It will be seen by careful examination that when the red and green oscillations in the primary are large and in phase, that the red and green oscillations in the secondary are small and opposed, and that as the

red and green oscillations in the primary gradually become smaller and draw out of phase, the red and green oscillation in the secondary gradually become larger and draw in phase, meaning that the energy transfers from the primary to the secondary. At the point of minimum energy in the primary where the gap "quenches," the influence of the primary on the secondary then ceases, the primary being unable to support current flow and therefore to take no energy from the secondary. The energy of the red and green oscillation in the primary then combines to form one powerful oscillation in the secondary, which I have illustrated by showing the purple oscillations commencing at this point as being much stronger than either the red or green oscillations, it having the combined energy of the two oscillations. The purple oscillations in the radiating [fol. 791] circuit then continue as a long drawn out train of oscillations having the frequency set by the natural period of the radiating circuit, the strength of the oscillation gradually decreasing as the energy is imparted to the surrounding space for useful communication of signals, together with a small loss in overcoming the resistance of the wire forming the radiating circuit.

It is seen that this is a system entirely different from that described by Marconi, which Marconi system has been termed by the art the "open gap" system, and by which term I will refer to it in the future for the sake of brevity. In the open-gap system, no beats are produced, first, because it is required that the primary circuit determines or sets the pace for the one frequency of the system, and to produce beats there must be two frequencies; second, because the primary must be persistent and have its oscillations drawn out for a long time, and it can not be persistent if it quickly transfers all of its energy to the secondary to produce the beat required in the quenched gap system, and the oscillations in the primary will not be long drawn out; third, because in the open-gap system, the primary must act as a reservoir and slowly feed energy to the secondary to persistently make up for the energy expended by the secondary in radiating for useful communication, whereas in the quenched gap system the energy is quickly dumped into the secondary during which period there is no useful radiation, and when the secondary is usefully radiating, the primary is entirely out of action and supplies no energy; and fourth, there must be a resonant transfer of energy

between the primary and the secondary in the open-gap system, because the primary is always and continuously supplying energy at a particular desired frequency to the secondary, and the secondary must have the same natural period of oscillation as the frequency of the oscillation from which it is being fed to obtain an efficient transfer at the slow rate of feeding, whereas in the quenched gap system there is no resonant transfer, the energy merely quickly going over at two widely separated frequencies, neither one of which corresponds to the natural period of either the primary or secondary circuit.

In Figure 6*b* of my sketch O, I illustrate the radiated result of the oscillations in the radiating circuit of the quenched gap system illustrated in Figure 6*a*, the diagram showing signal strength plotted against frequency, signal strength being represented by vertical dimensions and frequency by horizontal dimensions. The diagram shows that during the period of transfer of energy between the primary and secondary circuit, there are radiated two weak signals, one in green at a frequency lower than the desired frequency and one in red at a frequency higher than the desired frequency. These two signals are not very strong because the time of transfer is very short, and also the energy is divided between two frequencies. The diagram shows the radiated signal of the desired frequency in purple, as being considerably stronger than the signals resulting from the two coupling frequencies, this on account of the energy at the desired frequency enduring for a long time and being the combination of the energy of the two coupling frequencies. The desired frequency illustrated in the diagram is the frequency determined by the natural period of the radiating circuit, and is in no way derived from the period in the primary circuit, and when received by a two circuit receiving station having its two circuits [fol. 792] tuned to this frequency, the system is a three circuit tuned system instead of a four circuit tuned system as in the open gap system.

The signal diagram in my sketch O, is the same as that illustrated in Figure 6 of the Seibt patent, the two small humps marked as r_1^2 and r_1^1 in the Seibt diagram, indicating the green and red coupling frequencies in my diagram.

Comparing the quenched gap system of my sketch O with the open gap system of my sketch H, Figures 5, 5*a*, and 5*b*,

the differences in the two systems are readily apparent. Figure 5 of the open gap system shows powerful oscillations of long duration and without beat, and of one frequency in the primary circuit, while Figure 6 of the quenched gap system shows two oscillations, each relatively weak and with a quick beat, and of short duration in the primary circuit. Figure 5*a* of the open gap system shows relatively weak oscillations in the radiating circuit, first gradually building up, and then decaying, being weak because of the slow feeding from the primary circuit, and having the same frequency as the oscillations in the primary circuit, while Figure 6*a* of the quenched gap system shows, first, oscillations of two frequencies, which quickly combine to form oscillations very powerful and of one frequency not found in the primary circuit, being powerful on account of comprising practically all of the energy of the system quickly dumped into the circuit by the primary. Figure 5*b*, the signal diagram of the open gap system, shows signals of one frequency corresponding to the frequency of the primary circuit, and being relatively weak because produced by the more or less oscillations in the radiating circuit, while Figure 6*b*, signal diagram of the quenched gap system, shows two relatively weak signals at widely separated frequencies resulting from the tight coupling between the primary and secondary circuit during the period of dumping of energy into the secondary circuit, and one very powerful signal of the desired frequency corresponding to the frequency determined by the radiating circuit and not found in the primary circuit.

The foregoing clearly brings out that the quenched gap system is based upon the fundamental principles laid down by Ledge which I have previously quoted, namely, quickly dumping amount of energy into the radiating circuit, and as soon as this — accomplished to electrically remove the dumping source from a maintained connection with the radiating circuit in order that the radiating circuit may be free to form this energy into a long drawn out train of very powerful one frequency oscillations.

Considering now my discussion of the quenched gap system, the following quotation from the Seibt patent, page 3, lines 6 to 24, inclusive, become particularly significant:

"From the foregoing considerations it will be seen that in practical operation it is desirable that the spark snaps

off, or is quenched, or, in another expression of the idea, that the primary circuit is opened, at the instant when the current amplitude first reaches zero value in the primary circuit, or at the spark gap, and that the duration of the spark be as short as possible, that is, that the coupling between the circuits shall be sufficiently strong or close and adjusted to secure a rapid decrease of the oscillations in the primary circuit with corresponding reduction of the energy in the primary circuit to substantially zero value as indicated by the diagrams, in which case the maximum [fol. 793] of efficiency is attained in the transformation of energy from the primary to the secondary circuit."

I have previously stated that Seibt and others in conceiving the quenched gap system had their attention attracted by this first beat or period of minimum current in the primary circuit brought about by coupling two circuits closely, and in the quotation above, Seibt not only lays stress upon employing the first beat to obtain the quenching action, but brings out that it is desirable to secure this first beat as early as possible by tight coupling, and further examination of my sketch O will make clear how tight coupling may be utilized to produce an early beat. In Figure 6*b* of sketch O, I have shown on enlarge scale the oscillations in the primary circuit illustrated in Figure 6. In Figure 6*d*, it is seen that the green oscillations are slower than the red oscillations. I have shown by mathematical formula and explained how difference between the two frequencies depends upon the tightness of coupling—the tighter the coupling the greater the difference. In Figure 6*d*, it will be seen that the two oscillations start together, or at the same instant, but gradually draw apart or out of phase until the faster one becomes opposed to the slower one. Now it is apparent that the greater the difference in frequency between these two oscillations the sooner will the faster one reach the point at which it can oppose the slower one, and result in a beat or point of minimum or no current. In other words, the tighter the coupling, the sooner the beat will be reached. The value of an early beat is—first, to prevent the energy from unnecessarily long operating at two frequencies, for the shorter the time it so operates, the weaker will be the resulting radiated signal at these two frequencies; second, to prevent the energy from remaining long in the primary circuit where the ex-

penditure of energy in the spark gap is large; and, third, to separate the two coupling frequencies as far as possible to avoid interference.

There is also another way besides that of coupling of controlling the time at which the first beat is secured and which way is also utilized to secure the perfection of the beat; by perfection, I mean obtaining practically no current flow at this point by balancing the intensity of the opposed oscillations. This second way is through adjustment of the time periods of the two circuits, through either adjusting capacity, or inductance, or both. I have, in my analogy of electrical circuits to oscillating pendulums, pointed out that if two pendulums of different sizes are coupled together, as through a rubber band, they will transfer energy of oscillations back and forth from one to the other, but that it will take a long time for the smaller pendulum to get all of the energy of the larger pendulum and vice versa, so that production of beats or periods of no energy in the one and the other pendulum will be irregular. The same thing happens in coupling electrical circuits of different frequencies, so that in quenched gap systems, the time periods of the two circuits are adjusted approximately in accord to avoid irregular production of beats or to give better control over the point of production of the first beat. This adjustment has nothing whatever to do with the resonant transfer of energy between two circuits in a quenched gap system which is so vital to the open gap system. During the short interval of energy transfer in the quenched gap system, oscillations are t-king place at [fol. 794] two widely different frequencies, both widely different from the natural period of the two circuits, and resonance, or resonant transfer of energy, does not feature. The time period adjustment is entirely for the purpose of controlling the production of the beat. In the open gap system, the energy is slowly transferred at one frequency from the primary to the secondary circuit, and resonance is vital and necessary to secure an efficient transfer of energy as well as to avoid having two frequencies in the radiating circuit, one a forced oscillation, and the other an oscillation at the natural period of the radiating circuit, which I have illustrated in Figure 4*a* of my sketch II, where the two circuits are not in resonance, as compared to the

correct way illustrated in Figure 5*a* of the same sketch, where the two circuits are in resonance.

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It is therefore apparent in the quenched gap system that if the time periods of the two circuits are widely different, the production of beats will be irregular and more difficult to predict and to control. The transfer of energy to the circuit having large capacity for absorbing energy will be quick, while the transfer of energy to the circuit having small capacity for absorbing energy will be slow. Therefore, by adjusting the two circuits practically the same in time period, one variable element in proper adjustment of the system is eliminated.

In fact, however, the two circuits of a quenched gap system are not in practice adjusted to have the same time period, another feature in adjustment of quenched gap systems making it desirable to affect a compromise in this respect, and this feature is the production of a perfect or nearly perfect beat. In my sketch O, Figure 6*d* is an enlargement of Figure 6, which illustrates the two oscillatory currents in the primary of a quenched gap system. I have pointed out that in order to secure a nearly perfect beat or period of no current in the spark gap, the two currents when they draw apart at the beat should be of practically the same value in order that one may cancel the other at this point of being in opposite phase to reduce the current to practically zero. If the two circuits are in precise adjustment in the matter of time periods being the same, the current of the higher frequency is found to be the stronger, and the current of the low frequency, the weaker. I have illustrated this by showing the red current at the point *x* extending above the line somewhat more than the green current at the point *y* extends below the line. The smaller green current would only neutralize a part of the larger red current, leaving a residual current flowing through the gap at the beat in a precise adjustment of the time periods of the two circuits. For this reason it is the practice in quenched gap systems to throw the two circuits somewhat out of adjustment in order to bring the two currents to practically the same value at the beat and obtain a resultant no-current effect. The result is that a properly calibrated or adjusted quenched gap system has the two [fol. 795] circuits out of adjustment in the matter of time

periods, while at the same time a properly adjusted open gap system has the two circuits in very precise adjustment to have the same time period. This out-of-adjustment condition of the quenched gap system is most apparent from analyzing the steps taken by an operator to calibrate such a system. In such a calibration, the operator will first carefully adjust the primary circuit to a definite frequency, using a wave meter which is an instrument for measuring frequency, being certain that the secondary or antenna circuit is open so as not to influence his measurement. He will then open the primary and adjust the secondary to the same frequency. Having so adjusted the two circuits, he then starts his set in operation, and listening to the note given off by the transmitter, will gradually throw the two circuits out of tune until a nice clear note is had, which indicates to the operator that this out of tune adjustment has been carried to a point where the two oscillations are practically neutralizing each other at the beat and good quenching is had; that is, that the spark gap is opening up and not reclosing to permit a retransfer of energy to the primary circuit.

Therefore, the adjustability of the circuits of a quenched gap system are first, for control over the point or instant of securing a beat, and second, for throwing the two circuits out of tune sufficiently to produce a perfect beat, and these purposes have nothing to do with a resonant transfer of energy between the two circuits, for the very idea of producing beats requires the production of two frequencies to which there can be no resonance.

In a quenched gap system, it is not only necessary to produce a perfect beat, but a spark gap must be used having such characteristics as to permit of employing this beat usefully. I have discussed somewhat at length the production of ionization in the space separating the two electrodes of a spark gap, and how it is this ionization that is responsible for current flow in the space, and have pointed out that if the gap structure is of such a nature as to allow some ions and electrons to remain in the space, after the main current has stopped flowing, it is easy for the new current to start in the opposite direction, and how vital this maintenance of ionization in the gap space is to the open gap system, where it is essential that the oscillations in the primary circuit persist for a long time. In the quenched gap system, there is required a gap having characteristics

just the reverse of the open gap. The ionization must quickly disperse, that is, during the first beat, so that when the secondary circuit which has received all of the energy tries to return some of the primary circuit, it will encounter the extreme high resistance of a completely de-ionized gap and cannot return. This essential characteristic of the quenched gap is obtained by very definite structure and choice of materials opposed to the open gap structure. I have pointed out that one of the requirements for an open gap to aid in persistent oscillations is high temperature, this high temperature being utilized to vaporize the metal of the electrode to fill the space with metallic ions which move slowly and can not be dispersed so easily, and also that high temperature causes the electrodes to emit electrons into the space, which action may be going on while the current is zero at a reversal, making available some electrons in the space when the current is ready to commence flowing in the new direction. At page 165, Mr. Waterman [fol. 796] quotes from plaintiff's Exhibit No. 60, Navy Contract No. 132, one of the requirements for the Wireless Specialty Apparatus type in plaintiff's Exhibit No. 87, as follows:

"Quenched spark gap, new design, perfect cooling by special central draft. (We reserve right to furnish our new type tumblar gap.) This latter having new feature of cooling and perfect sparking alignment with ease of dismantling."

Thus the gap was to be of the "quenched type," and particular emphasis was laid on cooling, one of the essentials for quick quenching as opposed to persistency. The designation of the gap as "quenched" type also bring out that it had many other characteristics well known to those skilled in the art for securing quenching. I am familiar with many designs of quenched gaps which have been put into practical use, and all of them embody the following features looking toward quick quenching:

(1) Arrangements for good cooling through choice of materials having high thermal conductivity, provision of large cooling surface, and use of water cooling or air-blasts in high power installation.

(2) Choice of materials for electrodes or sparking surfaces which do not easily vaporize or oxidize, such as electrolytic silver, and electrolytic copper.

(3) Use of a number of very small gap spaces in series; that is, instead of having one gap say of one-half inch total length, to divide this over a plurality of gaps such as 10 to 15.

(4) Using sparking surfaces of very large extent, such as flat discs, two to three inches in diameter, instead of spark balls or cylindrically shaped electrodes of about one-half inch in diameter.

(5) Inclosing the sparking space in an air-tight arrangement to prevent oxidization of the sparking surfaces from further supply of air after the small amount which is entrapped in the air-tight space on closing is consumed, and to maintain the space under partial vacuum.

(6) Avoiding the admission to the gap space of gases having high atomic weight with resulting slow moving ions.

The good cooling on (1) prevents vaporizing the metal of the electrodes, thus keeping the gap space clear of metallic vapors of high atomic weight, which would create ions which move too slowly to disperse in the gap space before the new current starts, and also keeps the temperature of the electrodes sufficiently low to prevent the emission of electrons set into motion by heat.

The choice of materials of the electrodes of (2) cooperates with the low temperature to prevent vaporization, and through not oxidizing, does not create a new substance which will vaporize, and being a material of good thermal conductivity cooperates in obtaining good cooling. The lack of oxidation maintains the good thermal conductivity characteristics of the metal.

The dividing of the total gap length into a number of short gap spaces of (3) gives the electrons and ions in each of the short spaces a very short distance to travel to get to an electrode during the short period of no current, over the travel required of the electrons and ions left in a long gap space.

The use of sparking surfaces of very large extent of (4) gives the electrons and ions in the spaces easy access to the electrodes, not being compelled to crowd to areas of small extent.

[fol. 797] The inclosing of the sparking space of (5) aids in preventing oxidation, which would be had with a free access of air to the sparking surfaces, and if such oxidation is had, it results in reducing the thermal conductivity to

destroy good cooling, as well as creating a vaporizing material on the surface of the electrode. The inclosing also allows the creation of a partial vacuum, and where a partial vacuum exists, fewer collisions can take place between electrons and atoms forming the gas in the space, and under such conditions, the ionization dispersion is always more rapid.

The avoiding of the admission to the gap space of gases having high atomic weight of (6) provides for the use of rapidly moving ions which can disperse in a short interval of no current.

These are all features which would militate against securing the persistency of oscillations in the primary circuit of the open gap type, as such features tend to cause the gap to open or quench long before the primary circuit has delivered a material part of its energy to the slowly fed radiating circuit, thereby preventing the primary circuit from being a reservoir of energy for the dependent radiating circuit. Such a gap structure would also have a high resistance, resulting in large energy losses in the primary circuit, if the energy endeavored to flow or persist for a long time, and would thereby militate against the primary circuit being a good conserver of energy, which is essential to the open gap system. This high loss feature is not important in the quench gap system, because the system is based upon the principal of getting the energy out of the primary circuit as early as possible into a circuit that has no spark gap, and whose only loss aside from useful radiation is the small resistance of a wire that can be made very small by proper choice of size and material of wire.

Summarizing, the quenched gap transmitter of the Wireless Specialty Apparatus type illustrated in plaintiff's Exhibit 87, is entirely different from the open gap type of transmitter of the Marconi patent 763772, because (1) it is based upon the principle of quickly dumping the energy of the primary circuit into the radiating circuit, where the frequency of the system is then determined by the period of the radiating circuit in its electrically disconnected relation to the primary circuit as disclosed by Lodge in his patent in suit prior to the Marconi application, as compared to the principle of the open gap system in which the energy is maintained for a long time in the primary circuit as oscillations of the desired frequency for the entire system as determined by the natural period of the primary circuit, and

which energy is slowly and resonantly fed to a radiating circuit at the rate at which it can be radiated; (2) because there is no resonant transfer of energy between the primary and secondary circuits of the quenched gap system, the energy going over at two widely separated frequencies, neither of which is of the desired frequency and neither of which has the frequency of either the primary or secondary circuit, as compared with the open gap system where the energy is transferred at one frequency, which is the frequency of the primary circuit and the frequency of the secondary circuit precisely tuned to the primary circuit; (3) because the arrangements for the adjustments of the two circuits of the two systems are for entirely different purposes, in the quenched gap system, the adjustment being for the purpose of controlling the point of production of a beat of no energy in the primary circuit, which beat is [fol. 798] entirely foreign to the principle of the open gap system, and for throwing the two circuits somewhat out of adjustment to control the perfection of the beat, while in the open gap system, the purpose of the adjustment of the constants is to obtain a precise resonant transfer of energy from one circuit to another in no way forming a feature of the quenched gap system; (4) because the quenched gap system depends upon a tight coupling or close relation of the two circuits that will produce two frequencies sufficiently widely separated to obtain an early beat while the open gap system depends upon a coupling relation between the two circuits so loose that for all practical purposes, the two frequencies will be merged into one; and (5) because when used with a two-circuit receiver the quenched gap transmitter results in a three-circuit tuned system, the frequency of the oscillations being determined by the radiating circuit with the primary circuit entirely out of action, while the open gap system is a four-circuit tuned system, the frequency of the oscillations being determined by the primary circuit at the transmitter, which is in action during practically the entire time of radiation.

(Defendant's counsel offers in evidence the following exhibits referred to by the witness:)

F-2. The London Electrician for September 14, 1888, pages 587-589; September 21, 1888, pages 625-627; September 28, 1888, pages 663-665; October 5, 1888, pages 697-698; October 12, 1888, pages 725-726; October 19, 1888, pages

757-758; October 26, 1888, pages 788-789; November 9, 1888, pages 16-18; November 16, 1888, pages 41-44.

G-2. Lightning Conductors and Lightning Guards, by Lodge, published at London, England, 1892, pages 352-354.

H-2. Modern Views of Electricity, by Lodge, published at London, England, 1889, page 373.

I-2. Transactions of American Therapeutic Association, New York, 1894, article on D'Arsonval modification of current of great frequency.

J-2. Instructions for Use of Wireless Telegraph Apparatus, by Hudgins, published at Government Printing Office, Washington, D. C., 1903.

K-2. Gesellschaft fur drahtlose Telegraphie, published at Berlin, 1904.

L-2. Certified copy of drawings from Navy Department.

M-2. Loftin sketch F.

N-2. Wireless Telegraphy, by Zenneck, New York, 1915.

O-2. Loftin sketch G.

P-2. Loftin sketch H.

Q-2. Loftin sketch I.

R-2. Loftin sketch K.

S-2. Hutin Leblanc patent 838545, December 18, 1906.

T-2. Pupin patent 519347, May 8, 1894.

U-2. Pupin patent 640516, January 2, 1900.

V-2. Loftin sketch L.

W-2. Loftin sketch M.

X-2. Telsa patent 645576, March 20, 1900.

Y-2. British Telsa patent 20981 of 1896.

Z-2. British Braun patent 1862 of 1899.

A-3. British patent, Braun 12420 of 1899.

[fol. 799] B-3. Loftin sketch N.

C-3. Seibt patent 1216615, February 20, 1914.

D-3. Loftin sketch O.

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Answer to question 29 continued. So far I have discussed the transmitter only of the complete system illustrated in plaintiff's Exhibit No. 87, Wireless Specialty Apparatus type. The system illustrated includes both a transmitting station and a receiving station, the receiving station having two circuits comprising an open or elevated-conductor circuit coupled to a secondary closed circuit. The complete system illustrated is a three-circuit system, instead of a four-circuit system as described in the Marconi patent

for, as I have explained, the primary circuit at the transmitting station of the Wireless Specialty Apparatus quenched-gap type only functions to quickly deliver a large quantity of energy to the radiating system at two frequencies not featuring in the operation of the system as a whole, and then goes out of action while the rest of the system is in action, as compared with the function of the primary circuit at the transmitting station of the Marconi open-gap type in which the primary circuit remains in action during the entire period of action of the other three circuits, the primary circuit during all this time acting as a reservoir of energy, determining the frequency of oscillation of the entire system, and slowly feeding the energy to the radiating circuit, a dependent stepping-stone in the system. The Marconi open-gap system requires the precise adjustment of the time periods of all four of the circuits to be the same, because all four are in action at the same time and for a long time. In the Wireless Specialty Apparatus quenched-gap type, there is required for good selectivity a precise adjustment of the time periods of but three circuits; namely, the open radiating circuit at the transmitter and the two circuits at the receiver. It is immaterial to the circuits of the receiver what the time period of the primary circuit at the transmitting station is, for this primary circuit has no frequency in common with the receiving station, and also it is entirely out of action when the receiving station is in action. In this respect the Wireless Specialty Apparatus quenched-gap type is similar to the Lodge type prior to Marconi, for Lodge determined the frequency of his system in the secondary or radiating circuit and employed two circuits at the receiving station, one of which was definitely tuned to the frequency of the radiating circuit at the transmitting station, while the secondary circuit of Lodge is impliedly tuned by Lodge, and definitely tuned by Marconi immediately after Lodge in his 1899 patent.

30. Question. Compare the three groups of claims of the Marconi patent 763772 with the Wireless Specialty type of apparatus and say whether, in your opinion, the language of said claims is or is not as applicable to said Wireless Specialty Apparatus as to the prior art which you have discussed.

[fol. 800] Answer. Considering first the group of claims relating to the transmitting station, I have previously

pointed out that this group of claims contains very definite language to the effect that the primary circuit at the transmitting station unqualifiedly has the duty of determining the frequency of the oscillations for the entire system, this language, in referring to the apparatus in the primary circuit, being generally stated as follows: "A means which automatically causes oscillations of the desired frequency." In the Wireless Specialty Apparatus quenched-gap type, plaintiff's Exhibit 87, there is not included at the transmitting station any provision for the primary circuit automatically or otherwise causing oscillations of the desired frequency. The two circuits at the transmitter are tightly coupled to produce oscillations of two undesired frequencies, as far as the system is concerned, for a purpose foreign to the purpose of the open-gap system, and it is my opinion that the language of these claims makes them not applicable to the Wireless Specialty Apparatus quenched-gap type, for if applicable to the quenched-gap type, it would be applicable to the Lodge type. In my opinion, the language is applicable to the type shown in the Tesla patent I have discussed and beyond all doubt applicable to the Stone patent and the Stone to Baker letters.

The transmitting claims further include means or instrumentalities for tuning or adjusting the two circuits at the transmitter to resonance or accord, in general, about as follows: "Means for adjusting the oscillation period of each of the two circuits connected with the transformer to bring them into accord with each other." In the Wireless Specialty Apparatus type, there are included variable inductances and capacities which were found in the art prior to Marconi and are found in the Marconi patent 763772, but these variable elements are not for the purpose of adjusting the two circuits in the quenched-gap type to resonance or accord, but are for the purpose of permitting an adjustment or control of the point of securing a beat, and for throwing the two circuits out of a precise adjustment to the same time period to secure a perfect beat. These variable elements were found in Lodge in the way of a variable inductance coil, in Tesla in the way of variable capacity or inductance, in the Marconi 1899 patent in the way of variable inductance and variable capacity, and in the Stone patent and Stone to Baker letters as variable inductance specifically, and impliedly variable capacity, these all being shown in the radio art prior to Marconi. These vari-

able elements were also found in numerous publications referring to electricity in general and high frequency electrical currents on wires. Marconi took them for his open-gap system for use in a particular way, that of precisely adjusting the circuits so that oscillations generated in one at the desired frequency could be resonantly transferred to another circuit, but in my opinion, this was used in the old Tesla patent I have referred to and in the Stone patent and Stone to Baker letters at a transmitting station. The quenched-gap Wireless Specialty Apparatus Type system took the same old instrumentalities and used them for an entirely different purpose, that of controlling the point of production of beats and securing a perfect beat, and it is my opinion that there is nothing in common between the two uses that was not already known to the art.

[fol. 801] Receiving station claims: In this group of claims, two or them, namely, Nos. 2 and 13, do not in any way refer to the matter of resonance between the two circuits of the receiving station, and I have previously pointed out that their recitation of simple combinations of electrical elements makes them easily found in numerous showings of the prior art, such as Lodge's Figures 12 and 13 illustrating his receiving station, in Figure 1 of the Marconi 1899 patent, and in the Stone patent and Stone to Baker letters, and in my opinion, these claims are just as applicable to the simple prior art as to the Wireless Specialty Apparatus type of receiver, plaintiff's Exhibit No. 87.

The rest of the claims of the group all include means or instrumentalities for adjusting the two circuits to resonance, the means being included in either one of the circuits, or in both. The means illustrated in the Marconi patent figures and described in the Marconi specification simply amount to variable inductances and variable capacities found in the art prior to Marconi, as for example, the variable coil of Lodge, the variable inductance and variable capacity of the Marconi 1899 patent, the variable inductance and variable capacity of the Tesla patent, and the variable inductance specifically mentioned by Stone, and the variable capacity impliedly included by Stone, all being in the radio art. I have also referred from time to time to other art concerning the use of these variable elements, in the general application of electricity as well as high-frequency oscillations in connection with wire work. The Tesla patent, the Marconi

1899 patents, and the Stone patent and Stone to Baker letters cover the use of these variable elements for tuning two circuits in a radio system to resonance, all of them having specifically shown receiving stations so tuned except Tesla. In my opinion, the receiving station claims of the Marconi patent in suit are just as applicable to the prior art as they are to the receiving station of the Wireless Specialty Apparatus type.

Claims covering both stations: The first claim of the two in this group, claim 10, broadly claims having four circuits of the system in resonance. In my opinion, this claim is not applicable to the Wireless Specialty Apparatus type, because the operation of the quenched-gap transmitter results in having but one circuit available for tuning with the two circuits of the receiving station, resulting in a system having but three circuits in resonance. The claim is in my opinion applicable to the prior art, as for instance, the Tesla transmitter having two tuned circuits taken in connection with the Marconi 1899 receiver having two tuned circuits, or, to the Stone four-circuit tuned system shown in his patent and the Stone to Baker letters.

The other claim of the group is restricted to means or instrumentalities for adjusting the four circuits to resonance, and these means or instrumentalities merely amount to variable inductances and capacity shown in the prior art discussed in connection with both the transmitting group and receiving group. In my opinion, this claim is not applicable to the Wireless Specialty Apparatus type because at the transmitting station the adjusting means are not for the purpose of tuning the two circuits to resonance, but for the purpose of securing control over beat production, as well as best perfection, which operation in no way involves resonance but is, in fact, opposed to it. It is my opinion that this claim is applicable to the prior art, as for instance, the two-tuned circuit transmitter of Tesla taken in [fol. 802] connection with the two-tuned circuit receiver of the Marconi 1899 patent, as these showings include variable elements for adjustment, or as shown as a complete system by Stone in his patent or in his Stone to Baker letters, Stone having employed variable or adjustable elements for tuning to resonance.

* * * * * * *

Before leaving the discussion of the Wireless Specialty Apparatus quenched-gap type, plaintiff's Exhibit No. 87, I desire to point out that the bid of the Wireless Specialty Apparatus Co. to furnish this type was based on Navy Wireless Specification No. 16-T-5, plaintiff's Exhibit No. 37, these specifications bearing date of 1910. This date was before quenched-spark apparatus became available, and the specifications do not require quenched-gap type of apparatus. The contract placed by the Navy with the Wireless Specialty Apparatus Co. for the quenched-gap type, plaintiff's Exhibit No. 60, contract No. 133, is dated in the year 1913, at which time quenched-gap apparatus was well known and available, and the contract provided for this new type. On page 5, paragraph 12, (a) of the specifications 16-T-5, under the heading "Oscillation transformer and antenna helix," there is found the following language quoted by Mr. Waterman at page 168 of his deposition:

"(a) The oscillation transformer shall consist of two inductively coupled coils with means for variation of coupling over a wide range. This range should include an indicator and easily made adjustment for close coupling. The contract shall state the recommended normal degree of coupling, and this shall be such as will give only one frequency in the antenna, the change of coupling to be made preferably by mechanical movement of one coil with relation to the other."

Appreciating that these specifications were written in the day of the open-gap type of transmitter, when the quenched-gap type was not yet available, the meaning of the above quotation becomes perfectly clear. It first requires means for variation of coupling over a wide range, this in order to secure very loose coupling for normal operation when selectivity due to having but one frequency was desired, and at the same time be able to secure a close coupling for emergency purposes. It has long been the instructions to operators that in an emergency, when it was desired to attract the attention of stations who might be listening on other wave lengths or frequencies, to employ a tight coupling in order to broaden their tune to cover a wide range of frequencies. Distress calls by ships, commonly known as "S. O. S. calls," are always made with a tight coupling in

order that the ship may have a better chance of attracting the attention of other ships.

The quotation then refers to a "normal degree of coupling," and states that it shall be such as will give "only one frequency in the antenna." Thus, for normal operation, it was required in the old specifications, that the degree of coupling should be sufficiently loose to permit of there being a transfer of energy between the two circuits at but one [fol. 863] frequency. The quotation in no way intends to imply that the old type of open-gap transmitter under consideration when the specification was drawn, was to be normally operated with a close coupling. When it was operated with close couplings, the use was abnormal and deliberately intended to destroy the selectivity which was one of the objects of the Marconi specification.

I also wish to point out that plaintiff's witness Langley, in plaintiff's Exhibit 87, has marked the condenser in shunt to the telephone R at the receiving station as j^3, which is the same designation given to the condenser between the two parts of the coil j^2 in Fig. 2 of the Marconi patent, and is the same as was done by Mr. Waterman in his sketch No. 3, "Marconi Simplified Receiving Circuit," to which I have previously taken exception, as the action of the condenser j^3 inserted between the two halves of the coil j^2 in the Marconi Patent is entirely different from that of the condenser j^3 in plaintiff's Exhibit 87, Waterman Sketch No. 3. This difference I have discussed more at length beginning page 680 of the typewritten record of my deposition.

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31. Question. Mr. Waterman, at page 171 of his deposition, makes reference to the Navy Manual of 1915 and the Signal Corps book Radiotelegraphy as supporting his contention that the circuits of the Wireless Specialty type of apparatus are in resonance. Do you agree with Mr. Waterman's conclusion?

Answer Mr. Waterman's quotation from the Navy Manual of 1915, plaintiff's Exhibit No. 78, page 57, is as follows:

"89. In Figure 29a, A B and C D have been given some turns in common, forming an air core-auto-transformer, but, whether directly or inductively connected these two circuits—the close and open circuits—must have equal natural

periods in order to produce and radiate electric waves efficiently."

Examination of Figure 29a referred to in the quotation shows that the quotation itself was concerned with the open-gap type of transmitter instead of a quenched-gap Wireless Specialty Apparatus type, both because the figure conventionally illustrates an open gap and also because the figure is entitled "Slaby Arco", which was a commercial type of open-gap apparatus that went out of existence before the quenched-gap type came into use. The quotation very correctly describes the tuning between the primary and secondary circuits of the open-gap type to which it refers, but forms no basis for contending that because the Slaby Arco open-gap type had resonance between the two circuits that the Wireless Specialty Apparatus quenched-gap type also had such resonance.

Mr. Waterman also quotes from page 163 of the same publication as follows:

"This includes calibration and tuning. A station is tuned when both sending and receiving circuits are correctly calibrated, coupled and adjusted to the standard damping and standard wave lengths."

This is a very general statement as to the desirability of having the transmitting and receiving stations of a system [fol. 804] in tune, and adjusted to be in tune at the standard wave lengths. There is nothing in this quotation from which to draw conclusions as to the difference between the open-gap type of transmitter and the quenched-gap type. The statement applies just as well to a system having but one circuit at each station as to a system having two circuits at each station. In my opinion it is in no way a basis for Mr. Waterman's contention that the two circuits of the Wireless Specialty Apparatus quenched-gap type are in resonance.

Mr. Waterman further quotes from the same page of the same publication as follows:

"The closed sending circuit should be in resonance with the open circuit and the coupling and decrement of the open circuit such as to afford the necessary selectivity to the receiving circuits with the best efficiency of radiation."

This is also a very general statement in no way disclosing whether the type of apparatus referred to is the quenched-gap type or the open-gap type, and furthermore, is a very loose and indefinite technical statement. It in fact reads that the closed sending circuit is not only in resonance with the open circuit, but is in resonance with "the coupling and decrement of the open circuit." Such a statement has no technical meaning, as there is no such thing as resonance between a circuit and a coupling, or between a circuit and damping. In my opinion the statement has no technical value in drawing a conclusion as to the operation of the two different types of systems under consideration. The writer of the quotation evidently had in mind the open-gap type of circuit with loose couplings as will be apparent from an analysis of a statement in the paragraph immediately following, also quoted by Mr. Waterman:

"Receiving circuits to receive from such a sender should be in resonance with each other and with the sending circuits and should have the same coupling as the sending circuits. The telephone disphragm should be in resonance with the wave train (alternator) frequency and with the operator's ear."

This is also a very loose technical statement. In no system is it necessary for the receiving circuits to be in accord with the circuits at the transmitting station as far as time periods of the circuits themselves are concerned. The receiving station circuits are not concerned with the time periods of the transmitting circuits, but only with the frequency of the energy-bearing waves that emanate from the transmitting circuit. For instance, a generator of a definite frequency can impress oscillations upon a radiating circuit which has a natural time period entirely different from the frequency of the oscillations being impressed upon it, and this radiator will radiate energy waves at the frequency impressed. Under such circumstances it would be absurd to try to adjust the time periods of the receiving circuits to the time period of the detuned radiating circuits. The point I make is that the receiver is not concerned with whether the frequency of the system originates in the primary circuit as it does in the case of the open gap type, or originates in the radiating circuit as it does in the quenched-gap type, as long as there is one definite frequency and the oscillations

are sufficiently long drawn out to employ resonance. Therefore, in my opinion, there is nothing in the quotation on which to found the contention that the Wireless Specialty [fol. 805] Apparatus quenched-gap type employs resonance in the same way as the Marconi open-gap type.

The quotation is important, because it shows that the previous quotation as to the sending circuit refers to the open-gap type, rather than the quenched-gap type, for it states that the receiving circuits, to be in resonance, should have the same coupling as the sending circuits. Now, for the receiving circuits to be in resonance, they must have loose couplings between them to avoid transferring energy at two frequencies, and if the sending circuits are to have this same loose coupling, the open-gap type of circuit is implied.

Mr. Waterman quotes from the Signal Corps book, Radiotelegraphy, plaintiff's Exhibit No. 91, page 57n, as follows:

"When the adjustments of a quenched spark transmitter have been correctly made—that is, the circuits are in resonance, the coupling is right, etc.—a simple experiment will show that the primary current is a minimum; that is, the spark has been quenched and the primary current has been stopped quickly, as at the point Q of Figure 53, and that at the same time the secondary current is a maximum; that is, it persists for a long time, as shown in Figure 56."

This quotation definitely refers to the quenched-gap type, and specifically brings out that the adjustment for proper quenching to quickly stop the flow of energy in the form of oscillations in the primary circuit and thus to leave the action to the radiating circuit, depends upon proper coupling as well as upon a condition very loosely and incorrectly termed in the quotation as "resonance" between the primary and secondary circuits. It is a great failing among workers in the art to speak of "resonance" under all circumstances of two circuits having the same natural periods, irrespective of couplings between the circuits. Correctly used, resonance means responding at the frequency of the action from which the responder drives its response creating energy. In the tightly coupled two circuits of the quenched-gap type of transmitter, while the two circuits may have their time periods adjusted to be approximately but not precisely the same, there is no resonant effect between them

as the energy oscillates in the two circuits at frequencies entirely different from the frequencies that would result from resonant response if the two circuits were loosely coupled.

The quotation clearly brings out that the current in the primary circuit is of very short duration, being stopped quickly, and that it is the current in the radiating circuit that persists for a long time. In a discussion of the Lodge patent, Mr. Waterman and I agreed that persistency of oscillations is necessary for resonance, and there is no basis for his contention that this quotation which clearly brings out a lack of persistency in oscillations in the primary circuit supports his contention that the Wireless Specialty Apparatus quenched-gap type actually employs resonance as between the two circuits.

I am therefore of the opinion that Mr. Waterman's contention finds no support in the Navy Manual of 1915 or the Signal Corps book Radiotelegraphy.

32. Question. Please make the same comparison with respect to the other types of apparatus used by defendant and referred to by Mr. Waterman.

Answer. I have examined the exhibits and the testimony of the various witnesses describing the other types of ap- [fol. 806] paratus referred to by Mr. Waterman as coming within the terms of the Marconi patent 763772, and find that the following types in all practical aspects correspond to the Wireless Specialty Apparatus Co. quenched-gap type which I have just discussed.

Kilbourne & Clark type, plaintiff's Exhibit No. 95, based on Navy Specification 16-R-1.

Navy type, described by witness Weagant, plaintiff's Exhibit 93.

Wireless improvement type, plaintiff's Exhibit 88.

Simon type, plaintiff's Exhibit 89.

National Electrical Supply Co. type, field radio pack set, plaintiff's Exhibit 80.

Atlantic Communication Co. type (no exhibit).

Garwood Electric Co. type (no exhibit).

Radio Telephone & Telegraph Co. type (no exhibit).

Signal Corps pack set, 1915 type (no exhibit).

Tractor sets (no exhibit).

Navy Specification No. 16-R-1*a* (no exhibit).

Portable wireless set (plaintiff's exhibit 41).

United States Signal Corps Specification, radio field wagon set, plaintiff's Exhibit No. 44.

In some of the above types I find that at the receiving station the secondary circuit is of the type known as "untuned." That is, there is no provision made for varying the time period of the secondary of the receiving circuit to correspond to the frequency of the incoming signal, the receiver depending upon tuning the primary or open circuit only. Of the above types the following have untuned secondary circuits at the receiver.

Atlantic Communication Co. type.

Signal Corps pack set, 1915 type.

The exhibits and testimony of plaintiff's witnesses make it clear beyond all doubt that the transmitting stations of all of the above types have quenched-gaps, and are therefore subject to the same differentiations over the open gap type of the Marconi patent that I have brought out in connection with the Wireless Specialty Apparatus quenched gap type, as for instance (1) no resonant transfer of energy between the primary and secondary circuits; (2) no means for adjusting the two circuits to resonance, the adjustment means in the quenched-gap system being for controlling the point of beat production and for throwing the two circuits somewhat out of time period adjustment to obtain a perfect beat; (3) no provision for causing the primary circuit to "automatically produce oscillations of the desired frequency," and (4) the inclusion in the quench-gap type of specific means, a quenching gap, to prevent the primary circuit from being a persistent oscillator, a reservoir for the radiating circuit, and a good conserver of energy in the primary circuit.

In all of the above types, like the Wireless Specialty Apparatus type, the radiating circuit at the transmitter determines the frequency of the oscillations and is the place where the oscillations persist or are maintained for a long time, and it is this circuit therefore to which the receiving station absorbing circuit is tuned, if there is but one tunable circuit at the receiving station, and to which the two circuits are tuned, if there are two tunable circuits at the receiving station. Therefore, these types are either two [fol. 807] tuned circuit systems, or three-tuned circuit systems, and not the four-circuit tuned system of the Marconi patent.

I have also named two types in the above group which have a secondary circuit at the receiving station which is not tunable. That is, the secondary circuit is designed to remain fixed in frequency or natural time period to be used with a primary or absorbing circuit which is tunable through a wide range of natural time periods. This of course makes these receivers different from the idea of tuning the two circuits to the same time period which runs through the Marconi specification and claims. They merely amount to the receiver shown in Figure 13 of the Lodge 1898 patent in suit.

I note that Mr. Waterman at page 182 of his deposition, in referring to one of the Telefunken types of receivers which has an untunable secondary comments as follows:

"It differs from that of Marconi's Fig. 2 and of the Telefunken E_3 receiver only in the omision of condenser k'. This means merely that capacity enough is provided for in the coil itself, the coil referred to being the coil j^2 of the oscillation transformer."

Following such line of argument the secondary circuit of the Lodge receiver, Figure 13, is a tunable circuit if this is what Mr. Waterman means to imply. The Lodge secondary winding a inherently has distributed capacity as does the coil j^2 of the Marconi Figure 2.

In the group above, the Signal Corps pack set, 1915 type, has a type of receiver far removed from that shown in the Marconi patent, this type being illustrated in plaintiff's Exhibit 91. This receiver has no oscillation transformer between the primary and secondary circuits. Two small capacities marked in plaintiff's Exhibit 91 as "fixed coupling condensers" entirely displace the two winding oscillation transformer of the Marconi Figure 2. This type of coupling entirely removes the receiver from the language of the receiver claims of the Marconi patent, all of the claims being based upon an oscillation transformer. In the "long-wave" type illustrated in plaintiff's Exhibit 91, the secondary circuit is in no wise tunable, and in addition to being outside the Marconi patent on account of the type of coupling, is also lacking in the tuning of the secondary circuit in the Marconi specification and claims.

Therefore, all I have said as to the dissimilarity of the Wireless Specialty Apparatus Co. quenched-gap type, and

the Marconi open-gap type applies to the above group of types with the addition that the above group of types includes receivers which are, in my opinion, entirely outside of the showing in the Marconi patent.

* * * * * * *

The following group of types are like the Wireless Specialty Apparatus type in respect to having quenching gaps and the necessary circuit relation for quenched-gap action, and therefore are different from the Marconi open-gap type for the same reason as I have set forth for the Wireless Specialty Apparatus Co. quenched-gap type. But [fol. 808] the apparatus of this group also differs from the open-gap type of the Marconi patent for a reason which I will set forth after I list these types as follows:

Telefunken type (plaintiff's Exhibit No. 79).

Lowenstein type (plaintiff's Exhibit No. 101).

Army pack sets (testimony of plaintiff's witness, Weagant).

Telefunken field wagon apparatus (plaintiff's Exhibit No. 90, pages 91-101).

Foote-Pierson pack set (plaintiff's Exhibit 102).

Signal Corps pack set, 1913 Model (plaintiff's Exhibit No. 92).

North American Wireless Co. type (plaintiff's Exhibit No. 42).

All of the transmitters of this group of types do not have the two-winding oscillation transformer linking the primary and secondary circuits illustrated, described, and claimed in the Marconi patent, except the testimony of plaintiff's witnesses admits that plaintiff does not know whether the North American Wireless Co. type has or has not the two-winding oscillation transformer. Plaintiff's witnesses in the text of their testimony with respect to this group have admitted that there is but one winding to which both circuits are directly connected, but in their diagrammatic sketches, plaintiff's Exhibits 7, 9, 101, and 102, have illustrated two windings, one in black and one in red, drawn in close relation. These illustrated two windings in the exhibits are therefore not in accord with the testimony of the witnesses and the descriptive matter in plaintiff's exhibits describing these types.

The claims of the Marconi patent refer to two windings in the oscillation transformer interlinking the two circuits.

one winding being in circuit and one winding being in the other circuit. In the Marconi open-gap type there is particular reason for employing a two-winding transformer, for I have explained that the Marconi system depends upon getting a very loose coupling between the two circuits, and since a two-winding transformer permits of specially separating the two windings to give any desired degree of loose coupling. In the quenched-gap type, where a tight coupling is vital to the operation, no particular benefit results in having two windings from a point of view of coupling. In those types of quenched-gap sets having two windings, the arrangement is adopted simply for the purpose of permitting ease of adjustment in calibrating the apparatus for use. In the direct-coupled type the only way coupling can be adjusted is by changing the number of turns in the one winding to which the two circuits are directly connected. Each circuit may have means for independent connection to the winding, so that one circuit may include more turns of the common winding than the other circuit; that is, one circuit may have for instance but five turns, while the other circuit has 15 or 20. But this adjustment to obtain coupling also varies the inductance of the circuit, and therefore the natural time period. I have explained that in the quenched-gap type there is necessity for adjustment of both coupling and natural time period, and it may be readily seen that where the adjustment of one of these factors affects the adjustment of the other, some difficulty may be had in calibration. With the two winding transformer the coupling adjustment may be had by moving the two windings with respect to each other without interfering with the time period adjustment. Therefore, the better design requires two windings for facilitating adjustment, but this is not a matter bearing upon the [fol. 809] mode of operation of the apparatus, as in the open-gap type where very loose coupling is essential, and where the desired degree of loose coupling is very difficult to obtain in a direct-coupled type.

In this respect of direct coupling, this group of types directly descend from the Lodge 1898 patent which discloses the fundamental principle on which the quenched-gap type is based, which fundamental principle I have explained is the one of quickly dumping all of the energy from the primary circuit into the open radiating circuit, and then cutting off the primary circuit so that it will in no way

interfere with the action of the radiating circuit. Figure 4 of the Lodge patent, which illustrates the apparatus for executing his fundamental principle, has the primary and open radiating circuit related through a one-winding directly connected to both circuits, as is the case in this group of types.

In my opinion this group of types is entirely dissimilar to the Marconi open-gap type, because the types are all operated on the quenched-gap principle, and further dissimilar to the Marconi open-gap type, because of the direct coupling relation between the two circuits at the transmitter which makes them particularly similar to the Lodge patent type.

In the Foote-Pierson type the receiving station also includes this feature of direct coupling between the two circuits, but I note that contrary to the testimony and the descriptive matter of plaintiff's exhibits, plaintiff's diagrammatic illustration of this receiver, Exhibit 102, shows two windings, one in black and one in red. The receiving claims in the Marconi patent also include the oscillation transformer having two windings. At the receiver it is also particularly desirable to have loose coupling, and therefore two windings which may be moved one with respect to the other, for obtaining a degree of coupling sufficiently loose for selectivity. While Lodge and the Marconi 1899 patent show the two-winding oscillation transformer at the receiver, the direct-coupled type of this Foote-Pierson apparatus was also shown in the Lodge patent, Figure 12, as well as in some of the receiver patents referred to in the Marconi specification.

I also find that in the following types of the group now under discussion, the receiving stations have untunable secondary circuits:

Telefunken type.
Foote-Pierson type.

These two types having untunable secondary circuits at the receiving station are therefore subject to the same comments of mine in connection with the previous group, wherein a number of the receivers had untunable secondary circuits.

The following types refer to receivers only:

Navy Specifications 16-R-2 (plaintiff's Exhibit No. 40).

Receiver arranged with terminals for any form of detector (plaintiff's Exhibit No. 113).

Vacuum tube receivers (plaintiff's Exhibit No. 114).

Direction finder (plaintiff's Exhibit No. 115).

Federal Telegraph Co. receivers (Fig. 89, plaintiff's Exhibit No. 78).

These receivers are all the same as that illustrated in plaintiff's Exhibit No. 87, Wireless Specialty Apparatus [fol. 810] type, and are subject to the same comment I have made as to that type. These receivers mainly show the use of vacuum tubes as detectors in lieu of the crystal detector shown in the Wireless Specialty Apparatus type, but my understanding of the Marconi patent is that it relates to circuit arrangements only, the type of detector being a matter not affecting the showing.

As far as this particular group of receivers is concerned, it is my opinion that the Marconi patent applies as equally well to the prior art as to these receivers, particularly to Figure 13 of the Lodge patent, Figure 1 of the Marconi 1899 patent, to the various receiver figures of the Stone patent, and to the Stone to Baker letters of June 30, 1899, and July 18, 1899. So far as these receivers have any bearing on the Marconi patent, they comprise an open absorbing circuit associated with a closed secondary circuit with means provided for adjusting the two circuits to be in tune with the incoming frequency of the radio signals. This arrangement is shown in Figure 13 of the Lodge patent, while the arrangement and the matter of tuning are fully shown and described in the Marconi 1899 patent and the Stone patent, and the Stone to Baker letters.

The witness, Clark, in paragraph 15 of his answer to Question 2, page 239 of the printed record, refers to devices termed "wave changers," which devices are discussed by plaintiff's witness Waterman, at page 263 of the printed record. I am thoroughly familiar with this device, having seen it embodied in many types of quenched-gap radio transmitters of the Navy. It merely amounts to a mounting having suitable coils for the primary and secondary of an oscillation transformer, together with such other windings as may be necessary to permit obtaining the necessary inductance in both circuits for the transmitter to be capable of transmitting at a number of different frequencies or wave lengths. The device also includes a switching arrangement

so that an operator in changing from one wave length to another can do so by merely throwing the switch from one position to another, the switch mechanically taking care of readjusting the inductance in each circuit to meet the new wave length setting. The Navy wave changers in general were provided for including anywhere from 3 to 9 different positions corresponding to assigned wave length or frequencies for communication, depending upon the service to which the apparatus was to be put. The necessity for this apparatus came about through the increasing use of radio, often making it necessary for the operator to quickly change from one wave length to another to avoid interference. In the old arrangement, it was necessary for the operator in changing his wave length to make a number of connections himself, and then by a cut and try method to ascertain when his apparatus was correctly adjusted. Quite often operators were not skilled in adjusting with the result that their efforts to adjust were very slow and frequently gave very poor results. With the wave changer device, the adjustment at each wave length was carefully made by an engineer skilled at this sort of work, and with these adjustments all connected to one switch arm, all the operator had to do in the practical operation of his set was to move the arm until an indicator pointed to a dial indicating the proper wave length, the apparatus itself automatically making the several adjustments, which had been set by the skilled engineer in calibrating the set. These wave changers were particularly designed to take care of the proper [fol. 811] adjustment of the quenched-gap type of set; that is, they included means for tight coupling and means for obtaining an approximate adjustment of the time period of the two circuits so as to secure a beat or point of no current in the primary circuit at the proper moment, and also a means commonly termed a "variometer" for throwing the adjustment of the time periods somewhat out of accord to secure beat perfection. The mere fact that these wave changers included arrangements for adjusting the inductance of the two circuits in which the device was connected does not mean that the adjustment was for the purpose of securing resonance between the two circuits as contended by Mr. Waterman, for in the quenched-gap type, resonance between the two circuits is not used, and the adjustments are for an entirely different purpose. If it could be contended that these wave changers were for the purpose of

securing resonance between the two circuits, then in my opinion, they would apply as well to the prior art as to the Marconi patent, for they simply included a one-switch means, not a part of the Marconi patent, for controlling the variably acting inductance coil of the prior Lodge patent, particularly illustrated in the radiating circuit, and the variably acting inductance coil described in the Stone patent in connection with the primary circuit and not described or illustrated in the Marconi patent, and the device as a whole is a most suitable "empirical" means for accomplishing the tuning of the two circuits together, referred to by Stone in his letter of June 30, 1899, to Baker.

* * * * * * *

The next type, Federal Telegraph Co.'s Arlington arc transmitter, discussed by Mr. Waterman at page 211 of the printed record, I have already explained commencing page 513 of the typewritten record, is an entirely different organization from the spark type of apparatus disclosed in the Marconi patent. Commencing page 526 of the typewritten record, I explained in careful detail the difference between the arc type of transmitter and the spark type of transmitter. From a reading of Mr. Waterman's deposition, at page 212, I understand that he makes only a conditional contention that the Arlington arc transmitter is within the terms of the Marconi patent 763772, this condition being dependent upon whether or not the circuit containing the condenser *c* and the arc, marked "gap," in plaintiff's Exhibit 104 is a tuned circuit, that is, has the same natural time period as does the elevated conductor circuit, *f* to *E* inclusive, plaintiff's Exhibit 104. I understand that Mr. Waterman would contend that this type is within the Marconi patent if the two circuits are in tune, but admits that there is no evidence in the descriptive matter of plaintiff's exhibits leading to the belief that such tuning exists.

Even though such tuning did exist, it is my opinion that an arc type of transmitter is not within the terms of the Marconi patent. I have explained that the arc generates what is known as continuous waves instead of trains of waves as in the spark-gap type. There is no storing of a large amount of energy in a condenser which suddenly [fol. 812] breaks down a spark gap and starts a train of

oscillations which gradually die out and cease to await the recharging of a condenser for another train, and so on. In the arc type the stream of oscillations is continuous, and the arc is always active instead of part active and part idle as in the spark-gap type. There is no reservoir circuit storing a large amount of energy and slowly feeding it to another circuit, as in the open gap Marconi type. The energy is utilized at the same rate at which it is fed. The arc type operates from a low voltage source of direct current compared to the requirement of a high voltage source of alternating current in the spark type. For instance, the voltage in the arc type is in the neighborhood of 500, while in the spark type it is in the neighborhood of 10,000 to 25,000 volts. The spark type would be absolutely inoperative for practical purposes at such a low voltage supply. In the arc type, the continuity of the stream of oscillations can not be interrupted, for if this is done, the arc will extinguish and it will be necessary to manually strike the arc by forcing the two electrodes in contact. Signals can only be made by some method that does not interrupt the flow of current through the arc, such as changing the frequency or diverting the energy from a radiating circuit to a nonradiating circuit. In the spark type the oscillations are automatically interrupted between every train of oscillations, which happens in the neighborhood of from five hundred times to one thousand times per second, but since the spark type automatically creates oscillations these interruptions present no difficulty in this type, while they would be absolutely impossible in the arc type as it would be out of the question to manually restrike the arc five hundred to one thousand times per second. Also in the spark type, the key action to make signals actually starts and stops flow of supply current. This could not be done in the arc type as the arc would not reignite when the key is pressed to make a signal unless the arc electrodes are shoved together manually, and as these electrodes weigh anywhere from three to twenty pounds, depending upon the size of the transmitter, such action would be hopelessly unpractical. The Marconi claims require "means for automatically creating oscillations of the desired frequency." The arc type does not do this, as once it is started, it must not be stopped, for it is not automatically self-starting.

In my prior testimony I have explained in detail the difference in action in the arc itself from the action in the

spark gap, and think it unnecessary to repeat this explanation here.

On account of the entirely different action in the two systems, it is my opinion that no arc transmitter, no matter what its circuit arrangements are, can be said to be within the terms of the Marconi open-gap type of transmitter, and I have never heretofore encountered any contention that the two types have anything in common.

Returning now to the one condition on which Mr. Waterman contended that the Federal Arlington arc transmitter might be considered to come within the terms of the Marconi patent, that of having two circuits in tune, I am thoroughly familiar with the arc transmitters which have been installed by the Navy, as well as arc transmitters which have been installed in England and France, and know of no instance where two tuned circuits have been used between the time of the experimental radio telephone installations on vessels of the United States Fleet on the cruise around the world in 1908, such installation having been [fol. 813] made by Dr. Lee De Forest, and the experimental effort during the last two years to employ coupled circuits in order to meet a popular demand that Government arc transmitting stations be in some manner cured of their tendency to emit harmonics and so-called "much" which have proved somewhat annoying to the popular practice of listening in to radio broadcasting. This last experimental work is now resulting in the Navy redesigning its arc stations to include two coupled tuned circuits such as illustrated in Figure 29D, page 58, of plaintiff's Exhibit No. 78, Navy Manual of 1913, but this work has all been subsequent to the expiration of the Marconi patent. Heretofore all of the installations of arc transmitters have been as illustrated in plaintiff's Exhibit 104, except that the placing of a condenser c in shunt to the arc was long ago discontinued. For a time it was thought that such a condenser in some way acted to stabilize the action of the arc through keeping the current flowing therethrough more uniform, and to a measure prevented the production of undesirable harmonic and so-called "mush." Experience, however, taught that there was nothing gained by such a condenser and it was abandoned. Even with a condenser in shunt with the arc, there is no possible hope of contending that the circuit containing the condenser is a tuned circuit. There is no inductance in the same circuit, and the discus-

sion of tuning all through the testimony in this case clearly shows that a circuit to be properly tuned must have both inductance and capacity.

Plaintiff's Exhibit No. 104 also shows that the arc, marked "gap" in the diagram, is placed directly in the antenna circuit. The removal of the spark gap from the antenna circuit is the very foundation of the Marconi patent as stated in the specification, and the Arlington arc transmitter violates this foundation.

Mr. Waterman's deposition, page 212, also refers to Federal arc transmitters of plaintiff's Exhibits 65, 66, 67, and 68. These exhibits are Navy contracts with the Federal Telegraph Co. purchasing from time to time arc transmitters subsequent to the purchase of the Arlington arc. These subsequent purchases were all installed in the same manner as the Federal arc illustrated in plaintiff's Exhibit 104, and if the earlier ones were first installed having a condenser in shunt with the arc, a matter with which I am not familiar, this condenser was removed later, for I am familiar with the standard Navy practice and know that it did not include such a condenser

Mr. Waterman refers to a part of the specification of the Navy contract comprising plaintiff's Exhibits 65 and 66, as follows:

"If it be necessary to use coupled circuits to give maximum antenna input, necessary condensers and inductances will be supplied."

I know that this condition of the contracts was never found necessary in practice.

Mr. Waterman also refers to a provision in the Navy contract comprising plaintiff's Exhibit No. 65, which provided "that the transmitting apparatus shall be so designed that by the operation of a single switch the energy radiated may be emitted either in wave trains or continuously, as desired."

It is difficult to interpret what this provision means, unless at the time of drawing the specifications for this contract, which was quite early in the Navy's experience with arc sets, it was meant that the company should supply both an [fol. 814] arc transmitter and a spark transmitter to operate on the same antenna, and by throwing a single switch either one of the sets could be put into operation. I know of no

such installation in the Navy, and do not believe that the Federal Co. ever supplied one.

It is my opinion that none of the arc type of transmitters, no matter how connected, apply to the Marconi patent 763772, on account of the differences in apparatus and operation which I have brought both here and in my prior testimony, but aside from this that none of the types of apparatus referred to by plaintiff had the circuit arrangement on which Mr. Waterman based his condition that the types might be said to come within the terms.

* * * * * * *

33. Question. In your last answer you pointed out that Mr. Waterman's sketch, plaintiff's Exhibit 102, purporting to illustrate the Foote-Pierson pack set, is inaccurate in showing two windings in the oscillation transformer. Will you submit a sketch illustrating correctly the Foote-Pierson pack set and also the Telefunken and Lowenstein set?

Answer. In my last answer I invited attention to the fact that Mr. Waterman's sketch, plaintiff's Exhibit 102, shows two windings in the oscillation transformer between the two circuits, one in red and one in black, but that the illustration of two windings is not in accordance with the testimony of plaintiff's witnesses in respect to this set, or in accordance with the exhibits of plaintiff describing this set, and that the same showing of two windings was made in the sketch illustrating the Telefunken type, plaintiff's Exhibit 79, and the Lowenstein type, plaintiff's Exhibit 101, also not supported by testimony of plaintiff's witnesses or the exhibit describing these types.

In a sketch marked "Loftin sketch P" I have illustrated my understanding of the type of connection between the two circuits in all of these three types, based upon the testimony of plaintiff's witnesses and the descriptive exhibits. The illustration of the transmitter of my sketch refers to all three types, while the illustration of the receiver refers to the Foote-Piersen type only. The sketch shows but a single winding interlinking the two circuits, the primary circuit being arranged to include any desired number of turns of the winding therein, and the secondary or open circuit also being arranged to include any desired number of turns of the winding therein. The number of turns in each of the two circuits need not be the same, and, in fact, they usually differ

widely. The arrangement is not a two-winding oscillation transformer, as illustrated in the Marconi patent and generally claimed.

34. Question. In your answer to question 32 you described the operation of the "wave changers" referred to by plaintiff's witness, Clark. Will you explain what determines the wave-length marks on the dials of these instruments?

Answer. The "wave changers" referred to by plaintiff's witness, Clark, were developed and designed for practical [fol. 815] use after the quenched-gap type of transmitter was adopted by the Navy as the preferred form, and therefore included in the design particular consideration for the conditions to be met in quenched-gap operation, particularly in the matter of obtaining tight coupling. Since in the quenched-gap type of apparatus the wave length or frequency is determined entirely by the wave length or natural frequency of the open or antenna circuit, the wave-length marks on the dials of these instruments would be determined entirely by the adjustment of capacity and inductance of the antenna or open circuit In practice the wave lengths for a system are predetermined by the regulations governing the communication from the apparatus in accordance with the service which the apparatus is performing. The dials are marked with these predetermined wave lengths, and in setting up the apparatus for use when it is a quenched-gap type it is compulsory that the antenna or open circuit be adjusted to the dial marking irrespective of any other adjustments of the apparatus.

It was not possible, however, to use these wave changers with the open-gap type of transmitter, though I have never known one to be so used. If so used, the wave-length marking on the dial would determine the natural frequency of the primary circuit, as in the open-gap type the primary circuit has the duty of establishing the frequency of the entire system. That is, if of the open-gap type, assigned predetermined frequencies marked on the dials of the wave changers, it would be compulsory to adjust the frequency of the primary circuit to correspond to the markings irrespective of other adjustments.

35. Question. Can you refer to literature of the art supporting your views as to the difference between the Marconi persistent open-gap type of transmission and the defendant's quenched-gap type of operation?

Answer. Practically every piece of literature of the radio art that considers the matter of the Marconi persistent open-gap type of transmitter and the quenched-gap type of transmitter supports my view as to the difference between the operation of these two types. For sake of brevity of the record, I will refer to only a small part of the literature, having chosen the literature of the best recognized authorities.

A very early reference to this difference is contained in an article by J. A. Fleming in The Electrician, of London, June 11, 1909, commencing page 332. Professor Fleming has written a number of very elaborate textbooks on the subject of radio, commencing as early as 1906, and is recognized internationally as an authority on the subject. The article opens as follows:

"In my lecture last Friday evening at the Royal Institution time did not permit me to do more than give a brief description and show one experiment with the multiple small-gap flat plate discharger which has been devised by the experts of the Gesellschaft fur Drahtlose Telegraphie for giving practical effect to Prof. M. Wien's method of excitation by shock in spark telegraph."

Professor Fleming's reference to "the multiple small-gap flat-plate discharger" clearly conveys to one skilled in the art that he had reference to the quenched-gap type of transmitter. His reference to "excitation by shock" clearly shows that he was differentiating the new method from that of the Marconi open-gap type, in which the excitation [fol. 816] of the antenna was not accomplished by shock action or by "impulsive rush," as described by Lodge, but by the slow feeding, nonshock action from a reservoir, persistently oscillating circuit.

The article then points out that Professor Fleming in a previous lecture brought out the fact that when two circuits are coupled and the spark in the exciting circuit endures for a long time oscillations are produced in the system at two frequencies, and explains that this was illustrated by two pendulums coupled through a loose string. Professor Fleming states that the new system he is discussing is based on the principle of stopping the oscillations quickly in the exciting circuit, leaving the energy free to oscillate with a single period in the secondary circuit, and he illustrates this in a figure, Figure 1, accompanying the

article, in which the first two diagrams illustrates the action occurring in the open-gap type of transmitter when the coupling is sufficiently tight to transfer the energy back and forth between the two circuits, producing alternate beats of no energy, just as I have done in my sketches. The second pair of diagrams of the figure illustrates the action in the new system, the quenched-gap type, under discussion by Fleming, it being shown that the oscillations in the primary circuit are quickly stopped, being cut off at the first beat, leaving all of the energy in the secondary circuit to oscillate at one frequency determined by the natural frequency of the secondary circuit.

Professor Fleming then describes the construction of the new type of gap responsible for these results as follows:

"The discharger I used consisted of 12 round flanged plates of copper, 5 inches in diameter, the surfaces being turned true and having a groove in them. (See fig. 2.) A mica ring is interposed between each pair of copper plates of such size that the mica half covers each groove. This groove is important, for without it the discharge spark tends to take place always at the edge of the mica. The mica is of such thickness as to make an air space of not greater than 0.01 inch between the flat copper surfaces. In this discharger we have then, say, 11 air gaps, each about 0.01 inch wide and of circular section. When this discharger replaces the ordinary spark-gap in the primary circuit it damps out instantly the primary spark, and hence excites the free oscillations in the secondary circuit by shock. If, then, we place the cymometer alongside of the secondary circuit we find in it oscillations of only one frequency and not two. Also, if we place it alongside the primary circuit, we can not detect in that circuit any oscillations, because they are so rapidly damped out that they have too small a mean square value to affect the cymometer or cause the Neon tube to flow perceptibly."

The gap described in the quotation is illustrated in Figure 2 accompanying the article, and an examination of this figure clearly shows the division of the total spark-gap length into a number of short gaps by the use of a plurality of disks of large area provided with flanges for good cooling. Professor Fleming speaks of the use of 12 of these disks, which makes it readily apparent that a large amount

of metal is in use over which the heating is distributed, provided for low distributed temperature as well as excellent opportunity for dissipating the heat. The material of the disks is stated to be copper, which is a good conductor of [fol. 817] heat and which also does not easily vaporize. The short length of each division of the spark gap provides the necessary opportunity for quick deionization of the gap spaces through dispersion of ions and electrons to the electrodes. The article later states that the copper may be silver plated, and in the case of large discharges arrangements for water cooling through making the disks hollow may be used.

Thus the spark-gap construction described by Professor Fleming included many of the requirements which I have previously explained are necessary for rapid deionization to obtain good quenching as compared to the necessity for maintaining ionization for persistent oscillation in the Marconi open-gap type. The multiple disk type of spark gap illustrated in Figure 2 of the article is in all general arrangements and construction the same as that which has been universally used in quenched-gap transmitters. Some improvements have been made looking toward more efficient cooling, such as increasing the extent of the cooling flanges, while other improvements more or less go to the matter of ease of assembly and disassembly of the gap structure, as well as switching in or out any desired number of gap units.

The quotation of the Fleming article states that when this new type of spark gap replaces the ordinary type it damps out "instantly" the primary spark and, hence, "excites the free oscillations in the secondary circuit by shock." It is certainly obvious from such language that Professor Fleming at that early date appreciated the great difference of operation between the open-type gap transmitter and the new quenched-gap type.

The quotation refers to a simple method of determining that oscillations of only one frequency existed in open or antenna circuit, and that oscillations were rapidly damped out of the primary circuit. The article is concluded with the following statement:

"Finally, as the whole of the energy transferred to the secondary circuit expends itself in the production of radiation of one single wave length it must be more economical

than methods which generate waves of two wave lengths, but capture at the receiver radiation conveyed by only one of these wave lengths."

This is a very clear statement, recognizing that in a quenched-gap system all of the energy is dumped into the antenna, where it acquires a frequency of oscillation determined by the natural period of the antenna and is thus usefully employed in the production of radiation of one single wave length, as compared to a system in which the energy remains in both circuits during the entire time of radiation resulting in waves of two frequencies, Fleming having in mind here that in the open-gap type no matter how loose the coupling, there are, in fact, two frequencies, and that the energy must be distributed over these two frequencies instead of concentrated in one frequency.

Immediately following the article above referred to, Fleming has another article commencing at page 333 of the publication entitled "The utilization of the total radiation from an inductively coupled antenna in radio-telegraphy." Fleming describes in this second article the same quenched gap system and states, near the bottom of page 333:

"The primary spark is then quenched with great rapidity and the action upon the secondary or antenna circuit is of the nature of a blow or shock, setting up the free oscilla [fol. 818] tions of the secondary. For this reason this method of excitation is called, in Germany, 'Stosserregung'."

Thus again he describes the new system as one which excites the antenna by "a blow or shock," thus clearly differentiating it from the Marconi open-gap, slow-feeding reservoir system. It is, of course, clear from such language that Fleming did not consider that there was any such thing as a resonant transfer of energy between the two circuits in this "blow or shock" action. In discussing the Lodge patent in suit, which has to do with inserting an inductance coil in the circuit to cause the oscillations to be long drawn out or persistent, Mr. Waterman and I have both pointed out that unless the oscillations are sufficiently long drawn out or persistent, as stated by Lodge, there is no resonant action or resonant transfer of energy. This, of course, is just as true in the quenched-gap type of sys-

tem as in any other system in which energy is being transferred, and this reference by Fleming to a "blow or shock" excitation of the primary circuit upon the secondary circuit naturally compels the thought of no resonant energy transfer.

In the The Electrician, of London, November 10, 1911, commencing page 171, there is an article entitled "The Telefunken system of wireless telegraphy," which clearly describes the quenched-gap system discussed by Professor Fleming in the article I have just referred to. In fact, Figure 1 of the second article, which illustrates the oscillations in the two circuits, is undoubtedly a reproduction of Figure 1 in the Fleming article, and Figure 8 of the later article, illustrating the structure of the quenched gap, is undoubtedly a reproduction of Figure 2 of the Fleming article, which illustrates the structure of the quenched gap.

This later article discusses the quenched-gap action in very much the same way as does Fleming, but includes the following statement on page 172 concerning a matter not touched upon by Fleming:

"To give the best result it is necessary that the reaction of the secondary circuit should assist the quenching in the primary, and for the reason the two circuits are slightly mistuned, namely, to the extent of about 2 per cent. The closer the coupling the greater must be the mistuning."

I have previously stated that the arrangements in the quenched-gap type of apparatus for adjustment of capacity and inductance of the two circuits are not for the purpose of obtaining a resonant relation or resonant transfer of energy between the two circuits as is the case in the Marconi open-gap type of transmitter, but for an entirely different purpose, that of securing adjustment or control over the time or point of producing a beat or period of no current in the primary circuit at which time quenching may take place, and that, in fact, the proper adjustment results in the two circuits being somewhat different in the time periods in order to secure a currentless or perfect beat. The language I have quoted above bears me out in this statement, and points out that the closer the coupling between the two circuits the greater must be the difference between the time periods.

I have already referred to United States patent 1216615, of February 20, 1917, to Seibt, defendant's Exhibit C-3, in

which there is a clear explanation of the operation of a quenched-gap system supporting my view of the operation, and which clearly shows that the operation is entirely dif- [fol. 819] ferent from the Marconi open-gap type. Figures 12, 12a, 13, and 14 of the Seibt patent illustrate the multiple disk type of spark gap, very similar to that illustrated in the Fleming article, and which is clearly described by Seibt in the matter of characteristics necessary to obtain rapid quenching as opposed to persistently oscillating as in the Marconi open-gap type.

I now refer to Wireless Telegraphy, by Zenneck, as translated from the German by A. E. Seelig, 1915. Professor Zenneck is an internationally recognized authority in the subject covered by his book. At page 87, article 58, Professor Zenneck clearly brings out that when two circuits of an oscillatory character are coupled, there result oscillations of two frequencies not the same as the natural frequency of the circuit. At page 88, article 59, the mathematical relation between the natural frequency of the two circuits and of the two coupling frequencies is given. In Figure 124, page 89, there is shown photographic oscillograms of actual circuits showing that when coupled there results an alternate transfer of energy between the two circuits resulting in alternate beats of no energy in these circuits. Figure 125, page 89, shows a photograph of sparks produced at the spark gap inserted in coupled circuits which clearly show that there is an alternate transfer of energy between the two circuits. Commencing page 93, article 62, Professor Zenneck discusses the quenched-gap type of system. In Figure 130, page 94, there are two diagrams showing the alternate transfer of energy between the circuits, resulting in beats of no energy alternately in each of the circuits when there is no quenching action. Figure 131, on the same page, shows the result of quenching the primary circuit at the first beat. These figures agree with the illustrations I have previously made and described, as well as those of the Fleming article and the Seibt patent I have previously referred to.

Figure 132, page 94, illustrates photographs of sparks produced in two-coupled circuits in which there is quenching action, the photographs clearly showing that the oscillations exist for a very short time in the primary circuit and endure for a long time in the secondary circuit.

At pages 94 and 95 Professor Zenneck describes the quenching action and resulting oscillations as follows:

"The conditions may be such, however, that the spark gap, during the time in which the amplitude in the primary circuit is very small, becomes so deionized that the EMF induced by the secondary is no longer sufficient to start or 'ignite' a spark discharge across the gap. As a result the spark gap remains quenched—whence the terms 'quenching action' or 'quenched gap.' The oscillations in the primary then discontinue entirely and the secondary circuit continues to oscillate with its natural damping and at its natural frequency just as if the primary circuit did not exist."

I invite particular attention to the similarity of this language of Zenneck to that of Lodge in his 1898 patent, where the principle of quickly exciting the antenna circuit with energy from a primary circuit, and then severing relation between the two circuits in order that the antenna circuit would be left free to oscillate at its own natural frequency and uninfluenced by any maintained connection with the primary circuit.

[fol. 820] Page 95, article 63, Zenneck describes various types of gaps suitable for quenching and the necessary characteristics of these gaps, pointing out the characteristics that I have previously referred to in detail.

Commencing bottom of page 96, Zenneck states as to the manner of throwing the two circuits somewhat out of adjustment as to time period as follows:

"The pureness of the pulsations probably also plays a part in the explanation of the fact that by bringing the primary and secondary circuits slightly out of resonance, a pure quenching can be obtained, after the quenching had been spoiled with primary and secondary entirely in tune."

Thus, Zenneck supports my statement that the arrangement for adjusting capacity and inductance are not for the purpose of obtaining a resonant transfer of energy between the two circuits, but for obtaining pure quenching to stop further transfer of energy between them.

On page 97, article 65, Zenneck covers the requirement of a gap for quenching action, preceding a detailed statement of requirements, such as I have previously covered

in detail, by a statement of the fundamental object sought, that of quickest possible deionization, as follows:

"The general requirement for the best quenching action is identical with the requirement for the quickest possible deionization of the spark gap."

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I next refer to a book entitled "Wireless Telegraphy and Telephony," by Eccles, published at London by Benn Bros., in 1918. Doctor Eccles is internationally accepted as an authority on the subject matter of this book. Commencing page 199 of the book, Doctor Eccles discusses the quenched-spark type of apparatus under the title of "Quenched-spark methods." Doctor Eccles opens the discussion as follows:

"Probably all short-spark dischargers set their circuits into oscillation by what is variously called 'impact' or 'shock' excitation; and the terms 'short spark' and 'quenched spark' are often taken to be synonymous. Max Wien published in 1906 the first full account and explanation of the phenomenon. His explanation is expressed diagrammatically in Figure 110. The two curves (a) show the beating oscillations (on a time base) produced in a tuned pair of coupled circuits by a persistent spark in the primary; the curves (b) show how the quenching of the spark at an early stage leaves the secondary circuit in possession of all the energy and free to vibrate with its natural frequency. The damping of the primary should be at least ten times that of the secondary. Thus quenching ensures singleness of frequency."

Examination of Figure 110 referred to in the quotation shows that it is pre-isely the same as that of Fleming, Zenneck, and Seibt, previously referred to by me, and to the illustrations I have included in my sketches of the effect that takes place between two closely coupled circuits, first, when there is no quenching in the primary circuit allowing the energy to alternately transfer from one circuit to [fol. 821] another, alternately producing beats of no energy; and, second, when the gap is of the type designed to quench at the end of the first beat in the primary circuit leaving all of the energy in the secondary circuit to oscillate at the natural period of the secondary circuit uninfluenced by any maintained connection to the primary circuit.

It will be noted that Doctor Eccles points out that the first condition is obtained through the use of a "persistent spark in the primary"; that is, the type essential to the Marconi open-gap system, where persistency of oscillations in the primary is the fundamental basis of the Marconi system. I have fully explained, however, that the Marconi open-gap system in addition to having a persistent spark in the primary must also have loose coupling between the two circuits so as not to transfer the energy alternately back and forth between the two circuits with the beat phenomenon illustrated in the first pair of diagrams in Figure 10 of the Eccles article, but to have a slow feeding of the energy from the primary circuit, acting as a reservoir, to the secondary circuit at the rate that it is rediated by the secondary circuit.

Eccles explained that the second effect is obtained by the use of "short spark" or "quenched spark," remarking that the two terms are synonymous, and that it is this kind of spark that is responsible for a very early stopping of oscillations in the primary circuit and leaving the energy all in the secondary circuit free to vibrate with the natural frequency of the secondary, thus insuring singleness of frequency. It is, of course, to be understood from such explanation that this singleness of frequency is determined by the open or secondary circuit, and not, as in the Marconi open-gap type, determined by the primary circuit and maintained single through a loose coupling and a careful adjustment of the two circuits for a resonant transfer of energy at the frequency determined by the primary circuit.

Eccles refers to the type of transfer of energy between the primary and secondary circuits in the quenched-gap type as "impact" or "shock" excitation. This, of course, forbids any idea of a resonant transfer of energy between the two circuits. In the discussion of the Lodge patent in suit, it was clearly brought — that Lodge taught there could be no real resonant transfer of energy in impact or shock excitation systems; that is, systems in which the oscillations were not drawn out for a long time or persistent. The Lodge teaching applies as well to the transfer of energy between the primary and secondary circuit of a transmitter as well as between the radiating circuit of a transmitting station and the absorbing circuit of a receiving station.

On page 200 Doctor Eccles explains that one of the important features in good quenching is having short gap lengths with provision for rapid removal of the heat. This is in accord with what I have said and with the publication I have referred to.

At the bottom of page 200 Doctor Eccles gives a small table showing that in the quench-gap system there is no precise adjustment of the time periods to accord, but, rather, that there is a considerable difference between the time periods of the two circuits in a properly arranged quenched-gap transmitter. Adjustment IV of the table gives a coupling of 18.2 per cent, which is approximately the percentage of coupling used in ordinary practice, though probably a little under the average value. Doctor Eccles shows that under such circumstances the primary wave length should be 1,230 meters for a wave length in [fol. 822] the secondary of 1,340 meters. This is a difference of 110 meters, or approximately 10 per cent, and any such difference of adjustment in the open gap, loose coupled, persistently oscillating primary of the Marconi type would be absolutely ruinous to the system.

The discussion of Doctor Eccles is quite brief but extremely pertinent, making it clear that the quenched-gap type in no way has an operation the same as the open-gap type, and even in its proper adjustment depends upon an adjustment of the two circuits to be different as compared to the Marconi system in its proper adjustment, requiring a very precise adjustment of the two circuits to accord.

I next refer to a book entitled "The Principles Underlying Radio Communication," second edition, Signal Corps, United States Army, published at Washington by the Government Printing Office, 1922, in which book, at page 378, I find the following statement:

"It is well to note that the principles of operation of the quenched gap and plain gap are exactly opposite. The former aims to stop the primary oscillations quickly, after the secondary has been brought to full activity. The latter aims to keep the primary oscillations going as long as possible, all the time giving energy to the secondary as it is radiated away; the coupling is loose and the primary decrement is kept low. The rapid decrease of the oscillations in a quenched-gap circuit is assisted by having a large ratio of capacity to inductance. This has the incidental advan-

tage that the voltages across the condenser and coil are thus kept low."

This very clear and brief summary of the differences between the quenched-gap system and the Marconi open-gap system is prefaced by the comments that the principles of operation are "exactly opposite." It well sums up the matters I have explained in detail which go to make the principle of operation exactly opposite from that of the open-gap type.

I next refer to a book entitled "Wireless Telegraphy," by Leggett, published at New York in 1921 by E. P. Dutton & Co. The author of this book clearly brings out that he is an Englishman and has the following to say in the opening paragraph of the author's preface:

"It is a matter for comment that whilst numerous works have been published, and others are still being produced, dealing with the highly important science of wireless telegraph, yet none of these give more than a mere outline of the quenched-spark system, a system which has been employed in almost every country throughout the world. In view of its extensive adoption in such countries as the United States of America, Australia, Japan, China, and Germany, and considering that it can for land stations claim to rank with the Marconi system in importance, this lack of literature in England is difficult to understand. It is, however, probably the result of national prejudice, since the system had its origin in Germany, where it was experimented with and established by the Telefunken Co."

At page 9 of the book Leggett says:

"In Fleming's treatise the achievements of Mr. Marconi and the apparatus of the Marconi Co. are dealt with at great length, but it is a matter for comment that the apparatus of this company's greatest competitor, namely, the Telefunken and quenched-spark system, receives very [fol. 823] scanty notice, and, indeed, its name does not appear in the index to his book.

"Eccles's book is far more general in nature, but as the book is much more restricted in size, his matter on the Telefunken and quenched-spark systems is necessarily small."

Professor Fleming and Doctor Eccles are both Englishmen, it being a matter of common information that Fleming is affiliated with the Marconi Wireless Telegraph Co. of Great Britain. The author of the book I am referring to charges Professor Fleming with deliberately suppressing in Fleming's book information concerning the quenched-gap system, but condones scanty information in Doctor Eccles's book because of the restricted size of the book.

Continuing, on page 9, Leggett states:

"The average English reader is practically unaware of the existence of any important commercial system of wireless telegraphy other than that of the Marconi Co., and is quite astounded when told of the existence of another system which, outside England and a few of its colonies, is perhaps for land stations the most extensively adopted by other countries."

Thus the author points out the successful outcome on the public mind of suppressing information concerning the quenched-gap system. The author then next touches upon the relative efficiency of the two systems, stating at page 9 as follows:

"There is, however, only one test of any scientific apparatus, namely, its efficiency. Since the quenched-spark gap has at least twice the efficiency of any other form of spark gap, it is far from patriotic to neglect the possibilities of this system. On the contrary, it is a truer form of patriotism to examine, impartially and scientifically, the merits and demerits of foreign scientific work, German or otherwise, and then to utilize the results of such examination to the furtherance of British science and technology."

There is no difficulty in appreciating the foundation for Leggett's statement that the quenched-gap system is twice as efficient as the Marconi open-gap system. In the quenched-gap system the energy is immediately delivered to the secondary circuit, where it is practically all expended in useful radiation, there being only a small loss in the small resistance of the antenna wire, while in the Marconi system the energy is retained in the primary reservoir circuit, where it for a long period of time is occupied in making heat, noise, and light in the spark gap as well as overcoming the resistance of the wire in the primary

circuit, and these losses in the primary circuit are large and must be deducted from the total energy that is available for a slow feeding to the secondary or antenna circuit.

Leggett, at page 17, then points out the practical effect upon British shipping of continuing to employ the less efficient Marconi open-gap type:

"As evidence that the only true test of any scientific apparatus depends upon actual results, the author might mention the following incident described by an English paper, The China Coast Shipping Gazette, as long ago as 3d November, 1911.

"The English steamer *Brodmore* was in Hankow's harbour in distress with a perishable cargo of meat. The skipper, owing to destruction of the land lines by insurgents, was unable to wire to Shanghai for a relief ship to salve his cargo. He approached the British consul with [fol. 824] a request that a British warship in harbour should be utilized to send a wireless message to Shanghai and was informed that the wireless range of this warship was insufficient for it to do so. Lying in the harbour was the German warship *Leipsig* fitted with Telefunken apparatus. As it was in permanent communication with the German warship *Nurnberg* in Shanghai the captain of the *Leipsig* offered to assist the *Brodmore* skipper by sending his message, the cargo so being eventually salved.

"The above-mentioned paper quoted upon the incident to the following effect: 'The system upon which the English Navy depends shows itself in a very bad light, and the English ships are unable to bridge large distances, while the German warships fitted with the Telefunken system are in easy permanent direct communication between Hankow and Shanghai. The German warship *Leipsig* in Hankow is, we hear, in permanent communication with the *Nurnberg* in this harbour, and exchanges regular communication between Nanking and Tsingtau, a distance of 260 miles, and, under favorable conditions, between Hankow and Tsingtau, a distance of not less than 450 miles.' "

At pages 55, 56, 57, 58, and 59 Leggett goes into the matter of the difference of operation between the open-gap type and the quenched-gap type. At page 55, Figure 13, he shows the usual diagrams for the alternate transfer of energy between two coupled circuits having alternate beats

in each circuit. At page 57, Figure 14, he shows the usual diagram of the effect of quenching at the first beat in the primary, leaving all of the energy in the secondary free to oscillate at the natural period of the secondary. Near the bottom of page 57 he states:

"As, however, unless one recognizes the differences in coupling in the original curves the whole difference between open and quenched gaps is apt to be overlooked, the author has taken the liberty of redrawing them in a series of curves (fig. 15), each of which show the open and quenched gap curves for the same particular degrees of coupling.

"In the case of the open-gap curves when quenching does not occur, the curve will be found to have two distinct peaks of very different wave length and low current value, which is proportional to the energy radiated."

Here Leggett lays stress on recognizing the difference in degree of coupling that is permissible in the two systems, and the diagram on page 58, Figure 15, clearly illustrates the importance of this feature, showing how utterly impossible it would be to endeavor to use the open-gap system with a degree of coupling permissible in the quench-gap type. For instance, diagram C of the figure illustrates what happens in the case of a coupling of 16 per cent. The diagram shows that with this degree of coupling the transmitted signal from the quenched-gap type, illustrated in the full-line curve, is very peaked or sharply resonant and strong. Such a signal would allow a distant receiver to tune to it very sharply, excluding other interferring signals, and getting a strong signal from the transmitter. The dotted-line curve shows the type of signal that would be radiated from an open-gap installation having the same coupling between circuits. It is seen that there are two humps, neither one *one* of them being half as strong as the [fol. 825] quenched-gap signal. The distant receiver would be able to find this signal over quite a wide range of tuning, but would not be able to receive the signal at any tune at anywhere near as great a distance as with the quenched-gap signal. Other receivers in the vicinity would also be able to receive the open-gap signal over a very wide range of tuning, with the result that they would be seriously interfered with in the matter of trying to receive their own signal from a station supposedly on a different assigned

frequency from that of the open gap. The selectivity or, as termed by Marconi in his patent, "localization," the object of the Marconi patent, is measured by the sharpness or peakedness of these curves, and it is easy to see that the broken-line curve of the open-gap type is in no way sharp or peaked suitable for selectivity.

Diagram D of the figure compares the resulting signals with a coupling of 11 per cent. In this diagram the quenched-gap curve is very sharp and suitable for extreme selectivity, showing tha the frequency is determined by the open of antenna circuit uninfluenced by a connection to the primary circuit. The broken-line curve of the open-gap type shows that the two humps or two frequencies are beginning to become close or nearly the same, but not nearly so strong as or sharply defined as the quenched-gap curve. While the energy is more nearly concentrated than in the case of the C diagram, yet it is not much stronger, because the coupling has been loosened, resulting in a lower rate of transfer.

The diagram at the bottom of the figure compares the quenched-gap curve with a coupling of 11 per cent with the open-gap curve with a coupling of 4.5 per cent. It will be seen that in the matter of sharpness or peakedness, these curves compare quite favorably. The text, however, points out that it requires two and a half times the energy input in the open-gap type to obtain the same strength of signal as in the quenched-gap type. The text states, page 59, the efficiency relation as follows:

"The last curves of this series show the difference of coupling necessary to obtain the same current effect with open and quenched gaps. These couplings are, according to Fleming, 11 per cent for the quenched gap as opposed to a much weaker coupling of 4.5 per cent for the open gap. This means that the coupling must be weakened and therefore a less transference of energy from excitation and aerial circuit takes place, and to render the aerial currents equal much greater energy in the prime circuit must be present. According to Fleming's figures it would be presumably necessary to use $\frac{11}{4.5} = 2.5$ times the prime energy to obtain the same aerial energy, i. e., with the quenched gap the efficiency is about 75 per cent if we take the usual value

of 25 per cent for the open gap, a figure for the quenched gap which has been questioned by its opponents."

The Marconi specification speaks of efficiency, and his system provides for obtaining a certain kind of efficiency. For instance, comparing diagram- C and D of the figure, it will be seen that the looser coupling arrangement of diagram D is more efficient than the tighter coupling arrangement of diagram C, because the energy in diagram D is more nearly concentrated into one peak than in diagram [fol. 826] C. Also, by having a loose coupling which permits of practically one frequency in the primary circuit allows a resonant transfer of energy by precise adjustment of the two circuits to accord, and a resonant transfer is always more efficient than a nonresonant transfer. The efficiency obtained in the quenched-gap type is entirely of a different kind from that of the open-gap type. It comes about through a quick transfer of energy between the two circuits in a nonresonant way to remove the energy from a system, the primary circuit, and its spark gap, in which the losses are high, and to confine it to a system in which the losses are low, namely, the antenna circuit.

* * * * * * *

From pages 60 to 63 Leggett describes the structure of gap elements for good quenching, bringing out the desirability of cooling, the use of flat disks instead of more or less pointed electrodes, the choice of materials of electrode surfaces, the division of the total gap length into a number of short lengths, and mentions protection of the gap from ultra-violet light as did Lodge in his early disclosure (1898 patent) of the fundamental principle on which the quenched gap system is based.

Summarizing, the literature of the art supports my view that the quenched-gap system employs a coupling between the primary circuit and secondary circuit so close (in the neighborhood of 20 per cent) that if used with a gap of the persistent type as required by the Marconi or Stone open gap type, there would result two frequencies so widely separated as to render the system worthless in the matter of localization of communication and efficiency, and with such coupling there is no possible chance of the primary circuit automatically creating oscillations of the desired frequency

as required by the Marconi specification and claims, nor can there be a resonant transfer of energy between the two circuits, as the circuits are tuned to one frequency while the oscillations are two in number and of entirely different frequencies from the circuits. That with tight coupling, even though the persistent type of gap is used, there is no reservoir action in the primary circuit slowly feeding energy into the secondary circuit at the rate it can be radiated, because the energy is rapidly alternately transferred between the two circuits, and the two circuits are therefore alternately reservoirs of the energy of the combined systems. The art shows, as I have contended, that the energy in a quenched-gap system is quickly dumped in its entirely into the secondary circuit from the primary circuit, and that when this function is completed, the quenched gap opens up and effectively puts the primary circuit out of action from the point at which the secondary circuit commences to effectively radiate energy at the desired frequency, and that it is this secondary circuit which is responsible to the system as a whole including the receiver for setting the frequency of the oscillations, instead of the primary circuit as in the Marconi or Stone open gap system. The art makes clear that the transfer of energy between the primary and secondary circuits in the quenched gap system is of the "shock" or "impact" type, which is not capable of resonance in the sense of a resonant transfer of energy as fully explained by Lodge in his 1898 patent, [fol. 827] because its duration is too short to employ a resonant building up through a cumulative effect, and furthermore, that the transfer takes place at two frequencies so widely separated one from the other and from the frequency of either one of the circuits that there is no common frequency anywhere in the circuits or oscillating energy on which the consideration of resonance can be based. The art brings out that in fact the two circuits do not even have the same natural time periods, for a proper adjustment of circuit relation to obtain good quenching requires throwing the two circuits somewhat out of adjustment to obtain a currentless beat to give opportunity for complete deionization of the gap. And the art lays great stress on the fact that the characteristics of the gap itself in the quenched gap type are directly opposite to the characteristics of the gap in the Marconi or Stone open gap type—the former must act to quickly stop the flow of current and

the latter must aid to make the flow long drawn out or persistent.

36. Question. What has been the commercial history of the persistent open-gap type and of the quenched-gap respectively?

Answer. In the Navy as soon as the quenched-gap type became an assured successful design of radio transmitter, which was about 1911, it was immediately adopted as the standard type of transmitter for ship stations and low-power and intermediate-power shore stations, the old type of open gap, transmitter being replaced by the new type of quenched gap transmitter as rapidly as funds became available. At first, the new type was not commercially available in American manufacture, and many sets of the quenched-gap type were purchased from the German Telefunken Co., this Telefunken type being illustrated in plaintiff's Exhibit 79. I have in recent years examined the records of purchases of radio apparatus of both the United States Army and the United States Navy since 1910, and while an extremely large number of sets were purchased since that date, particularly during the war, I do not recall a single instance of purchases of the open-gap type in the records which I have examined, and in fact, am familiar with the use of the open-gap type in but a few instances since 1910, these instances being in the case of the battleship division of the United States Fleet which joined the British fleet in its North Sea operations. The ships of the British fleet were equipped with a special arrangement of open gap transmitter employing an extremely and unusual degree of loose coupling, these sets being for the purpose of communication within the fleet only, the theory being that by using such a loose coupling resulting in a very inefficient order of radiation, that the signals would be heard only 10 or 15 miles at the most, thus keeping the fleet communications probably secret from the Germans. The ships of the American division were promptly equipped with this type of apparatus obtained from the British in order that their communication scheme would conform to that of the fleet which they had joined. This of course, was a use in which dependence was being placed upon inefficiency in the matter of communication and the open-gap type was particularly suitable.

The Navy during the war assumed the task of equipping all of the ships of the Shipping Board and Emergency Fleet

Corporation with radio apparatus, the ships being those taken over from private shipping companies and those built [fol. 828] by or under contract for the Emergency Fleet Corporation, and all of these ships were equipped with quenched gap apparatus.

When the war came on, there arose the necessity of providing radio apparatus for airplanes, and a large number of radio transmitters of the quenched-gap type were purchased in this country and in England for equipment of naval airplanes.

In the book by Leggett I have just previously referred to, pages 10 and 11, there is shown a table of the land radio stations of the world compiled from the International List of Radio Telegraphic Stations up to June, 1913, which shows that, even at that early date, 129 of the land stations of the world were of the Telefunken quenched-gap type, as compared to 138 of the Marconi type. Many of the miscellaneous stations in the list are not classified as to type, but 59 stations are listed as belonging to the United States Government, and in 1913, most of these were of the quenched-gap type. In the same book, page 14, there is shown a list of the ship stations of the world compiled from the International List of Radio Telegraphic Stations up to June, 1913, which shows that 579 ships at this early date had the Telefunken quenched-gap type as compared to 1,081 having the Marconi type. The list also shows a number of miscellaneous installations not classified as to type, but includes 214 vessels of the United States Government, a large number of which at that date had the quenched-gap type. The author, page 13, in accounting for the large number of ships having the Marconi type, points out that England, under the control of the Marconi Co. in the matter of radio apparatus, has a relatively much greater mercantile marine, as follows:

"Whilst it will be seen that the largest number of ships' installations are those on the Marconi system, in estimating the relative importance of the Telefunken stations we must bear in mind—

"(1) That England as compared to any other nation has a relatively much greater mercantile marine, and therefore offers much greater scope for any wireless company operating in England.

"(2) The original Telefunken apparatus was not developed for ship work and did not enter upon such installation work until relatively late in wireless history.

"As far as naval ship stations are concerned, with the exception of Britain and Italy, these are either manufactured by the Telefunken Co. (Germany, Holland, Russia, South America Latin nations, etc.), or are modifications of this system. They are, however, not specified as such in the Berne list and therefore not given as such in the above figures."

The Marconi Co. of America was somewhat slow in adopting the quenched-gap type for its own commercial land stations and for ships with which it had contracts for providing radio service and suffered much criticism in the radio field for its adherence to the old type open-gap system. Before the war the market for radio apparatus in the commercial field was extremely limited, the Government at that time being the principal buyer. The Government insisted upon having the best obtainable and in seeking this line of business the Marconi Co. of America was forced to develop quenched-gap apparatus to meet Government specifications in order to compete with numerous other companies in the field of supplying Government radio apparatus.

. . . . . .

[fol. 829] 37. Question. Mr. Waterman in answer to question 30 produced a drawing, plaintiff's Exhibit 105, purporting to illustrate the defendant's apparatus involved in the case of this plaintiff against the National Electric Signaling Co., 213 F. R. 815. Will you say how the defendant's apparatus involved in the case referred to, and also the defendant's apparatus involved in the later case of this plaintiff against the Kilbourne & Clark Manufacturing Co., 239 F. R. 328, compare with the defendant's apparatus involved in this case?

Answer. Mr. Waterman in his sketch, plaintiff's Exhibit 105, illustrates the National Electric Signaling system as comprising the plain or open-type or spark gap, the quenched-gap type, and the rotary-gap type. I have carefully examined the decision of Judge Veeder in the case of plaintiff against the National Electric Signal Co., 213 F. R. 815, and fail to find any evidence in the opinion of Judge Veeder having considered anything but the plain

or open-gap type, this being at page 849 of the report, where he states:

"While in the defendant's apparatus the loose coupling emits only one wave and admits of electric resonance."

This conclusively shows that defendant's apparatus in that case which was considered in Judge Veeder's opinion was of the Stone or Marconi plain-gap type, depending upon loose coupling to allow the oscillations in the primary circuit of the transmitter to be of one frequency and admitting of electrical resonance between the primary circuit, and the secondary circuit. In defendant's quenched-gap type the coupling is tight to the extent that two decided waves would be emitted, in the absence of a quenched gap, and there is no such thing as electrical resonance between the two circuits either with or without a quenched gap, for in both instances, while energy is being transferred, there are oscillations of two frequencies, neither of which have the same time period as the circuits.

Defendant's apparatus in the present case is of the quenched-gap type, or impulse type, in which the frequency of the oscillations is determined by the energy taking up the same period as the natural time period of the secondary or antenna circuit, after it has been nonresonantly and quickly dumped from the primary circuit into the secondary circuit, while the only description of the apparatus in suit in the National Electric Signaling Co. case is that there was loose coupling between the two circuits admitting of resonance between these circuits, which necessarily implies a slow feeding of energy from a primary reservoir circuit oscillating at the same frequency to which the antenna circuit is tuned, which was the case in the Stone or Marconi open-gap type. In the later case of this plaintiff against the Kilbourne & Clark Manufacturing Co., 239 F. R. 328, two transmitters were considered in the court's opinion, one known as the Simpson mercury valve transmitter, described at page 343 of the reported decision, and the other known as the "impulse" transmitter, described at page 348 of the reported decision. Both of these transmitters are fundamentally the same as defendant's quenched-gap type in that they are based on the fundamental principle [fol. 830] of the Lodge impulse excitation set forth in Lodge's 1898 patent; that is, the principle of quickly de-

livering the energy from the primary circuit into the antenna circuit nonresonantly and separating in effect the primary circuit from the secondary circuit once the delivery is complete, leaving the energy in the secondary circuit free to oscillate at the natural period of the secondary circuit uninfluenced by any maintained connection to the primary circuit. Referring to the Simpson type, Judge Netcrer states at page 346 of the reported decision as follows:

"The effect of this circuit upon the radiating circuit, as stated by Doctor Kolster, 'is such as to get the energy into that radiating circuit very quickly, and to thereafter allow it to oscillate freely in its own natural way.' This circuit has enormous decrement, and is nonpersistent. It is not, as in the Marconi patent in suit, primarily a reservoir or persistent oscillator, and does not cooperate with the antenna on the principle of resonance."

This — precisely the same as the operation of defendant's quenched-gap type of apparatus. In fact, the Simpson transmitter, as well as the impulse transmitter, were of the quenched-gap type, the decision covering this point at page 345, as follows:

"The quenched spark gap introduced into this country in 1908 by the Telefunken Co., of Germany, and now used upon all apparatus in suit, has added much to the efficiency of wireless apparatus. By it the character of the wave can be readily controlled, and the quality (the sharpness and purity) of the wave can be brought into harmony with the result desired, and the high-frequency generator impulse system will enable the operator to hitch 'your (his) wagon to the earth and shake it, * * *" and send messages to distant parts of the world, as stated by Pupin, supra."

Thus the Kilbourne & Clark two types of apparatus both included improvements over the original Lodge disclosure of the principle of impulse excitation; that is, the use of a later developed type of spark gap which aided the effect desired by Lodge of removing the primary circuit from any maintained connection with the secondary circuit after the energy had been delivered to the secondary circuit.

The Simpson and impulse transmitter of Kilbourne & Clark did not provide for adjustment of the time period of the two circuits to control the point of production of the first beat, and for carrying this adjustment to that degree where the two circuits are out of accord in time period adjustment, the proper amount, to get a perfect beat or period of no current, which I have previously explained in detail. This adjustment is a second improvement over the original Lodge system, which permits of more perfectly obtaining the result desired by Lodge, that is, of quickly and certainly cutting off the primary circuit from a maintained connection with the secondary circuit. In every impulse type of transmitter there are several swings or oscillations of the energy at a double frequency before the first beat is reached where quenching can take place, and there seems to have been some contention on the part of the plaintiff in the Kilbourne & Clark case that this was sufficient to satisfy the requirements for persistent oscillations of the Marconi or Stone open gap type. At page 2598 of the record, in the case of Marconi *v.* Kilbourne & Clark Mr. Waterman, plaintiff's expert in that case, testified as follows:

[fol. 831] "The next statement is that it 'has enormous decrement.' Well the decrement was measured, Mr. Kolster measured it and found it to be about 0.5. The instrument did not read that far, but that is the estimate which he made—0.5. That means between 10 and 11 complete oscillations."

And again, at page 2691 of the record, Mr. Waterman testified as follows:

"With respect to the use of the term 'impulse,' if I have understood the defendant's witnesses correctly, the reason why this word 'impulse' is said to be properly applicable to the defendant's transmitter is because, due to this high ratio of capacity, this big condenser and single loop, and owing to this linear decrement, that is, variable spark-gap resistance, the number of oscillations in the primary circuit is small. Well, that number of oscillations was measured by Doctor Kolster on the steamship *Admiral Evans*, in the joint test, the decrement found to be substantially 0.5. Now, according to the ordinary formula, 0.5 means somewhere between 10 and 11 oscillations."

The testimony shows that the measured decrement referred to was that of the primary circuit of the Kilbourne & Clark type. Now, the Kilbourne & Clark type had tight coupling, which means that before quenching took place there were two coupling oscillations at different frequencies. Starting the number of oscillations based on a decrement measurement, as Mr. Waterman did, where there are two coupling oscillations instead of a single oscillation, is likely to lead into difficulty. For instance, Mr. Waterman states that there were somewhere between 10 and 11 oscillations, and there is nothing to show whether he meant 10 or 11 oscillations of each kind or a total of 10 or 11 of both kinds; for instance, six oscillations of the higher coupling frequency and five oscillations of the lower coupling frequency. He states, however, that his 10 or 11 oscillations are arrived at by applying the 0.5 decrement to the ordinary formula, which would lead to the belief that he was assuming a condition of one oscillation only, which is necessarily an incorrect assumption for a tight coupler arrangement such as was had in the Kilbourne & Clark apparatus. And even with the assumption of a one frequency condition, there would not result 10 or 11 oscillations, as stated by Mr. Waterman, where a decrement of 0.5 exists. For corroboration of my statement, in this matter, I refer to Wireless Telegraphy, by Zenneck, as translated by Seelig, 1915 edition, which I have many times previously referred to. Beginning page 390 of this publication, Zenneck gives a number of figures showing the oscillations had for different decrements, and in Figure 467, page 391, gives the plot for a decrement of 0.5. Now remembering that an oscillation represents a complete cycle, that is, a full swing above the line and a full swing below the line, as in Figure 467, it will be seen that there are not more than seven oscillations shown in the Zenneck figure.

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In defendant's quenched-gap type in the present case, there need be no cause for dispute as to the number of each [fol. 832] of the two coupling oscillations in the primary before quenching takes place and free oscillations in the antenna circuit begin, for this is a matter readily calculated from the formulæ which I have given at page 623 of the typewritten record mathematically expressing the relation of the two coupling frequencies to the degree of

coupling. A 20 per cent coupling is a good average value of coupling used in the quenched-gap transmitters of the defendant in this case, and at page 625 of the typewritten record I have shown that with such a degree of coupling, where the desired frequency is 1,000 kilocycles per second, there will be two coupling frequencies, one of about 1,112 kilocycles per second and the other of about 913 kilocycles per second; that is, that one coupling frequency is about four-fifths of the other coupling frequency. In other words, under such a condition of coupling with the two frequencies starting out together in the primary circuit after one has completed four oscillations, the other will have completed five oscillations, and the fifth oscillation of the second will be opposed to the fourth oscillation of the first to give the beat desired for quenching. This is all illustrated in my sketch O, illustrating the action in the quenched-gap system, and I make particular reference to my Figure 6*d*, where it can be easily followed that under conditions of two oscillations, where the frequency of one is four-fifths that of the other, they will be opposed at the fourth oscillation of one and the fifth oscillation of the other to give the desired beat. My Figure 6*a* of the same sketch shows that when this beat point is reached and quenching takes place in the primary circuit, there are no longer any oscillations in the primary circuit, but from this point on the real oscillations of the system begin, which are the free, single-frequency oscillations determined by the secondary or antenna circuit. Therefore, taking average conditions in apparatus of defendant in this case, there are four oscillations of the lower frequency and five of the higher frequency in the primary circuit.

Judge Netterer in his decision in the case of Marconi *v.* Kilbourne & Clark, disposed of this contention of the plaintiff that the double oscillations in the primary before quenching took place was sufficient to support the requirement in the Marconi patent of persistent oscillation, as follows, quoting from page 347 of the reported decision:

"And the further fact that it is shown that, as stated by Doctor Zenneck, "there was only one system, the dummy antenna, and only one kind of oscillations, the free oscillation of the antenna'; and it further appears that oscillatory circuits are not necessarily tuned circuits, and good tuning is not possible with two and one-half waves in the train.' No

facts shown indicate that the oscillations were the result of resonant transfer of energy."

The expression "dummy antenna" is explained by the fact that the experiment referred to was of a laboratory nature and instead of using an elevated wire for an antenna, a laboratory circuit having the characteristics of an antenna was used, and such a circuit is known to the art as a "dummy antenna."

The quotation makes it clear that there was but one system involved in the useful oscillations, namely, the antenna, as contrasted to the Stone and Marconi plain-gap type, in which the oscillations originate in the primary circuit, travel across a linkage between the primary and secondary circuits as oscillations of one frequency, and then act in the [fol. 833] antenna circuit as oscillations of the frequency determined by the primary circuit.

The quotation then adds that the circuits are not necessarily tuned circuits, and I take this to mean that since the energy is not being transferred at the natural periods of the circuit, no advantages arise from tuning.

The quotation then makes it clear that even if an effort were made to take advantage of tuning to transfer energy, that no real advantage would be obtained because where the number of oscillations are few, such as two and one-half, good tuning is not possible on the principle brought out by the Lodge 1898 patent to the effect that it was necessary to have persistent oscillations for good tuning. The quotation does not mention the matter, but it must be remembered also that in addition to the oscillations being few in number they are also of two different frequencies not corresponding to the natural periods of the circuits, and under such circumstances it is impossible to in any wise consider a tuning relation between the circuits.

The quotation concludes as follows:

"No facts shown indicate that the oscillations were the result of resonant transfer of energy."

Thus Judge Netterer makes it clear that in the Marconi system or Stone system, where the oscillations of the desired frequency originate in and are determined by the primary circuit, they arrive in the antenna circuit for useful work as a result of a resonant transfer of energy between the two circuits, as contrasted to the quenched-gap system, in which

there can be no resonant transfer because the oscillations of the desired frequency do not come into being until the transfer has taken place and the primary circuit is quenched and eliminated from the system.

Judge Netterer also clearly showed that he did not consider that it made any material difference as to how many oscillations there were during the period of the transfer of the energy from the primary to the secondary circuit as long as the system was one resulting in quickly getting the energy into the antenna, where free oscillations were set up and determined by the antenna by quoting from Professor Zenneck's testimony at the bottom of page 347 of the reported decision, as follows:

"From the standpoint of a physicist, therefore, and considering the result, it seems to me very immaterial whether the free oscillations start after one-half an oscillation or after two and one-half."

On page 350 of the reported decision, Judge Netterer held that the Kilbourne & Clark apparatus was identical with the apparatus of Figure 4 of the Lodge 1898 patent, and differentiated the Lodge system from the Marconi or Stone system as follows, quoting from page 350:

"Lodge does not use one circuit as a reservoir for the other, there being no resonant transfer of energy, the circuit in which the change originates being entirely separated when the radiating circuit is charged."

This statement as to the action of Lodge, which Judge Netterer says is the action of Kilbourne & Clark apparatus, is precisely the action of defendant's quenched-gap type in the present case. The quenched-gap type has no reservoir circuit, the primary circuit merely being a quick acting [fol. 834] charging or exciting circuit for the secondary. There is no resonant transfer of energy in the quenched-gap type, because (1) the energy is transferred at two frequencies entirely different from the frequencies to which the circuits are adjusted, (2) because the transfer of energy is too rapid to take any advantage of tuning were it possible in some way not yet known to the art to transfer the energy at but one frequency, and (3) the two circuits are not adjusted to have the same natural time period, but are out of adjustment to aid in getting the perfect beat necessary to good quenching action.

Judge Netterer further states on the same page as follows:

"For the purpose of furnishing a pure wave, Lodge provides that the energy undelivered to the radiating circuit be cut off, and states, on page 2 of his patent, that 'the advantage of this is the charges so communicated are left to oscillate free from any disturbance due to maintained connection with the source of electricity,' and the maximum effect will be produced on the receiving circuit."

This is precisely the operation sought and obtained in the quenched-gap type of apparatus. The quenched gap, due to its efficient quenching action, allows a tight coupling to quickly deliver the energy to the radiating circuit because when the beat is reached it will effectively deionize and withstand a powerful attempted reaction of the radiating circuit without breaking down, and this good quenching is further obtainable through adjusting the natural time periods of the two circuits to a difference that obtains a perfect or currentless beat, with the result that free oscillations in the antenna are obtained uninfluenced by any maintained connection with the primary circuit. Judge Netterer further states on the same page of the reported decision as follows:

"The operation of Lodge patent, Figure 4, is identical with defendant's in using impulse charging and variable inductance coil in the antenna. No reservoir circuit is used, and, when the radiating circuit is charged, it is entirely separated from the source of supply circuit which necessarily has some natural period."

This quotation describes precisely the quenched-gap type of apparatus in the present case. In all of the types there is found the Lodge variable-inductance coil in the antenna, and it is the adjustment of this Lodge variable-inductance coil that determines the frequency of the oscillations after all of the energy is delivered to the antenna and the primary circuit is out of action, just as did Lodge determine the frequency of his free oscillations in Figure 4 of his patent. The supply circuit or primary circuit in the quenched-gap type of apparatus has some natural period, just as did Lodge's primary or supply circuit and the primary of supply circuit of the Kilbourne & Clark apparatus. In the quenched-gap system, the natural period of the supply circuit is

adjusted to obtain a perfect beat or period of no current, but such adjustment results in the product of capacity and self-inductance being different from that of the product of capacity and self-inductance of the antenna circuit. This adjustment of the primary circuit has nothing whatever to do with the frequency of the radiated oscillations, this circuit being entirely out of action when these oscillations commence, and has nothing whatever to do with a resonant transfer of energy between the two circuits because the transfer takes place at two frequencies entirely different [fol. 835] from the time period adjustment of the circuit, and also because the time period adjustment of the primary circuit is different from that of the secondary circuit.

* * * * * * *

Summarizing, it is my opinion that defendant's transmitting apparatus in the present case is entirely different from the apparatus considered in Judge Veeder's decision in the case of Marconi *v.* National Electric Signaling Co., and is the same apparatus as that considered in Judge Netterer's decision in the case of Marconi *v.* Kilbourne & Clark.

Considering now defendant's receivers, I note that Judge Netterer held that the Kilbourne & Clark receiver was the same as the receiver shown in Figure 13 of the Lodge 1898 patent, the Kilbourne & Clark receiver having a tuned antenna circuit, as did the Lodge receiver, and a secondary circuit in which a detector was placed coupled to the tuned antenna circuit, the secondary circuit of Kilbourne & Clark not being arranged to vary the tuning to correspond to variations in the antenna circuit.

Some of the types of defendant's receivers in the present case are identical with the Kilbourne & Clark type of receiver, these being the Atlantic Communication Co. type and the Signal Corps pack set type, 1915, classified by me at page 803 of the typewritten record, and the Telefunken type and Foote-Pierson type, classified by me at page 811 of the typewritten record. At page 805 of the typewritten record, I have referred to the Signal Corps pack set type as having not only an untuned secondary circuit, but also including a coupling between the two circuits consisting of a small condenser. In respect to the matter of an untuned secondary circuit, it corresponds exactly with the Lodge patent. In respect to the matter

of a coupling, it is absolutely unlike both the Lodge patent and the Marconi patent under consideration.

The other types of receivers of defendant in the present case only differ from the Kilbourne & Clark type in having a variable condenser in the secondary circuit, which is the variable condenser of Figure 1 of Marconi patent 627650 of 1899, this being the condenser K, as illustrated in my sketch M, opposite page 701 of the typewritten record. The Marconi patent in suit provides for varying the inductance in the secondary circuit for the precise adjustment of the two circuits to have the same natural time period, but defendant's apparatus employs the variable condenser K of the earlier Marconi patent for this purpose. In defendant's type of apparatus the inductance is not changed for the purpose of precise adjustment, but arrangements are made for varying the inductance in large steps for the purpose of making the receivers useful over a wide range of frequencies, this being done in a number of ways, such as entirely removing one coil having a certain number of turns and replacing by another coil having a different number of turns, or by a series of space contacts on the winding of a coil of large extent. For instance, it is not in the practice of defendant to build a receiver to cover the range of 30 kilocycles to 300 kilocycles, in as many as 10 steps, requiring 10 different coils for insertion in the receiver, or 10 different con- [fol. 836] tacts. With one coil in place, the range would be, for instance, from 30 kilocycles to 50 kilocycles. With the next coil in place, the range would be from 40 kilocycles to 60 kilocycles, and so on with each range provided by the coils overlapping somewhat. With a particular coil in place, no effort is made to obtain the precise adjustment necessary for tuning, this always being done with the variable condenser of the Marconi 1899 patent. Either method of accomplishing the tuning was adequately provided for by the prior art and particularly in the Stone to Baker 1899 letters and the Stone patents.

The receiver shown in plaintiff's Exhibit 105, by Mr. Waterman, as being the receiver in the case of Marconi *v.* National Electric Signaling Co., differs from the Kilbourne & Clark type and those types of defendant that I have just referred to as having untuned secondaries in that the National Electric signaling system had a tuned secondary. It differs from those types of defendant in the present case

having tuned secondaries in that the arrangement for precise adjustment is through the variation of inductance, as illustrated in the Marconi patent, instead of the variation of capacity as provided for in the Marconi 1899 patent, and employed in defendant's types of apparatus in the present case.

However, Stone made provision for the particular type of adjustment shown in the National Electric Signaling Co. apparatus, that of varying the inductance, in his patent 714756, previously referred to by me, at page 6, commencing line 75 of the specification, where he states:

"In both the organizations illustrated in figures 5 and 6 the inductance coils L may be made adjustable and serve as a means whereby the operators may adjust the apparatus to the particular frequency which it is intended to employ."

Summarizing, it is my opinion that those types of apparatus of defendant in the present case having untuned secondary circuits are precisely the same as the Kilbourne & Clark type of apparatus held by Judge Netterer not to infringe, and are different from the National Electric Signaling Co. type. That the types of apparatus having tuned secondary circuits only differ from the Kilbourne & Clark type in that they employ the variable condenser K of Figure 1 of the Marconi 1899 patent, and differ from the National Electric Signaling Co. type in that they do employ the variable condenser instead of the variable inductance shown by the Marconi patent in suit, but which was provided for by Stone, as quoted above.

Defendant's counsel offer in evidence the following exhibits referred to in the deposition of this witness:

Defendant's Exhibit Z–4. Page 58 of Navy Manual of 1915.

Defendant's Exhibit A–5. Loftin Sketch P.

Defendant's Exhibit B–5. Pages 332 and 333 of the Electrician, of London, published June 11, 1909.

Defendant's Exhibit C–5. Pages 171 to 175, inclusive, of the London Electrician, published November 10, 1911.

Defendant's Exhibit D-5. Pages 87 to 97 and 390 to 391 of Wireless Telegraphy, by Zenneck, published in 1915.

Defendant's Exhibit E–5. Pages 199 to 200 of Wireless Telegraphy and Telephony, by Eccles, published in London, England, 1918.

Defendant's Exhibit F–5. Pages 377 to 378 of Principl Underlying Radio Communication, published at Washington, 1922.

[fol. 837] Defendant's Exhibit G–5. Preface and pages 9, 17, 55 to 59 of Wireless Telegraphy, by Leggett, published at New York, 1921.

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38. Question. What effect did the act of August 13, 1912, to which you have already referred, have upon the system described in the Marconi patent 763772 and upon the quenched-gap system, respectively?

Answer. The act of August 13, 1912, under section 3, contains a number of regulations governing the character of waves permissibly emitted by radio transmitters, and the third and fourth regulations affect the manner in which the Marconi or Stone open-gap type can be used, these regulations reading as follows:

"Third. At all stations if the sending apparatus, to be referred to hereinafter as the 'transmitter,' is of such a character that the energy is radiated in two or more wave lengths, more or less sharply defined, as indicated by a sensitive wave meter, the energy in no one of the lesser waves shall exceed 10 per cent of that in the greatest."

"Fourth. At all stations the logarithmic decrement per complete oscillation in the wave trains emitted by the transmitter shall not exceed two-tenths except when sending distress signals or signals and messages relating thereto."

Referring to the first regulation, I do not know of any manner in which the plain-gap type of transmitter can be adjusted when sufficiently tightly coupled to cause the energy in one of the coupling waves to be not more than 10 per cent of the energy in the other coupling wave. Referring to my sketch G, Figure 2b, I have shown the two coupling waves practically in their relative proportions in the manner of strength of signals. It generally happens that the wave at the higher frequency, which I show in red in the sketch, is slightly stronger than the wave at the lower frequency, which I show in green in the sketch. But the difference is only a few percent and never approaches the 90 percent difference required by the first quoted regulation.

Therefore, to comply with the regulation it is necessary to employ a coupling between the primary and secondary circuits of the transmitter that in effect but a single wave

is radiated, as I have illustrated in Figure 5b of my sketch H. The result of the use of such a loose coupling is the transfer of but a very small percentage of the total energy available in the primary circuit to the secondary or antenna circuit, very seriously reducing the overall efficiency of the transmitter.

The quenched-gap type of transmitter is capable of complying with the first quoted regulation when a very tight coupling between the primary and secondary circuits is used. Referring to my sketch O, Figure 6b, it is seen that waves are radiated at three different frequencies, two of them being due to the two coupling frequencies which exist while the energy is being quickly transferred from the primary to the antenna circuit, which I have illustrated in green, the lower frequency, and in red, the higher frequency, [fol. 838] in the sketch. The third frequency is the desired signaling frequency, and I have illustrated this in purple in the sketch. The two coupling frequencies exist for such a short period of time that in practice the energy in them as indicated by a sensitive wave meter is less than 10 per cent of the energy in the desired frequency, as required by the regulation.

Thus, the quenched-gap type can use a very tight coupling resulting in a quick and efficient transfer of energy from the source to the antenna circuit, where the energy is efficiently used for useful radiation of signals, and at the same time complies with the law.

The second quoted regulation definitely fixes the decrement permissible for a transmitter, and the decrement referred to is merely a measure of the sharpness of the tune, or referring to my sketch O, Figure 6b, the peakedness or pointedness of the signaling wave. The narrow or more pointed the curve of frequency, such as the purple curve in the figure, the more sharply can a receiver be tuned to the signaling wave without interference from other sharp signaling waves, and this simply means that the decrement is low. And the regulation has set this decrement not to exceed 0.2. The decrement or sharpness of the wave is determined by the number of oscillations in the train—the more the number of oscillations in the train the less is the decrement or the sharper the wave. For instance, in Figure 6a of my sketch O, where I have shown the oscillations in the antenna circuit of a quenched-gap system, it is seen that the purple oscillations which come into being after

ail the energy has been transferred to the antenna circuit exist for a long time, this being on account of a large amount of energy being transferred and suffering only very small wasteful dissipation in the antenna circuit, nearly all being usefully employed in radiation. Therefore the quenched-gap system easily complies with the law in not exceeding the 0.2 decrement allowed, and at the same time is extremely efficient in the handling of electrical energy.

In the plain-gap type, if the two circuits are closely coupled, there results two signaling waves as illustrated in Figure 2b of my sketch G, and since the energy is transferred from one circuit to another and encounters large losses in the primary circuit where there is a spark gap, the oscillations will not endure for a long time, and in practice it is found that they die out so quickly that neither one of the curves shown in Figure 2b will be sufficiently sharp or peaked to give the 0.2 decrement required by law. If the coupling is loosened to some point between what is generally known as "loose coupling" and the tight coupling permissible with the quenched-gap type, the two coupling frequencies come close together, so that the decrement can not be measured for each of the curves separately, but must be measured as if the two curves are but one, which results in obtaining a very high decrement in no wise within the limits set by the law. The result is that in the open-gap type a coupling sufficiently loose must be used that for all practical purposes there is but a single frequency such as I have illustrated in Figure 5b of my sketch H. When this is done the plain-gap type will come within the sharpness or decrement fixed by law, but under such loose coupling the transfer of energy from the primary to the antenna circuit is so inefficient that there results a very low overall efficiency for this type of transmitter.

[fol. 839] Summarizing, while it is possible to adjust the Marconi or Stone plain-gap type of transmitter so that it gives a wave sufficiently sharp and pure to meet the requirements of the law, this is only accomplished through a tremendous sacrifice in overall efficiency, with the result that the quenched-gap type which easily complies with the law under adjustment that permits of high overall efficiency entirely displaced the plain gap-type in commercial use as soon as the quenched-gap type became a commercial design.

39. Question. Please state the relative extent of use of

the two-electrode and three-electrode vacuum tubes in the wireless art, both in commercial practice and in governmental use?

Answer. I have been more or less intimately associated with radio practice for the past 14 years and have never encountered a two-electrode vacuum tube in use anywhere. I am thoroughly acquainted with radio practice in the United States and know that no use is or has been made of the two-electrode vacuum tube in radio. I have visited most of the important radio stations in Europe and most of the important radio manufacturing plants and laboratories, and am acquainted with many of the prominent workers in radio in Europe and have conferred with them in numerous ways from time to time, and have never encountered a single trace of a two-electrode vacuum tube being placed in practical use. I have read a large part of the literature of the world on the subject of radio and do not recall a single reference to the practical use of the two-electrode tube. I have recently made a complete survey of all of the radio apparatus bought by the Army and Navy since 1910, and so far as I can find these services have come into the possession of but a very small number of two-electrode tubes, and these only in connection with one purchase of apparatus in which the vacuum tube did not form a vital part, and the tube was not specified in the purchase. The purchase I refer to was one by the Navy in which the Marconi Wireless Telegraph Co. of America furnished a few devices known as the Bellini-Tosi direction finder, on which occasion the Marconi Co. supplied a small number of two-electro vacuum tubes to be used as detectors with these devices. I personally experimented with one of these direction finders in 1912 or 1913, and did not use the two-electrode tube as a detector, but a crystal detector.

On the other hand the three-electrode vacuum tube has been in extensive use throughout the world ever since it became a commercially available article. I have seen its actual use in all of the important radio stations that I have visited, as previously referred to, and know of its large manufacture in plants in Europe which I have visited, as well as in this country. From my survey of the purchases of radio apparatus by the Army and the Navy since 1910 I know that both of these services have bought three-electrode

vacuum tubes in very large numbers ever since it became commercially available. I am familiar with practically all of the circuit arrangements which have been used by both the Army and Navy in radio apparatus for many years, and know that in all arrangements wherein vacuum tubes are used, that they are specifically designed for the use of three-electrode vacuum tubes instead of two-electrode tubes, and the difference is readily apparent to one skilled in the art, as a circuit for use with a two-electrode tube would be characteristically different from a circuit for use with a three-electrode tube.

[fol. 840] The three-electrode vacuum tube is now being extensively manufactured in small sizes for radio receiving and in large sizes for radio transmitters, the present tendency of the art being to discard the quenched-gap type of radio transmitter which has been so popular for ships and other uses requiring small and intermediate power transmitters for a more recent design of radio transmitter employing three-electrode vacuum tubes as the oscillation generator.

During the present-day popularity of radio broadcasting, the three-electrode vacuum tube is a household article, being manufactured and sold by the million through small shops located in large numbers throughout the country, and in all of this activity it is almost impossible to find a two-electrode vacuum tube for sale. In fact there is no such thing as a comparison of the extent of uses of the two devices. The two-electrode vacuum tube simply has not been used, while the three-electrode vacuum tube has found use so extensive that the extent is simply a matter of conjecture.

(Direct examination closed.)

* * * * * * *

Cross-examination by Mr. Betts.

40. Cross-question. In your answer to question 1, you stated that you were assigned in 1919 to what was known as the Interdepartmental Radio Board, of which you were elected chairman. Who assigned you to this duty and who were the other members of the board?

Answer. As I recall it I was assigned as a member of the board in a letter from the Secretary of the Navy to the Attorney General, being merely furnished with a copy of

the letter and not given any definite written orders for the duty. I was elected chairman of the board by the members of the board. The other members were Harry E. Knight, Esq., representing the Department of Justice, who relieved H. C. Workman, Esq., who represented the Department of Justice for a very short period of time; R. H. Young, Esq., and Capt. Guy Hill, United States Army, representing the War Department and Commander S. C. Hooper, representing the Navy Department.

41. Cross-question. How long did this board exist?

Answer. About two years and a half, in completing the task set for it, but so far as I know, it has never been officially dissolved.

42. Cross-question. Prior to your giving your present deposition, and while you were active as a member of the interdepartmental board, did you as a part of your study of the art of radio research and development examine the record in the following mentioned cases:

. . . . . .

Marconi Wireless Telegraph Co. of America *v.* National Electric Signaling Co., United States District Court, Eastern District of New York, on Marconi patent 11913, Lodge 609154, Marconi 763772, decided by Judge Veeder; Marconi Wireless Telegraph Co. of America *v.* Atlantic Communication Co., United States District Court, Eastern District of New York, Marconi patent 763772, on motion for preliminary injunction before Veeder, J.; Marconi Wireless Telegraph Co. of America *v.* Kilbourne & Clark Manufacturing Co., United States District Court, Western District of Washington, Marconi Patent 763772; Marconi Wireless Telegraph Co. of America *v.* De Forest Wireless Telegraph & Telephone Co. on Fleming patent, the foregoing patents being the patents in suit, and did you familiarize yourself with the prior art as set forth in those cases?

[fol. 841]

Answer. In connection with my duties with the Interdepartmental Radio Board I examined during the two years and a half in which the board was active an enormous amount of literature of various kinds, including records involving litigation of patents before the board. I do not recall definitely any of the particular records examined, but such records as were examined were in some way included in the files of the board, which are now, to the best of my knowledge and belief, in the custody of the Navy

Department. Since my duties in connection with the board were performed as an officer of the Navy, I do not feel at liberty to discuss in detail those matters which are a part of the files of the Navy Department without the department's consent.

43. Cross-question. Don't you remember, Commander, the fact that at the time you were serving as a member of the interdepartmental board claimant's counsel submitted to you copies of the record in the cases listed in the last question?

* * * * * * *

Answer. I recall that numerous claimants before the board submitted records of various kinds, including records involving prior litigation, and that claimants' counsel was among those who submitted such records. And I also recall that after the completion of the board's active work I made special effort to return those records which had been loaned the board for temporary use only.

44. Cross-question. Please answer the question which is limited to the records of the specific cases mentioned.

* * * * * * *

Answer. The only record of those listed in the question that I definitely recall is that of the Kilbourne & Clark case, which, as I recall it, was secured from the Kilbourne & Clark Co. I do not definitely recall any of the other records listed.

45. Cross-question. The interdepartmental board of which you were chairman made a report, did it not, with re- [fol. 842] spect to the present claimant's claim under the Marconi patent 763773, and Fleming patent 803684, and you signed that report as its chairman.

Answer. The board upon the completion of its work made a report which, so far as I know, has never been released for public consideration, and in the absence of any definite authority from the Navy Department, which I represented on the board, I do not consider that I am at liberty to discuss the results of the board's work.

46. Cross-question. I did not ask you to discuss any report, but whether the report was made by the interdepartmental board, and whether you signed such a report as its chairman?

Answer. I have not consulted the Navy Department concerning its willingness as to the extent that I may discuss

the operations of the Interdepartmental Radio Board since my resignation in March just past, but do know that up to the time of my resignation, it was unwilling to have the operations of that board open to the public disclosure, and therefore, do not feel at liberty to discuss in my testimony, the particular form of the report or such other details as the question involves.

47. Cross-question. Do you decline to state whether or not the interdepartmental board of which you were chairman made a report touching the claim of the present plaintiff upon the patents discussed in your direct examination?

Answer. In the absence of the express consent of the Navy Department, I do.

48. Cross-examination. Do you decline to state whether or not you signed a report as chairman of the interdepartmental board, touching the claim of the present plaintiff upon the Lodge patent involved in this suit?

Answer. In the absence of the express consent of the Navy Department, I do.

49. Cross-question. Will you state whether or not prior to October 1, 1920, you were aware of the fact that suits had been brought by the Marconi Wireless Telegraph Co. of America against National Electric Signaling Co. in United States District Court in the Eastern District of New York; against De Forest Wireless Telegraph & Telephone Co. on the Fleming patent in suit; against the Kilbourne & Clark Manufacturing Co. upon Marconi patent 763772; against the Atlantic Communication Co. upon Marconi patent 763772?

[fol. 843] Answer. I have been for some time aware of most of the litigation referred to and believe that my knowledge was acquired prior to October 1, 1920.

50. Cross-question. Prior to October 1, 1920, had you examined and were you familiar with the record in the following cases:

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Marconi Wireless Telegraph Co. of America *v.* National Electric Signal Co. on Marconi patent 11913, Lodge patent 609154, Marconi patent 763772 (Veeder, J.)

Marconi Wireless Telegraph Co. of America *v.* Atlantic Communication Co. Motion for preliminary injunction before Veeder, J.

Marconi Wireless Telegraph Co. of America *v.* Kilbourne & Clark Manufacturing Co. on Marconi patent 763772.

Marconi Wireless Telegraph Co. *v.* De Forest Wireless Telegraph & Telephone Co. on Fleming patent?

Answer. My knowledge of the litigation in question was acquired from both examination of records and discussion with others, many of whom were principals in the litigation, and I think I had some familiarity with most of the litigation in question prior to October 1, 1920.

51. Cross-question. Since you say you were aware of the foregoing litigation, prior to October 1, 1920, do you not conceive that it was part of your duty representing the Navy Department on the interdepartmental board at this time to thoroughly examine and familiarize yourself with the litigation listed in my cross-question 49?

* * * * * * *

Answer. I had other duties in addition to my duty as a member of the board, and was but one of five members on the board. I took my share of the work of the board to the best of my ability, but the task was enormous and it would have been impossible for any one member to consider every claim in every phase that was presented in detail.

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52. Cross-question. Please answer the specific question I put to you in cross-question 51?

* * * * * * *

Answer. No; I do not consider that it was my undivided duty to thoroughly examine and familiarize myself with all of the litigation listed in your cross-question 49.

* * * * * * *

53. Cross-question. I did not ask about your "undivided" duty. Will you please limit your answer to the question propounded? You have stated in your direct examination that you were elected in 1919 chairman of the Interdepartmental Radio Board. You have also stated that prior to October 1, 1920, you were familiar with the litigation listed in cross-question 50. Do you not conceive that it was your duty, representing the United States on this interdepartmental board with respect to a claim of the present plaintiff against the United States for infringement of letters patent which had been involved in this prior litigation,

to examine the records in this prior litigation, and to thoroughly familiarize yourself with what was set up in the prior art in those cases, and did you not so do?

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[fol. 844] Answer. In the absence of the express consent of the Navy Department, I do not feel at liberty to discuss the procedure of the board in connection with the consideration of the claims of any of the claimants that appeared before the board.

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54. Cross-question. (Question repeated.)

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Answer. Each and every claim presented to the board was considered as carefully as it was humanly possible to do so with the facilities at the disposition of the board and in a reasonable period of time. I have stated that the board made a report to the proper officials in connection with the work assigned the board, but since it was my definite knowledge that the Navy Department was not willing to disclose the proceedings of the board up to the time that I resigned from the Navy, and since I have not been instructed to the contrary since my resignation, I must decline to answer questions as to the procedure of the board, unless the court instructs otherwise.

• • • • • • •

55. Cross-question. I am not now asking you questions as to the procedure of the board. My question is a personal one, namely, as to what you personally did or did not do at the time inquired about in Cross-question 53 with respect to the records in the litigations listed in cross-question 50?

• • • • • • •

Answer. I was a member of the board as an official in the Navy Department, and I do not understand that my personal acts in connection with that duty can be separated from the official capacity in which I acted.

• • • • • • •

56. Cross-question. I understand, then, that you decline to state whether you examined and thoroughly familiarized

yourself personally with the records in the litigations listed in cross-question 50?

Answer. I do.

* * * * * * *

57. Cross-question. Are you now familiar with the records of the litigations listed in cross-question 50?

Answer. I am to varying degrees in the several cases.

58. Cross-question. When first did you begin to study these records?

Answer. In 1919.

[fol. 845] 59. Cross-question. Can you refer to a single patent or publication or prior-art device which you have referred to in your direct examination in the present case which was not involved in the litigations listed in cross-question 50?

Answer. I have referred to an extremely large number of publications and patents, but, limiting the consideration to the prior art, I do not recall that I have referred to any which was not in one case or another in the prior litigations brought out, though I should like to reserve opportunity for correcting this statement in case a detailed examination should show that I have used other art.

Mr. Betts. Certainly, up to the time that the present deposition is closed.

60. Cross-question. Referring to Marconi patent 763772, is there any particular kind of spark gap illustrated and described in the specification; that is to say, is what you have called the open gap or the rotary gap or the quenched gap specifically illustrated and described in the patent as the form of gap which is to be employed? Please quote all portions of the specification which describe such form of gap and point to the figures of the drawings which illustrate the form of gap.

* * * * * * *

Answer. Figure 1 of the patent quite definitely illustrates a form of gap known to the art as an open gap, this being the device c in the figure comprising two spherical electrodes illustrated by the two small circles somewhat separated, and the figure does not illustrate any inclosing arrangement for these electrodes. The language of the specification does not definitely specify any form of spark gap, nor does the particular mode of operation of the

Marconi patent require any particular form of gap except a preferred form flows out of the reqvirements for "best results" set up in several places in the specification. At page 2, lines 12 to 20, Marconi states:

"My experiments have demonstrated that the best results are obtained at the transmitting station when I use a persistent oscillator—an electrical circuit of such a character that if electromotive force is suddenly applied to it and the current then cut off, electrical oscillations are set up in the circuit which persists or are maintained for a long time—in the primary circuit * * *."

To obtain "best results" in the matter of persistent oscillations or oscillations that are maintained for a long time in the primary circuit, the open type of gap satisfies the Marconi system much better than the quenched-gap type or rotary type.

61. Cross-question. Referring to Loftin sketch A, what figure of what patent or publication do you find sets forth the apparatus of Loftin sketch A?

Answer. The high-frequency oscillation generator system illustrated has all of the circuits included from the primary P of the two-winding transformer $p\ s^1$ and to the left in the second system to the left in Figure 165 of the book entitled "Inventions, Researches, and Writings of Nikola Tesla," by Martin, published in 1894. The Tesla book describes various applications to which the high-frequency current produced by the systems illustrated in Figure 165 may be put, and on page 346 definitely proposes the production of electric waves by such currents for the transmission of telegraph messages without wires. On page 348, in con- [fol. 846] nection with Figure 185, the book proposes an electric wave producing system for association with a source of high-frequency currents, comprising an elevated conductor surface connected to one end of the terminals of the source, such as that illustrated in Figure 165, the other terminal of the source being connected to the earth or water main presumably buried in the earth. My figure in Loftin sketch A simply pictorially illustrates such a connection.

62. Cross-question. I understand, then, from your last answer that your Loftin sketch A, Tesla transmitter, is a combination of what you say is shown in Figure 165 of Tesla's book of 1894, and what is shown in Figure 185, is that right?

Answer. Figure 185 of the Tesla book illustrates diagrammatically a complete system, it being understood from the text that the source of high-frequency oscillations illustrated as associated with the antenna circuit is any one of the numerous sources illustrated in Figure 165 of the book. My sketch simply adds the details of such a high-frequency source omitted by the Tesla book in Figure 185, because the book had provided the details in the earlier pages.

63. Cross-question. So you answer my question in the affirmative?

Answer. Yes.

64. Cross-question. Where do you find the transformer P S [1] of Loftin sketch A to be suggested by Tesla as a part of the organization of either Figure 165 or Figure 185 of the Tesla, 1894, book?

Answer. In Figure 165, the second system from the left, includes a two-winding transformer having a primary P and a secondary winding S [1]. This system is a source of high-frequency oscillations to which any work circuit, such as a radio antenna, can be connected, the two terminals for connection to the work circuit being illustrated as the wires leading away from the end of the secondary S [1].

65. Cross-question. Figure 165 of the Tesla, 1894 book does not purport to illustrate, does it, a radio or wireless system?

Answer. Figure 165 has all the essentials of a wireless system. * * * The figure has all the inherent capabilities of transmitting electrical energy through space and therefore purports to do what it is inherently capable of.

66. Cross-question. In what figure of the Tesla, 1894, book do you find illustrated as a part of a radio telegraph system a transformer such as that which you have illustrated at P S′ in Loftin sketch A, Tesla transmitter?

Answer. In Figure 165.

67. Cross-question. Do you mean to say, Commander, that Figure 165 illustrates a radio telegraph system?

Answer. It does.

68. Cross-question. In what figure of the defendant's Exhibit F-4 do you find illustrated the apparatus which you have exhibited in "Loftin sketch B, Popoff receiver"?

Answer. Figure 2 of defendant's Exhibit F-4 illustrates in detail the coherer and the appurtenances for making it

an effective detector of electrical impulses. Commencing with the last paragraph, page 15, of the exhibit, there is a complete description of the manner in which the coherer is to be used when the electrical impulses arrive through space, which description provides for the use of an elevated [fol. 847] conductor connected to one end of Figure 2 and a ground connection to the other end of Figure 2. My sketch B reproduces Figure 2 merely pictorially, illustrating the elevated conductor and ground connection provided for in the text.

69. Cross-question. Referring to your Loftin sketch A, Tesla transmitter, what have you intended to illustrate by the part lettered *dd dd*?

Answer. These illustrate spark gaps or devices referred to in the Marconi patents in suit as "spark producers."

70. Cross-question. Where do you find in the Tesla, 1894, book, either in Figure 165 or Figure 185, spark gaps or "spark producers" such as you have illustrated in Loftin sketch A, Tesla transmitter?

Answer. Such devices are illustrated in all six of the organizations shown in Figure 165 of the Tesla book, being uniformally referred to throughout the organization by the reference letters *d d*. In the particular figure or organization which I have copied, namely, the second from the left, the spark producer is shown as having either of two positions, one in series with the condenser and inductance of the oscillatory circuit, and the other in parallel with these elements, this position being represented by the broken-line structure in the figure.

71. Cross-question. Do I understand you to say that the parts marked *d d* in Figure 165 of the Tesla, 1894, book were used for the purpose of acting as spark producers in a radio or wireless telegraph system?

Answer. They were.

72. Cross-question. In your direct examination you have, I believe, referred to coupling as being loose and coupling as being tight. What degree of coupling do you include in each of these phrases?

Answer. In my testimony I stated that a coupling would be considered tight when it caused a double frequency sufficiently widely separated as to be detectable with practical receiving apparatus; that is, an operator provided with an ordinary receiver would be able to tune his apparatus to

two definite points in which he would find a maximum strength of signal. For instance, if the assigned frequency for the transmitting station is 1,000 kilocycles, and if the operator sets his receiver at this point and does not find the signal, or finds it with the signal very weak, but by tuning to 1,050 kilocycles and 950 kilocycles, he finds signals stronger than at 1,000 kilocycles, tight coupling may be said to exist, as far as radio communication systems are concerned. On the other hand, if the assigned frequency to the transmitting station is 1,000 kilocycles and the operator finds the maximum signal strength at this point, and by tuning to other frequencies finds that the signal gradually grows weaker, loose coupling may be said to exist. In radio practice couplings are used in the neighborhood of 20 per cent for quenched-gap systems, which if used in the open gap of Marconi system would give two frequencies located at about 1,100 and 900 kilocycles if the assigned frequency is 1,000 kilocycles. In the open-gap type of system, when the coupling is loosened to the neighborhood of 3 per cent, it is found in practice that ordinary receiving apparatus will detect but one frequency, and in [fol. 848] practical operation such a coupling is commonly known as loose, though couplings less than 3 per cent are sometimes employed for extreme selectivity.

73. Cross-question. Irrespective of the form of spark gap employed in a two-circuit transmitter, what degree of coupling between the transformer coils would you designate as loose couplings and what degree of coupling would you designate as tight couplings between such coils?

Answer. I would designate any coupling that with practical receiving apparatus gives a detectable double hump as a tight coupling. In the Marconi system such conditions arise in going from 3 per cent up.

74. Cross-question. In the Marconi patent 763772 there is illustrated and described several different transformers for coupling the two transmitter circuits together. Is that not so?

Answer. Yes.

75. Cross-question. Have you ever personally built or had built under your supervision any of the transformers disclosed in the Marconi patent 763772 for coupling the two transmitter circuits together?

Answer. No.

76. Cross-question. So you do not know the percentage or degree of coupling between the coils of the two-circuit transformers disclosed in the Marconi patent 763772?

Answer. No one does. The structure of a transformer is not a measure of the coupling that it will create between two circuits. The coupling is a function not only of the two parts of the two systems which are interlinked, but of the remainder of the system in which the coupling elements are included. A coupling coil which might give a very loose coupling in interlinking two circuits because of other characteristics of the two circuits might give a very tight coupling under other arrangements of circuits. Merely to know the structure of a transformer in no way decides what the coupling between the two circuits will be when the transformer is put into use.

77. Cross-question. What are the other characteristics of the two circuits besides the degree of coupling between the structure of the transformer which determines the degree of couplings between the circuits? I am not referring to physical pieces of apparatus.

Answer. I have clearly illustrated the effect of other features of the circuit on the degree of coupling in Figure 5 of my sketch F. In that figure I have shown a coupling transformer comprising the coils d and d^1, which are closely related so as to have their magnetic fields interlinking. I have also shown in the two circuits inductance coils g^1 and g. In developing this figure, I have explained that the total energy of the oscillatory currents in the system is distributed over the coils of the system in proportion to the number of turns or inductance of the coils. Referring to the figure and, considering the primary circuit, if there are more coils in g^1 than in d, it is apparent that there will be more energy in the coil g^1 than in the coil d, which I have illustrated by making the lines or circles of magnetic force of greater extent for the coil g^1 than for the coil d. Now, if the coil d is the only one closely related to the secondary circuit and has only a small fraction of the energy of the primary circuit, it is apparent that it can only transfer a small amount of the energy of the primary circuit to the secondary circuit, no matter how closely the two coils of [fol. 849] the coupling transformer are related. Reducing this to actual physical apparatus, if we insert in the coupled circuits large coils in addition to the coils involved in the

inductance we may reduce what might ordinarily be a coupling transformer for tight coupling to a very loosely coupled system. This matter is considered in detail in the patent to John Stone Stone, 714756, the application for which was filed on February 8, 1900, prior to the Marconi application for the patent now in suit.

78. Cross question: In the course of your study prior to October 1, 1920, of the art of radio or wireless telegraphy, and of its development, did you read and are you familiar with the judgment of Mr. Justice Parker in the suit of Marconi et al. *v.* The British Radio Telegraph & Telephone Co. (Ltd.) on British Marconi patent 7777?

Answer. I may have; I do not recall definitely.

79. Cross-question. Do you remember ever having read and examined this judgment?

Answer. I do not recall.

80. Cross-question. Do you recall reading or examining the judgment of Mr. Justice Eve in the suit of G. Marconi and Marconi Wireless Telegraph Co. (Ltd.) *v.* The Helsby Wireless Telegraph Co. (Ltd.), dated July 24, 1914, in the high court of justice, chancery division, on Marconi patent 7777?

Answer. I recall having examined in a superficial way some records in the matter of litigation in the British courts involving the Marconi patent, but nothing definite occurs to me at this time as to my impressions from such examination.

81. Cross-question. You are at least aware of the fact that the Marconi British patent 7777 of 1900, to which I have referred, is the so-called corresponding British patent to the American Marconi patent 763772, in suit?

Answer. That is my understanding.

82. Cross-question. In what patent or publication granted or published prior to November 10, 1900, do you find illustrated and disclosed a radio or wireless telegraph transmitter composed of an open or radiating circuit coupled to a closed circuit which includes a spark producer, the two circuits being tuned together?

Answer. There has been such a lax use and general misunderstanding as to the meaning of the term "tuned" in the electrical art as well as that application of the electrical art having to do with electrical communication, commonly termed wireless or radiotelegraphy, that before answering

your question I would be pleased to understand in just what sense the expression is employed in the question.

83. Cross-question. You may answer the question giving your own interpretion of the word "tuned" in your answer.

Answer. In my direct testimony I have explained that tuning in its correct sense is not obtained through a mere adjustment of the time periods of the two circuits to be the same, where coupling exists between the circuits having their time period so adjusted any more than would two stretched strings be in tune if after carefully adjusting their tension they were tied together by a third string, unless the linking of the two systems, either electrical or mechanical in the case of the stretched string, is sufficiently loose in practice not to noticeably interfere with the individual action of each of the units of the system. The Marconi patent named in the question very specifically [fol. 850] points out the precise adjustment of the time periods of the two circuits. Without qualifying the specific specification the arrangement is found in Tesla patent 645576, of March 20, 1900.

84. Cross-question. Is that the only instance of which you now know of?

Answer. It is also found in great detail in the Stone patent 714756, the application for which was filed February 8, 1900. There is, of course, no difference between the principles of the transfer of energy at a transmitting station and the transfer of energy from one circuit to another at a receiving station, and the principle of tuning two circuits together at a receiving station was definitely set up in Marconi patent 627650.

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85. Cross-question. Is the Tesla patent No. 645576, published March 20, 1900, the only patent or publication which you know of at the present time which complies with my cross-question 82?

Answer. Limiting the matter to the transmitting end of an electrical communication system, and giving the matter of tuning the meaning which I have myself outlined, the Tesla patent is the only one that I now recall that was published prior to the date in question.

86. Cross-question. What other meaning of the word tuning is there than the one that you have outlined?

Answer. Tuning, or, as sometimes termed, resonance, is a very precise and definite physical phenomena in which a responding system is capable of responding with the least resistance to a periodic impressed or applied force.

87. Cross-question. Giving the word tuning any of the meanings which you have done in your answers to cross-questions 83 and 86, is the Tesla patent 645576, the only patent or publication which you know of at the present time which complies with my cross question 82?

Answer. Still limiting the consideration to the mere transfer of energy between two circuits at a radio transmitter the Tesla patent is the only one which complies with the specific adjustment condition set up in the Marconi patent, which I stated necessarily did not imply any use of tuning in its true sense, but does comply with the physical adjustments provided for in the Marconi patent.

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88. Cross-question. Yesterday you declined to answer certain cross questions (such as cross-question 47, 48, 53, 56), giving as a reason therefore absence of express consent of the Navy Department. Since you have resigned from the Navy, do you think that you can decline to answer the questions in a court of justice regarding matters to which [fol. 851] you have referred to on your direct examination here without some unnamed official of the Navy Department O. K.ing or giving his consent to the scope and character of your testimony?

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Answer. I do not recall any instances in my direct testimony where I touched upon matters of procedure during the activities of the Interdepartmental Radio Board.

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89. Cross-question. In answer to question 20 in your direct examination, you referred to some drawings of the Bureau of Equipment of the Navy Department of various dates. Did you obtain the express consent of the Navy Department to refer to these drawings in this case?

Answer. The list of drawings to which I referred in answer to question 20 are included in defendant's Exhibit L-2, which is a number of drawings certified to as being parts of the files of the Bureau of Engineering of the Navy Department over the signatures of the Chief of Bureau of

Engineering of the Navy Department and the Acting Secretary of the Navy, under dates of March 5, 1924, and March 6, 1924. These dates are prior to the time of my resignation from the Navy. In my official capacity in the Navy Department I arranged for selecting these drawings from the files of Bureau of Engineering and through the regular channels in the Navy Department provided for the certification of the drawings and transmittal to defendant's counsel in this suit.

90. Cross-question. In the concluding paragraph of your answer to direct question 20, you state "I have made a very careful search of the drawing files of the Bureau of Engineering." Who authorized you in the Navy Department to make that search?

Answer. I made the search referred to before my resignation from the Navy. At the time of making the search, I was assigned duty in the Office of the Judge Advocate General of the Navy Department and acted in this particular instance under the direction of that officer.

91. Cross-question. When did you make the search?

Answer. Sometime prior to March 25, 1924, and not more than two months prior to that date.

92. Cross-question. And at the time you made that search, you were chairman of the Interdepartmental Radio Board?

Answer. My last active service in connection with the Interdepartmental Radio Board took place some time in the month of May, 1921. While the Interdepartmental Radio Board has to my knowledge never been officially dissolved, it has in effect been considered inoperative since May, 1921.

93. Cross-question. You answer the question then in the affirmative?

Answer. No; I do not consider that in the performance of the act under consideration that I was in anywise acting as the chairman of the Interdepartmental Radio Board. [fol. 852] Under the circumstances connected with the completion of the Interdepartmental Radio Board's work had new work come to my attention requiring the consideration of the interdepartmental board for the purpose for which it was organized, I would have considered it my duty to have called the attention of the proper authorities to the matter and requested instructions as to whether or not the old board should be considered still in existence for its original purpose.

94. Cross-question. When you testified regarding these Navy contracts defendant's Exhibit L-2, you had resigned from the Navy, but were testifying in regard to matters which you learnt when an officer in the Navy, since you say that the search was made by you prior to the time that you resigned. You have heretofore declined to answer certain cross questions as to matters or acts which you performed touching the interdepartmental board before your resignation from the Navy on the ground that you did not have the expressed consent of the Navy Department so to do. Who gave you express consent in the Navy Department to testify in this case regarding these contracts?

Answer. When I resigned from the Navy, I knew positively that the Navy Department was unwilling to make matters concerning the proceedings of the Interdepartmental Radio Board open to the public. When I resigned from the Navy, I knew positively that the Navy Department was willing for me to testify in this case because I commenced my testimony before my resignation and repeatedly made official trips under official orders from the Navy Department for the purpose of giving such testimony, and the Navy Department was aware of the fact that following my resignation the Department of Justice would continue to employ me for the purpose of completing the testimony. I therefore consider that I had the complete official sanction of the Navy Department to testify in all matters except those which I knew to be withheld by the department, particularly matters relating to the proceedings of the Interdepartmental Radio Board.

95. Cross-question. From what individual or individuals in the Navy Department did you acquire the knowledge that the Navy Department wished certain matters to be withheld by you in your testimony in this case, particularly matters relating to the proceedings of the Interdepartmental Radio Board?

Answer. From the Judge Advocate General of the Navy who at the time was Rear Admiral J. L. Lattimer, United States Navy, under the following circumstances: Numerous requests were received by letter asking the Navy Department to open the files of the Interdepartmental Radio Board for inspection. The first of these requests which came to my desk was taken up by me with the Judge Advocate General, who instructed that in view of the fact that most of the claims which had been considered by the Interdepart-

mental Radio Board had taken the form of suits against the Government in the Court of Claims, and since the Department of Justice is charged with the defense of the Government in these suits that the Navy Department would be governed entirely by instructions from the Department of Justice as to the opening of the files of the Interdepartmental Radio Board for inspection, and to so inform all companies or individuals making such requests, and not to disclose the files until the matter had been passed upon in such manner. In carrying out those instructions I never [fol. 853] had occasion to open the files to anyone through arrangements with the Department of Justice.

96. Cross-question. What other matters than those relating to the proceedings of the Interdepartmental Radio Board did you learn that the Navy Department wished to be withheld from your testimony in this case?

Answer. The Navy Regulations provide for the nondisclosure of all printed matter marked secret, confidential, or for official use only until such time as the publications are officially released from this status, and there is an enormous mass of material in the Navy Department under such status.

97. Cross-question. Are there any other contracts in the drawing files of the Bureau of Engineering during the period covered by the 19 drawings which you have referred to in answer to direct question 20, that is to say, 1904 to 1909, descriptive of set purchased by the Navy Department during that period of time; or do these contracts comprise all of the contracts for sets purchased by the Navy Department during that time?

Answer. The drawings are merely illustrative of types of sets which were purchased from time to time and I did not examine the contracts to ascertain how many of each type was purchased. Some of the drawings indicate that a number of sets of each type were purchased, specifically naming some of the naval ships chosen to receive the installations. As I recall it, there were duplicates of some of the types showing that types had been bought at different periods destined for different groups of naval ships or naval stations.

98. Cross-question. Was it necessary for you to get permission from anyone in the Navy Department before you could produce and testify about defendant's Exhibit L-2?

Answer. I consider that I had the consent of the Acting Secretary of the Navy, who signed the certificate, the Chief of the Bureau of Engineering, who signed the certificate and the Judge Advocate General of the Navy who transmitted the certificate to the defendant's counsel in this case.

99. Cross-question. And without such consent you would not have felt free to produce defendant's Exhibit L-2 and testify concerning same? Is that right?

Answer. That is not correct. I was at the time a commissioned officer in the Navy with 20 years service charged with numerous responsibilities, and was thoroughly familiar with the Navy Regulations, Navy Department procedure and policy, and particularly familiar with the radio installations of the Navy and those features which it was desired to keep confidential. The particular matter named in the certificate I positively know to be of a nonconfidential character and would not have hesitated to testify as to the particular matter even though it had not gone through the definite official channels status which I have outlined for the particular certificate.

100. Cross-question. Do the Navy Regulations and Navy procedure permit the inspection by one who is not a commissioned officer of the Navy of the drawing files of the Bureau of Engineering from which you selected defendant's exhibit L-2?

Answer. The Navy regulations charge each bureau chief with the responsibility for the preservation of the files, and the matter of inspecting by any one is a matter within the [fol. 854] discretion of the chief of the bureau, except as to secret and confidential matter in which he has no discretion.

101. Cross-question. As I understand you, then, no one could inspect the drawing files of the Bureau of Engineering of the Navy Department from which you selected defendant's Exhibit L-2 under Navy regulations without first obtaining permission so to do from the chief of that bureau?

Answer. From the chief of the bureau, or from some one to whom the chief of bureau has delegated his discretionary powers, and under custom and practice in the Navy Department, such discretionary powers are delegated to a large number of officials.

102. Cross-question. Was it necessary for you, a commissioned officer of the Navy, to obtain such permission?

Answer. No.

103. Cross-question. You have in your direct examination referred to 20 per cent coupling between two circuits, 11 per cent coupling, and 4 per cent coupling. Which of those couplings do you consider loose couplings and which do you consider to be tight couplings?

Answer. Limiting my reply to radio communication practice, 4 per cent would be considered loose, and 20 per cent tight, with 11 per cent somewhat too tight for good selectivity in the Marconi open-gap type of system.

104. Cross-question. Would, in your opinion, 11 per cent coupling be too tight for good selectivity in a transmitter using a quenched gap instead of an open gap or a rotary gap, in radio communication practice?

Answer. The coupling has nothing to do with selectivity in the quenched gap type of system. It would be normally somewhat too loose for good quenching action in the quenched-gap type of system. If used in the Marconi open-gap type of system having a gap or spark producer built along the lines of the modern multiple disc quenched gap it would be too tight for good selectivity.

105. Cross-question. Prior to your resignation as an officer of the Navy, had you considered the file wrapper and contents of the Marconi patent in suit No. 762772?

Answer. Without something to refresh my memory, it is impossible for me to say.

106. Cross-question. As I understand your direct examination, you predicate your evidence upon the proposition that the Marconi patent 763772 is limited in its claims directed to the utilization of a transmitter to a spark gap of the open type as distinguished from the system in which a rotary or quenched gap might be employed?

Answer. That is not correct. I have contended that the Marconi patent, and its transmitter claims, is limited to a system in which oscillations of but one and the desired frequency are created in the primary circuit of a transmitter and are transferred at this one and desired frequency into the secondary circuit, or radiating circuit, without change in frequency. I have not contended that it is necessary to employ the open-gap type of spark producer to create these oscillations of the one and desired frequency, for it may be accomplished with a rotary gap form as well as the modern structure of multiple disc form known as the quenched gap. I have contended, however, that for the "best results" in

the matter of getting a persistent long drawn out train of [fol. 855] oscillations in the primary circuit the open-gap form is the preferred form.

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107. Cross-question. Will you please refer to those portions of the drawings and specifications of the Marconi patent 763772, which in your opinion, requires that the Marconi claims should be limited in the way that you contended for in your last answer?

Answer. Figure 1 of the patent, which refers to a transmitting station, shows a spark producer *c* which as it is illustrated, is of the open gap form, merely consisting of two electrodes, which are spherical in shape. With such a type of gap, if it should be endeavored to quickly throw all of the energy from the primary circuit into a secondary circuit with the object of having the secondary circuit determine the frequency of oscillations, which would necessarily be accomplished by tight coupling, nothing but confusion and disorder would result as the secondary circuit would not be able to hold the energy into itself. The energy would, once in the secondary circuit, be returned through the tight coupling to the primary circuit, as the open type of gap will not quench to stop such return of energy. The result would be a long drawn out repeated transfer of energy from one circuit to the other at two widely separated frequencies. To avoid this action it is necessary to employ loose coupling so that the energy is mainly retained in the primary circuit and slowly fed over into the secondary circuit.

The figure also shows one turn of wire in the primary circuit coupled to but two turns of wire in the secondary circuit with quite a large number of turns in a separate coil *g* in the secondary circuit. Such an arrangement is illustrative of a loose coupling arrangement in the manner I explained in answer to Cross-question 77. The drawing is therefore typically illustrative of a system in which the energy would be retained in the primary circuit oscillating at but one and the desired frequency and slowly transferred to the secondary or radiating circuit.

The Marconi patent states as its object, page 1, lines 15 to 19—"to provide new and simple means whereby oscillation of electric waves from a transmitting station may be localized when desired at any one selected receiving sta-

tion or stations out of a group of several receiving stations."

This object specifically looks forward to creating electric space oscillations of but one and the desired frequency. Without the use of the multiple gap, quench gap developed in about 1909, and therefore not available to Marconi, it was impossible with his system to take the energy quickly out of the primary circuit into the radiating circuit and keep it there. Any effort to do so would have resulted in a repeated transfer of oscillations from one circuit to the other at two different frequencies totally destructive to the object set up in the Marconi patent.

Page 2, lines 12 to 20 of the specification, state:

"My experiments have demonstrated that the best results are obtained at the transmitting station when I use a persistent oscillator—an electrical circuit of such a char- [fol. 856] acter that if electromotive force is suddenly applied to it and the current then cut off electrical oscillations are set up in the circuit which persist or are maintained for a long time—in the primary circuit * * *."

No language could be more definite than that quoted as to where the operative oscillations (the one frequency desired oscillation) are to have their seat of operations, namely, the primary circuit.

Claim 3 contains the following element:

"which include a condenser discharging through a means which automatically causes oscillations of the desired frequency."

The elements referred to in this quotation from the claim are elements in the primary circuit, and the claim requires that these elements "automatically" cause oscillations of the desired frequency. If these elements in the primary circuit transfer this duty to the secondary circuit, they would fail to meet the requirements of the claim of automatic action on their part to create the oscillations of the desired frequency. Numerous other transmitting claims in the patent include the same language.

108. Cross-question. Is it your opinion then that quenched gap transmitters in which there is a close coupling between the primary and secondary circuits should not be included or held tributary to the Marconi patent 763772?

Answer. That is my opinion.

109. Cross-question. What percentage of coupling is embodied in the transmitting apparatus as disclosed in the Marconi patent 763772?

Answer. It is my opinion that to use the Marconi apparatus to acomplish the object set up in the manner set up, as I have quoted in my answer just previous, that the coupling should not exceed 3 or 4 per cent.

110. Cross-question. Please state what the percentage of coupling is in the apparatus which is described in the specification of the patent.

Answer. I consider that the specification, in setting up the objects and manner of operation quoted by me described a coupling not in excess of 3 or 4 per cent. No specific coupling is referred to in the patent.

111. Cross-question. In the Loftin sketch J, have you intended therein to show the progressive amplitude of the oscillations in what you have designated as the lateral circuit?

Answer. The prime purpose of my sketch J was to illustrate the total number of oscillations before the energy fell to 1 per cent of the original in the primary circuit of a Marconi transmitter using the same assumption as to characteristic of the circuit set up by Mr. Waterman, as outlined at page 661 of the typewritten record of my testimony. I calculated the number of oscillations from the mathematical formulas which I set up at page 660 of the typewritten record, arriving at 24 oscillations instead of three oscillations as contended by Mr. Waterman. In making the sketch I used great care to illustrate the total number of oscillations resulting from my calculations and only approximate care in the matter of illustrating the progressive amplitude of the decaying oscillations.

112. Cross-question. Do you agree or disagree with the following statement of what constitutes the essential features of the invention disclosed in the Marconi patent 763772:

"In order to get over a well known difficulty in applying the principle of resonance as between transmitter and re- [fol. 857] ceiver in a system of wireless telegraphy, a difficulty involved in the impossibility of a single circuit being at once a good radiator or absorber and a persistent oscillator, the inventor proposed to substitute for a single circuit, in both transmitter and receiver a pair of circuits,

one of which is so constructed as to radiate or absorb or absorb readily and the other of which is so constructed as to oscillate persistently and be a good conserver of energy. The two circuits of the transmitter are tuned together, and linked by means of a transformer in such a way that electrical oscillation in a closed and persistently oscillating circuit build up, and, inasmuch as the primary can act as a reservoir of energy for the secondary, maintains similar oscillations in the open and readily vibrating secondary. Similarly, the two circuits of the receiver, tuned to the same period as the circuits of the transmitter, are linked through a transformer in such a way that electrical oscillations in the readily absorbing primary build up similar oscillations in a closed and conserving secondary until such oscillations have strength to break down the coherer."

Answer. With the understanding that it is the invention disclosed in the Marconi patent, and that I do not admit that Marconi was the one who contributed the invention to the art, and if permitted to insert some explanatory comments which would in no way alter the principle of the invention involved, I would agree that the quotation is a fair interpretation of the system disclosed in the Marconi patent.

113. Cross-question. In what patent granted prior to November 10, 1900, or in what publication published prior to that date do you find disclosed a wireless telegraph receiving system comprising two circuits one of which is an open or absorbing circuit and the other circuit being a closed circuit containing a wave responsive device, the two circuits being tuned or in resonance with one another?

Answer. Limiting the meaning of tuning or resonance to a statement of it in the Marconi patent, and further limiting my answer to the particular date set up in the question, I refer to Lodge patent 609154 of August 16, 1898, that part of the specification referring to the receiving apparatus illustrated in Figure 12 and Figure 13 of the Lodge patent, and particularly the following quotation from page 4, lines 62 to 68:

"In all cases it is permissible and sometimes desirable to shunt the coils of the telegraphic instrument by means of a resistance or a capacity, as shown at w in Figure 12, in order to connect the coherer more effectively and closely

to the capacity areas or receiving arrangement whereby it is to be stimulated."

The providing of a capacity in shunt with the coils of the telegraphic instrument would act to tune the lateral circuit and, as stated by Lodge, "connect the coherer more effectively and closely to the capacity areas or receiving arrangement."

While the Lodge patent is not as full in its instructions as it might have been for the layman, the gap was completely filled by Marconi patent 627650 of June 27, 1899, which is one of the numerous receiving patents referred to in the Marconi patent 762772, as illustrating a receiving arrangement suitable for use in his system. The earlier Marconi patent shows an arrangement in Figure 1 providing for tuning in as specific a manner as is set up in [fol. 858] the later patent. The specification states, in referring to the primary or absorbing circuit of the receiver of Figure 1, at page 1 of the specification, lines 30 to 37 as follows:

"It is desirable that the induction coil should be in tune or syntony with the electrical oscillations transmitted, the most appropriate number of turns and most appropriate thicknes of wire varying with the length of wave of the oscillation transmitted."

Page 1, lines 38 to 42 of the specification, provides for tuning the secondary circuits of the receiver as follows:

"The capacity of the condenser on the connection between the imperfect contact and the secondary of the coil should be varied (in order to obtain best effect) if the length of wave is varied."

Here are specifications for tuning both the primary and secondary circuits of a two circuit receiving station using both of the means which had been provided for in the art even prior to the earlier Marconi patent, namely, varying inductance as by varying the number of turns of the coil of wire, and varying capacity as by varying the area of exposure of a pair of conducting plates.

114. Cross-question. An authority who has considered the invention of the Marconi patent in suit 763,772, has made the following statement:

"Is it an essential feature of the Marconi invention that the primary should oscillate so that as energy is radiated

by the aerial the primary will persistently replenish the secondary with at least an equivalent amount of energy, and thereby maintain the radiating secondary? I do not think it is."

Do you agree or disagree?

Answer. I consider that the quotation illy expresses any action that goes on in the system disclosed in the Marconi patent and is totally inadequate in the one feature considered to lead to a discussion of the Marconi system, and therefore is worthless.

115. Cross-question. And you disagree?

Answer. I do not agree that it has any value in a consideration of the Marconi system.

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116. Cross-question. When did you resign from the Navy?

Answer. I submitted my resignation on or about February 26, 1924, and it was accepted and became effective on March 25, 1924.

117. Cross-question. I show you a letter dated October 8, 1920, to the Marconi Wireless Telegraph Co. purporting to be signed E. H. Loftin, lieutenant commander, United States Navy, chairman, and having attached thereto 14 typewritten pages headed "Claim No. 2, Marconi Wireless Telegraph Co." Is that your signature on that letter?

• • • • • • •

Answer. The papers handed me relate to matters which at the time of my resignation from the Navy I knew positively were considered confidential by the Navy Department. Since my resignation I have been more or less in close contact with these matters on account of my previous connection with them and I have not been advised of any change in the confidential status of these matters, nor have I encountered any circumstances that would indicate that such status had been changed. For these reasons I refuse to answer the question, until instructed to do by the court, or other proper authority.

Mr. Cosgrove. The commissioner is requested to mark the letter and accompanying typewritten sheets as plaintiff's Exhibit No. 120 for identification.

117A. Cross-question. I hand you a letter dated April 16, 1921, addressed to Messrs. Sheffield & Betts, and pur-

porting to be signed E. H. Loftin, lieutenant commander, United States Navy, chairman, is that your signature?

• • • • • • •

Answer. I note that the correspondence refers to the same matters as the correspondence in the question just prior and for the same reason given in my answer to the prior question, I refuse to answer the present question unless instructed to do so by the court or other proper authority.

Mr. Cosgrove. The commissioner is requested to mark the letter just referred to as plaintiff's Exhibit No. 121 for identification.

118. Cross-question. In your answer to question 1, you state "although the board completed its work and made definite recommendations for the settlement of claims, the purpose of the board failed due to the failure of Congress to make the necessary appropriations to cover the recommendations of the board." There was a public hearing before the Committee on Military Affairs in the House of Representatives of the Sixty-seventh Congress on a proposed bill to make appropriations to cover the recommendation of the board, was there not?

Answer. I recall that there was a hearing some time in 1921 before one of the committees of the House of Representatives.

119. Cross-question. In relation to a bill to cover the board's recommendations?

Answer. That was the purpose of the hearing.

[fol. 860] 120. Cross-question. You were present at that hearing and made a statement, did you not?

Answer. Yes.

121. Cross-question. And you furnished to the commitee a draft of the preamble of the board's report to the Secretary of War. Attorney General, and Secretary of the Navy, did you not?

Answer. I do not recall definitely whether or not the preamble of the board's report was included in the matter submitted to the committee holding the hearing.

122. Cross-question. I show you a printed pamphlet issued by the Government Printing Office entitled "Hearings before the Committee on Military Affairs in the House of Representatives, Sixty-seventh Congress, First Session,

Monday May 23, 1921." Did you ever see that pamphlet before?

Answer. I do not recall having ever seen the printed report of the hearing, such as you have handed me. I recall having been submitted a proof copy of my statement before the committee for correction.

123. Cross-question. Will you please examine that pamphlet and state whether it refreshes your recollection as to the submission to that committee of the preamble of the report referred to in cross-question 121?

Answer. I believe the preamble was furnished the committee of the House in accordance with a statement I note in the printed copy of my statement to the committee at the time of the hearing.

124. Cross-question. That preamble to the report is contained on pages 20 to 30, inclusive, of the printed pamphlet shown you, is it not?

Answer. I have no way of verifying the matter printed on and between the pages referred to with the copy which I submitted to the committee, but have no reason to believe that it is not a correct reproduction in substance at least.

125. Cross-question. Does this printed pamphlet contain a correct or substantially correct statement or statements, made by you to the committee on that hearing?

Answer. As far as my recollection permits, the printed copy of my statement is substantially correct.

Mr. Cosgrove. The commissioner is requested to mark the printed pamphlet referred to in cross-question 122 to cross-question 125 and answers thereto as plaintiff's Exhibit No. 122 for identification, "Printed Report of Hearing before Military Affairs Committee."

126. Cross-question. You do not deny that you signed the letters dated October 8, 1920 and April 16, 1921, previously referred to in your cross examination, do you? I am referring to plaintiff's Exhibits Nos. 120 and 121 for identification.

* * * * * * *

Answer. I refuse to answer for the same reasons and on the same conditions as given in connection with my previous answers referring to the same correspondence.

* * * * * * *

[fol. 861] Redirect examination of Mr. E. H. Loftin.

127. Redirect question. In your answer to cross-question 112, you stated that you would agree that the quotation therein referred to is a fair interpretation of the system disclosed in the Marconi patent if you were permitted to insert some explanatory comments. Will you please now make these comments?

Answer. The first few lines of the quotation state as follows:

"In order to get over a well known difficulty, in applying the principle of reasonance as between the transmitter and receiver in a system of wireless telegraphy, a difficulty involved in the impossibility of a single circuit being at once a good radiator or absorber and a persistent oscillator."

The difficulty referred to in the quotation in the matter of a single circuit arises from having the spark producer at the transmitter directly in series with the single circuit (the radiating circuit) and the detector at the receiver directly in series with the single circuit (the absorbing circuit). A spark producer in a circuit increases its resistance to a large extent, and is a source of enormous loss as I have explained in my direct testimony. Since an elevated radiating circuit can not be as easily constructed to have large electrical capacity for storing electrical energy as can a closed circuit, since such electrical capacity of the elevated conductor circuit depends upon its physical dimensions, it is apparent that if it also includes a spark producer, the small energy it can take is soon dissipated in its large source of loss. The result is the oscillations do not persist more than a few cycles. I have pointed out that tuning, resonance, or syntony, in the true sense of these synonymous terms depends upon persistency of oscillations. Therefore the single circuit offers serious difficulty in the application of the principle of resonance.

Aside from Hertz, Marconi stood almost alone among the early workers in offering the single circuit system, it having been shown almost exclusively by him in his patents and other works prior to patent 763772, in suit. On the other hand, Tesla, as shown by my sketch A, proposed the two-circuit systems as early as 1894 with the spark producer in the closed circuit, and again, in his patent 645576, of March 20, 1900. The removal of the spark gap from the radiating circuit is also shown by Lodge in his patent 609154 of August 16, 1898, by Braun in his British patent

1862 of 1899, and by Stone in his patent 714756, the application for which was filed February 8, 1900. These publications refer specifically to systems involving the application of electrical principles to electrical communication without wire. During the same period of time there were many showings of spark producers used in connection with wire communication, and such showings almost universally included the spark producer in a primary circuit.

The point is that Marconi seemed to have created a difficulty himself for himself alone.

Similarly at the receiving station, if there is but one circuit including the detector in series, the effect of the detector on the destruction of the resonance capabilities is many fold worse than in the case of a spark producer in the sin-[fol. 862] gle circuit at the receiving station. A detector is a very high resistance device, being of the order of thousands of ohms, and a circuit that has a high resistance in series with it is termed in the electrical art "aperiodic" no matter what the adjustment of capacity and inductance may be. The term means that the circuit is not capable of resonant response.

In the matter of the receiver, Marconi likewise was practically the only one of the early workers who persisted under this difficulty, but he broke away from it at the receiver earlier than he did at the transmitter, as specifically shown in his patent 627650 of June 27, 1899. In the time prior to patent 763772 in suit, Tesla, Lodge, Braun and Stone at least of the workers in the art showed they were not having any such difficulty as evidence by the same publications I have just previously referred to. These publications show that these workers provided two circuit receivers with the detector in the closed circuit. The wire art also was not misled, having also used two circuits at the receiving station.

The statement then provides:

"The inventor proposed to substitute for a single circuit in both transmitter and receiver a pair of circuits, one of which is so constructed as to radiate or absorb readily and the other of which is so constructed as to oscillate persistently and be a good conserver of energy."

The only thing shown by Marconi to make one of his circuits radiate readily at the transmitter or absorb readily

at the receiver is the physical arrangement of having the circuit linear or vertical, and the other circuit to oscillate persistently and be a good conserver of energy is the physical arrangement of making the circuit turn upon itself or be almost physically closed. This arrangement was included at the transmitter in the Tesla 1894 organization as shown by my sketch A, the Tesla, Lodge, Braun, and Stone patents just referred to; and at the receiver by the Tesla, Braun, Stone, and 1899 Marconi patents as before.

The statement then provides as to the transmitter:

"The two circuits of the transmitter are tuned together, and linked by means of a transformer in such a way that electrical oscillation in a closed and persistently oscillating circuit build up, and, inasmuch as the primary can act as a reservoir of energy for the secondary, maintain similar oscillations in the open and readily vibrating secondary."

The language here is somewhat lacking in technical precision, but having in mind its effort to interpret the system disclosed in the Marconi patent and give to Marconi's imprecise statements of operation real meaning, I think it intends the following more precise statement:

"The two circuits of a transmitter are adjusted to have the same time period, and are linked by means of a transformer, the linkage being adjusted or of such a nature that the electrical energy is retained in major part or reservoired in the closed circuit and there manifests itself as persistent oscillations (maintained for a long time), at first building up similar oscillations in the secondary circuit and then, due to the persistency of the oscillations in the closed circuit, maintain similar oscillations in the secondary circuit."

[fol. 863] My statement follows Marconi precisely in the matter of adjustment of the two circuits, his statement being that the time periods are adjusted to be the same. It is incorrect to refer to circuits as being in tune, the reference as to tuning being more properly based on the oscillations in the circuit, tuning or resonance being had when the oscillation in the two circuits are the same.

Marconi definitely states that the oscillations in the two circuits should be the same ("similar oscillations"), but provides no instruction for obtaining the specified

result other than the adjustment of a time period, which in itself is not complete as the matter of coupling is of paramount importance. He does provide structures which are typical for the required "loose coupling."

Marconi also provides a type of spark gap or spark producer which is typical of the required persistent oscillations in the closed circuit, namely, the single gap open gap type of spark producer illustrated in Figure 1 of the patent.

So far as satisfying the adjustment definitely specified by Marconi (adjusting the time periods of the two circuits), this is found in the earlier patent to Tesla referred to in the two-circuit transmitter illustrated and described by him. The patent to Stone, 714756, and the Stone to Baker letters, which I have frequently referred to in my direct testimony, go far beyond Marconi in that they not only provide for adjustment of the time periods, but are in themselves full treatises on the subject of "loose coupling," its effect on preserving "similar oscillations" between two coupled circuits, and the manner of obtaining the required loose coupling.

The remainder of the quotation deals with the receiving station, as follows:

"Similarly, the two circuits of the receiver, tuned to the same period as the circuits of the transmitter, are linked through a transformer in such a way that electrical oscillations in the readily absorbing primary build up similar oscillations in a closed and concerning secondary until such oscillations have strength to break down the coherer."

The same explanation is made as to the use of the word "tuned" in this quotation as previously. Marconi definitely provided for adjustment of time periods of the circuits only, and in the specification does not provide any statement as to results desired such as the "similar oscillations" referred to at the transmitting station. There is therefore not the basis in the reference to the receiving station for that part of the quotation which has to do with the two circuits being linked through a transformer in "such a way as to build up similar oscillations" in a closed secondary circuit.

Marconi's 1899 patent made complete provision for the adjustments at the receiver specifically provided for in the later Marconi patent in suit. Lodge's 1898 patent

provided the necessary apparatus with language fully indicating that he had time-period adjustment in mind. The Stone patent and the Stone to Baker letters provided not only for the time-period adjustment, but are full treatises on the subject of the effect of "loose coupling," and the matter of obtaining the required degree with suitable apparatus.

128. Redirect question. In your answer to 106, you state that the open gap is the preferred form for getting best results in the matter of getting a persistent long drawn [fol. 864] out train of oscillations. Will you explain why the quenched gap is not adapted to attain such results?

Answer. The functions of the open type of gap and of the quenched type of gap are diametrically opposed in the matter of persistent oscillations. I have explained in great detail the numerous considerations that enter into the construction of the quenched gap that came into existence in about 1909 to cause it to open up or stop oscillations as early as possible for what the art terms "quenching." It is therefore apparent that a type of gap which is deliberately constructed to remove those qualities which existed in the open type of gap of Marconi's time for the maintenance of a long drawn out or persistent train of oscillations will not give the "best results" that the Marconi specification referred to as resulting from obtaining persistent oscillations. In fact, the quenched-gap type of structure would be totally destructive to such results. My answer points out that a quenched gap will not prevent obtaining oscillations of the one desired frequency in the primary circuit of the Marconi open-gap system; that is, the type of gap has nothing whatever to do with the frequency as this is entirely measured by the capacity and inductance of the circuit, but the type of gap plays an extremely important part in the length of time that the oscillations of the one-desired frequency will endure or be maintained.

129. Redirect question. To one skilled in the art, what do the diagrammatic representations of spark gap and coupling shown in the drawing of the Marconi patent in suit typify?

Answer. The diagrammatic representations as to the gap typify a one gap, open-gap type of spark producer. The diagrammatic representation as to the coupling typify "loose coupling" in two of the manners which I have discussed at length in both my direct testimony and in my testimony in response to cross-questions, namely, the rela-

tion between the turns of wire in the transformer itself coupling the two circuits as well as inserting a large body of inductance in the form of a coil in a part of the circuits, which is not included in the transformer.

130. Redirect question. In your answers to cross-question 114, and cross-question 115, you disagreed with a certain quotation. Will you state your reasons for this disagreement?

Answer. I repeat the quotation:

"It is an essential feature of the Marconi invention that the primary should oscillate so that as energy is radiated by the aerial the primary will persistently replenish the secondary with at least an equivalent amount of energy, and thereby maintain the radiating secondary? I do not think it is."

This quotation infers a relation between the primary and secondary circuits which is measured by the rate at which the secondary circuit can dispose of energy. The Marconi patent does not provide for relating or associating the two circuits on any such basis. The only provision made in the Marconi patent bearing upon the relation (which is the degree of coupling) of the two circuits is that the secondary circuit should be supplied with oscillations similar to those in the primary circuit. This condition is entirely governed by the degree of coupling, and has no other interpretation other than that the coupling must be loose. Hav- [fol. 865] fixed a loose coupling to give the prescribed similar oscillation in the secondary, the radiating qualities of the secondary circuit may be changed from those of a good radiator to those of a poor radiator or vice versa, as may be done by different physical arrangements of the structure, and yet the coupling can not be changed to meet the variable conditions of rate at which the energy can be disposed without upsetting completely the adjustment for obtaining similar oscillations in the secondary as required by Marconi.

The quotation also gives the idea that the primary circuit always supplies energy to the secondary at the same rate. This of course is entirely incorrect as will be seen by reference to my sketch H, Figures 5 and 5a. When the primary circuit commences to oscillate with a large amount of energy and the secondary circuit has no energy, the transfer is more rapid with the result that the secondary

receives energy faster than it can dispose of it, illustrated as an increasing amplitude in the oscillations in Figure 5a. A little later in the train when the energy in the primary has been reduced to some extent the secondary is not supplied with energy at a rate sufficiently rapid to replenish the secondary with at least an equivalent amount of energy, and the oscillations begin to decay gradually falling to practically zero.

131. Redirect question. Do you find anything in the plaintiff's Exhibit 122, marked for identification, inconsistent with anything that you have testified to in your examination?

. . . . . .

Answer. No. The pamphlet speaks for itself and plainly shows an effort to bring to the attention of Congress numerous considerations leading the heads of several executive departments of the Government to recommend provision for the settlement of a large number of claims based on patents relating to radio in particular, which had been pending and pressed against the Government in numerous ways for a long time. The pamphlet shows that numerous considerations led to the specific recommendation for settlement included in the pamphlet. It points out that to bring all of these claims to final termination through the ordinary channels of litigation would involve years of such litigation accompanied by the usual large expenditures of moneys and use of the time of experts in prosecuting such litigation. It shows clearly that hundreds of patents were considered in the short space of about two and a half years and that these patents were among the holdings of a very large number of claimants. It shows, for instance, that the Marconi Co., one of the claimants, presented about 350 patents, but finally reduced the consideration to 4 patents with the understanding that if a satisfactory settlement could be obtained on the 4 patents the remainder of the 350 would be included in the settlement. It points out that the stated amount of claims of but 7 of the claimants was in the neighborhood of $15,000,000, leaving 17 claimants who had not set any particular value on their claims, but making it certain that the total claim was many times the $15,000,000, and that the settlement proposed to Congress, which was acceptable to the claimants was in the neighborhood of $2,000,000.

[fol. 866] 132. Redirect question. Did Congress pass the proposed bill printed on page 4 of this pamphlet?

Answer. No.

(Redirect examination closed.)

133. Recross-question. In your last answer you do not mean to imply, do you, that the Marconi Co. presented a claim against the Government for the infringement of 350 patents, do you?

Answer. My answer referred in a general way to things brought out by the pamphlet. I find that the pamphlet on page 13 makes the following specific statement as to the subject-matter of your question:

"For instance, the Marconi Co. has about 350 patents. They presented only four patents finally to the board. The board allowed three of these four patents. They will include in their release to the Government all of the 350 patents that they own, and also the one not allowed by the board, so that it will be a complete and sweeping release of that company on practically 350 patents."

134. Recross-question. You haven't answered my question. However, this suit was brought on those four patents prior to the time those patents were presented to the board for consideration under the claim made by the Marconi Co. on those four patents? Is that correct?

Answer. I do not find that the pamphlet lists the patents which are stated to have been finally considered. On page 23, it lists the Marconi Wireless Telegraph Co. as merely retaining for final consideration four patents in number. On page 25, it states that reissue patent 11913 of the Marconi Co. was denied. I recognize the patent listed as denied as being one of those in this suit.

135. Recross-question. You also find on page 26, do you not, the following:

"The board recommend that an offer of settlement be made to the following claimants: The Marconi Wireless Telegraph Co. of America under letters patent of Lodge No. 609154; Fleming, 803684; and the Marconi patent 763772"?

Answer. I do.

136. Recross-question. And you also know, do you not, that this suit was brought on the three patents last referred

to and on the Marconi reissue patent before the Marconi Co. presented their claim finally or otherwise, to the board on those four patents?

Answer. It is my understanding that this suit was filed in 1916. I note on page 23 of the pamphlet a statement that the board commenced to consider numerous claims, including in the list the Marconi Wireless Telegraph Co., sometime prior to September 25, 1919.

Mr. Cosgrove: Plaintiff's counsel offers in evidence the pamphlet referred to as plaintiff's Exhibit No. 122, "Printed Pamphlets of Hearings before Committee on Military Affairs."

The examination by counsel being concluded, the witness, in compliance with the rule of the court requiring him to state whether he knows of any other matter relative to the claim in question, and if he does to state it, says he does not.

E. H. Loftin.

* * * * * * *

[fol. 867] Edward H. Loftin, having been recalled as a witness on behalf of the defendant, was examined by counsel for defendant, and in answer to interrogatories, testified as follows:

Direct examination.

By Mr. Edwards:

137. Question. Since the last session of your previous deposition I have made inquiry through the Department of Justice as to whether or not there is objection on the part of the Navy Department to your answering the questions relating to the interdepartmental board which questions were put to you in the course of your cross-examination in your previous deposition, and I am informed that there is no objection to your answering such questions. Will you therefore please refer to cross-questions 45 to 48, inclusive, and state whether or not the Interdepartmental Radio Board made a report with respect to a claim of the present claimant under the Marconi patent 11903, the Lodge patent 607154, the Marconi patent 762773, and the Fleming patent 803684, and whether or not such report was signed by you as its chairman?

Answer. Such report was made and I signed it as chairman.

138. Question. Please answer cross-question 51, which was as follows: Since you say you were aware of the foregoing litigation prior to October 1, 1920, do you not conceive that it was part of your duty representing the Navy Department on the interdepartmental board at this time to thoroughly examine and familiarize yourself with the litigation listed in cross-question 49?

Answer. It was naturally a part of my duty to consider litigation involving the patents before the board and, to the best of my recollection, I did consider all of the litigation listed in cross-question 49. The records involving this litigation were most voluminous and it was, of course, impossible to give them more than their proportionate share of attention that the claim of the Marconi company bore to the whole situation presented to the board.

139. Question. Please answer cross-question 56, which was as follows: "I understand then that you decline to state whether you examined and thoroughly familiarized yourself with personally the records in the litigation listed in cross-question 50?"

Answer. To the best of my recollection, I examined and familiarized myself with the records and litigation listed in cross-question 50. These records were voluminous and received their proportionate share of attention that the claims of the Marconi company bore to the whole situation presented to the board.

140. Question. Referring to your answer to cross-question 117 and cross-question 117a, and to the exhibits marked for identification as "Plaintiff's Exhibits 120 and 121," will you say whether you signed those exhibits as chairman of the radio board?

Answer. I did.

141. Question. Will you now state when and for what purpose the Interdepartmental Radio Board was organized, and who were the members of the board, explain its procedure and set forth the action taken with respect to the Marconi Lodge, and Fleming patents involved in this suit.

* * * * * * *

[fol. 868] Answer. I was assigned to duty in connection with such a board in about January or February of 1919,

and, as I recall it, merely by a letter from the Secretary of the Navy to the Attorney General naming me for such duty. It appears that such a board was suggested some time during 1918, and that two officers of the Navy Department were named as members of such a board, but when I arrived in Washington these two officers had been assigned to sea duty and I was undoubtedly the named relief of one of them. As far as any traces were left, nothing appears to have been done by such a board prior to the time I joined it, undoubtedly accounted for by the fact that the war was still in progress when the earlier board was named and had only just finished in the matter of active operations when I reported to duty.

The board which I joined included H. C. Workman, Esq., representing the Department of Justice and chairman of the board; Maj. R. H. Young, United States Army, and Capt. Guy Hill, United States Army, representing the War Department, Commander S. C. Hooper, United States Navy, and myself, representing the Navy Department. Sometimes during the fall of 1919 Mr. Workman severed his connection with the Department of Justice and that department retained Harry E. Knight, Esq., as its representative on the board. I was elected chairman of the board following the resignation of Mr. Workman.

No definite instructions were furnished the board by any one of the several heads of the department who had supplied the members for the board, and the board more or less assumed that no one possessed the necessary knowledge of what such a board might accomplish to furnish such instruction, and it was also appreciated that since the board was an interdepartmental one, there might be some difficulty in obtaining written instructions from any one of the several heads of department represented.

It appeared that several of the larger companies holding radio patents, including the Marconi company, the plaintiff in this case, had asked that a board be organized or some other means provided for recognizing their patents which they contended were being most extensively used by the Government, particularly during the war, and that the Government was placing contracts for apparatus involving their patents with other radio manufacturing institutions.

After a short period of investigation the board which I joined came to the conclusion that if any satisfactory results

were to be had by such a board it would be necessary to include to a fair extent consideration of practically all of the radio patents which might be made the subject of a claim against the Government, and therefore instead of proceeding with merely hearing those companies, which had pressed for consideration, of their patents, contact was established with as many of radio patent holders as could be traced in one way or another, and they were all invited to present claims if they saw fit to do so. The result was that prac- [fol. 869] tically all of the important radio patents came before the board in 1919, or shortly thereafter, materializing into about 24 claimants, possessing patents numbering all the way from 1 to about 350 to each claimant. Some of these claimants had previously had some of their patents adjudicated and some of them had made no such effort. Many of the claimants appeared to have no real appreciation of what their patents represented or their relation to the art as it had been or then was practiced. Some of the claimants were more or less familiar with Government types of apparatus and others were not. Under such circumstances, the board found itself presented with a real task, that of trying to allocate in the neighborhood of 2,000 patents with respect to the operations of the Government, and having determined which ones of these patents had been on the face of them used to further determine whether or not they were valid in view of possible prior publications, prior uses, and other general defenses against patents.

The board found the task an extremely difficult one and also one of great responsibility not only on account of the labor of scrutinizing these patents and comparing them with the Government practice, making searches for prior publications throughout the literature of the world, and prior uses that were learned of in many ways, but because it was at once both the defense and the court; that is, it had to create itself the defenses of the Government against the numerous claims under the patents, and then had to pass itself upon these defenses and the arguments brought against them by the claimants. In addition, in the cases of those patents which had been in litigation, and some of them many times, it was necessary to consider volumes upon volumes of records. Many questions arose as to whether apparatus in such litigation was the equivalent of apparatus which had been used by the Government. Many

questions arose as to interpretations which should be given decisions of courts. Much thought was given to the matter of whether or not the board which though lacking definite instructions as to its duties was certain that its purpose was of an advisory nature to several heads of executive departments, should, in making recommendations, take exception with the decision of courts where the board believed there was error in such decisions. For many reasons, including the fact that the board had no authority to swear witnesses, it was decided that the decisions should be accepted as they stood and effort made only in the matter of an interpretation of a decision with respect to Government apparatus.

Serious question was often raised by the claimant and counsel as to the authority under which the board was acting and the prospects of ever having the recommendations of the board, if favorable, materialize into actual compensation to the claimants. There was little or no precedent as far as the board could determine for any such body. It was early appreciated that if the board did recommend substantial compensation to the claimant, there were no funds available out of which such compensation could be paid, due to both the unwillingness of bureau chiefs to expend current appropriations in any such manner and doubt as to the legality of such expenditures under the language of appropriations in case bureau chiefs had been so willing to use their funds. It therefore materialized that [fol. 870] the only hope claimant would have would be in the matter of special legislation by Congress providing a fund, and it was hoped that upon being able to present to Congress a showing of a very careful consideration of the whole situation and a possible saving to the Government of actual expenditures in the matter of final award to the claimants if carried through in litigation and saving of cost of litigation, as well as the practical economical aspects of utilizing the Government's experts and the expert of the companies in development of the art, rather than controversy over what had already been accomplished, as is always necessary in litigation, Congress would be willing to accept substantially the board's recommendations if supported by the several heads of department.

I, as chairman of the board, carefully informed all of the claimants that the proceedings before the board were

entirely on a basis of practical negotiation in an attempt to settle a very complicated and difficult situation, and that the board would use its utmost endeavor to have its effort materialized into effective results to those claimants who succeeded in convincing the board that their claims had merit, but that in view of the absence of any definite authority under which such a board could act and the absence of any provision of law or otherwise to make effective the action of such a board, all hearings and proceedings before the board would be without prejudice in future proceedings, should such be necessary, such as actions in the Court of Claims. The board asked the claimants to freely bring before it and lay on the table all matters of fact considered of value in arriving at the real merit of each case and stated that claimants could do so without fear that disclosures made to the board would not be taken advantage of in case litigation had to be resorted to.

In arriving at its conclusions and recommendations, the board considered that its duty in exercising its double function of both defense and court required bringing forward all of the usual defenses open as against a patent, but in passing upon the defenses raised by itself and the arguments made against them by the claimant the board considered that it had a very broad latitude in weighing matters of doubt to arrive at its recommendation, particularly looking to the saving of the Government long drawn out, annoying, and expensive litigation. The board considered that it had a right to include in its considerations the practical relation of the Government to the development of the art with which the War and Navy Departments had been in close contact ever since its inception and which departments had been the principal incentive for the development of practical radio apparatus in this country. The board knew that the development of radio was not considered anywhere near complete, there being many problems of great value to the military services yet unsolved, and it therefore hoped that it could pave the way for settling by give and take methods well within reason difficulties that threatened to tie up valuable expert talent in passing upon old work. In other words, it felt that if matters in dispute could be settled upon a reasonable basis, satisfying insistence of claimants that they were

entitled to consideration in matters of patents and yet keep the Government in expenditure of funds within what might be hoped for if litigation was carried to a final determination that a valuable service would be accomplished both to the Government and the art in general.

[fol. 871] When the board was first presented with about 2,000 patents to consider, it was unquestionably necessary to reduce this number to something practical if any consideration was to be had at all. Some elimination was readily had through quick conferences with the claimants by pointing out that no use had been made of the particular showing, or that the use was so small, or the patents so unquestionably invalid that they could be ignored if the claimant had other more substantial patents on which to stand. This procedure, of course, led to compromising considerations from almost the very start.

Having reduced the number of patents to something that would be practical to consider, the board proceeded to raise its defenses and very early commenced to state these defenses in the form of preliminary reports or less hurriedly drawn to form a basis of discussion with the board. Such procedure resulted in numerous hearings in which free discussion was permitted, often leading to patents being withdrawn from the board or the board revising its view as expressed in the preliminary reports. This procedure continued on until it was decided that the board must set final hearing on which to base a final report and make effort to secure means for making good the board's recommendations for those claims favorably considered. This final work took place in about May, 1921, nearly two years and a half after the board actively commenced its work.

Taking up the latter part of the question, which concerns the action of the board with respect to the Marconi, Lodge, and Fleming patents, involved in this suit, these patents represent the four patents that the company decided to rest its case upon with the board out of approximately 350 patents owned by the company. All of these patents had been in litigation, the two Marconi patents in suit having been in litigation a number of times. The other Marconi patent 762773 had a number of decisions favorable to it, but none of them involved the quenched gap type of apparatus in the particular form used by the Government. The litigation on this patent prior to the Kilbourne

& Clarke case out West involved the open-type gap, except a motion for preliminary injunction against the Atlantic Communication Co., in which final hearing was started, but the case was never completed, having been stopped during trial on account of Mr. Marconi, who was engaged in testimony or about to testify, being called back by the Italian Government then entering upon the World War. The Kilbourne & Clarke case involved a quenched gap type of apparatus not precisely the same as that in standard use by the Government, because the time period of the primary circuit in which the spark gap was located was not arranged to be adjusted to the same time period as the secondary circuit. Whereas the Government's quenched-gap apparatus had an arrangement for adjusting the two circuits, though the final adjustment is not one in which the two time periods are precisely the same. This left the board with a situation which had not been definitely passed upon by the court, and while it made allowance for [fol. 872] the patent in the matter of the Government's type of quenched-gap apparatus, it was a reduced form of allowance, the situation being unquestionably one where a compromise was necessary.

* * * * * * *

In the matter of Fleming patent 803684, it had just been given a very broad interpretation in the suit of Marconi *v.* De Forest. The board did not agree with the decision in this case and there was some dispute as to the interpretation of the decision, particularly as the accounting in the case had not proceeded to a point where the decision was interpreted in the matter of its application to real apparatus. However, in view of the decision and the board's policy of accepting the decisions of the courts then existing, a recommended allowance was made for the patent.

142. Question. Was there any cross-examination of the claimant or parties appearing on their behalf, or countershowing by adversely interested parties in the proceedings before the Interdepartmental Radio Board?

Answer. No.

143. Question. Referring to the report of which plaintiff's exhibit for identification No. 120 is a copy, do you find

any statement in the report inconsistent with what you have testified to in your examination in this case?

* * * * * * *

Answer. The report covers the four patents in suit and I have testified concerning the two Marconi patents and the Lodge patent and have not testified in the matter of the Fleming patent. As before stated, all of these patents had been in litigation and were the subject each of one or more decisions. The report clearly shows an effort on the part of the board to adhere to its policy of accepting the decisions of the courts where they were definite and left no room for question as to the apparatus involved and [fol. 873] where the decisions were of such nature and based upon such apparatus as to leave open for argument whether or not the Government's apparatus came within the scope of the decisions to compromise with and accept the claimant's interpretation of the decision.

* * * * * * *

In discussing the second Marconi patent in suit, I have pointed out that this Lodge patent disclosed impulse excitation such as is employed in the quenched-gap type of apparatus against which the later Marconi patent is being pressed. In this respect I am also consistent with the board's report.

Taking up Marconi patent 763772, the report points out that the prior litigation did not involve apparatus precisely the same as that of the Government's type of quenched-gap apparatus against which claim was being made, and therefore the decision left room for dispute. The report shows that the board in a spirit of compromise accepted the claimant's contention that the exemption by the court in the Kilbourne & Clark case of the Kilbourne & Clark type of apparatus did not free the Government's type of apparatus from the earlier decisions where in non-quenched-gap types two circuits were used and had their time period's adjusted to bring about resonant transfer of energy because the Government's apparatus definitely included arrangements for adjusting the time periods of the two circuits. I have pointed out in my deposition that there is a persistent misuse of the synonymous terms "resonance," "syntony" and "tuning" pointing out the inclination to refer to the mere adjustment of the time

periods of two circuits to be the same as a resonant or tuned condition, irrespective of whether or not the coupling relation between the two circuits is such that they permit of but one frequency existing in the coupled system, and [fol. 874] I have pointed out that resonance depends not upon the time period of the circuits themselves but whether or not the resulting oscillations are of the frequency corresponding to the time period and can resonantly act upon the circuits. This loose understanding as to the meaning of resonance or syntony naturally brought in considerable dispute as to whether or not the Government's tightly coupled quenched-gap transmitters did not come within the meaning of the words "resonance," "syntony" and "tuning," as it had been referred to in the various decisions prior to the Kilbourne & Clark case. After referring to the Kilbourne & Clark case, the board's report states:

"This, however, is not decisive of the present issue, as to the use of quenched gap by the government in which there is a close coupling and a slight or negligible detuning, and in which, undoubtedly, advantage is taken of syntony to secure an effective transfer of energy."

The board, therefore, brings out that the Government apparatus was tightly coupled, and, therefore, did not have a one-frequency condition in which a true resonant transfer of energy from the primary circuit to the secondary circuit could take place, and its reference to "syntony" in the quotation is therefore in the loose form generally meaning that condition in which the time period of the two circuits are independently considered the same. I clearly point out in my deposition that use is made of this adjustment arrangement for transferring the energy from one circuit to the other, but that the use is for quickly bringing about a definite and predetermined beat of no energy in the primary circuit at which the quenched gap can act to open the primary circuit and effectively disconnect it from the radiating antenna circuit. The quotation brings out the slight throwing out of this adjustment to make the beat a perfect one, as illustrated by me in my sketch O, Figure 16. This use of the adjustment of the time periods of the two circuits in the quenched-gap system is entirely different from that of the adjustment in the Marconi open-gap system where the purpose is to have a slow, long drawn

out transfer of energy at a definite desired frequency established by the primary circuit, and therefore a truly resonant transfer.

The board's report points out as I have done in my deposition that impulse excitation was provided for in the earlier Lodge patent, and that this impulse excitation is the foundation of the quenched-gap type of transmitter. It points out that the Lodge system did not include the later improvement in the matter of adjusting the time periods of the two circuits to get the definitely located first beat.

The report does not go into the matter of the prior art as I have done, this being unnecessary in view of the policy of the board to not to endeavor to alter the decisions of courts in arriving at its recommendation.

The board touched upon the relation of the patent to several types of apparatus other than quenched-gap spark transmitters, but only one of these types has been pressed in the present suit, namely, the arc type of transmitter. The board contended that this type of apparatus did not come within the terms of the patent which is in keeping with my deposition relating to this patent.

Summarizing, under the board's policy of accepting the decisions of courts where there was no question as to their relation to the Government's type of apparatus in view of [fol. 875] the types that had been in the prior litigation, and discussing the effect of decisions where the type of apparatus passed upon left room for doubt as to the effect on Government's apparatus, the board's scope was naturally extremely limited in the case of a report such as that of the Marconi company where all of the patents had been in litigation. I do not find that any part of my deposition is inconsistent with or in conflict with the report of which plaintiff's exhibit for identification No. 120 is a copy.

* * * * * * *

Cross-examination.

By Mr. Cosgrove:

144. Cross-question. Are the 13 or 14 typewritten pages annexed to your letter of October 8, 1920, and forming part of plaintiff's Exhibit No. 129 for identification, a correct copy of the preliminary report of the interdepartmental board on the claim presented by the plaintiff herein to that board?

Answer. I have no way of determining whether or not these pages represent a correct copy of the preliminary report referred to in my letter of transmittal, nor do I believe that there is now any way of determining whether or not these pages are a correct copy, as preliminary reports were drafted from time to time in an attempt to arrive at a final report. I have no reason to believe, however, that these pages do not contain the report referred to in my letter of transmittal of October 8, 1920.

145. Cross-question. Have you any reason to doubt that the pages referred to are the copy of the report referred to in and which accompanied your letter?

Answer. I have not.

Mr. Cosgrove: I offer in evidence the letter referred to as plaintiff's Exhibit No. 120, copy of preliminary report of the Interdepartmental Radio Board on plaintiff's claim accompanying letter of October 8, 1920.

146. Cross-question. Did the board make any final report on the claim of the plaintiff and what form did that report take?

Answer. Yes; a typewritten report was made and submitted to the Attorney General, Secretary of War, and Secretary of the Navy.

147. Cross-question. Presumably that final report is on file in one of the departments of the Government at Washington, is that correct?

Answer. There should be at least one copy in each of the departments of which the officials just previously named are heads.

148. Cross-question. Referring to plaintiff's Exhibit No. 122, printed pamphlet of hearings before Committee on Military Affairs, what relation does the report printed on pages 20 to 31, inclusive, of that exhibit bear to the final report of the interdepartmental board?

Answer. The subject matter contained on the pages named in your question appears to correspond to a part of the board's final report which was termed the preamble.

[fol. 876] 149. Cross-question. According to this preamble to the final report of the board, the plaintiff herein was awarded $1,253,389.02. Your letter of April 16, 1921, plaintiff's exhibit for identification No. 121, states, "If acceptable, the board's recommendation to the several heads of department will be an award to the Marconi Telegraph Co.

of $1,253,389.02." What relation does your letter of April 16, 1921, bear to the final report of the board?

Answer. To the best of my recollection, the final report of the board recommended a sum the same or substantially the same as that set up in the letter of April 16, 1921.

(Mr. Cosgrove offers in evidence the letter of April 16, 1921, as plaintiff's Exhibit No. 121, interdepartmental board's letter of April 16, 1921.)

150. Cross-question. Excepting yourself, what qualifications had the other members of the interdepartmental board to deal with or pass upon technical and engineering questions relating to radio apparatus and patents and what qualifications had any of them to deal with or pass upon related legal questions as to the validity, scope, or infringement of the Marconi company's patents upon which they base their claim?

Answer. The technical members of the board were Commander Hooper, Captain Hill, and myself. Commander Hooper to the best of my knowledge has been working in Navy radio matters since about 1908. His work has been more or less of an administrative nature in the matter of directing communication system involving the use of radio apparatus and supplying the naval establishment with its radio equipment. He has never had any particular educational training to qualify him for technical radio work other than the academic course of the Naval Academy. He has little or no knowledge concerning patent law and practice, and never showed any real inclination to delve deeply into such matters. To the best of my knowledge, Captain Hill had an educational training as a foundation for taking up radio work. I understand that he attended courses at the Massachusetts Institute of Technology, probably of a general electrical character, as his attendance was some time prior to 1910, before the educational institutions made any attempt to specialize in electrical communication. I understand that he was employed by some one of the radio companies prior to taking up employment with the Navy Department in radio work about 1913 or 1914. He continued his work in the Navy Department until about 1918 when he accepted a commission in the Army, and has since that time been engaged in radio work for the Army. As far as I could estimate, he had little or no knowledge of patent matters. Mr. Knight and Mr. Young were the members of

the board having patent law experience. It is my understanding tha. Mr. Knight has been practicing patent law in the neighborhood of 30 years or more, and has had a very wide experience, having handled some very extensive and important litigation, some of it being in connection with radio patents. Mr. Young is a patent lawyer of considerable experience. He accepted a commission in the Army some time in the early stages of the war and thereafter was engaged in advisory capacity in connection with patents for the Bureau of Aircraft Production and I also think in connection with the Signal Corps. As far as I could ascer- [fol. 877] tain, he had no experience in connection with patents involving electrical matters.

151. Cross-question. Do you know whether or not Mr. Knight was counsel for the defendant in the case of Marconi Wireless Telegraph Co. of American against the Atlantic Communication Co. referred to in your deposition?

Answer. It is my understanding that he was.

152. Cross-question. What do you mean in your answer to question 142 by the statement that there was no countershowing by adversely interested parties?

Answer. I understood the question to mean had the board given opportunity to parties who might have been adversely affected by the board's attitude toward patents which had been presented to it to be heard before the board made its final report, and my answer was intended to state that no such proceedings were had.

153. Cross-question. Would adversely interested parties include parties other than the plaintiff who had presented patents to the board and based a claim against the Government on their patents?

Answer. I do not know, as no such proceedings took place.

154. Cross-question. Did the claims presented by any patentees or owners of patents to the board for adjustment other than the plaintiff herein conflict with or overlap the claims of the plaintiff?

Answer. A claim submitted by the American Telephone & Telegraph Co. bid fair to conflict seriously with the claims of the plaintiff. However, this claim of the telephone company did not last long before the board, as a settlement was made with the War and Navy Departments which permitted the withdrawal of the claim from the board. The conflict as between these two claims would have involved the matter of the interpretation of patents and claims of

patents. After the withdrawal of the telephone company's claims there did not appear to arise any conflict among the claimants as to the overlapping and interpretation of patents. There were matters of adjustment in attempting to arrive at the relative values of contribution of numbers of patents involved in the same piece of apparatus, the patents in many instances being diversely held. The board attempted to adjust these matters for itself and found a little or no inclination on the part of the claimants to interfere.

155. Cross-question. What patent or patents of the American Telephone & Telegraph Co. do you recollect, or what was the nature of the claim of that company which conflicted with the claim of the plaintiff?

Answer. The telephone company owned patent 714756 to John Stone Stone, the application for which was filed February 8, 1900, which I have referred to as prior to Marconi patent 763772. The attorneys and technical representatives of the telephone company in their first hearings before the board set up this patent as prior to the Marconi patent and as being for the same device as the Marconi patent. The telephone company also controlled the De Forest three-electrode vacuum-tube patent, and if they had persisted before the board would have probably brought forward many claims as against the Fleming patent here in suit. Their first hearing before the board indicated that they were fully prepared to do so.

156. Cross-question. You have stated that the procedure of the board resulted in numerous hearings and arguments; [fol. 878] was any stenographic report kept of the hearings before the board at which representatives of the plaintiff were present?

Answer. The board had no facilities for making stenographic notes of the proceedings. An assistant of the board at first attempted to make scattering notes in long hand which I have frequently examined from time to time and found of little or no value. I recall that some of the claimants provided stenographers and notes were kept, but I do not recall that this was done by the plaintiff.

157. Cross-question. Did the board in considering technical matters relating to radio apparatus and patents have the benefit of the advice of any experts and engineers other than the individual members of the board?

Answer. To a limited extent technical advice was sought from several sources.

158. Cross-question. Were those sources qualified to give such advice?

Answer. Some of the instances resulted in advice considered of no value and in some instances the advice was considered of assistance.

159. Cross-question. Did not the hearings before the board so far as they related to the claims of the plaintiff and at which hearings the plaintiff was represented consist of discussions by the board or members thereof on the one hand and the plaintiff's representative or representatives on the other hand?

Answer. Yes.

160. Cross-question. In none of the hearings before the board on plaintiff's claim were witnesses produced and examined and cross-examined by the plaintiffs or the Government, is that correct?

Answer. No sworn testimony of any kind as introduced into the board's proceedings.

161. Cross-question. The first hearing before the board on the plaintiff's claim at which hearing a representative of the plaintiff was present, was about the middle of October, 1919. Is that not so?

Answer. I can not recall.

162. Cross-question. Have you any way of fixing that date?

Answer. No.

163. Cross-question. Referring to plaintiff's Exhibit No. 122, I find the following on page 23 of the preamble to the board's final report:

"The board thereupon proceeded to consider the several hundred patents set forth in these claims, and on September 25, 1919, had progressed so far with this examination that a letter was sent to the several claimants appointing hearing."

Does that help to refresh your recollection as to the date the first hearing was had on plaintiff's claim at which hearing a representative of the plaintiff was present?

Answer. I have no reason to believe that the quotation does not state the fact, and I believe that a hearing was had with the Marconi company shortly after the date set up in the quotation.

164. Cross-question. Was that the first hearing on the Marconi claim at which a representative of the Marconi company was heard?

Answer. I believe that the board met with representatives of the Marconi company before that date, though I have nothing in mind at present to make the matter definite.

[fol. 879] 165. Cross-question. That is, you can not fix the date of the hearing referred to or who was present at that hearing on behalf of the plaintiff?

Answer. No.

166. Cross-question. Between September, 1919, and October 8, 1920, the date of your letter forming part of plaintiff's Exhibit No. 120, no hearings were had before the board in respect to the plaintiff's claim at which a representative of the plaintiff was present; that is correct, is it not?

Answer. I don't think so. As I recall it, there were hearings from time to time amounting possibly to five in number, and I believe one or more of them came within the dates specified in the question.

167. Cross-question. When and where were these hearings and who was present at them?

Answer. The hearings took place in the Navy Department at Washington, always with a quorum of the board present. As I recall it, the Marconi company was always represented by Mr. Betts, as counsel, and he varied to some extent the personnel accompanying him. I recall no definite dates of hearings.

168. Cross-question. As a matter of fact, the hearings you refer to were after your letter of October 8, 1920, with the accompanying preliminary report, was sent to the Marconi company, isn't that true?

Answer. I do not know that it is true.

169. Cross-question. Well, is there any record anywhere which will show the date of these hearings and who was present at them?

Answer. There are some scattered notes made by an assistant of the board in the manner I have just heretofore explained, but I am afraid that they are of such a nature that it will never be possible to establish through them a series of dates of hearings that can be relied upon.

170. Cross-question. At the hearing before the Military Affairs Committee reported in plaintiff's Exhibit No. 122, you stated, did you not, "The board finally came down to a real serious consideration of 149 patents. This considera-

tion involved searches of the art, writing of long reports, receipt of briefs from claimants, hearings, more briefs, revised reports, * * *."?

Answer. I believe the quotation is correct.

171. Cross-question. At this hearing you were asked certain questions and in answer thereto made the following replies, did you not?

"Mr. Morin: The allowance has been based on the use of the patents that have been found valid?

"Commander Loftin: Yes; and the manufacture also. This whole settlement includes the contractors for the Government as well as the Government, the particular necessity for that being that the Government has agreed in many cases to save the contractor harmless. Now, under the act of 1918 we have the entire responsibility anyway.

"Mr. Morin: You have not allowed any claims where the validity of the patent is in doubt?

"Commander Loftin: No, sir; unless the doubt was such that it could reasonably be resolved in favor of the patentee. I might say here that I am informed that the courts gen- [fol. 880] erally lean over backward to sustain a patent, but I do not think we have gone quite that far. We have required them to come somewhere near the middle ground before we have held that the patent is good. But the courts are very liberal with inventors and will generally resolve a very strong doubt in their favor."

Answer. I believe the quotation is correct.

172. Cross-question. Do you not find the following statement in the preamble to the board's final report as incorporated in plaintiff's Exhibit No. 122:

"In the case of each claimant the various patents have been carefully examined with the aid derived from briefs or oral arguments submitted, and the board has, where necessary, examined the history of the patent as disclosed by the Patent Office record and reports of litigation, and has made as extensive a search of the prior art as has seemed necessary in each case."

Answer. I do.

173. Cross-question. You have stated that the board's preliminary report does not refer to the prior art and in another place you state that there was no necessity for the board touching the prior art as you have done in this case.

Were not the board's preliminary and final report so far as they may relate to the plaintiff's claim based upon a consideration of the prior art?

Answer. In the case of the Fleming patent it was not. There were court decisions on this patent which, in view of the nature of the apparatus involved in the earlier litigation and the board's policy of not attempting to readjudicate petents, made it unnecessary to introduce prior art into the board's report. In the case of the Marconi patent 762773, the board's report does refer to the earlier Lodge patent as being the fundamental patent covering the quenched-gap type of apparatus, because the prior litigation had not covered apparatus the same as the Government's quenched-gap transmitter. In other words, the board did not include prior art where the decisions made it unnecessary and did include prior art where the decisions permitted. In the first part of my answer I neglected to point out in connection with the Fleming patent the board did refer to the earlier Edison patent on the same device used in connection with the low-frequency work, and pointed out that in view of this earlier patent no allowance would be made for vacuum tubes employed in low-frequency systems or in systems involving a combination of high and low frequencies on those portions of the systems which took up the low-frequency function.

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174. Cross question. In the report of the Military Affairs Committee forming part of plaintiff's Exhibit No. 122, Mr. Knight is reported as stating that the attitude of mind of the board in considering claims was to "try to find out as far as we could what the Court of Claims, which would be the tribunal hearing these cases against the Government, would do in the way of awarding fair and just compensation under the present act of Congress." Later Mr. Knight is reported as stating that the board—

[fol. 881] "examined to see whether he had a valid patent, and then we have examined to see how broad that patent was, what its scope was, and we have tried to find out how many and what apparatus the Government had made which were under patent. That gave us some basis of estimating what payment should be made. If we thought the patent invalid or insignificant, that the improvement was not

worth paying for, we have so declared; but if it was a substantial improvement and the Government used it and had the advantage of the invention and it was a legal claim which the Court of Claims would allow, we have in that case favored the claim.

Assuming that Mr. Knight is correctly reported, do you agree with his statements?

Answer. Assuming that these quotations are correct, I do not agree that they, taken by themselves as they are from a long series of statements, repeatedly interrupted by questions from the committee, precisely state the attitude or mind of the board; that is, my understanding of its attitude or mind, and I think perusal of the entire statement of Mr. Knight of which these are but fragmentary quotations brings out the reason why I can not entirely agree.

* * * * * * *

178. Cross-question. Well, the plaintiff only relied upon its patents which had been adjudicated in presenting its claim to the board; is that not correct?

Answer. The negotiations finally came down to that.

179. Cross-question. Did the board in reaching its final conclusions on the plaintiff's claim follow or adhere to the decision of Judge Veeder in the case of Marconi Wireless Telegraph Co. *v.* the Atlantic Communication Co. granting a preliminary injunction restraining that company from using a quenched-gap transmitter in infringement of certain claims of the Marconi patent 763772?

[fol. 882] Answer. The preliminary injunction proceedings referred to received the attention of the board, but, in accordance with my understanding of the attitude of the board, no particular weight was given to these proceedings on account of being merely of a preliminary injunction order.

180. Cross question. Did the board take this attitude in respect to every decision on a motion for preliminary injunction involving any of the patents of the plaintiff which were presented to the board for consideration and which are involved in this suit?

Answer. I do not recall any other motion for preliminary injunction other than the one just cited being pressed before the board by the plaintiff, in support of its claim. That is, I do not recall that any other motions for prelimi-

nary injunction were considered by the board in passing upon the claims of the plaintiff.

(Cross-examination closed.)

(The examination by counsel being concluded, the witness, in compliance with the rule of the court requiring him to state whether he knows of any other matter relative to the claim in question, and if he does to state it, says he does not.)

(Deposition closed.)

GREENLEAF W. PICKARD

At the request of counsel for the Government and subject to correction should error appear, it is stipulated that if Greenleaf Whittier Pickard were called as a witness on behalf of the Government he would testify as to the following portions of his testimony given in the case of Marconi Wireless Telegraph Company of America *v.* Kilbourne & Clark Manufacturing Company in the United States District Court for the Western District of Washington, Northern Division, on the 23d day of March, 1916, through and including the 29th day of March, 1916, and that copies of the following portions of said testimony and the exhibits offered in connection therewith may be received as a correct statement of said testimony, with the same force and effect as if said witness had been duly called, sworn, and examined on behalf of the Government in this cause.

* * * * * * *

Question. Will you please state briefly the history of radiotelegraphy and the condition of that art with relation to the Lodge and Marconi patents here in suit, with particular reference to the circuits and apparatus therein involved and their relation to each other. You may preface this answer by a brief explanation of the mode of operation of radio telegraphy?

Answer. * * * The next contributor to the prior art is Prof. John Stone Stone in defendant's Binder A-8, which is Stone patent 714756.

* * * * * * *

[fol. 883] In Figures 5 and 6 of this Stone patent, No. 714756, are shown a transmitter and a receiver, consisting of at the transmitter a closed oscillatory circuit C-S-i-1-L

inductively associated with an open or radiating circuit, V-M-i-2-E. That is Figure 5, At the receiver, Figure 6, an open absorbing circuit V-i2-E is inductively associated with a closed circuit, i1, C1, CL, this latter circuit being connected to a detector K which in turn is connected to an indicator R and a battery B. Returning to the transmitter, the original source of power is shown as the alternator A—(I may remark parenthetically that the symbol shown at A is the conventional symbol for an alternator, that is two interlinked circles with two slanting lines above and below. This is supposed to represent the two rings of an alternator with the two brushes bearing thereon). This alternator supplies through a telegraphic key K a step-up transformer, ii-i2. The secondary terminals of its winding i2 are connected to the condensor C, and when the key K is pressed currents from the alternator A will flow through the primary winding i1 of the stepup transformer M, will introduce in the secondary winding a high potential which will charge the condensor C, and this in turn will discharge across the spark gap S, and through the inductance i1 and L thereby setting up persistent oscillations. I say persistent oscillations because the specification of this patent at a number of places lays great stress upon the careful construction of the condensor C and the coils i1 and L, in order that there shall be the minimum resistance or loss in these elements, so that the most persistent oscillations may be obtained. These oscillations are transferred from the circuit C-S-i1-L to the opening or radiating circuit through the oscillation transformer (or as it is now termed inductive coupler), i1-i2, to the open or radiating circuit V-Mi2-E. Similarly at the receiver of Figure 6 the received current alternations or oscillations pass through the open or absorbing circuit, V-i2-E and by reason of the association of this open circuit with the closed circuit, C-i1-L-C, through the oscillation transmitter or inductive coupler M, set up oscillations in this closed circuit. The specification states, page 2, line 16 to 18, "The frequency impressed upon the elevated conductor may or may not be the same as the natural period or fundamental of such conductor." That is to say, the circuit shown in Figure 5 may be adjusted to be in resonance, or if preferred for some of the special purpose which are elsewhere set forth in the specification, may be purposely put out of resonance, that is out of tune. Similarly at the receiver, Figure 6, the circuit V-i2-E may

or may not be placed in resonance with the closed receiving circuit C1-i1 L-C. The reason why in this patent the constructor is given the choice, so to speak, of whether or not he tunes the two circuits is shown by some of the other [fol. 884] forms of apparatus disclosed in this patent, such for example as the transmitter and receiver combinations of Figures 13 and 14. Without going into any lengthy description of this, I will say that this arrangement is for multiplex radio communication, in which two sets of closed primary circuits at the transmitter, Figure 13, were associated with a single elevated conductor. Of course the elevated conductor could not be in tune with both at the same time, two circuits of different frequencies. Therefore, as Stone states, in the specification, this elevated conductor of Figure 13 V-M-M1-E was to be either an aperiodic circuit, that is one without any tune at all, or a circuit which might be out of tune, though still having a tune of its own. Stone's object was simply to force or impress vibrations of different periods upon this radiator from the closed primary circuits. Similarly at the receiver in Figure 14 a single absorbing circuit V-M-M1-E is shown and associated with this are two separate tuned receiving circuits, these being the circuits C1-L-C1 Sub 1; L1-Sub 1, which specification states are tuned to different periods.

In February, 1899, Professor Stone disclosed to me a system of transmitting receiving circuits such as are shown diagrammatically in Figures 5 and 6 of the Stone patent I have just discussed. This disclosure was some time in the latter part of February, 1900, and took place at the office of a Mr. Maynadier, which, as I remember it now, was at the corner of Court and Washington Streets, in Boston, Mass. I at that time was acting as technical adviser for an early American radio telegraphic company, and this company, which controlled or owned the Dolbar patents on radio telegraph, had been ap-roached by either Mr. Stone or some of his representatives to see if they would be interested in the commercial application of his inventions. Shortly before this conference with Professor Stone I was informed by Mr. Learned of the Dolbear Co. (may remark parenthetically I have forgotten this company s exact title so I have called it herein the Dolbear Co.), Mr. Learned teliing me that Professor Stone had some interesting inventions in the line of some selective or sharply

tuned radio telegraphic apparatus, and that he wished me to meet Stone, and his, Learned's, attorney, Mr. Maynadier, to discuss this matter and to see whether or not these inventions would be of use. Pursuant to this conversation with Mr. Learned I went over to Mr. Maynadier's office and met Professor Stone, and as I now recall we had a conversation lasting some hour or two, perhaps the greater part of the forenoon, in which Stone disclosed to me his system of radio telegraphy. At the transmitter Stone proposed to use for the primary circuit a closed oscillating circuit, using air condensers and carefully constructed inductances so as to avoid any possible loss and to obtain the greatest persistency and purity of wave. And that, associated with this closed persistent oscillating circuit at the transmitter, was to be linked or connected to an open or radiating circuit, which was to be tuned or brought in resonance to the period of the primary or closed circuit. At the receiver he proposed to use an elevated conductor and a ground connection, forming an open circuit, and to tune this circuit to the two circuits at the transmitter, and lastly to associate with this third circuit at the receiver a fourth or closed circuit which should either include or be connected to the detector, and that this fourth circuit should be tuned to all of the three preceding circuits: that is to say to the closed [fol. 885] oscillating circuit at the transmitter, the open radiating circuit at the transmitter, and the open or absorbing circuit at the receiver. At this same conference with Professor Stone he also disclosed to me some further inventions, which as I remember consisted of having a plurality of circuits at both receiver and transmitter. That is to say, instead of directly connecting or associating by means of the oscillation transformer, his closed persistent oscillary circuit with his open or radiating circuit, he suggested the use of an intermediate, or I believe he called it a "weeding-out" circuit, interposed between the first or closed oscillating circuit and the open radiating circuit. Similarly at the receiver he proposed to use an intermediate circuit between the open absorbing circuit of the receiving station and the closed detector or secondary circuit. When these intermediate or weeding-out circuits were used, Professor Stone explained to me they also were to be tuned accurately to the frequency of all the other circuits. In addition to this disclosure Professor Stone also explained

to me a simple means by which he attained what is called loose coupling; that is, a less intimate association of, say, the two circuits at the transmitter. This, I recall, he did by means not of removing one coil, such as, for example, the coil L of figure 2 of my sketch G W P 10, from the coil L1 of the other circuit, but by inserting in one or the other of the two circuits a large inductance coil. I think I can recall his exact language, which was that this coil would have the effect of swamping the coupling or coil inductance of the transformer and so loosen the coupling, the object of this loose coupling being to allow the circuits to vibrate more freely than if they were too intimately associated with each other. At the time, or a few days after this conference, I made a note in my diary as to this conference and to the fact that Professor Stone had disclosed a selective system of radiotelegraphy to me, embodying several resonant circuits, and although I have not this diary here with me to-day, nor have I a copy of it, I can produce this copy later. The original diary, I understand, is now an exhibit in an eastern court.

The Court: This concludes the record in relation to Stone?

Answer. To Stone; yes.

* * * * * * *

My recollection of Professor Stone's disclosure to me of his system of radiotelegraphy has, within the last year or two, been refreshed by reference to a note in my diary, and, within the last day or so, has again been refreshed by reference to a photographic copy of the pages of my diary containing these notes. I have here a photographic copy of that portion of my diary containing the notes as to Professor Stone's disclosure. The original diary, I und-rstand, is now an exhibit in the court in Brooklyn, and is not available to me.

[fol. 887] Question. Has that been identified, Mr. Pickard? Has that been identified? Did you refer to it before?

Answer. No; I did not refer to it before.

Mr. Skeel: Then I offer it in evidence.

The Court: Let it be marked as the next exhibit of the defendant, whatever it may be.

(Admitted and marked "Defendant's Exhibit 7".)

The Witness: Under the date of February 28, 1900, I find the following short note: "Am now examining some pats. offered to Learned. Most of these entirely impracticable. J. B. Stone has interesting system of several resonant circuits and claims great selectiveness." I find, immediately preceding this note, under the date of February 24, a note reading as follows: "60 Sta. today, my first out-of-door trip." These two notes from my diary recall to me the exact circumstances, which are briefly as follows: In the winter of 1899-1900 I was confined to the house with a severe illness, and I did not get out of doors until some time in February. Immediately upon my first visit to the office of Mr. Learned, which, as I now recall, was the first day I got out, Mr. Learned asked me to investigate and confer with Professor Stone as to his system, and, as appears from my diary notes, which were made at intervals of approximately one week, this conference of mine with Professor Stone apparently was some time between February 24 and February 28. I recall, although only vaguely, several other conferences with Professor Stone subsequent to this—within a period of a week subsequent, in which he, as I recall now, merely amplified and gave further details of his first disclosure.

I have prepared a chart showing in the two figures—the left and the right hand figures—the Stone transmitter and the receiver. This chart is entitled "Pickard Chart of Stone Four-Circuit Tuning Patent." (See vol. 2, p. 544.) The left-hand figure, as I have said, is the transmitter disclosed to me by Professor Stone, consisting of the following elements: A closed, oscillating circuit, D E C L, the element D being an inductance coil, constituting the primary of an oscillation transformer; the element L being another inductance coil, which as I have stated, was explained to me by Professor Stone as a means for loosening the coupling between the closed and the open circuit, and thereby obtaining a purer wave; that is to say, a wave more adapted for selectivity or sharpness of tuning between the receiving and transmitting stations. The element C was a spark gap, and I do not recall that Professor Stone disclosed to me any particular form of spark gap. He simply stated that it was a spark gap. The element E was a variable condenser, preferably having air as a dielectric. Professor Stone insisted upon that, as I recall, because, as he said, such a condenser had practically no loss due to

hysteresis, as it is called, which is found in other condensers, such as those constructed of glass, like the ordinary Leyden jar. The source of potential for charging the condenser E, shown in my chart at A B, was disclosed to me by Professor Stone as either an induction coil, or an alternating current transformer. The open or radiating circuit, A 2 D'2, was disclosed to me by Professor Stone as an elevated conductor A, which might be a wire or group of wires [fol. 888] running up into space to any desired height, a ground connection E and interposed between the aerial A and the ground connection E, was the secondary of the oscillation transformer, consisting of the winding D'. Professor Stone stated at our first conference that the closed oscillating circuit D E C L of my chart, was to be tuned or made resonant to the open oscillating circuit A^2 B' 2 E.

At the receiver shown in my chart of the Stone system, at the right-hand side, the open receiving or absorbing circuit A 3 J' 3 E, was to be placed in tune or resonance with the two circuits at the transmitter. This open or absorbing circuit at the receiver comprised the following elements: An elevated conductor A, a ground connection E, and the primary winding of an oscillation transformer J'. Inductively associated with this first or absorbing circuit of the receiver was a closed oscillating circuit shown in my chart of the Stone system as an inductance winding, constituting the secondary winding of the oscillation transformer J^2; a variable condenser H'; a second fixed condenser J^3; a second inductance G^2. Professor Stone explained to me these elements substantially as follows: That the condenser H' of the second or secondary circuit of the receiver was to be—as shown in the transmitter in the left-hand figure—a variable air condenser; that the inductances J^2 and G^2 were to be air core inductances, constructed to have the minimum resistance or resistance losses when traversed by high frequency alternating currents. Connected to this closed, oscillating secondary circuit at the receiver in the manner commonly known as a shunt or parallel connection, was placed a detector, such as a coherer, T, and its local or indicating circuit, including a battery, B, and a receiver, R. Professor Stone stated to me that this secondary circuit $J^2H'H2G^2$ was to be tuned or made resonant to the open absorbing circuit, A', 3, J^1, 3, to the open or radiating circuit of the transmitter at the left-hand figure A 2 D^1 2 1 E and also to the closed persistently oscillating cir-

cuit E C L D of the transmitter. I have not shown in this chart the further modification which I have already testified Professor Stone disclosed to me, wherein, at the transmitter shown at the left-hand figure and between the coils D^1 and D was placed a so-called weeding out or tertiary circuit—a third circuit of the transmitter. Neither have I shown at the receiver a modification, which I have already testified was disclosed to me by Professor Stone, of an intermediate or tertiary circuit interposed between the windings J^1 and J^2 of the receiver at the left-hand figure of my chart. However, when these were used, the system then became a three-circuit system at both transmitter and receiver; that is to say, there were in the complete system, embracing both transmitter and receiver, six tuned circuits, all tuned to the same frequency.

* * * * * * *

Question. Was this third circuit disclosed to you at the same time as the others?

Answer. Yes. The third circuit was disclosed to me at the same time, at the same conference with Professor Stone. I may say, before concluding, that this disclosure to me was partly verbal and partly by sketches. Professor Stone did not at that time show me any actual apparatus in operation. He simply told me, as I recall very clearly indeed, just what the elements were, and made that even clearer by [fol. 889] sketches, the sketches being, as I recall them, substantially the sketches I have made here upon my chart. It was not, I think, until two or three years later that I actually saw a Stone transmitter and a Stone receiver in operation, constructed according to Professor Stone's disclosure to me, and also according to the diagrams which I have given in my chart, "Pickard Chart of the Stone system," as illustrative of his disclosure.

* * * * * * *

Question. Will you please give this chart the number G. W. P. 10a?

Answer. Yes. I had better place that on it myself. That was very careless of me. I should have thought of that.

(The chart referred to was thereupon marked by the witness "G. W. P. 10a").

* * * * * * *

The Witness: The Stone 1899 system, which I have illustrated, is taken from Stone's disclosure to me in 1899, and at the left-hand figure, the transmitter, I have shown the closed, persistently oscillating primary circuit, inductively coupled with the open radiating ci. uit, and in the right-hand figure, I have shown Stone's open absorbing circuit inductively coupled with a closed persistently oscillating secondary or detector circuit. As I have stated, these four circuits were specified by Professor Stone as being tuned one to the other—that is, all four circuits were tuned to the same frequency.

Cross-examination:

Question. I now refer you to your chart G. W. P. 10a marked "Pickard Chart." Did you originate the words on this chart reading as follows: "Stone four circuit tuning patent 714756 filed prior to Marconi's filing and granted prior to Marconi's new defense as to validity and noninfringement in pending Brooklyn trial against Atlantic Co."?

Answer. I originated those statements. I am not entirely responsible for the exact phraseology, as that was arrived at in conference between myself and one of the attorneys in the case. The statements are my own, however.

Question. And you originated also the statement of this chart "New defense, almost identical with figures 1 and 2 of Marconi patent in suit. Never before used in trial against Marconi patent save in uncompleted trial in Atlantic Communication case."

Answer. Those are my statements of facts known to me.

Question. I ask you whether you originated those statements on that chart?

Answer. I did.

Question. From what prior patent or publication of Stone's in 1899 did you take the transmitter shown in G W P 11?

Answer. This transmitter is shown in figure 5 of Stone's United States patent No. 714756.

Question. Granted when?

Answer. Filed February the 8th, 1900, and granted December the 2d, 1902.

[fol. 890] Question. In what patent of Stone's do you find a receiver such as you have illustrated in G W P 11 opposite "Stone 1899"?

Answer. The same Stone patent No. 714756 in Figure 6.

Question. That patent wasn't granted until 1902, is that correct?

Answer. That is correct, as appears from the patent before me.

Question. At the time that Mr. Stone made this disclosure to you such as you have referred to in your direct examination did he show you a copy of the application for his patent which had been previously filed?

Answer. No; he did not.

Question. You testified, did you not, Mr. Pickard, to this same matter in a suit of Marconi against the Atlantic Communication Company?

Answer. Yes; I did.

Question. And didn't you testify May 11, 1915 as follows:

"Cross-question 52. Now, just state fully, exactly what Mr. Stone said to you when he made this alleged disclosure?

"A. As I now recall Mr. Stone's disclosure to me he said that he had devised a system for radio communication, which would give far higher selectivity than any of the systems at present in use. He described the means by which he obtained this increase in selectivity, broadly as being a very loose coupling between his circuits. He then showed me one way in which this loose coupling could be obtained, which was by inserting additional inductance in one or both of the coupled circuits, I mean by that, inductance additional to the inductance of the windings of the oscillation transformer. He then went into a rather long description of the system employing a multiplicity of tuned and loosely coupled circuits at both transmitter and receiver, stating, as I recall, that this would have the advantage of still further selectivity owing to the weeding out effect of several tuned circuits interposed between the receiver and the aerial and the detector circuit, and that a similar effect would be produced at the transmitter by an interposition of several tuned circuits between a primary or condenser discharge circuit and the transmitting or radio circuit aerial.

"Cross-question 53. Is that, as near as you now can put it, what Mr. Stone's disclosure to you was in the last week of February, 1900?

"A. That is all that I now recall."

Did you so testify?

Answer. Yes; I recall the substance of that language.

Question. Now, in your note book that you referred to on direct examination here, there are no diagrams of any circuit arrangements of Mr. Stone's disclosure to you?

Answer. No.

Sheffield & Betts, Attorneys for Claimant. Clifton V. Edwards, Special Assistant to the Attorney General. Herman J. Galloway, Assistant Attorney General.

Dated New York, N. Y., March 13, 1925.

[fol. 891] *Deposition of Joseph O. Mauborgne, for Defendants, Taken at New York City, on the 16th day of March, A. D. 1925*

Joseph O. Mauborgne, having been produced as a witness on behalf of the defendant, was by me sworn, before any question was put to him, to tell the truth, the whole truth, and nothing but the truth relative to the said question, and thereupon deposed and said that his name was Joseph O. Mauborgne; that his occupation is major, Signal Corps, United States Army; that he is 44 years of age; that his residence is Washington, D. C.; that he has no interest direct or indirect in the claim in controversy; and that he is not related to the plaintiff; and thereupon the said Joseph O. Mauborgne was examined by counsel for the defendant and in answer to interrogatiories testified as follows:

Direct examination.

By Mr. Edwards:

1. Question. Please state what experience you have had in the use of radio apparatus and in keeping in touch with the development of the radio art?

Answer. My first interest in radio was due to the yacht races some time around 1898 or 1899 in which Mr. Marconi employed wireless communication for the New York Herald in reporting the results of these races. I was at that time pursuing a collegiate course in the College of

St. Francis Xavier, this city, resulting in my graduation with an A. B. degree in 1901. While not a scientific school, the course in science was a very good one and was accompanied by a considerable amount of laboratory work. During the course of this I had a chance to have access to apparatus including a coherer, spark coil, etc., with which the very elementary principles of the transmission of Herzian waves were demonstrated. I purchased at that time several books on radio including Fahie's History of Wireless Telegraphy, and from that time on have followed the development of the art through reading and experimental work.

In 1903 I was commissioned as a second lieutenant of Infantry in the United States Army and served at Fort Leavenworth, Kans., until the early part of March, 1905, when I was transferred to the Philippine Islands.

In the year 1906 my regiment was moved to Zamboanga, Mindanao, where I observed the erection of the first radio station in the Philippines, established by the Signal Corps. As signal officer of the post at Zamboanga I had occasion to examine the various devices used in that installation. Later I visited the island of Jolo, where the companion station to the Zamboanga station was being erected, and I observed that the same type of construction and connections of apparatus was then installed, though the station was not finished and in operation until after my departure for the United States in November, 1906. During the period from my return to the States until the year 1909 I experimented with radio in my own home so that by the time I was ordered to the Army Signal School, Fort Leavenworth, Kans., in August, 1909, I had accumulated a considerable quantity of radio apparatus and entered the school with a complete transmitter and receiver installed in my quarters.

[fol. 892] From 1909 to 1910 I was a student at this school and took a course in signal engineering, which included, among other things, a study of direct and alternating current and radiotelegraphy. The Army Signal School at that time had a very well-equipped laboratory containing not only the then existing types of radio apparatus in common use, but also some of the very earliest pieces of apparatus ever used by the Signal Corps of the Army in connection with radio work; among other things I remember some untuned spark coil transmitters and receivers, coherers of the very earliest type, two sets of Marconi receiving appa-

ratus employing a tapper on the coherer, a Lodge-Muirhead receiver with a form of detector consisting of a steel wheel touching a cup of mercury, a Marconi magnetic detector, crystal detectors of various types, various transmitters and receivers used by the Signal Corps from the earliest kinds covering the spark stage development.

During the summer of 1910 I was on duty with a field company of the Signal Corps during the maneuvers in which the first Telefunken wagon set using a quenched gap was employed. Prior to my graduation from the Signal School in 1910 there was used and tested at that school two quenched spark Telefunken sets with bicycle-driven ventilators. It is thus seen that during that period from 1909 to 1910 I became familiar with the apparatus used by the Signal Corps from the very earliest days of radiotelegraphy.

From 1911 until 1913 I was attached to the Army Signal School as an instructor—first as the instructor in charge of the practical work in the laboratory, and during the year 1912 as instructor in the theory of radiotelegraphy. During my tenure of office as instructor I was constantly engaged in experimental radio work, as well as in the practical operation of radio stations. During that period I took the examination for a first grade commercial operator's license and obtained such a license. During that period also I wrote several papers for the scientific press, one of which was copied by the London Electrician and had to do with the coupling function in receiving circuits. I also prepared for the Signal Corps a small volume on the uses of the wave meter in wireless telegraphy which in 1913 I had published for commercial use. While I was not an officer of the Signal Corps while at the Army Signal School, I was, nevertheless, doing nothing but Signal Corps work, and more particularly radio work.

During the year 1912 I was sent on a trip to Fort Riley, Kans., to assist in the installation of the first quenched spark transmitter on an Army aeroplane and to make tests of this apparatus in conjunction with the aeroplane control of artillery fire.

Due to the operation of the so-called Manchu law I was obliged to join a regiment of infantry in the early part of 1913 and was ordered with my regiment to Galveston, Tex., where a force of troops had been gathered pending certain happenings in Mexico. While at Galveston, I un-

officially assisted in the radio work of a signal company camped at the same place About October, 1913, I was ordered to the Philippine Islands where I was stationed at Corregidor Island, Manila Bay, and notwithstanding the fact that I was nominally an infantryman I was loaned by the Infantry to the department signal officer, Manila, to assist in the radio work of the Signal Corps.

[fol. 893] Primarily in the work of revamping the big Corregidor radio station, installing new antennae, designing and installing a new counterpoise system, supervision of the erection of an additional 250-foot tower and the installation of new transmitting and receiving devices in the station itself. I was also called to Manila upon the arrival of each transport to inspect and install apparatus and make changes in the radio apparatus of each transport, as well as to tune and check the tuning of the interisland transport fleet. Early in 1914 I built and used in a plane the first receiver which actually received a message on an Army aeroplane from a radio station on the ground.

From 1914 to 1915 I was stationed in the city of Manila itself, and from 1915 to the latter part of 1916, at Fort McKinley, a short distance outside of the city of Manila, during which two years I continued to serve the Signal Corps in an unofficial capacity in connection with radio operation, as well as carrying out my duties as an officer of Infantry.

In September, 1916 I was detailed as captain of the Signal Corps, and ordered to Fort Leavenworth, Kans., as acting commandant and instructor at the Army Signal School, where I stayed until the latter part of 1917, carrying on experimental radio work, instructing in radio and hurriedly organizing during the last month or two signal troops for the Great War.

In the latter part of 1917 I was ordered to duty in the office of the chief signal officer at Washington, D. C., for a month or two in charge of training, then being assigned as officer in charge of the electrical engineering division, which for a few months was entirely separate from the radio division under Major Slaughter.

Early in 1918 I was placed in charge of the entire engineering and research division, in which were consolidated the radio and the electrical engineering divisions. My duties involved, among other things, passing upon engineering questions concerned with the development of radio

and other apparatus. While still on this duty in 1919 I was taken overseas by General Squier, then the chief signal officer, and had a chance to observe the field and fixed radio stations of our own and the allied troops in France and Germany. Before returning home I was accredited as a delegate from the United States to the first Allied Radio Conference, held in Paris. I then returned to the United States and continued my duties as chief of the engineering and research division, and during the period immediately following the conclusion of the war was associated with General Squier, Doctor Cohen, and Captain Hill, radio corps, in a large amount of experimental work, in which I took a practical part. For example, General Squier's experiment on wired wireless, tree telegraphy, the transmission of radio over bare wires laid in the water, and a number of experiments with resonance wave coils resulting in the filing of more than 20 patent applications with one or more of the gentlemen named, both in the United States and foreign countries.

In 1921 I was sent as a representative of the United States to the Inter-Allied Provisional Technical Committee of the International Communications Conference held in Paris, France. Upon my return from abroad in 1921 I was transferred from Washington to Chicago, Ill., where I performed the duties of corps area signal officer, in which [fol. 894] position I controlled and assisted in installing a number of radio stations of the Army within the Sixth Corps Area.

During my stay in Chicago I performed some further experiments in wired wireless at the direction of the Chief Signal Officer of the Army. After a year and a half in Chicago I was ordered back to Washington, D. C., with station at the Bureau of Standards, where I am at present nominally the commanding officer of the Signal Corps radio-laboratory, but practically engaged in experimental and research work entirely of a radio character.

Last summer, 1924, I was sent as a technical adviser to the delegation from the United States to the Pan-American Communication Conference held in Mexico City, Mexico, for two months or more. At the close of the conference I returned to my laboratory work at the Bureau of Standards. Shortly after the beginning of this present year, in addition to my duties at the Bureau of Standards I was appointed as Army liaison officer with the Naval Re-

search Laboratory, Bellevue, Anacostia, D. C., where I am also engaged in laboratory work, entirely along radio lines. At the present time, two days a week are spent at the Bureau of Standards laboratory, and four days a week at the Naval Research Laboratory.

2. Question. What are the relative advantages or disadvantages of connecting a detector at a receiver or spark gap at a transmitter in the antenna circuit, so that one terminal is connected to the antenna and the other to the earth, as illustrated, for example, diagrammatically at G and T in the schematic diagram of Marconi Reissue 11913 at the left hand side of plaintiff's Exhibit No. 99 on the one hand, and connecting the detector at the receiving station and the spark gap at the transmitting station in a lateral circuit inductively coupled to the antenna, as illustrated diagrammatically, for example, in the diagram Wireless Specialty Apparatus type, plaintiff's Exhibit 87, or for example, in the diagram, Foote-Pierson pack set, plaintiff's Exhibit 102?

Answer. Referring to Figure A, plaintiff's Exhibit 99, the left-hand figure illustrates a spark-gap transmitter in which one terminal of the gap is connected to an elevated capacity area *f*, and the other to ground or earth at *e*. The only known advantage that such a transmitter had was its ability to create highly-damped disturbances in the ether such as would be desirable in the case of distress messages so that a maximum of interference to radio communication might be brought about and attention attracted to the distress signal. In touching upon its sole advantage I have pointed out its great disadvantage for practical radio communication—namely, its high damping—resulting in unreasonable interference. Comparing this diagram with plaintiff's Exhibit 87, the left-hand figure, and with the left-hand figure of plaintiff's Exhibit 102, both of which indicate a coupling between the primary and secondary circuits, the latter two circuits employing a means for coupling the primary circuit to the antenna, represent a considerable advance in the art over the apparatus employed in Figure A, plaintiff's Exhibit 99, before referred to. This advantage lies in the fact that selectivity results from the use of coupled circuits, for where energy produced in the lateral circuit which is comparatively highly damped, can be communicated through proper coupling to an antenna system of much lower damping, the energy will be radiated from

[fol. 895] the antenna in purer form on a sharp wave in such a manner as to comply with the present law of the United States which require that the damping of the transmitter shall not exceed 0.2. The plain spark-gap apparatus illustrated at the left hand of plaintiff's Exhibit 99 (Marconi reissue 11913, 1896) can never be arranged to have so small a damping. Practically the employment of a circuit at the transmitter permits of the radiation of a single sharply tuned wave capable of giving the minimum amount of interference from such a spark system.

Referring now to the right-hand figure of Figure A, plaintiff's Exhibit 99, which indicates a receiving station where an imperfect contact device or coherer has one of its terminals connected directly to an elevated capacity area, its other terminal being connected to earth, and having further reference to plaintiff's Exhibit 87, the right-hand diagram of which indicates a coupled circuit receiver having a detector in a lateral circuit in inductive relation with an antenna circuit, and having reference also to plaintiff's Exhibit 102, the right-hand figure, illustrating also a receiving station having a lateral detector circuit inductively coupled to an antenna system comprising an inductance and antenna and an earth connection, again as in the case of the transmitter shown in plaintiff's Exhibit 99, lack of selectivity follows the use of a detector placed directly in the antenna circuit, as compared with the coupled receiving circuits illustrated in the right-hand figures of plaintiff's Exhibits 87 and 102, respectively.

This question of selectivity is one of the most important practical questions in radio communication. The ability to loosely couple the lateral circuit with the antenna circuit permits us to sharpen the tuning with reference to the station which we desire to receive; in other words, to select and receive without interference the signals from a certain station without interference from stations operating on a wave length fairly close to the station which we desire to receive. In a word then, low damping and selectivity are gained by using loose coupling in both transmitter and receiver circuit.

3. Question. What can you say as to the commercial importance and extent of use of connecting the detector at the receiver or the spark gap at the transmitter in the antenna circuit, as indicated in the Exhibit 99, left-hand figure, as compared to connecting the detector in a coupled

lateral circuit, as indicated in plaintiff's Exhibits Nos. 87 and 102?

Answer. The use of the spark gap directly in the antenna as compared with the use of a spark gap in a lateral circuit coupled to an antenna system from a commercial standpoint can scarcely be compared, for it was so early found that selectivity was essential and that the spark gap in the antenna failed to provide such selectivity that its use amounts to practically nothing, as compared with the use of the coupled circuit transmitter affording far greater selectivity. So far as the Signal Corps is concerned, I saw but few types of apparatus employing a spark gap directly in the antenna, ever even offered for test to the Signal Corps. Similarly, with reference to the receiver, the use of a circuit in which the lateral detector circuit was coupled with the antenna circuit has been almost universal, both in commercial and Army practice. In connection with some later testimony, I shall introduce in evidence some [fols. 896-897] official documents from the War Department showing the widespread use of apparatus from the very earliest days employing these coupled circuits.

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7. Question. Will you refer to the defendant's Exhibit B-4, Loftin sketch A, and to the defendant's Exhibit B-4, Inventions, Researches, and Writings of Nikola Tesla, and say whether in your opinion the Tesla article describes and illustrates in Figures 165 and 185 the subject matter of said Sketch A?

* * * * * * *

Answer. Having reference to the second figure from the left, or more properly speaking, the second circuit from the left, illustrated in Figure 165, I find that the organization of a transformer *T* having a primary supplied with power from an alternating-current generator *G*, said transformer *T* having its secondary windings *S* shunted by a fixed condenser C, said condenser C also forming part of what is known in the radio art as a closed oscillatory circuit comprising an inductance P and two spark gaps, the terminals or electrodes of which gaps are each marked *d*, and in inductive relation with another circuit consisting of an inductance S_1, each end of which is supplied with a conductor leading to something not shown in the diagram, Figure 165, corresponds exactly to the organization shown

in Exhibit R-4, otherwise noted as "Loftin sketch A," Tesla transmitter, with the exception of the fact that the secondary S_1 in Exhibit R-4 is connected to a capacity area P and an earth connection E. Considering also Figure 185 and the accompanying description on the same page, namely 348, Inventions of Nikola Tesla, I find that Tesla has described what might be termed a coupled circuit spark transmitter capable, if actually set up to-day, of transmitting radiotelegraphic signals of damped type. That Tesla actually foresaw what this device would do is evident from the language employed on page 348 referred to. He assumes a source of high-frequency alternating current connected to an elevated body of large surface P which corresponds exactly to the horizontal part of a modern antenna system, while the lower part of the source S_1 is connected to earth, as in previous pages of the book now under consideration; and with particular reference to Figure 165, as he has indicated in the text that any one of the sources [fols. 899-900] of high-frequency alternating current may be utilized in this connection, I am of the opinion that Mr. Tesla not only foresaw that his apparatus would result in the actual propagation of radio signals but he has also described how at a distance a similar apparatus comprising an elevated conductor of large surface connected through a suitably tuned circuit to earth could be utilized to receive the energy from the transmitter such as assembled by Loftin in Exhibit R-4, from a consideration of the Figures 165 and 185. Quoting this article, the writer states:

"When the electrical oscillation is set up there will be a movement of electricity in and out of P and alternating currents will pass through the earth converging to or diverging from the point C where the ground connection is made. In this manner neighboring points on the earth's surface within a certain radius will be disturbed. But the disturbance will diminish with the distance and the distance at which the effect will still be perceptible will depend on the quantity of electricity set in motion."

He then goes on to describe the tuning organization necessary to effect the reception of signals from the transmitter described, as follows:

"Now, it is quite certain that at any point within a certain radius of the source S, a properly adjusted self-induction and capacity device, can be set in action by resonance."

While Mr. Tesla's conception of the transmitter shows that he thought the earth necessary, as Marconi did, for the transmission of energy to distant points on the earth's surface, there to be received by a synchronous device consisting of an elevated capacity area of vertical wire connecting the same to tuning elements consisting of self-inductance and capacity and a suitable earth connection for the purpose of receiving and reradiating in the case of his power experiments the energy supplied from the original transmitter, nevertheless he has described in the parts of the book quoted a perfectly operable transmitting system with suitable tuning devices and with a suitable receiving device having tuned circuits. Whether Mr. Tesla intended to tune the closed circuit C-d-P to the open radiating system P-s-l-E illustrated in the combined sketch of what he proposed, Exhibit R-4, so that both circuits had the same time period of oscillation, or whether he intended to excite the antenna system, as we may call it, in a harmonic relation, is not known. That, however, is immaterial. He appreciated the necessity of synchronism and he taught the use of coupled circuits long before Marconi or Lodge.

I forgot to note that in both Figure 165 and Exhibit R-4 a switch is provided between the source of alternating current G and that primary of the transformer T; the diagram shows in both cases that both circuits may be interrupted so that signals could be sent with such a device whether only one blade of the switch were opened or both, thus affording a complete system for the transmission of radio signals.

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[fol. 901] 10. Question. What are the relative differences and advantages of the type of transmitting apparatus illustrated in plaintiff's Exhibit 87, wireless specialty type, employing a quenched gap, as compared with the open-gap, loose-coupled type of apparatus, illustrated at the right of plaintiff's Exhibit 99, Marconi 763772?

Answer. Referring to the type of transmitter shown at the right of plaintiff's Exhibit 99, Marconi 763772, I find an arrangement of circuits in which the primary transmitting circuit consists of a spark gap G, a condenser c, and an inductance of very few turns. This inductance is in relation with an inductance of more turns than that in the primary transmitting circuit and is referred to in the

figure as *d'*. This coupling inductance in the secondary or antenna circuit has one end connected to earth and the other end is connected to a variable contact *l* on a loading coil *g*, the upper end of which is connected by wire to an elevated capacity area *f*. Without referring to Marconi patent specification, my understanding is that what he was trying to accomplish was to secure the loosest possible coupling between the primary and the secondary circuits which would give him the most efficient radiation on a single wave from his antenna. In order that his primary circuit might be a persistent oscillator, he made the capacity *c* as large as possible and the inductance as small as possible for one reason so that the coupling between the primary and the secondary circuits might be reduced to the smallest practical value and still transfer energy to the antenna system which he loaded and adjusted to the period of the primary circuit by putting more or fewer turns between the variable contact *l* and the lead to the antenna. Moving this contact *l* had the effect not only of varying the time period of oscillation of the antenna circuit but also in a certain degree varying the coupling between the two circuits. By the arrangement described the primary circuit became a reservoir of energy which was slowly fed to the antenna with very loose coupling so that the energy in the antenna might be radiated most efficiently and not retransferred to the primary circuit, as would be the case if anything but the loosest coupling were employed in such a system,

[fol. 902] The desire was to secure the transmission of a wave having but a single frequency which was determined practically by the adjustment of the primary circuit. The energy in the antenna persisted only as long as the oscillations in the primary circuit existed. This I know is not in accordance with the idea introduced by Mr. Waterman, as illustrated in Waterman's sketch No. 2, which to the average student of the radio art is a diagram showing what happens not in the open-gap type of transmitting apparatus but what happens practically in the quenched-spark type of apparatus where in a very short period of time, practically when the first beat occurs between the primary and the secondary circuits, the energy in the antenna circuit persists for a long time while the energy in the primary or exciting circuit is wiped out after the first beat in practice. This does not accord with Mr. Marconi's

idea that his primary circuit must be a good reservoir to keep feeding energy to the antenna circuit. In the apparatus arrangement shown in the plaintiff's Exhibit 99, the left of Figure C, the desire of the inventor was to keep supplying energy just as long as possible from his closed circuit to his open circuit, whereas in the quenched-spark circuit, plaintiff's Exhibit 87, where a quenched-spark gap is employed, the object is to transfer the energy from the primary circuit in an extremely short time, open that circuit at the spark gap automatically after the energy is all transferred to the antenna system at the first beat, and let the antenna circuit continue to oscillate in its own time period of oscillation.

Referring now to plaintiff's Exhibit 87, diagram of the transmitting station, we find a somewhat different arrangement with respect to the gap employed and the coupling between the circuits, as illustrated in the diagram by the fact that there are more turns in common, more linking of lines of force—in other words, tighter coupling between the primary and secondary circuits than is desired to be obtained in the apparatu shown in plaintiff's Exhibit 99, Marconi 763772, at the left of Figure C. This desire for loose coupling in one case and close coupling in the other is what determines the principal difference between these arrangements. In the Marconi arrangement the pace-setting circuit is the primary circuit, whereas in plaintiff's Exhibit 87, diagram of transmitting station, the pace-setting of frequency-determining circuit is the antenna circuit. In the latter circuit it is entirely desirable, as before stated, that the energy be transferred as rapidly as possible from the closed oscillatory circuit to the open oscillatory circuit. The latter arrangement, that of the Wireless Specialty Apparatus Co., or the quenched-spark transmitter, which, by the way, furnishes excitation and which has been aptly termed "impulse excitation," has many advantages over the Marconi type of transmitter which caused it to supersede the plain spark-gap type of apparatus. In the first case of the Marconi apparatus a tremendous amount of the energy developed is wasted in the primary circuit where at the gap noise, heat, and light are produced and where the resistance of the circuit as an oscillatory circuit is comparatively so high that an immense amount of work must be done on that primary circuit itself, leaving less energy to be transferred to the antenna circuit to be used in useful

radiation, whereas in the quenched-spark type of apparatus the gap, due partly to its peculiar arrangement and construction and principally to the critical degree of coupling [fol. 903] employed between the primary and the secondary circuits, ceases to operate after the first beat when the energy in the primary circuit has fallen to zero and that in the antenna has risen to maximum, leaving the antenna circuit free to dissipate this energy as useful radiation, with the result that the energy was transmitted in practice to much greater distances with the quenched-spark apparatus employing a given amount of power in the input as compared with that distance which could be obtained by transmitting from the Marconi type of loosely coupled transmitter with the same power applied to the input. It is very interesting to note in this connection that there was a good old thumb rule that with one kilowatt in the input of a well-adjusted Marconi plain gap transmitter the distance obtainable in the daytime over the sea could be counted on as a hundred miles, whereas with the same input a quenched-spark transmitter with the same height of antenna when properly adjusted would give a range of 200 to 300 miles in daylight over the sea. I have made this comparison myself of the efficiency of the two types of transmitter, observing that with a given antenna, if four to six amperes could be put into the antenna circuit with the open-gap transmitter into the same antenna with the one kilowatt Telefunken quenched-gap set, I have put 15 amperes into the antenna. The Telefunken company claimed an over-all efficiency of 75 per cent, but in practice we figured the efficiency from prime mover to antenna was roughly 50 per cent—decidedly higher than ever could be obtained with the Marconi type of open-gap transmitter. The principal advantages in favor then of the quenched-spark type of apparatus was the fact that the over-all efficiency was much higher, the damping of the system much lower, the oscillations in the antenna more persistent, giving cumulative results at the receiving station, enabling better reception at longer distances to be carried out or obtained.

I should like to continue my testimony with reference to that particular question. In a loosely coupled circuit of the Marconi type, unless the circuits are closely coupled, beats do not occur as in the case of the quenched-gap sets between the primary and the secondary circuits, as they do

happen in a quenched-spark set when the circuits are necessarily tightly coupled. In practice we have found that the coupling in a quenched-spark transmitter must be about 20 per cent, but in the case of the quenched-spark transmitter it is to be noted that, due to the quenching action, even with this close coupling a wave of only a single frequency is produced, whereas if the open gap Marconi type of circuit were used with a tight coupling of say 20 per cent, two widely separated humps would be radiated or noticed with a wave meter as well as two widely separated frequencies received at the receiver from uch a tightly coupled Marconi transmitter. To repeat what I was saying about Mr. Waterman's sketch No. 2, I intended to convey the idea that that diagram closely resembled a diagram showing what happens in a quenched-spark set and also indicating that this is not my understanding of what occurs in the Marconi type of transmitter when loose coupling is employed and where, as may be shown by diagrams from well-known text books, the energy in the primary is never reduced to zero, nor does the gap cease functioning before the energy in the antenna is completely radiated.

[fol. 904] 11. Question. In practice how are the two types of apparatus above referred to calibrated?

Answer. In the case of the Marconi transmitter, by coupling the wave meter to the primary circuit and at the same time disconnecting the antenna and the ground from the antenna coupling coil and loading coil, if one be used, the primary circuit is excited and measurements made of the frequency or wave length turn by turn, as the inductance in the circuit is increased from a minimum to a maximum value. A table can be made or preferably a curve plotted showing the wave length corresponding to the various turns of the inductance. This curve, then, is a calibration curve of the primary circuit and enables the operator to determine at once what adjustment of the primary circuit is necessary in order to give a certain chosen wave length. To measure the antenna circuit, the antenna and ground are connected to the inductances while the coupling between the primary and secondary is kept at zero and the spark gap not actuated. A detector of the crystal type may be shunted around the antenna inductance which forms part of the coupling system and with a pair of telephone receivers shunted around the detector a wave meter using buzzer excitation may be used to excite the aerial, and as the

inductance in the antenna is varied turn by turn from no turns up to a maximum the wave length of the antenna system can be determined for each adjustment and another curve plotted, preferably on the same sheet as that on which the primary circuit calibration was plotted, with the result that the operator is now in a position to choose from his curves the exact adjustments necessary in each circuit so that the circuits may be adjusted to emit a wave of given frequency provided the coupling between the primary and the secondary circuits is maintained at a very small value, for in this case only with very loose coupling can the circuits be put in inductive relation with each other and be expected to emit but only one frequency. The law of the United States requires that transmitters of this sort, due to their bad adjustments in the early days, be so coupled and adjusted that they shall emit a pure wave; that is, a wave of a single frequency and without harmonics, and that the transmitter shall have a decrement, or emit a wave having a decrement of not over 0.2.

We must now consider how the operator goes about securing the emission of as pure a wave as possible. As I before described, the circuit which is the pace setter with this particular arrangement is the primary circuit. If tight coupling takes place, two waves are emitted, neither of which has the frequency of the wave to which the primary and the secondary circuits were both originally tuned. The operator therefore having the constants of the two circuits adjusted so that the product of L and C in the case of the secondary equals *of* the product of L and C in the primary circuit, the coupling between the two circuits is gradually increased until the energy transferred to the antenna is a maximum, while the wave meter in suitable proximity to the antenna circuit but not coupled to the loading coil indicates the existence of but a single humped resonance curve which meets the requirements laid down by governmental regulations. Such calibration should necessarily include the measurement of the decrement to be sure that the transmitter stays within but 0.2 prescribed by law. Now, in the case of the calibration of a quenched-spark transmitter, due to the peculiar difference between such a [fol. 905] transmitter and the open-gap type of Marconi transmitter, calibration can not be accomplished quite in the same way as that prescribed. What the operator really needs to know in this case is the adjustment he must make

in order that when real quenching takes place in the gap a wave of a certain definite frequency or length, say 600 meters, will be emitted from the set. Likewise, he wants to know what adjustments in turn he must make so that waves of 700 or 800 meters may be radiated with a maximum efficiency. In this case it is highly essential that the calibration of the antenna circuit be accurately determined, since in this case it is this circuit which determines the frequency of the radiated wave. The method for determining the wave lengths corresponding to the various settings of the inductances in the antenna circuit may be determined practically along the same line as outlined for the calibration of the antenna circuit of the plain gap transmitter; that is, by using the antenna circuit as a receiving antenna to which is connected around a few turns of the inductance a crystal detector shunted by a pair of telephone receivers with which signals are received from a buzzer-driven wave meter and the wave length or frequency corresponding to each setting of the loading coil or other antenna inductances noted and then plotted in the form of a curve, if necessary showing what adjustments in the antenna are necessary to have that antenna oscillate at any given frequency.

The secondary circuit throughout these measurements has been completely separated from the antenna circuit so that there shall be no mutual inductance between the two. It is not absolutely essential that we calibrate the primary circuit, although this may be done with a view to determining about what adjustments are necessary so that a wave of given length may be emitted by the primary. Such calibration would be of little use if we were then to couple together the primary and the secondary circuits with say 20 per cent coupling, which is approximately the amount needed for the proper operation of a quenched-spark transmitter if the quenched spark replaces the open spark. What practically happens is that the primary circuit is adjusted for a given wave length and the secondary circuit, more or less in tune with the primary, is given the proper degree of coupling with the primary, and then final adjustments are made for the critical coupling necessary, as well as for the final determination of the frequency of the primary circuit, necessitated by such close coupling in order that when the energy is transferred from the primary to the secondary circuit proper quenching may take place and but a single wave of very low damping be emitted. This last adjustment

may cause the primary and the secondary to be slightly out of tune with each other, as can be demonstrated by a measurement of the primary if the antenna and ground be disconnected.

So therefore a table of adjustments for various frequencies or wave lengths can only be correct if the practical degree of coupling can be determined and recorded. We might even say that with a quenched-spark set, that there really is only one circuit oscillating when efficient radiation is taking place, because, due to the fact that beats take place between the currents in the two circuits while the energy is being transferred from the primary to the secondary circuit when the proper coupling has been [fol. 906] found, the energy in the open circuit will be found to be a maximum when the energy in the primary or closed circuit is found to be a minimum and the gap ceases to function when the first beat takes place and the energy in the antenna due to radiation and other causes is gradually dissipated, but making many more swings or oscillations before the current in the antenna is reduced to one-tenth of its maximum value than can ever hope to be produced by means of the Marconi open-gap transmitter.

12. Question. In the next to the last paragraph of your last answer beginning "The secondary circuit through etc.," you used the term "secondary circuit" and "primary circuit." Will you please read over this part of your answer carefully and indicate whether these terms in this part of your answer are intended to indicate the antenna circuit or the lateral circuit?

Answer. As I have been considering only the transmitter, the term "primary circuit" is used to indicate the lateral circuit, and the "secondary circuit" in this case is to be understood to mean the antenna circuit. I see that I have made an error and said something which I did not mean in the second line of the second paragraph on page 1038, where the word "antenna" should read "primary." Likewise, I notice another error which I request corrected—the word "primary," seventh line, second paragraph, page 1038, should read "secondary." I notice other errors, and I request that the second paragraph on page 1038 be rewritten to read as follows:

"The secondary circuit throughout these measurements should be completely separated from the antenna circuit so that there can be no mutual inductance between the

two. It is not absolutely essential that we calibrate the primary circuit, although this may be done with a view to determining about what adjustments are necessary so that a wave of given length may be emitted by the secondary. Such calibration would be of little use if we were then to couple together the primary and the secondary circuits with say a 20 per cent coupling, which is approximately the amount needed for the proper operation of a quenched-spark transmitter. What practically happens is that the secondary circuit is adjusted for a given wave length and the primary circuit, more or less in tune with the secondary circuit, is given the proper degree of coupling with the secondary and then final adjustments are made for the critical coupling necessary, as well for the final determination of the frequency of the primary circuit, necessitated by such close coupling, in order that when the energy is transferred from the primary to the secondary circuit, proper quenching may take place and but a single wave of very low damping be emitted. This last adjustment may cause the primary and the secondary to be slightly out of tune with each other, as can be demonstrated by a measurement of the primary if the antenna and ground be disconnected."

13. Question. What has been the extent of use in the wireless art of the two types of apparatus referred to in question 10?

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Answer. So far as the Army is concerned, once the efficiency of the quenched-spark transmitter as compared with the open-gap Marconi type of transmitter was demonstrated, the Army as fast as governmental appropriations allowed, started to install in both its fixed and mobile stations apparatus of this type. The reason that there are [fol. 907] still in existence a number of the old open-gap Marconi transmitters is probably a question of funds on the part of shipowners who still cling to this old type of apparatus because they can not afford to make replacements. The fact that the Marconi company itself saw the advantages of the quenched gap is evidenced by the fact that they manufactured sets of this type such as that furnished to the Signal Corps, and referred to in my answer to question 9. My general impression is that as far as possible, considering the patent situation, the quenched-spark

gap was installed in preference to the Marconi open type of gap set in the commercial field, as well as in the Army and Navy, which, it must be pointed out, have in this country been two of the biggest factors in the development, use, and encouragement of radio that the country has ever known. I may add that these quenched gaps were usually supplied with 500-cycle generators, which produced a musical spark which was much better for the receiving operator, since he could read it with greater ease through static then he could a low rumbling note of the spark sets of Marconi type which were not at all easy to read through even a small quantity of static when separated very far from the receiver. I should also like to point out other advantages which induced commercial companies such as shipowners to purchase quenched-spark apparatus. Among other things it was found that with the Marconi type of transmitter, due to the type of transformer employed and the nature of the circuits themselves, as well as the kind of gap employed, high voltages were set up which had a tendency to break down antenna insulators and generally develop insulation faults, whereas with the quenched-spark type of transmitter the voltages developed were comparatively lower with decreasing losses due to broken insulators and other ruptured insulation. For these same reasons the Army and the Navy adopted the quenched-spark gap about the year 1909, as I have before pointed out.

14. Question. Will you refer to Figure 1 of the Fleming patent 803684 and state whether or not two-element vacuum tubes, such as illustrated in this figure, for example, have been used in practice in the Signal Corps, so far as you know?

Answer. To the best of my knowledge and belief, the Signal Corps never has had one of these tubes operating at any time in any of its circuits. The device apparently offered no advantages over the instruments in use, and while I am quite satisfied that our radio engineers were cognizant of the trials of this detector elsewhere, none was ever purchased for use in the Signal Corps.

15. Question. What type of vacuum-tube device has the Signal Corps always used, so far as your knowledge goes.

Answer. The Signal Corps has always used a three-element tube, and as I have been with the Signal Corps ever since the first tubes were used I feel that I have first-hand knowledge of the various types of tubes, or, I should

say, various makes of tubes of three-electrode type, which have been put into practical use in the Army of the United States.

16. Question. Will you give a brief historical statement indicating the development of the wireless art and the chronological introduction of important development?

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[fol. 908] Answer. As I look back over the period from 1899 to the present day, during which period I have been in touch with the development in the art of radiotelegraphy, partially through the reading of literature, the study of text books, the examination of apparatus submitted to the Government department by various native and foreign commercial concerns, there are certain outstanding steps of progress marking epochs which we are better able to evaluate looking backward than we could at the instant of the development of each. The contribution of Mr. Marconi in gathering together and combining in a working apparatus the coherer of Branley and the receiver of Popoff together with the transmitter of Hertz, as put into practical form by Tesla, formed the first step in the practical system about the year 1896. The introduction by Lodge of tuning elements was the next step, which at that time, looking forward instead of backward, appeared to be a wonderful advance which Marconi was glad to incorporate in his four-circuit patent to a certain extent, but which syntonic arrangements had been described before by Tesla and others. The Signal Corps itself was not behind in the development of radio. The development of radio in the Signal Corps in its early days can be shown by extracts from the report of the Chief Signal Officer, and it is interesting to note from these reports that in the year 1901 he states, "In wireless telegraphy the Signal Corps has perfected its own system, which was the first one ever successfully operated in the United States, on September 30, 1899, between Fire Island and Fire Island Lightship, a distance of 10 miles."

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Continuing with reference to extracts from the report of the Chief Signal officer of the Army indicating how the art developed a perusal of the reports for the years 1901, 1902, 1903, and 1904, shows the early efforts of the Signal Corps to established communication over a distance of ap-

proximately 100 miles in Alaska, and how the Signal Corps attempted to make contracts for Fessenden and Marconi apparatus which would give them effective working at this distance, or similar distances; how the DeForest system was used during the Army and Navy maneuvers on Long Island in the year 1903, the messages being received by telephone and the De Forest responder. An interesting extract from the report of the year 1904 is the following:

"Owing to the repeated failure of several wireless telegraph companies to furnish a reliable and satisfactory system of wireless telegraphy in Alaska over a distance of 100 miles, the Chief Signal Officer decided in 1903 to have all existing systems examined with reference to their practical qualities. He decided to obtain by elimination, substitution, or invention some system for Army use which would embody qualities necessary for the reliable and successful transmission of messages."

[fol. 909] This report is practically a résumé of what was done from the year 1899 to the time the report was written and shows that the Signal Corps tested a Braun-Halske field wireless train and that—

"Experiments were carried out under Captain Wildman's personal supervision during the past year with instruments purchased from the Lodge-Muirhead Wireless Telegraph Co. (Ltd.), of Great Britain; the Braun-Siemens-Halske Wireless Telegraph Co. of Germany; the National Electric Signaling Co., of Washington; and from the De Forest Wireless Telegraph Co. of New York.

"Experimental apparatus were purchased by the Chief Signal Officer from time to time in addition to the instruments furnished by companies and individuals; comparative tests were also made with all obtainable receivers, responders, and coherers on the market as well as with many different types of special appliances, particularly those in the Stone-Stone system.

"Notwithstanding the popular idea with wireless telegraphy over great distances is an accomplished fact, none of the systems investigated proved satisfactory for Army use."

This is a commentary on the state of the art for the year 1904, where manufacturers could not be found who could furnish apparatus satisfactory to give communication at 100 miles.

The Signal Corps then from the record, supported by the photographic evidence already introduced, being Exhibit No. H-5, developed its own system, employing an open-spark set with linking coils or leading coils for tuning purposes in both transmitting and receiving circuits. The detectors used were practically all the electrolytic type until the crystal detector came into general use because of its decided advantages about the year 1906. This practice of substituting crystal detectors for others was not confined to the Army and Navy of the United States, but spread rapidly all over the world in commercial as well as governmental practice. A real step in the wireless art was taken when the efficient quenched-gap apparatus came into use in 1909. The advantages of this apparatus over the open-spark type of apparatus have been pointed out before, namely, higher overall efficiency resulting in greater distances, the radiation of a pure single wave instead of the highly damped, that is to say, comparatively highly damped, waves of the old spark-type transmitter.

Quite another distinct step of importance occurred about 1913 with the introduction of continuous-wave telegraphy, and while various advances have been made in this art by the introduction of the arc, the alternator, and means of reception for continuous waves, nevertheless the greatest progress ever made in the art of radiotelegraphy was the introduction of the three-electrode vacuum tube, about which the whole radio art to-day revolves. The enormous progress in radio since its introduction far outshadows not only the work of Mr. Marconi but Hertz himself. The advance made by Mr. Marconi over his predecessors, including Hertz, can not in any way be compared to the wonderful advance made by the introduction of the three-electrode tube. To-day we find tubes of 80 kilowatts being manufactured for transmission purposes. The whole real practice of radiotelephony has grown up about this tube, and because of its amplifying power it in turn made possible generation of high-frequency oscillations not obtainable by any other method. The arc and the alternator had their place, but the frequencies which they could use were so limited [fol. 910] with reference to those which can be produced simply by the three-electrode vacuum tube that we can almost say that radio was really born when the three-electrode tube arrived.

As for the remarks made by counsel for the plaintiff regarding my competency as a witness concerning the progress of the art, outside of what was done by the Signal Corps, I should like to state at this time that my observations as to actual transmission and reception systems has by no means been confined to the apparatus and stations used by the Signal Corps. I have seen many commercial ship and shore stations, and it is interesting to note that the only time I ever saw a two-electrode Fleming valve was in the Marconi station located in the Wanamaker Store, New York City. It is also interesting to note that on this occasion the receiver used contained two of these vacuum tubes. The most interesting thing in connection with this visit was the fact that the operator was using a crystal detector instead of the vacuum tube for receiving from Philadelphia. About the same time I had occasion to visit the De Forest station in this city and the station, which I believe was Marconi, established on the Waldorf Hotel. During the course of my official duties, as I have stated, I have seen many commercial stations not only in America but in Mexico, France, Germany, and England. In addition, I have paid visits to many of the wireless telegraph and telephone stations established in this country. While visiting the stations at Nauen, Ste. Assize, Bordeaux, Lyons, the Eiffel Tower, and both commercial and governmental stations in England as well as in Mexico, I have been accompanied by some of the greatest radio engineers in the world, who have carefully gone into explanations concerning the apparatus and connections used in each case. Hence I believe that I am quite well qualified to talk about the facts connected with radio development in the commercial world. In my position as executive officer of the engineering and research division of the Signal Corps for four years, it was my duty to visit practically all of the manufacturing plants of radio apparatus in the United States in which I have followed the progress of the art by an examination of the apparatus which they were building, some of which was later used by the United States and a great part of it by commercial companies.

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17. Question. Is the two-electrode vacuum tube inherently capable of either amplifying or oscillating?

Answer. The two-electrode tube is not inherently capable either of amplifying or oscillating. I have made some ex-

periments bearing on the subject as to whether or not the two-electrode tube will oscillate or amplify, and, leaving aside for a moment consideration of the question as to why the two-electrode tube has not the inherent qualities of amplification in the production of oscillations, I wish to state something concerning the experiments which I have performed to determine the oscillating and detecting qualities [fol. 911] of a two-electrode tube. It has not been my good fortune to be able to secure for examination any "soft" or gas filled two-electrode tubes made by the Marconi company. My examinations have been confined to the operation of a modern hard two-electrode tube, placed on the market about a year ago, for use as a detector only, and also to some old De Forest tubes of the type known as the "amplifier" tube, which was a tube produced by De Forest some time after his first "soft" audion detector tubes appeared on the market. By the time De Forest produced these tubes he had learned more about the art of producing a vacuum in the tube. Hence these tubes which I have examined are somewhat harder than the first tubes which he sold for detector purposes, but as his methods of pumping even then were not as good as they are to-day, these tubes which I have examined in some cases to which I will refer are what might be termed "semi-soft" or "semi-hard."

During the course of my experimental work I produced sketches showing Figures 1 to 8, inclusive, to which I shall refer in the course of my remarks. Using first the so-called "Diode" two-electrode tube placed on the market perhaps a year ago as a detector, I set up a circuit illustrated in Figure 1, marked "Mauborgne's sketches, Figure 1" in which a tuned oscillatory circuit consisting of inductance L and condenser C_2 which was variable is connected to a variable condenser C_2 through the plate P of the two-electrode tube, the other side of inductance L being connected to the filament at one point, the filament F being lighted in the usual way by a battery having a variable resistance in series for the control of the filament current. Telephone receiver T, as shown in the sketch, had one of its terminals connected to the same point of the filament battery while the other terminal of the telephones was connected to the minus terminal of the battery B, which could be varied from zero to 44 volts at will. The plus side of the B battery then passed, or was connectee to, the high-frequency choke,

marked "HF choke," the other terminal of which was connected to plate P. The manufacturer stated that the filament current would be correct if one and a half volts were applied to its terminals; however, I varied the filament voltage from 1.3 10 to 4 volts and varied the B battery voltage from zero to 44 volts, and secured no oscillations of any character, the device simply working as a detector even with a maximum variation of voltages indicated. In this particular case the tuned circuit L–C_1 had its constants so chosen that the wave length could be varied from approximately 400 to 700 meters, while the condenser C_2 had a range varying from 0.00002 to 0.007 microfarads. This large range was not obtained with one variable condenser, but substitutions of condensers were made giving the range indicated. As the apparatus was connected to real antenna and ground, incoming signals were detected and it was found that for detection filament voltage should be 1½ volts, but the most important thing that was discovered was the fact that as the voltage of the battery marked "B" was reduced step by step from 44 volts to zero, the detecting qualities of the circuit improved until it was found that the best signals were obtained when there was no "B" battery at all. Further elimination of the high-frequency choke, as would naturally be suspected, and the connection of the telephone T directly to the plate P gave the best received signals of all. It was to be noted that a considerable capacity existed across the telephone due to the particular kind of [fol. 912] jack used to connect the telephones to the rest of the circuit. Here at once we find one difference between this sort of two-electrode tube which in two ways can be identified as a very hard tube, and the three-electrode tube. I never yet have seen a three-electrode tube operated as such where the addition of a proper amount of "B" batteries did not increase the signal strength. It is to be noted that my Figure 1 does not differ materially from defendant's Exhibit "B," Fleming two-element valve. We know that this is a hard tube, because the magnesium flash used in the final stages of the evacuation of the tube is visible in the tube itself, and the fact that no blue glow or ionization could be obtained with plate voltage up to 44 volts is a good sign that it is a hard tube. The circuit shown in Figure 1 entirely disconnected from antenna and ground could not be made to oscillate.

In Figure 2, A shows the antenna, C_1 a series condenser connecting the antenna to the inductance L, the other end of which inductance was connected to ground G. C_2, P, F, HF choke, B, and T are reference letters which pertain to similar elements already described in Figure 1. With the filament voltage varied from 1½ to 4 volts and the plate voltage varied from no volts to 44 volts, the tube could not be made to oscillate.

Having reference now to Figure 3, the fixed high-frequency choke used in the two preceding experiments was replaced by a tuned high-frequency choke, marked in the drawing "Tuned HFC," consisting of inductance L_2 and C_3, the constants L_2 and C_3 being chosen so as to cover the range of wave lengths known to be possible to receive with the antenna circuit. The other letters in this figure designate similar elements to these similarly marked in Figure 2. No oscillations could be produced in this case.

Having reference now to Figure 4, which is similar to Figure 2 with the exception that the "B" battery B and the high-frequency choke have been removed, and the terminal of the telephones, formerly attached to B, has been directly connected to plate P. This circuit was then used for the reception of distant signals in order to determine the comparative value of this two-electrode tube as a detector, since it has no other function with a crystal detector used in practically a similar circuit, illustrated in Figure 5, of Mauborgne's sketches.

In Figure 5, A, C_1, L, designate the same elements used in Figure 2. D represents a detector of the iron pyrites variety which has been standing in the dust of the laboratory without cleaning for a number of months. T are the telephones, as in Figure 2. A comparison without an audibility meter showed that for given signals the detector of the crystal type was much superior to the two-electrode tube.

An audibility meter was then introduced, first in Figure 4 and then in Figure 5, or rather in the apparatus so connected, and measurements made on incoming broadcast signals, with the result that with the same signal an audibility of seven was secured for the two-electrode tube detector, as compared with an audibility of thirty for the Pyron detector, which is the trade name for the iron pyrites detector used. This demonstrates that a two-electrode hard tube is nothing but a detector, that it can not oscillate, nor, con-

versely, can it amplify. Also that as a detector it is far inferior to the crystal type of detector.

The next experiments were performed with an old De Forest semi-soft so-called "amplifier" tube having a Tungsten filament which the manufacturer stated could never be [fol. 913] operated with a greater filament voltage than 3½ volts without threatening the life of the tube. In this experiment this De Forest tube was connected up in the circuit shown in Figure 6, where F is the filament of the tube, P represents the plate which in this case really consisted of the plate and grid of the three-element tube connected by a wire so as to form but one element. L_2 and L_1 are inductances variable in character, while C was a variable condenser covering a considerable range. This particular diagram is one described in British patent 72 08 (January 1, 1908), S. Eisenstein, shown on page 56 of Scott Taggart's book Thermionic Vacuum Tubes and described as being a method for producing oscillations with a two-electrode tube. Using a wide range of filament voltages, capacities, and variable inductances, both in L_1 and L_2 as shown in the diagram, no oscillations could be obtained. Coupling between L_1 and L_2, variable in character, was tried without success.

In all the foregoing experiments a heterodyne wave meter near by, supplied with telephone receivers, was used to determine whether or not the circuits under test were actually oscillating or not. In a later test the exact circuit shown in defendant's Exhibit "B," Fleming two-element valve, was set up, and an antenna and ground connected thereto in the manner indicated in Figure 7 of Mauborgne's sketches. The only difference between this and Mauborgne's sketches, Figure 1, is the introduction of the variable condenser C_3, so arranged as to shunt or by-pass the high-frequency choke, the B battery, and the telephones. In these experiments I used a three-electrode De Forest tube, which was known as the De Forest amplifier tube, 3½ volts, Tungsten filament, and which as I have described, stands in an intermediate position between the early "soft" tube of De Forest and the very hard tubes of to-day. Some 25 tubes of this type were available, being fortunately found in the garret of the Bureau of Standards, where the obsolete apparatus has been lying for some time. Some of these tubes were found to be inoperative due to burned-out filaments. Ten good ones, however, were then taken for test and used in each case exactly as in Figure 7. The

values of L_1 and C_1 were so chosen that the circuit which they formed covered a range of from 400 to approximately 700 meters. Variable condenser C_2 had a maximum value of about 0.0016 microfarads, while the condenser C_3 had about the same maximum value. The high-frequency choke was the same one which was used in connection with the experiments described as relating to Figures 1 and 2. The B battery voltage could be varied from zero to 66 volts, while the filament voltage could be adjusted from 2 to 8 volts. With this circuit I succeeded in obtaining oscillations after the greatest possible difficulty experienced in adjusting B battery voltage and the filament voltage. I was able to obtain oscillations, however, over only a very limited part of the wave length range of the tuning system. Each time I threw the circuit out of adjustment and tried to get it to oscillate again caused me a considerable amount of fussing, indicating the unstability of the arrangement and its inoperability in the hands of the average operator. With the circuit oscillating as determined by listening in on a Navy type 1420–C receiver nearby, after a very short time in each case I noticed that the oscillations of the circuit would cease of their own accord. This could not in any way be imputed to the change in the batteries themselves or in their voltages, for I took the precaution to see that [fol. 914] I had new B batteries and storage batteries for the filament which were well charged. This instability then must be inherent in the tube itself, and undoubtedly is due to the varying condition of the gas in the tube. I have said in the beginning that these are semisoft tubes, and I am convinced that they fall in this class. The blue glow was set up in this tube, which I should have stated was numbered 17, when a plate voltage of 18 volts was applied, showing that this tube was comparatively soft. It was also noted that where after a good deal of struggling and most careful adjustment of filament and plate voltage that the oscillations occurred just about the place where the tube was about to show, or would show, a blue glow. Increasing the voltage of the B battery naturally stopped the tube from oscillating. As with the Diode tube in the earlier tests, when this De Forest tube with its grid and plate connected to form one plate was used as a two-electrode tube and actual signals were received, the signals were found to be a maximum and the detector action best when the B battery and the high-frequency choke were entirely removed and the

telephones connected directly to the plate P and the filament. I was unable for the particular signals being received on a wave length of 469 meters to make the tube oscillate; hence could get no advantage out of the freak action of this gas-filled tube which would oscillate only at certain narrow bands of frequency.

The other nine tubes of De Forest type were then one after the other put into the circuit shown in Figure 7, and the results may be briefly described as follows:

No. 2 tube: This tube oscillated with just about as much difficulty as did the preceding tube No. 17. It was equally unstable and the oscillations were obtainable only over a very narrow band of frequencies, as in the first case. This tube also was found to contain a considerable amount of gas, since the blue glow was produced with a plate voltage of 18 volts. None of the remaining tubes, numbered respectively 7, 8, 18, 20, 1, 14, 25, and 19, could be forced to oscillate by any combination of changes which could be made in the filament or B battery voltages, or otherwise. All of these were apparently harder tubes than tubes numbered 2 and 17 with which the oscillations were produced for the reason that not less than 40 plate voltage was required to produce the typical blue glow, and in some cases close to 60 volts was required before this condition obtained. It is to be noted that throughout the course of the examination of all these De Forest tubes, including those numbered 2 and 17, which produced oscillations, the filament voltage had to be between 6 and 8 volts instead of 3½ advised by the maker as the upper limit of voltage to be used. These tubes were burned so brightly that their life has been considerably shortened, and from my knowledge of other vacuum tubes no doubt the emission has been greatly reduced by running them at this excess temperature. Such an arrangement for the production of oscillations is too unstable and too costly and too inefficient, even when such oscillations can be obtained.

The experiment of the 13th of March, 1925, using the Diode tube which I described in connection with Mauborgne's sketches, Figure 1, was repeated with this same Diode tube, which it will be remembered was found to be a [fol. 915] hard two-electrode device, but referring to Figure 8, which shows the diagram of connections used in this last test, the addition of a variable condenser C_3 was made to the circuit of Figure 1, so as in every way to duplicate the ar-

rangement described by Mr. Waterman in connection with defendant's Exhibit B, Fleming two-element valve. This variable air condenser C_3 had a maximum value of 0.0016 microfarads. The results of the test of this circuit were similar to those described in connection with Figure 1. As the tube was a hard tube no oscillations could be produced, using a wide range of filament and plate voltage. Also it was again found that the best detection occurs when the plate battery B and the high-frequency choke are entirely removed from the circuit and the telephone receivers connected directly to the plate. In this case, however, the telephone receivers continued to be shunted by the condenser. Starting with zero plate voltage when the circuit arrangement was as shown in Figure 8, and increasing this voltage progressively by steps of two volts, showed a gradual falling off of signal strength from the loudest signals where no voltage was applied to a minimum where the B voltage was 22 volts. To show the effort that was made to obtain oscillations in these circuits, I wish to state that unfortunately I burned out two Diode tubes testing them in the circuit of Figure 8 by applying filament voltages in excess of that stated by the maker as the correct voltage to insure proper operation and expected life of this tube.

To return now to question 17, I wish to state that the two-electrode tube is not inherently capable either of amplifying or operating and, to the best of my knowledge and belief, never has been used in either of these ways in either commercial or governmental communication systems. The literature of the art points out the well-known fact which is known to all radio people, by which I mean not only engineers but operators and others concerned with the care and operation of radio stations, that a two-electrode tube can not be used for anything except straight detection, and by that I mean the rectification which is accomplished by a unilaterally conductive device, such as this two-element tube, or the well-known crystal detector. Nobody that I know of ever proposed to use this tube for amplifying purposes, and as an oscillator, as we glean from the writings of a number of authorities, the hard two-electrode tube simply will not function, whereas a two-electrode tube containing a certain amount of gas, preferably a considerable amount of gas, may be forced by the application of excessive amounts of both filament and plate voltage to cause a change in its characteristic curve, which is normally a rising one,

so that for a time, and with a very critical voltage applied, this tube may have its characteristic changed to a negative one, and thus, exactly like the arc, produce oscillations if the operator is extremely expert and has enough patience and happens to possess a tube in which this change of characteristic can be brought about. Thus there is possible in a few rare freak cases the production of oscillations with a two-electrode gas-filled tube which might suggest that it could be used as an amplifier. No such amplifier action has ever been put into shape for practical use that I know of, nor can I conceive how an audio-frequency amplifier using a couple of these two-electrode gas-filled tubes could be made to successfully operate.

[Vol. 916] While the three-electrode tube has been known to be an extremely stable amplifier—that is, a device by which an alternating current of radio or audio frequency applied in the input circuit, namely, the circuit connecting the grid to the filament, produces in the output circuit due to the additional voltage supplied in that circuit locally a much greater degree or amount of power which can be used either to be returned to the grid for the purpose of reinforcing the alternating current supplied to the grid circuit by the antenna or other source, and in this way producing oscillations of very stable character and easily produced over a wide range of frequencies, or the output of the power circuit can be supplied in the case of a radiofrequency device to a detector circuit where another tube or crystal detector can truly rectify the high-frequency oscillations and produce readable signals.

The three-electrode tube then as an amplifier, while having a rising characteristic, produces amplification due to the fact that the energy supplied by the grid needs simply be applied as a potential on the grid, whereas by the assistance of a suitable B battery in the plate circuit, the alternating current, making the grid first positive and then negative, is exactly reproduced as to character and frequency in the plate circuit in an exalted degree due to the application of the proper amount of plate voltage.

To conclude, then, the experiments which I have described simply bear out what the average radio man knows and which has been covered in a number of places in text books and other publications, namely, that there is a distinct difference between a two-electrode tube of the Fleming type, which was a gas-filled tube, and the three-electrode vacuum

tube, whether of the hard or soft type. A further distinction occurs with reference to the two-electrode hard tube which has a rising characteristic only, which can not be changed as can the characteristic of some two-electrode soft tubes. The two-electrode tube is simply a detector or rectifying device, whereas the three-electrode tube can be at once detector and amplifier or oscillator, or a combination of oscillator and detector. It is the one device on which the modern practice of radio is founded.

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Defendant's counsel offers in evidence the following publications and drawings referred to by the witness:

Pages 22 and 23 of the report of the Chief Signal Officer for the year 1901, marked "Defendant's Exhibit I-5."

Pages 46 and 47 of the report of the Chief Signal Officer, for 1902 marked "Defendant's Exhibit J-5."

[fol. 917] Pages 18 to 21, inclusive, of the report of the Chief Signal Officer for 1903, marked "Defendant's Exhibit K-5."

Pages 38 to 41, inclusive, of the report of the Chief Signal Officers for the year 1904, marked "Defendant's Exhibit L–5."

Page 56 of Thermionic Tubes, by John Scott-Taggart, published at London, 1921, marked "Defendant's Exhibit M–5."

Three sheets of Mauborgne's sketches, Figures 1 to 8, inclusive, and the same are marked "Defendant's Exhibit N–5."

Defendant's counsel also offers in evidence the chart "G. W. P. 10A Pickard Chart" forming part of the stipulation entered into, March 13, 1925, covering the stipulated testimony of Doctor Pickard, said sketch being marked "Defendant's Exhibit O–5."

Defendant's counsel also offers in evidence United States patent No. 627650, granted June 27, 1899, to G. Marconi, referred to in the deposition of Loftin, and the same is marked "Defendant's Exhibit P–5."

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18. Question, Referring to the experiment in which you connected up the two-element tube in the circuit of your Figure 6, how did you happen to take this particular circuit, which I understand is the same circuit as shown in the figure on page 56 of the Scott-Taggart book?

Answer. I search the literature of the art through many volumes before I could find that any writer had ever asserted that a two-electrode tube would oscillate, and this circuit referred to is the only case that I could find where anybody ever attempted to illustrate a circuit which purported to produce oscillations using a two-electrode tube. I was simply curious to find out, in spite of my feeling that this circuit would not operate, whether or not the man who patented the device or circuit really had an operable arrangement. My experiment simply confirmed my belief that the circuit would not operate, although I made every effort to have it do so.

19. Question. You have referred to the fact that these two-element tubes acted as detectors. Will you explain the action you referred to when you speak of detector action?

Answer. By detector action I mean that the device called a rectifier, whether it be a two-element tube or a crystal detector, simply rectifies the incoming alternating current by reason of a peculiar curve of the rectifying device itself, from which it can be determined that an incoming modulated signal, let us say, either at the transmitter or at the receiver, is converted by the rectifying device into an audible signal due to the fact that the rectifying device conducts current better in one direction through it than it does in the other. Practically speaking, the action of the detector, due to this unilateral conductivity, is to distort the incoming signal by cutting off the oscillations which would tend to pass through the detector in one particular direction, leaving the other half of the oscillations to actuate the dia- [fol. 918] phragm of the receiver. This is straight detector action and does not involve amplification in any way.

20. Question. Is there a resonant transfer of energy from the primary or lateral circuit to the secondary or antenna circuit in the quenched-gap type of transmitter, as, for example, the wireless specialty apparatus type, plaintiff's Exhibit No. 87?

Answer. No, there is not a resonant transfer of energy from the lateral circuit of the quenched-spark transmitter to the antenna circuit. This transfer of energy was practically one accomplished by brute force, and not at resonant frequencies, for in this case the energy is transferred from the lateral circuit to the antenna circuit at two frequencies, neither of which corresponds to the wave length emitted by the transmitter. The lateral circuit and the antenna cir-

cuit are not necessarily so adjusted that the time period of oscillation is the same in each of these circuits. In other words, that the product of L and C in each circuit is the same. The object is to transfer the energy from the lateral circuit to the antenna circuit in the shortest possible time and then stop the lateral circuit from oscillating, which is usually accomplished when beats are set up due to the fact that there are present two frequencies differing by a certain amount, hence not resonant. In this type of circuit, as compared with the open-gap type of transmitter of Marconi, it is highly desirable that the lateral circuit shall not persist in oscillating after it has transferred its energy to the antenna circuit at the end of the first beat. In practice we must be able to make such adjustments of the antenna circuit which is the frequency-determining or pace-making circuit upon which depends the frequency of the wave emitted. In this case the lateral circuit must be so coupled to the antenna circuit that it will transfer its energy in the shortest possible time to the antenna circuit, which is quite the opposite effect from that desired when adjusting the open spark gap set of the Marconi type. The word "tuning" is used loosely in connection with the adjustment of the circuits of a quenched-spark transmitter so that the apparatus may emit one single persistent wave. It does not mean the adjustment of one circuit to the same time period of oscillation as another in this regard, but it means the making of all adjustments including the adjustment of the values of L and C in the lateral circuit as well as in the antenna circuit, and the adjustment of the coupling to so tight a degree that the energy is transferred to the antenna circuit at two frequencies not the same as each other but differing by such an amount that beats between the two frequencies set up will assist in the operation of quenching out or preventing the further supply of energy from the lateral circuit to the antenna at the end of the first beat so that the energy may be radiated from the antenna at the predetermined frequency which is not the frequency of either of the two high-frequency oscillations by means of which the energy is transferred from the lateral circuit to the antenna.

21. Question. Is there a resonant transfer of energy from the primary or lateral circuit to the secondary or antenna circuit in the Marconi open gap loosely coupled transmitter,

as, for example, the right-hand figure in plaintiff's Exhibit No. 99, Marconi 763772?

Answer. Yes. With this arrangement it is essential, first, that the lateral circuit have its time period of oscillation accurately adjusted to the time period of oscillation of the [fol. 919] antenna circuit in order that efficient radiation may take place in this type of transmitter. Secondly, the coupling must be the least possible so that there may not be produced two frequencies in both circuits—lateral and antenna—neither of which frequencies is in resonance with or the same as the resonant frequency to which the lateral circuit and the antenna circuit are first adjusted. Third, it is necessary that the lateral circuit with its open-spark gap be of such character and arrangement that the oscillations in it will persist as long as possible, so that the energy may be fed from that circuit to the antenna circuit as slowly as possible in order that through resonance, or the resonant transfer of energy, the effects produced in the antenna shall be radiated at but a single frequency and with as much power as possible. If resonance between these two circuits did not exist, in other words, if the energy was transferred at two different frequencies, it would *b*ever be radiated at but a single frequency from the antenna. Mr. Marconi has carefully arranged his circuits for the accurate tuning of each providing for the resonant transfer of energy from one circuit to the other with the minimum coupling.

(Direct examination closed.)

Cross-examination.

By Mr. Vaill:

22. Cross-question. Major Mauborgne, you have been continuously in commission as an officer in the United States Army since your appointment in 1903?

Answer. I have.

23. Cross-question. Have you ever during your connection with the United States Army been retained by any electrical manufacturing concern as an electrical consulting engineer, or have you ever acted as such for any manufacturing concerns?

Answer. No, sir, not for any manufacturing concerns.

24. Cross-question. Have you ever acted for or been retained by any wireless telegraph company as a consulting engineer?

Answer. No, sir.

25. Cross-question. Referring to the year 1906 when you stated that your regiment was moved to Zamboanga, Mindanao, what concern erected the radio station which you mentioned in that connection?

Answer. To the best of my knowledge and belief, the radio station was installed by the Signal Corps itself, and not by any company.

26. Cross-question. You stated you observed the erection of this station. Was the work actually done by Army men or by outside employees?

Answer. As I recollect it, there were some civilian employees of the Signal Corps—I don't know their ratings—perhaps one of them at least may have been called an assistant at large, Signal Corps, but I did see several enlisted men assisting in the work of wiring the station and installing the apparatus, which I later saw in completed working condition.

27. Cross-question. Did you examine the apparatus in detail?

Answer. Enough to be able to say generally what the character of it was, but not making in any sense a wiring diagram of the connection.

28. Cross-question. Did you ascertain from your examination of this apparatus by whom it was manufactured?

[fol. 920] Answer. I did not examine each piece of apparatus to see which company made each piece of apparatus. A document which I have put in evidence, namely, defendant's Exhibit H-5, contains the wrapper only of the document numbered 152677, which letter I have recently perused. The letter itself unfortunately was not put in evidence. This letter contained certain appendices showing that the Chief Signal Officer of the Army directed the chief signal officer of the Department of California to have certain parts of the apparatus, such as the loading coils for the trasmitter, manufactured under Captain Wildman's direction and according to his design, somewhere in the vicinity of San Francisco. This letter also stated just where each article, such as keys and spark gaps, would be obtained. It also stated that De Forest receivers would be shipped. A picture of such a receiver installed at Jolo was referred to in connection with my description of defendant's Exhibit H-5.

29. Cross-question. Do you know whether this apparatus referred to in your last answer was a coupled set arranged according to a patent which I understand has been granted to Wildman for transmitting apparatus for wireless telegraphy?

Answer. Captain Wildman in June, 1904, was granted a patent on a direct connected or autotransformer arrangement for coupling the lateral circuit to the antenna. The photograph just shown as pertaining to Jolo shows this helix, and to the best of my recollection this helix was arranged with four connections to it, used for coupling the lateral circuit to the antenna circuit with the addition of what was called an anchor gap.

30. Cross-question. Although you have stated as to the source of some of the apparatus at Jolo, I believe you have not answered my question as to the source of the apparatus at Zamboanga. Will you state the answer to that question?

Answer. I did not put it clearly that the apparatus for both stations, Zamboanga and Jolo, was bought at exactly the same time and that the apparatus for both stations was identical.

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32. Cross-question. What were your special duties while stationed at Zamboanga?

Answer. I was on duty as an officer of a company of the Sixth Infantry, and for a while acting as post signal officer. This radio station, however, was not under my control, but directly under the control of the signal officer of the Department of Mindanao, stationed in the same post of Zamboanga.

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[fols. 921-922] 38. Cross-Question. During and up to the year 1914 to what extent were you familiar with the number and location of fixed transmitting land stations operated by the War Department and under the supervision of the Signal Corps?

Answer. Due to my practical work in operating radio apparatus in a number of stations of the Signal Corps, and from my contact with publications of the various governmental departments including the Department of Commerce, I can say that I had a good general idea of the

location of the fixed stations which were operated by the Signal Corps within the period 1904 to 1914.

39. Cross-question. Will you please state specifically the name and location of fixed land transmitting stations, operated by the United States Army and under the supervision of the Signal Corps which you had inspected or operated personally up to and including the year 1914?

Answer. Fort Leavenworth, Kans.; Fort Riley, Kans.; Fort Omaha, Nebr.; Fort Mills, Corregidor, Philippine Islands. As far as I can recollect, these are the only fixed stations of the Signal Corps which I actually inspected and operated up to the year 1914.

40. Cross-question. Of the stations you have just mentioned, which ones did you actually personally operate yourself?

Answer. I have just testified that I operated all of the stations mentioned, and by that I mean personally.

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[fol. 923] 52. Cross-question. Referring to plaintiff's Exhibit 87, Wireless Specialty Apparatus Type, will you please state when and where if at all you personally operated a transmitting station having the connections shown at the left hand side of this exhibit?

Answer. I have operated at Fort Leavenworth, Kans. a pack set having somewhat the same arrangement as that shown in the exhibit mentioned, although the inductances or loading coils in the case of the apparatus which I actually operated were not inductively connected but the linking be-
[fol. 924] tween the closed oscillating circuit shown in red in the drawing was accomplished by means of an auto-transformer shown in Photograph 5449, which forms part of defendant's Exhibit H–5 which is the 500 cycle quenched gap field set of November, 1912. Also in the year 1917 I operated at Fort Leavenworth, Kans. the inductively coupled quenched spark type of pack set shown in Photograph 6202 forming part of defendant's Exhibit H-5. This latter set had two coils or spiral inductances which formed a variometer or arrangement for tuning or adjusting the time period of oscillation or the closed or lateral circuit corresponding to the circuit shown in red in plaintiff's Exhibit 87. In this case a separate loading coil or inductance was inserted in the antenna circuit for receiving the energy transferred from the lateral circuit corresponding to the

coil *d'* shown in plaintiff's Exhibit 87. This is a slightly different organization from that shown in plaintiff's Exhibit 87 inasmuch as no loading inductance *g* was placed in the antenna circuit and additional means for varying the inductance of the lateral circuit had been provided.

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53. Cross-question. Will you please state whether or not you have personally operated a transmitting set having the same connections and apparatus indicated in the left-hand portion of plaintiff's Exhibit 87?

Answer. I have not operated a set of the Wireless Specialty Apparatus type with the connections shown in plaintiff's Exhibit 87, but anyone skilled in the art will recognize the fact that the inductance *d* shown in plaintiff's Exhibit 87, being a variable inductance simply is no different in function from an inductance variable not only by changing turns but also by the action of changing inductance in that circuit brought about by varying the coupling between the two coils which form the variometer. In other words a variometer is nothing but a variable inductance and can readily be substituted in the red circuit, plaintiff's Exhibit 87, instead of the variable inductance *d* shown in the circuit in red. The fact that the 1915 pack set had no loading coil separated as indicated in the diagram in plaintiff's Exhibit 87, at the point *g* from the inductance spiral which provided the method of tuning the antenna and the means for coupling the antenna circuit to the lateral circuit, presents no functional difference over the organization shown in plaintiff's Exhibit 87 in the antenna circuit of the transmitting station, as anyone versed in the radio art will testify. Hence my knowledge of the tuning of a transmitting station such as that shown in the left-hand figure of plaintiff's Exhibit 87 can not be questioned because to the lay observer there appears to be a difference which does not in fact exist, between the transmitting station connections shown in plaintiff's Exhibit 87 and the circuit arrangements which existed in the 1915 Signal Corps pack set, illustrated in Photograph 6202, forming part of defendant's Exhibit H–5.

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[fol. 925] 60. Cross-question. In a previous answer on direct examination you mention a Major Russell. Is he the same gentleman who was chief signal officer of the American Expeditionary Forces in the World War?

Answer. Yes, sir.

61. Cross-question. Is he generally considered a capable and efficient officer as to his conduct of affairs relating to radio signalling?

[fol. 926] Answer. General Russell has left the service, and up to the year 1915 or 1916 could be said to be one of the most efficient officers of the Signal Corps so far as a knowledge of radio communication systems and apparatus was concerned, but the General himself, while I was traveling with him in France in the early part of 1919, stated that he had lost all direct contact with the intimate details of the radio art which had been born with the advent of the modern vacuum tube transmitter and receiver. He stated that in his position as an executive officer he had had no time to keep up with the advance and progress of the radio art, although his efficiency along other lines undoubtedly was as high, if not higher than that which he had ever attained before.

62. Cross-question. Was Major Russell the commanding officer at Fort Leavenworth when you were stationed there in 1909 or 1910?

Answer. No, sir. He was the commandant and assistant director of the Army Signal School at Fort Leavenworth, Kans., at that time.

63. Cross-question. Do you know Prof. G. W. Pierce?

Answer. I am not personally acquainted with the gentleman, although I have read many of his contributions to the literature of the art and at one time was in communication with him as a result of his noticing an article of mine concerning the action of coupled circuits which he had seen in the London Electrician and about which he made some comments in writing to me, inclosing a mathematical treatise of his own on the same subject.

64. Cross-question. In answer to the first question on direct examination you state that you prepared for the Signal Corps a small volume on the uses of the wave meter in wireless telegraphy which you published in 1913. You sent this book, or the manuscript or draft of it, before publication to Professor Pierce for criticisms and suggestions, did you not?

Answer. No, sir; I did not. The McGraw-Hill Co., who later published the volume, before deciding whether or not to publish this volume, submitted the manuscript to

Professor Pierce for consideration in order to determine whether or not they should publish it.

65. Cross-question. I presume that you will admit that this was because of the high regard that the McGraw-Hill Co. had for Professor Pierce's wide knowledge and experience in radio matters?

Answer. I believe so.

66. Cross-question. Are you a member of the Institute of Radio Engineers?

Answer. Yes, sir; I hold a membership in that society.

67. Cross-question. What are the objects and functions of the Institute of Radio Engineers, according to your understanding?

Answer. I suppose the principal object of this organization is to promote the general interest in radio engineering and to afford a means for promoting discussions among its members concerning live radio topics with a view to the further advancement of the art. Its proceedings, which it publishes, form one of the principal sources of up-to-date knowledge concerning radio engineering principles.

68. Cross-question. It is generally understood, is it not, that the publications of the Institute of Radio Engineers [fol. 927] are accurate statements of matters relating to the distribution of the advanced knowledge of radio principles?

Answer. No, sir; it is not so understood. In fact, I think you will find that in every volume of these proceedings the editor states that the papers presented therein represent the individual views of the writers of the paper, and that the institute simply reproduces these papers usually after a discussion by other members of the institute, which discussion in many cases brings out a marked difference of opinion between the various members in discussing the paper as to the accuracy or correctness of the principles enunciated by the writers of the paper without in any way putting its official stamp of approval on the papers published as representing an accurate statement of facts or that the views of the writer are, in the opinion of the institute as a body, to be taken as gospel truth. These are not the exact words employed, but is about the substance of what the editor has to say.

69. Cross-question. The same is true, is it not, of practically all of the publications of other well known engineering associations of high standing in this country?

Answer. Yes; with the exception that where the principles announced have been accepted by the majority of radio engineers and scientists as agreeing with their judgment based on their own individual experiences, such principles gradually find their way into the text books which form the basis of the teaching of the principles of the art, and which may or may not be disproved at a later date as having been incorrect in the light of more recent developments and knowledge of the art obtained.

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70. Cross-question. Are you a member of the American Institute of Electrical Engineers?

Answer. No, sir.

71. Cross-question. What is your understanding of the value of the publications of the American Institute of Electrical Engineers as regards the distribution of advanced knowledge of electrical subjects?

Answer. My comments concerning the publications of the Institute of Radio Engineers are equally applicable to those of the American Institute of Electrical Engineers. These publications enrich the knowledge of the profession, concerning recent developments, but no paper appearing therein, unless it be the official report of standardization proceedings, or the report of some official decision of the institute itself, can be taken as anything more than the individual expression of opinion on the part of the writer of the paper. In some cases the doctrines expressed in this manner by individuals are determined to be correct only after litigation, as is well known.

72. Cross-question. According to your experience what has been the maximum distance attained by a transmitter of the closed or loop circuit type?

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[fol. 928] 73. Cross-question. In answer to question 6 on direct examination you mentioned the reception of radiotelephony. Will you please state from your knowledge of Signal Corps matters when radiotelephony first began to be used as a regular means of communication in the Army?

Answer. Radiotelephone sets for the use of the Army, particularly with aircraft, and from aircraft to ground, were designed in 1917 and some were tested, either during the last few months of that year or in the early part of 1918.

74. Cross-question. Have you ever used or witnessed the use of a two-element vacuum tube in the reception of spoken words by radiotelephony?

Answer. I have, as I described in connection with the tests which I made of both the Diode two-electrode tube and an early De Forest amplifier tube which had its grid and plate directly connected together so as to form but one element.

75. Cross-question. Is that the first instance of your having witnessed such a use of the two-element tube?

Answer. Yes, sir; although, as I state in my testimony, the Diode tube to the best of my knowledge was put on the market about a year ago for the purpose of providing radio broadcast listeners with a detecting device which the manufacturer sold with the view to replacing the crystal detector.

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[fol. 929] 80. Cross-question. During your experiments referred to in answer to cross-question 17 on direct examination, will you please state who was present at the time you made these tests or experiments?

Answer. A civilian, an employee of the Air Service, named Mr. Richardson, who is located at the Bureau of Standards, was present.

81. Cross-question. To what extent did you confer with Commander Loftin concerning these experiments before conducting?

Answer. I had no conference of any sort with Commander Loftin about conducting any such tests before I actually performed the experiments. I performed these experiments principally for my own satisfaction and showed the results which I obtained to the counsel for the defendant and Mr. Loftin after the first experiments were performed.

82. Cross-question. What did you mean by the use of the word "principally" in the last answer?

Answer. I wanted to have some first hand knowledge of how hard and soft two-electrode tubes would act; that is, as the opportunity actually presented itself for me to get hold of a modern two electrode tube, I wished to see how they bore out the theories concerning the action of these tubes which I had found in the works of Van der Bijl and other writers.

83. Cross-question. Did you conduct these experiments before or after you were requested to testify in this case?

Answer. After.

84. Cross-question. To what extent were you advised as to what you were to testify about?

Answer. Are you referring to this matter of vacuum tubes?

85. Cross-question. Yes?

Answer. I was advised to state exactly what happened in the tests, and as you noticed I brought here my original notes which I practically reproduced in the record, with but very little addition.

86. Cross-question. To what extent did you read over the testimony given by Commander Loftin in this case prior to testifying?

Answer. I think I read not over one-third of the Loftin record, and that was the first third.

87. Cross-question. Did you read over the portion of Commander Loftin's testimony wherein he testified concerning vacuum tubes?

Answer. I did not.

88. Cross-question. In answer to question 20 on direct examination you stated "Referring to the quenched gap type of transmitter as for example the Wireless Specialty Apparatus type, plaintiff's Exhibit No. 87, that "The lateral circuit and the antenna circuit are not necessarily so adjusted that the time period of oscillation is the same in each of these circuits." It is a fact, is it not, that in the usual practical operation of such circuits the antenna circuit and the lateral circuit are so adjusted that their periods are in the vicinity of each other?

Answer. That is the idea exactly, that they are in the vicinity of each other and not as in the case of the ordinary [fol. 930] coupled circuit transmitter of the open spark gap type, exactly on the same frequency to which it is highly essential as I have testified, that this Marconi transmitter be tuned in order that there may take place a transfer of energy at the resonant frequency from the lateral circuit to the antenna circuit.

89. Cross-question. Assuming that the primary and antenna circuit of a quenched spark transmitter had not been previously calibrated, and that you set the primary, or what I think you have called the lateral circuit, at some wave length within the range of the set, but which wave

length is at the time unknown to you, could you correctly adjust the transmitter so that the unknown wave length would be emitted with maximum radiation?

Answer. Yes, sir.

90. Cross-question. Will you describe briefly how you would accomplish this?

Answer. Perhaps I shall have to qualify my statement "Yes, sir," slightly, by answering that I could tune it to an unknown wave length which would probably not be the wave length to which the lateral circuit had been tuned, or at which it was accidently set before the operation starts. In this case we must proceed from the adjustment of the primary to the adjustment of the antenna circuit in order that there may be emitted from the transmitter a good clear note with the maximum radiation in the antenna ammeter. This involves then, briefly, the placing of the antenna inductance in fairly close coupling relation to the lateral circuit, and by actuating this circuit with such close coupling to so adjust the antenna inductance, that there will be produced in the antenna circuit a maximum amount of energy and when the note as listened to will be a clear one when the energy in the antenna, as indicated by the ammeter is greatest with the generator running at the proper frequency so that this note may be produced. The coupling must then be varied as well as the inductance in the antenna circuit, since this degree of coupling is highly critical if we are not to produce a ragged note and a double humped wave from the transmitter due to the extremely close coupling between the lateral circuit and the antenna circuit which we must employ if the quenching of the lateral circuit gap is to be accomplished. Had the lateral circuit been examined with a wave meter prior to this operation and its wave length determined, and then later had the wave meter been properly placed so as to measure the wave emitted by the antenna circuit when a single humped resonance curve was obtained, or in other words, a single frequency or wave length emitted from the antenna, it would probably be found that the wave length of the antenna indicated by the wave meter in this latter case was slightly different from that which we obtained as the wave length of the lateral circuit due to the fact that close coupling has been resorted to, and that in order to produce beats there must be set up two frequencies differing by such an amount that the beats can take place.

If the coupling is not right these two different frequencies will appear in the antenna circuit as measured by the wave meter and we will know that the gap is not being properly quenched. That is why I stated that there was not a resonant transfer of energy from the primary or lateral circuit to the antenna circuit in my direct examination.

[fol. 931] Now, in connection with your question I note that you have not started out with the same premise with which I started when I described how to tune a quenched spark transmitter, namely, that there must be emitted from the transmitter a wave of predetermined desired length which requires that the lateral circuit be adjusted as to its values of L and C and the coupling be so arranged that when the tuning operation involving all these adjustments is completed, the antenna shall emit not an unknown or undesired frequency, but one which is predetermined.

91. Cross-question. In adjusting a circuit, starting with an unknown wave length, as stated in my last question, how would you know or determine the relation of the product of L and C of the primary to the product of L and C of the secondary or antenna circuit when adjusting for maximum radiation?

Answer. In adjusting for an unknown wave length it is not necessary to determine in either case the product of L and C in the lateral circuit and in the antenna circuit if the operation of tuning is carried on as I have just described, because in this case we are not trying to make the product of L and C in the lateral circuit exactly equal to that of the antenna circuit, but rather we are trying for correct adjustment which will result, as I have stated, in the values of L and C of one circuit, being slightly different from the values of L and C of the other circuit, perhaps it is true by only a small amount, when we get the maximum radiation with a pure note and good quenching. Now, if you ask me how I determine the difference between these two frequencies which result from the product of L and C in the lateral circuit and the product of L and C in the antenna circuit, the lateral circuit in the first case can be measured with a wave meter, its wave length determined, and the values of L and C, or rather the product of these values, determined by substituting the wave length found in the formula, the wave length equals 1,885 times the quare root of LC. Similarly with the antenna coupled to the lateral circuit, however, the emitted wave is measured with

a wave meter, and by the same process, and using the same formula, the product of the L and the C of that circuit can be determined and this latter value with reference to the value found for the product of LC in the lateral circuit can be compared, but it is not seen that this process is at all necessary in order that the station may be adjusted to transmit a single frequency on a properly quenched transmitter.

92. Cross-question. It is true, is it not, that in tuning correctly to an unknown wave length the procedure in the act of tuning is carried out without a knowledge that the LC products in the primary and secondary circuits are the same or different?

Answer. That is true up to the point where we finally secure the maximum radiation with a pure note, and then, even if we have no wave meter, we are justified in saying that the station has its lateral circuit and its antenna circuit so adjusted that the product of L and C in the lateral circuit is very near the same as the product of the L and C in the antenna.

Redirect examination.

By Mr. Edwards:

93. Redirect question. Are you willing to repeat in the presence of counsel for the plaintiff and plaintiff's experts, the tests referred to in your direct examination?

[fol. 932] Answer. Yes, sir; whenever desired.

(Defendant's counsel offers to arrange for a repetition of the tests referred to if so requested by plaintiff's counsel.)

(The examination by counsel being concluded, the witness, in compliance with the rule of the court requiring him to state whether he knows of any other matter relative to the claim in question, and if he does to state it, says he does not.)

Deposition of Robert H. Marriott, for defendants, taken at Seattle, Wash., on the 26th day of March, A. D. 1925

Claimant's counsel, Edward W. Vaill, Esq.; defendant's counsel, Clifton V. Edwards, Esq.

Robert H. Marriott, having been produced as a witness on behalf of the defendant, was by me sworn, before any

question was put to him, to tell the truth, the whole truth, and nothing but the truth, relative to the said question, and thereupon deposed and said that his name is Robert H. Marriott; that his ocupation is radio engineer; that he is 46 years of age; that his residence is Bremerton, Wash.; that he has no interest, direct or indirect, in the claim in controversy; and that he is not related to the plaintiff; and thereupon the said Robert H. Marriott was examined by counsel for the defendant and, in answer to interrogatories, testified as follows:

Direct examination.

By Mr. Edwards:

1. Question. Where are you employed, Mr. Marriott, and what are your duties?

Answer. I am employed at the Puget Sound Navy Yard. My duty is to act as chief radio engineer for the naval radio activities at Puget Sound Navy Yard for the handling of naval vessels in the thirteenth naval district for the handling of naval shore stations.

2. Question. Please state what experience you have had in the use of radio apparatus and in keeping in touch with the developments in the radio art.

Answer. I became interested in wireless or radio some time previous to 1897 while in high school. I took up the subject theoretically and by experiment at Ohio State University from 1897 to 1901 in connection with general science course for degree of bachelor of science. In June, 1901, I obtained employment with the American Wireless Telephone & Telegraph Co. and took part in the building of radio stations in New Jersey. In the fall of 1901 I became chief engineer of the Pacific & Continental Wireless Telephone & Telegraph Co. and went to Denver, Colo., where I built transmitters and receivers. In April, 1902, I took those transmitters and receivers to southern California and constructed a radio station at Avalon, on Catalina Island, and another near San Pedro, on the mainland, and put these stations under operation. In the fall of 1902 I went east for the companies to prosecute some patent applications and get in touch with what was being done with radio in the East. While in Annapolis, Md., I examined the apparatus that the Navy had at Annapolis. That apparatus included transmitters and receivers of German and

[fol. 933] French manufacture. Later in 1902 I went to Denver, Colo., and went to work for the Carstarphan Electric Co., where I carried on experimental wireless work, manufactured X-ray apparatus, did some work for the De Forest Wireless Telegraph Co., and some wireless telephone work for the Ashley Wireless Co. This covered a period up the 1905. In 1905 I went to work for the American De Forest Wireless Telegraph Co. and constructed stations in Wyoming and Colorado, and acted as advisory engineer and inspector for the construction of stations in Texas and stations on some vessels entering Galveston. This covered a period up to 1907. In 1907 I went to the Pacific coast for the same company and made arrangements for the construction of stations at Seattle, Portland, Astoria, and elsewhere, directly supervising the construction of the station at Astoria and the station at Portland. In the fall of 1907 I returned to Colorado and dismantled the Colorado and Wyoming stations and went to New York. The De Forest Co., in the meantime, had been absorbed by the United Wireless Telegraph Co. At New York I carried on experimental work, and examined inventions for the United Wireless Telegraph Co. In 1909 I changed to construction and maintenance work, having to do with the construction and maintenance of stations, chiefly between Eastport, Me., and Cape Hattery, and those stations located on vessels entering that district. In 1911 I went with the American Marconi Co., acting as assistant chief engineer for a time and being in charge of the experimental apparatus part. In 1912 I became United States radio inspector, coming under the Department of Commerce and with headquarters at New York. In 1915 I changed from the Department of Commerce to the Navy Department, to carry on the work which I am now carrying on.

3. Question. In the development of wireless telegraphy and telephony in the United States since 1900, what have been, to your knowledge, the principal causes of the increases in distances of transmission and selectivity?

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Answer. Using my paper entitled "United States radio development," in the Proceedings of the Institute of Radio Engineers, June, 1917, Volume V, No. 3, as a guide to refresh my memory, the causes of increase in distances and selectivity are the changes made in detectors, receiving ap-

paratus, and transmitters. For example, in 1899, coherers were used. These devices were erratic and unreliable. Also they were easily rendered insensitive and were comparatively expensive. About 1901 an improvement was made when the combination of a telephone receiver and detector was brought into use. These detectors were often more sensitive than the coherer, and were inexpensive and easy to adjust or replace. Also by the telephone method of reception the operator was able to differentiate between the static and signals. For example, in 1901 I used an inexpensive detector which consisted of a contact between a polished steel point and oxidized iron. Along about that time, or a little later, two or three forms of electrolytic detectors came into use. Some of these were extremely sensitive. But the acid used in them was harmful and the [fol. 934] more sensitive ones were often injured by static. A little later the more durable and more easily adjusted crystal detectors came into use, and are still in use. In 1906 the three electrode vacuum tube detector came into use. It was a great improvement as a detector and later came into use as an amplifier, as a relay, and as a radio transmitter, and changed the entire status of radio telegraphy and telephony, including matters pertaining to distance and selectivity. In radio transmitters, the first transmitters used in about 1899 in this country consisted of an induction coil with a spark gap, one end of which was connected to the ground and the other end of which was connected to an insulated antenna. That transmitter was called the plain antenna type of transmitter. The induction coil used with it produced very low spark frequencies, and the voltage being applied directly to the antenna, caused the insulators to break down and the combination produced very short highly damped wave trains, all of which tended to limit distances and selectivity. In about 1903 tuned coupled circuit transmitters came into noticeable use in this country as compared with plain antennae transmitters. In these tuned coupled circuit transmitters the spark gap was connected at one end to an inductance coil and at one end to a condenser, the condenser and inductance coil being connected in a series. Another inductance coil in inductive relation to the inductance coil in the spark gap circuit was connected at one end to an antenna and at the other end to earth. The spark gap circuit and the antenna circuit were tuned to the same frequency. With this arrangement a

greater amount of power could be used without breaking down antenna insulators, and longer wave trains were obtained, which improved selectivity. Also in this country further improvement was made by using alternating current transformers in place of induction coils, producing higher spark frequency, which helped particularly in increase of range and distance. About 1909 impulse excitation transmitters came into use in this country. These transmitters consisted of a spark gap made up of a number of short gaps in series. One end of this gap was connected to an inductance, the other end to a capacity, the inductance and capacity being connected in series. Tightly coupled to this inductance was another inductance, one end of which was connected to the ground and the other end of which was connected to the antenna. The antenna circuit was adjusted to a given wave length and the spark gap circuit was adjusted to give maximum current in the antenna circuit. This impulse excitation produced longer wave trains with nearly all the energy radiated in one wave length, thereby improving selectivity and distance. In about 1912 constant amplitude transmitters came into noticeable use in this country. In this case the spark gap consisted of a direct current arc, one end of which was connected to earth, and the other end of which was connected through an inductance to the antenna. This produced a greater part of its energy in one wave length, and the waves were of constant amplitude and not successive trains of diminishing waves, as had been used heretofore. This again increased selectivity and distance. About 1915 the three-electrode vacuum tube came into prominent use as a constant amplitude transmitter, when it was used by the Bell Telephone interests in transmitting speech from Radio, Va., to Mare Island, Calif., Honolulu, and Paris. It was better adapted for use at all [fol. 935] radio frequencies and for use as a radio telephone than the arc was. It therefore served as an improvement for distances and selectivity as well as other features, and is the device now used for radio broadcasting and is taking the place of radiotelegraph arc and spark transmitters. Among the constant amplitude transmitters there were several high-frequency dynamos, such as the Goldschmidt dynamo used at Tuckerton, N. J., for transmitting across the Atlantic to Germany in 1913, and the Fessenden dynamo as used by Fessenden some years previous to 1913, and which was developed by Alexanderson, and is now in use

for trans-Atlantic communication. These dynamos were good for distance and selectivity, but they were limited as to the number of different wave lengths they could produce. Also they had to be very carefully constructed and cared for.

4. Question. Were the so-called impulse excitation transmitters, to which you have referred, known by any other name?

Answer. Yes; they were frequently called quenched gap transmitters.

5. Question. What can you say as to the relative importance, as manifested by increase in range, sensitivity, or extent of use, of the various improvements set out in your answer to question 3?

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Answer. In the time of the coherer and plain antenna transmitters the ranges were usually very short. It was often difficult to telegraph 10 miles, and 25 miles was fairly good working. With the use of the detector and telephone method reception, commercially reliable communication was obtained between the Catalina Islands and the mainland of California in 1902. The use of the detector method of reception with telephones and the use of the tuned coupled circuit made it possible to give fairly reliable service over a distance of about 200 miles in 1905; and in the winter of 1905 it was possible to hear ships on the Atlantic, although I was located in Denver, Colo. Using the impulse excitation transmitters and similar detector receivers and telephones, the reliable commercial distance was increased, to the best of my recollection, about fifty or a hundred per cent. Using the constant amplitude transmitters, the range was so increased that it was possible to span the Atlantic Ocean commercially, and as a test it has been possible since 1915 to read European stations in Bremerton, Wash. Part of the ability to read constant amplitude stations over this extreme distance was due to the use of the three-electrode vacuum tube as an oscillating detector and amplifier. However, the Atlantic was spanned commercially, using other forms of detectors, as was also the case between Honolulu and San Francisco. With the coming of the tuned coupled circuit transmitter, the plain antenna transmitter began to go out of use. They came back into use again temporarily in 1912 as an auxiliary, but were replaced by tuned coupled transmitters and other transmitters later. With the coming of the impulse excitation transmitters, they first began

to be installed instead of tuned coupled circuit transmitters, and later they more and more replaced the tuned coupled circuit transmitters until the tuned coupled circuit transmitters have nearly gone out of existence. The impulse [fol. 936] excitation transmitters likewise have given place in recent years to constant amplitude transmitters. The sensitivity of modern three-electrode vacuum tube apparatus is such that operators now require a signal about ten times as strong as they required when crystal detectors were used; that is, they are used to so much louder signals with the three-electrode tube arrangements and the three-electrode tube arrangements are so much more sensitive.

6. Question. From your experience what can you say as to the relative efficiency and extent of use of the so-called tuned coupled circuit transmitter, as compared with that of the impulse excitation transmitter?

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Answer. As I recall my experience as a radio inspector in New York, an impulse excitation transmitter, using about the same amount of power input, produced about twice as much current in the antenna as that produced by a tuned coupled circuit transmitter. As I recall my experience with the Marconi Co., we started in 1911 to deliver an impulse excitation transmitters instead of tuned coupled circuit transmitters, and to substitute them for tuned coupled circuit transmitters. While inspector in New York, the United Fruit Co. changed from tuned coupled circuit transmitters to impulse excitation transmitters, and the Navy changed from tuned coupled circuit transmitters to impulse excitation transmitters.

7. Question. You stated that the plain antenna transmitter came back into use again temporarily in 1912. Will you explain what caused this temporary use?

Answer. The law of the United States which went into effect in 1912 required that vessels of certain classes be equipped with radio, and so equipped that a radio transmitter could be operated for four hours without getting its power from the engine-room. In order to operate the regular radio transmitter, it would have been necessary to equip the vessel with a large storage battery or something equally expensive. Therefore the Marconi Co. brought back its cheap induction coil type, plain antenna transmitter, which could be operated from a comparatively small storage battery.

8. Question. So far as you know, are the tuned coupled circuit transmitters now in use for commercial or governmental work?

Answer. No.

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[fol. 937] 11. Question. Referring back to your answer to question 6, will you state what type of transmitter the Marconi Co. was employing before starting to deliver impulse excitation transmitters in or about 1911?

Answer. At that time the American Marconi Co. had taken over the United Wireless and its transmitters were *chiefly the ex-United* Wireless transmitters, which were tuned coupled circuit transmitters.

12. Question. And when you say that "We started in 1911 to deliver impulse excitation transmitters," do you mean that the American Marconi Co. started to deliver them?

Answer. I mean that the American Marconi Co. started to manufacture them in the latter part of 1911 and began deliveries of them around December, 1911, or January, 1912.

13. Question. And thereafter, except for the temporary use of the plain antenna transmitter in or about 1912, did the American Marconi Co. manufacture and use the impulse excitation type of transmitters and abandon the tuned coupled circuit transmitter?

Answer. Yes.

14. Question. In order that we may have no misunderstanding as to what is meant by the plain antenna transmitter, the tuned coupled circuit transmitter, and the impulse excitation transmitter, can you make a sketch or diagram illustrating each of these types?

Answer. I have made such a sketch.

The sketch made by the witness Figures 1, 2, and 3, is offered in evidence and marked "Defendant's Exhibit Q-5," Marriott sketch.

15. Question. Referring to Figures 2 and 3 of your sketch, Exhibit Q-5, what, if any, differences are intended to be indicated in the representations of the spark gap and the coupling coils LL-1 of the respective figures?

Answer. The spark gap in Figure 2 consists of the gap between the ends of two metal rods, the gap being about half an inch in length and in free air. The gap in Figure 3 [fol. 938] consists of a number of short gaps in series. The faces of these short gaps are broad and backed by considerable metal designed to carry away heat rapidly. The short gap is inclosed in such a manner that it is air tight. The short gap length between sparking faces is about one-hundredth of 1 inch. The entire gap comprises a number of these short gaps in series. All of the inductance L in Figure 3 is closer to all of the inductance L^1 than it is in Figure 2.

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17. Question. In your direct examination you have made reference to a paper entitled "United States radio development" written by yourself, and appearing in the Proceedings of the Institute of Radio Engineers in June, 1917. Please state what this paper purports to set forth and the basis for the facts therein stated.

Answer. The paper was intended to set forth all the important elements bringing about the evolution of radio in the United States up to 1915, and the statements are made from my experience in contact with radio and from the written records of the United States Government.

18. Question. Will you state how you came to prepare this paper, and give us some idea of the time required and sources availed of in the preparation of the paper?

Answer. In 1915 there was a World's Fair at San Francisco, in connection with which a Panama-Pacific Convention of Engineers was held, and the paper was desired for a joint meeting of the Institute of Radio Engineers and the American Institute of Electrical Engineers, and I supplied this paper entitled "United States radio development" and read it at that joint meeting. My own personal notes, from which this paper was taken, extended back to 1897. The time used in searching the Government records was from the latter part of February, 1915, to about July, 1915, most of the records being delivered to me at Brooklyn Navy Yard, New York, by order of some person in authority. I think it was the Attorney General.

19. Question. To the best of your knowledge, information, and belief, are the facts stated in that article and represented in the two charts accompanying the article, true?

Answer. Yes.

(The article referred to by the witness is offered in evidence by defendant's counsel. The article comprises pages 179 to 197, inclusive, of the Proceedings of the Institute of Radio Engineers for June, 1917, and is marked "Defendant's Exhibit R-5.")

[fol. 939] 20. Question. What, if any, experience have you had with two-element vacuum tubes?

Answer. I tried them as detectors on two or three occasions previous to 1911, and in 1911 and 1912 I had charge of what was called the Experimental Apparatus Department of the American Marconi Wireless Telegraph Co., in connection with their shop or factory at Cliff and Fulton Streets, New York, where one room was given over to the sale of radio apparatus. The Fleming valves, or two-element vacuum tubes, were advertised and sold from this point. I tested all of the valves that were sold in that manner and some of those that went through the shop in connection with other Marconi enterprises. The tests were usually made in laboratory fashion by using a buzzer for a transmitter; however, on some occasions I tested them by using an outside antenna and receiving from some radio station.

21. Question. To what extent were these two-element tubes sold by the Marconi Co.?

Answer. I can not recall exactly how many of those tubes were sold through me, but I believe it was about 100. There were possibly a few sold through others.

22. Question. Have you any idea as to how many may have been sold through others?

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Answer. As nearly as I can remember now, I believe I sold a majority of all that were sold. There may have been some arrangement between the American Marconi Co. and other Marconi companies whereby sales were made to these other Marconi companies of which I have no definite recollection at present.

23. Question. For what purpose were these two element tubes sold by the Marconi Co.?

Answer. The ones I sold were sold to schools and colleges for experimental work in radio and to amateurs for experimental work.

24. Question. For what use were these tubes represented to be suitable by the Marconi Co.?

Answer. For detecting radio signals.

25. Question. Were these tubes represented by the Marconi Co. to be capable of use as amplifiers, or as oscillators?

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Answer. Not to my knowledge.

26. Question. In what manner did these tubes operate in detecting radio signals?

Answer. I believe they operated as one way valves.

27. Question. Are these two element vacuum tubes capable of operating as amplifiers?

Answer. They never operated as amplifiers for me, so far as I know.

[fol. 940] 28. Question. Have they ever been used as amplifiers in commercial or governmental work, so far as you know?

Answer. No.

29. Question. What device is used as an amplifying device in the radio and telephone arts?

Answer. The three electrode vacuum tubes.

30. Question. How did the two element vacuum tubes compare with the crystal or carborondum detector with respect to sensitivity?

Answer. As a rule, as I recall it, the carborundam crystals, I used were more sensitive than the two element vacuum tubes.

31. Question. To what extent, if at all, did the two element vacuum tubes displace the crystal or carborundum detector?

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Answer. According to my recollection, they did not displace the crystal or carborondum detector except for temporary periods where they were tried in place of crystal detectors.

32. Question. In the last part of your answer to question 5 you referred to the sensitivity of the modern three-electrode vacuum tube apparatus being such that operators now require a signal about ten times as strong as they required when crystal detectors were used. What does this indicate as to the relative sensitivity of the three-electrode vacuum tube as compared with that of earlier apparatus?

Answer. It indicates that the three-electrode vacuum tube arrangements as now used are about ten times as sensitive as the former detectors, insofar as the operator's results are obtained.

33. Question. To what extent, if at all, has the three-electrode vacuum tube displaced other apparatus in transmitters and detecting devices in the radio art?

Answer. The three-electrode vacuum tube has almost entirely displaced all other forms of detectors, and the three-electrode vacuum tube as transmitter has been displacing other transmitters during the past few years, but in just what proportion I could not say.

Cross-examination.

By Mr. Vaill:

34. Cross-question. Mr. Marriott, I believe you stated in your direct examination that you first became connected with the Department of Commerce of the United States Government in 1912. Have you been continuously employed in that Department or the Navy Department since that date?

Answer. Yes; my appointment in the Department of Commerce beginning in 1912 automatically expired when my appointment to the Navy Department in 1915 took effect.

35. Cross-question. Under whose instructions or authority were you called to testify in this case?

Answer. I was requested by Mr. Edwards to meet him here for the purpose of testifying.

36. Cross-question. As a matter of fact, you had to obtain the permission or authority of some official of the Navy Department to testify in this cause before you came here, did you not?

Answer. No; I simply took leave.

[fol. 941] 37. Cross-question. Did not your commanding officer know the purpose for which you were taking leave before you came to testify in this cause?

Answer. The particular officer who you would probably mean is my commanding officer is away and while he knows that I am to testify at some time or other, he does not know at what particular time.

38. Cross-question. Through what channel did your commanding officer know that you were to testify in this cause?

Answer. Through me. I told him about the case some time ago.

39. Cross-question. Do you know whether any official order or written permission has been issued by any official of the Navy Department instructing or permitting you to testify in this cause?

Answer. I do not know of any orders relating specifically to this case and place.

40. Cross-question. Do you know of any orders or authority relating to this case issued by any department of the United States Government authorizing or requesting you to testify?

Answer. Orders were issued to me in 1923 to report to the Department of Justice for a period of time, which reporting covers this case, in that this case was mentioned in my conferences with the Department of Justice.

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[fol. 942] 50. Cross-question. In your answer to question 5 on direct examination you stated that by use of tuned coupled circuits it was possible to hear ships on the Atlantic, although you were located in Denver Colo. In making this statement, was the tuned coupled circuit you referred to at the receiving station or were you informed that these circuits were at the transmitting station?

Answer. The tuned coupled circuits I had in mind were the De Forest transmitters on board ships on the Atlantic. I was told what these transmitters consisted of, and I saw some of them on the vessels coming in to Galveston.

51. Cross-question. At the time of receiving the signals to which you referred, how did you know that it was from a tuned coupled circuit of the De Forest type mentioned by you?

Answer. From descriptive matter, letters, hearsay, and that they sounded like the transmitter of the same type in my immediate vicinity.

52. Cross-question. Did you know the name of the vessel which transmitted the signals to which you referred?

[fol. 943] Answer. The names of the vessels were often given in the context of the messages and the call letters were given, the call letters being assigned to the particular vessels.

53. Cross-question. Do you recollect what the particular vessel it was that transmitted the signal which you heard in Denver?

Answer. There was more than one vessel, and I do not now remember the names of any of them.

54. Cross-question. What type of receiving circuit was used by you in receiving this signal from ships on the Atlantic Coast in Denver?

Answer. Referring to defendant's Exhibit A-5, Loftin's sketch P, as I recall now, the receiving arrangement used was similar to the receiver indicated in that sketch, except that the condenser shown was connected between the lower end of coil J and the detector instead of between contact 5 and the detector; also that the other end of the antenna was connected to earth through an inductance, which was variable by making sliding contacts on the inductance.

55. Cross-question. The distance from Denver, Colo., to the ships on the Atlantic coast to which you have referred was in the vicinity of twenty-five hundred miles, was it not?

Answer. Ordinarily, I believe the ships were not quite that far away. However, some of them may have been, when they were in the vicinity of Cuba or Porto Rico.

56. Cross-question. In answer to question 5 on direct examination you stated that it had been possible since 1915 to read European stations in Bremerton, Wash., using the constant amplitude transmitters. To what type of constant amplitude transmitter did you refer in making that statement?

Answer. The one referred to in the particular year 1915 that I had in mind was of the dynamo type. I do not recall whether it was a Goldschmidt or Arco type, according to the then existing records of the type of apparatus used. The more recent one that I had in mind was that at Eiffel Tower, and I don't recall at present what type that is; I believe is an arc type.

57. Cross-question. You were aware, were you not, that during the year 1902, or thereabouts, Mr. Marconi transmitted signals by the use of a spark transmitter between the Pohldu Station in the British Isles and his station in Canada?

Answer. Do you refer to Marconi's getting the letter "S" across the Atlantic?

58. Cross-question. Yes, and to the press service established shortly thereafter.

Answer. In so far as Marconi's claim of getting the letter "S" across the Atlantic, which, I believe was the first incident claimed, I have always been more or less lost as to what to think about it, because very nearly the same time I made daily experiments with the coherer receiver on the Atlantic coast, and got such multitudes of dot letters, letter "S"s by the hundreds, two dot letters in greater numbers, and one dot letters in still greater numbers. In so far as the first alleged messages sent across the Atlantic are concerned, there have been a considerable number of statements made in print and otherwise that those same messages were sent by cable previously or simultaneously. [fol. 944] 59. Cross-question. It is a fact, is it not, that in 1902, or shortly thereafter, press service with Great Britain was maintained for several months by the use of the Marconi four circuit transmitting and receiving system through the station at Poldhu and the Canadian station?

Answer. I recall that statements somewhat similar to that have been made, but I do not know whether or not they are facts.

60. Cross-question. In giving your answer to question 8 on direct examination, in which you are asked if tuned coupled circuit transmitters are now in use for commercial or governmental work, and you answered "No," is your answer to be understood to be of the negative without regard to the means for producing the oscillations in such tuned coupled circuits, or is it to be understood as limited in some way?

Answer. What I meant was that the tuned coupled circuit transmitter as I have shown in Figure 2 of defendant's Exhibit Q-5, Marriott's sketch, is no longer in use.

61. Cross-question. In answer to question 2 on direct examination, you mentioned "some wireless telephone work for the Ashley Wireless Co." in the period prior to 1905; what did this work consist of?

Answer. Ashley got us to build quite a little apparatus according to his ideas in which, as I recall it, he tried to get high enough spark frequency or sustained waves so that it could be modulated with a telephone transmitter and intelligible by using a detector and a pair of phones at the receiver.

62. Cross-question. Did these ideas work out successfully?

Answer. Not that I know of.

63. Cross-question. Will you please state as accurately as possible the dates between which you were connected with the Marconi Wireless Telegraph Co. of America?

Answer. I do not remember the date I went with the Marconi Co., but it was the latter part of 1911, and my recollection is that I went with the Department of Commerce in October, 1912.

64. Cross-question. What was the reason for your leaving the Marconi Wireless Telegraph Co. of America?

Answer. The Department of Commerce was arranging to put on the radio inspection service, and as I had perhaps more experience in the maintenance of vessels running into New York than anybody else at that time, the Department of Commerce people talked to me a great deal about it before starting the service, and they suggested that I take the examination for inspector. I took the examination and received a telegram some time afterwards asking if I would accept appointment as inspector. I had to give a prompt answer, and I answered that I would, and then put in my resignation from the Marconi Co.

65. Cross-question. How long were you located at New York as inspector for the Department of Commerce?

Answer. As I recall, I was located at New York most of the time between October, 1912, and January, 1915.

[fol. 945] 66. Cross-question. What portion of the ships that you inspected at New York during the period last mentioned were equipped with Marconi wireless transmitting and receiving apparatus?

Answer. As I recall, most of the foreign ships were equipped with Marconi apparatus, and most of the United States ships were equipped with ex-United Wireless apparatus then owned by the Marconi Co.

67. Cross-question. Will you kindly state the types of transmitters and receivers which you found on the foreign ships which you inspected at New York, and also the types of transmitters and receivers which you found on the domestic ships during the same period of your inspection?

Answer. The transmitters included plain antenna transmitters, tuned coupled circuit transmitters, and impulse excitation transmitters. The receivers usually consisted

of a primary inductance and a separate secondary inductance, and the detectors were usually crystal detectors.

68. Cross-question. Does your last answer apply equally to the domestic ships and also foreign?

Answer. A large number of changes occurred between 1912 and 1915, and there were a great many ships. My recollection is that the answer applies to both foreign and domestic ships, but I could not say that it applies equally.

69. Cross-question. Why did you consider it necessary to examine so much at length defendant's Exhibit R-5, which I understand you have testified contains the article written by you?

Answer. I have given so little thought to the matter covered by the question during the past 10 years that I used the exhibit in an attempt to refresh my memory.

70. Cross-question. Do you find anything in defendant's Exhibit R-5 which you consider does refresh your memory as to the particular types of transmitting and receiving apparatus which you found on vessels inspected at New York durng the period you were inspector at that place?

Answer. The general trend of changes indicated in the exhibit does seem to bring back somewhat clearer a general idea of what was occurring between 1912 and 1915.

71. Cross-question. Will you please state what proportion of the vessels inspected by you at New York between 1912 and 1915 had tuned coupled circuit transmitters, what proportion had impulse excitation transmitters, and what proportion had plain antenna transmitters?

Answer. I do not remember the proportions at this time.

72. Cross-question. It is a fact, is it not, that you testified as a witness for the defense in a suit brought by the United States against officials of the United Wireless Co., in which the latter were indicted for unlawful stock operations?

Answer. I was subpoened by both sides in that case, and as I recall it, I gave some testimony regarding the patents that I had assigned to the United Wireless Telegraph Co., and I believe it was the defense that put me on the stand for that purpose.

73. Cross-question. You recollect, do you not, that similar suits were brought against officials of the De Forest Wireless Telegraph Co. and the Collins Wireless Telegraph Co.?

[fol. 946] Answer. I have no recollection of such suits against the De Forest Wireless Telegraph Co., but I have some recollection of some such suits against the Collins Co.

74. Cross-question. During your connection with the Marconi Wireless Telegraph Co. of America in 1911 and 1912, it is true, is it not, that the effect of these suits for indictments of officials of the companies referred to in the previous question had a very depressing effect upon the business of the Marconi Wireless Telegraph Co. of America and the wireless telegraph business in general so that profits realized from the business were practically wiped out?

A. That is not the impression which I retain of what happened at that time.

75. Cross-question. Among the advances made in radio transmission subsequent to 1900 concerning which you testified in answer to question 3, is it not true that the use of higher antennae contributed to a considerable extent to increased distance of transmission?

Answer. The use of higher antennae contributed in specific cases, such as, for example, at Tuckerton, the Goldschmidt station, and at Sayville, the Atlantic Communication Co. station.

76. Cross-question. Is it not true that during the same period that the use of antennae having increased capacity contributed to the increase of distance of transmission?

Answer. The increase of capacity contributed in specific cases.

77. Cross-question. It was true, was it not, that increase in the height of the antenna and increase in the capacity of an antenna, as a general proposition, was found to increase the distance of transmission?

Answer. Leaving out consideration of some practical points, such as wave length, I believe that is true.

78. Cross-question. It is true, is it not, that during the same period that increased distance of transmission was attained by lowering the so-called ground resistance and also the antenna resistance?

Answer. That apparently was true in some cases.

79. Cross-question. Do you know of any cases where the subject-matter of my previous question was not true?

Answer. For example, on ship board the antenna resistance and ground resistance was probably about the same

from the time of the first installations through the later installations.

80. Cross-question. Do you mean by that that it had always been low or that it was not lowered?

Answer. I mean that according to my observations it apparently was not lowered.

81. Cross-question. But it is true, is it not, that it was found, as a general proposition, particularly in land stations, that a lowering of the antenna and ground resistance resulted in increased distance of transmission?

Answer. Yes.

82. Cross-question. It was also found, was it not, during the period subsequent to 1900, that an increase in the height of the receiving antenna also contributed to the distance at which signals could be received?

Answer. Leaving out the consideration of wave length and static. I believe that is true.

[fol. 947] 83. Cross-question. During that period it was found, was it not, by experiment that the distance of transmission and reception was substantially proportional to the product of the respective heights of the transmitting and receiving antennae?

Answer. Leaving out the consideration of wave length and static, I believe that is true.

84. Cross-question. It was also true, was it not, during this same period that it was experimentally determined that by using a grounded transmitting antenna and a receiving loop, the distance of reception was increased in proportion to the product of the height of the transmitting antenna and the length of wire on the loop?

Answer. Leaving out the matter of wave length, that statement seems to correspond with my experience.

85. Cross-question. Is it not true that increased signalling distances were also obtained by using higher spark frequencies, that is, of 500 cycles per second or more, instead of 60 cycles or less?

Answer. Generally speaking, I believe that is true.

86. Cross-question. Is it not true that increased distance obtained with quenched spark transmitting sets was due in part to higher spark frequencies employed in such sets?

Answer. The increased distances were apparently attained with quenched spark sets partly by the use of spark frequencies in the neighborhood of 1,000 sparks per second.

as compared with lower spark frequencies, which had been used in the earlier types of sets.

87. Cross-question. It is true, is it not, according to your knowledge of the matter, that all of the quenched spark transmitters as developed for and used by the United States Navy involved a plurality of radio frequency oscillations in the primary closed circuit, as well as in the secondary or antenna circuit?

Answer. In so far as I recollect at the present time, the radiation from the antenna circuit indicated three frequencies when I used extremely sensitive frequency measuring apparatus. However, I can not say as to the oscillations in the primary at present.

88. Cross-question. Referring to your last answer, it is true, is it not, that of the three frequencies mentioned therein, the second or middle frequency was greatly predominant over the other two as to the amount of energy radiated from the antenna?

Answer. Yes.

89. Cross-question. It is true, is it not, that when the so-called het-rodyne reception is used, the operators adjust the circuits to prod. e a high beat note in order to obtain greater distances?

Answer. Operators to receive signals from constant amplitude transmitters use the het-rodyne method to enable them to get the signals, ordinarily speaking, regardless of distance.

90. Cross-question. According to your knowledge, what is the number of cycles usually employed by operators with the heterodyne reception to receive signals from comparatively distant stations?

Answer. This varies with operators. On an average, I believe they use a sound frequency of about 750 cycles.

91. Cross-question. In your direct examination you stated that impulse excitation transmitters have given place to constant amplitude transmitters. Is it not true that a very considerable portion of the so-called impulse excitation [fol. 948] transmitters installed on commercial ships was not replaced by constant amplitude transmitters until subsequent to about the year 1915?

Answer. I believe that is true.

92. Cross-question. It is true, is it not, that there are still a considerable number of the so-called impulse excitation transmitters in use on ships at the present day?

Answer. I believe that is true.

93. Cross-question. In the year 1905, will you please state what transmitting and receiving sets you personally inspected and traced the circuits, particularly those at stations owned and operated by the United States Government?

Answer. I did not inspect any stations in 1905, so far as I recollect, that were owned by the United States Government. I recall inspecting some stations owned by the American De Forest Co. in 1905. Among those stations was one at Denver, Colo., and one at Boulder, Colo. The transmitters used were the transmitters that were typical to American De Forest and United Wireless Cos. The receivers used were similar to that shown in Loftin sketch P, defendant's Exhibit A-5, except that the condenser was connected between the lower end of the inductance and the detector, instead of between slider 5 and the detector, and the other end of the antenna was connected to the ground through a variable inductance.

94. Cross-question. Will you please state at what particular stations operated by the United States Government you examined and traced the circuits of the transmitting and receiving apparatus during the years 1906 to 1912, inclusive?

Answer. I can not recall all of them; however, I recall the naval station at North Head, Wash., and naval installations at Brooklyn Navy Yard, and at Washington, D. C.

95. Cross-question. Do you recollect who manufactured the sets at the three places you have just mentioned?

Answer. I do not remember who manufactured the sets used at North Head, Wash. At Brooklyn Navy Yard, as nearly as I can remember, I saw sets that had been manufactured by Lowenstein, Telefunken Co., Atlantic Communication Co., De Forest Radio Telephone Co. At Washington, D. C., as I recall, I saw sets that had been manufactured by those same companies and by the National Electric Signaling Co.

96. Cross-question. Do you recollect what year you saw the Lowenstein set at the Brooklyn Navy Yard?

Answer. No; I do not.

97. Cross-question. Do you recollect what year you saw the Telefunken set at the Brooklyn Navy Yard?

Answer. No.

98. Cross-question. Do you know what year you saw the set made by the Atlantic Communication Co. at the Brooklyn Navy Yard?

Answer. I believe it was 1912 that I saw that set.

99. Cross-question. Do you recollect what year you saw at the Brooklyn Navy Yard the set made by the De Forest Co.?

Answer. No.

100. Cross-question. Do you recollect what years you saw the sets at the Washington (D. C.), Navy Yard, as manufactured by the four companies above mentioned, and the National Electric Signaling Co.?

[fol. 949] Answer. My recollection is that I saw sets of those makes in or about Washington, D. C., in 1912. I do not remember just what I saw at the Washington Navy Yard. Some of these sets, as I recall it, were at Radio, Va., where they were being put into the new naval radio station.

101. Cross-question. Regarding these various sets which you have stated you saw at the Brooklyn and Washington, D. C., Navy Yards, do you know whether these sets were owned and then operated by the Navy Department, or were they under test prior to being accepted by the Navy Department?

Answer. I do not remember.

102. Cross-question. In giving your answer to question 14 on direct examination I noted that you referred constantly to the pamphlet containing defendant's Exhibit R 5. Will you please state why this was necessary?

Answer. In order to get the spelling for some of the words I was using. In paying attention to making the sketch I became more or less confused as to the spelling of some of the words.

103. Cross-question. In the answer to question 20 on direct examination you stated you tested two-element vacuum tubes or valves at the shop of the American Marconi Wireless Telegraph Co. at Cliff and Fulton Streets, New York. Do you recollect of what material the filaments and plates of those tubes were made?

Answer. I may have made a mistake when I said Cliff and Fulton Streets. It may have been Cliff and Maiden Lane. I do not now remember what the filaments and plates of those tubes were made of.

104. Cross-question. Did you have occasion to test the amount of vacuum in the two-element tubes referred to in the previous question?

Answer. No.

105. Cross-question. Do you know, or were you informed, as to where and by whom those tubes were manufactured?

Answer. In some cases I knew and in some cases I was informed, but I do not remember now the names of the manufacturers.

106. Cross-question. Do you know, or were you informed, as to whether they were made in the United States or abroad?

Answer. As nearly as I can remember, part of them were made abroad and part of them were made in the United States.

107. Cross-question. Do you remember what proportion of them was made abroad and what proportion in the United States?

Answer. No.

108. Cross-question. In answer to question 20 you stated that radio apparatus was sold from the shop or factory of the American Marconi Wireless Telegraph Co. at Cliff and Fulton Streets. What other radio apparatus did you know of as having been sold from that place in addition to two-element vacuum tubes?

Answer. As I recall it, parts of the radio transmitters and radio receivers and complete radio transmitters and receivers and wave meters were sold from there for experimental purposes.

109. Cross-question. According to your recollection, while connected with the American Marconi Wireless Telegraph Co., was the volume of business done in the apparatus you have just referred to large or small?

[fol. 950] Answer. I believe it would be called a small business.

110. Cross-question. Do you have any knowledge of the profits resulting from the sale of such apparatus at the time referred to while you were connected with the American Marconi Co.?

Answer. I do not remember enough of the details to say.

111. Cross-question. During your connection with the Department of Commerce as radio inspector in 1912 to 1915, can you state to what extent foreign ships which you

inspected were equipped with receiving sets having two-element vacuum tubes or valves?

Answer. I can not remember to what extent they were so equipped at this time.

112. Cross-question. Do you remember whether any of them were so equipped with two-element vacuum tubes?

Answer. I remember that some of the ships from foreign countries had such tubes and places to use them; but, as I remember it, they had other forms of detectors; and I have not a clear recollection as to the use of the two-element vacuum tubes.

113. Cross-question. In answer to question 32 on direct examination, you stated that the requirements of the operators as to a stronger signal indicated that the three-el-ctrode vacuum tube is about ten times as sen/itive as former detectors in so far as operators' results are obtained. Is it not true that the stronger signals received through the use of three-electrode vacuum tubes are in part due to other factors, such as those referred to in previous questions, relating to the height and capacity of antennae and the greater power of the transmitting stations employed?

Answer. What I had in mind was transmitting stations which had not been changed and from which receiving operators copied business when they received audibility was only one; but after we had put in three-electrode vacuum tubes arrangements in place of the crystal detector arrangements, the operators would say that they could not receive from the other stations until the audibility exceeded about 10. In other words, the putting into use of the three-electrode vacuum tubes changed the common strength of received signals so much that operators would no longer try to receive the weak signals they had formerly received when using crystal detectors.

114. Cross-question. Is it not a fact that at the present day crystals are used to a large extent in receiving radio transmission, particularly the reception of broadcasting from the regular broadcasting stations?

Answer. Owing to the great number of tubes of the three-electrode type being used, for receiving radio broadcasting, I think it would be better to say that crystals are used to some extent, rather than to say that they are used to a large extent, according to my observation.

115. Cross-question. Is it not a fact that a considerable number of crystals are used to-day for reception of broadcasting with such crystals inserted in receiving sets or associated with the receiving sets through the use of tuned coupled circuits?

Answer. According to my observation, this year, there seem to be very few crystals used.

116. Cross-question. To what extent are you familiar with magazines dealing with amateur reception of radio broadcasting within the last year?

Answer. During the last year I think the only magazines of that nature that I have bought a copy of every month are [fol. 951] Radio Broadcast and Popular Radio and Q. S. T. However, I receive complimentary copies of other magazines from time to time, and see some of the other magazines every month.

117. Cross-question. Is it not true that many of these magazines recommend the use of crystals for broadcast reception on account of the excellent quality of the tones received by using such crystals?

Answer. One of the things that I thought I had noted during the past year was the decrease in such recommendations. As I recall it, such recommendations were very common in the magazines three years ago, and have been falling off ever since. I was caused to think of this last week when among a group of radio people, and the remark was made by one of them that he didn't want to have anything to do with a broadcast receiver combination in which a crystal detector was used, and I was surprised to note that none of those present were inclined to disagree with him, which caused me to think over the apparent falling off within the last two years.

* * * * * * *

118. Cross-question. Is it not true that prior to the year 1909 referred to by you on direct examination as about the date that impulse excitation transmitters came into use, certain transmitting sets, such as the Slaby Arco, Siemens, and Halske, or other German transmitting sets, employed a number of short gaps in series without means for quenching the spark gap in the closed primary circuit of a transmitter?

Answer. I believe I did see some such gaps, but I do not recall who they were made by.

119. Cross-question. Is it not true that prior to 1909 the Stone Co. manufactured and sold sets which employed a number of short gaps in series without means for quenching the spark as transmitting sets?

Answer. I don't remember.

120. Cross-question. If you had available a Marconi type tuned coupled transmitter with all the electrical constants, capable of adjustment, enabling it to be operated as a quenched gap transmitter, except that the gap is of the usual or older open type, could it not be changed over to a typical quenched spark transmitter simply by using a sufficient forced cooling of the gap to quench the spark, such as by blast of air?

* * * * * * *

Answer. I don't know.

121. Cross-question. Are you a member of the Institute of Radio Engineers?

Answer. Yes.

122. Cross-question. Have you taken part in the adoption of standardization rules by that organization during the last 10 years.

Answer. I don't recall that I have been on the standards committee, during the last ten years. However, I did have something to do with helping to write some definitions during the past year.

[fol. 952] 123. Cross-question. It is true, is it not, that the standardization rules of the Institute of Radio Engineers are accepted and published by other similar societies, such as the American Institute of Electrical Engineers, particularly as to definitions of terms relating to the radio art?

Answer. I think so.

124. Cross-question. What standing, according to your knowledge of the matters, do the Institute of Radio Engineers and the American Institute of Electrical Engineers have as scientific organizations?

Answer. As engineering organizations, I believe they stand first in radio and electrical engineering.

(The examination by counsel being concluded, the witness, in compliance with the rule of the Court requiring him to state whether he knows of any other matter relative to the claim in question, and if he does to state it, says he does not.)

Deposition of Frederick M. Sammis, for defendants, taken at New York City on the 6th day of May, A. D. 1925

Claimant's counsel, Edward W. Vaill, Esq.; defendant's counsel, Clifton V. Edwards, Esq.

FREDERICK M. SAMMIS, having been produced as a witness on behalf of defendants, was by me sworn before any question was put to him to tell the truth, the whole truth, and nothing but the truth, relative to the said cause, and thereupon deposed and said that his name was Frederick M. Sammis; that his occupation is exporter; that he is of mature age; that his residence is 890 Degraw Avenue, Newark, N. J.; that he has no interest, directly or indirectly, in the claim in controversy; and that he is not related to the plaintiff.

And thereupon the said Frederick M. Sammis was examined by counsel for the defendants, and in answer to interrogatories testified as follows:

Direct examination.

By Mr. Edwards:

1. Question. Mr. Sammis, a few weeks ago I called you on the telephone and requested you to appear here and give testimony voluntarily, did I not?

Answer. Yes.

2. Question. And you declined to appear without a subpoena?

Answer. Yes.

3. Question. And you are here now in response to a subpoena served upon you?

Answer. Yes.

4. Question. You gave testimony, did you not, as a witness in the case of Marconi Wireless Telegraph Co. of America against Kilbourne & Clark Manufacturing Co. in a suit in equity on the Marconi patent No. 763772, pending in the United States District Court for the District of Washington, in or about the year 1916, did you not?

Answer. I don't know it by that exact structure, but I do know I gave testimony some years ago in a suit against Kilbourne & Clark Co.

[fols. 953-954] 5. Question. I have here a printed copy of the record on appeal in the case referred to and show you the same, and call your attention to the deposition beginning at page 995 of that record. Are you the Mr. Sammis who gave that deposition?

* * * * * * *

Answer. Yes.

6. Question. What has been your connection with the art of radio telegraphy and telephony?

Answer. Beginning in 1901 or 1902 I joined the forces of the newly organized American Marconi Co. and continued with it for 13 or 14 years, the last 6 or 7 years as its chief engineer; then 2 or 3 years with the American Radio & Research Corporation as its commercial manager; then followed about 6 years with the Westinghouse Lamp Co. as its foreign sales manager; and for the last 2 years in my own business as exporter, largely of radio and electrical products.

7. Question. Will you give the full name of the American Marconi Co. to which you referred?

Answer. Marconi Wireless Telegraph Co. of America.

* * * * * * *

[fol. 955] 27. Question. In or about 1902 what type or types of transmitting apparatus was used by the Marconi Co.?

Answer. Most generally the 10" spark coil with one side of the spark connected to the antennae and the other side to the earth. Just about that time coupled circuits were developed, and I believe that I made personally, with my own hands, the first oscillation transformers that the Marconi Co. used in this country. That was before I actually joined the company, I being at that time store manager for J. H. Bunnell & Co., and Mr. Bradfield and Andrew Gray, of the London Marconi Co., came into our store and asked me to make such oscillation transformers for them, and it was done.

28. Question. In the Kilbourne & Clark case, according to the printed record, page 996, in answer to question 9, you testified as follows:

"In 1902 practically all of the transmitters then in operation were of the plain aerial type, in which the antennae was directly shocked by the spark therein. Later a type of

coupled circuits was used which contained a Tesla coil inserted in the antennae, in lieu of the spark gap, and in the primary circuit of this Tesla coil was connected the spark gap and the condenser."

To the best of your recollection was that testimony true?

* * * * * * *

Answer. Yes.

29. Question. Will you please make sketches showing generally and diagrammatically these two types of apparatus and describe them? Please first make the type that you have called the plain aerial?

[fol. 956] Answer. In attempting to do this I shall do it to the best of my ability, but it is a long while since I have made these sketches and I have been out of touch with the ultratechnical side of the matter. I am sure I can draw the plain aerial type, however. I have done so, and I have marked the antennae A, the ground B, and the spark gap C; I have also made the tuned circuit.

Mr. Edwards: The sketches made by the witness are offered in evidence by the defendants, that of the plain aerial type being marked "Defendants' Exhibit T-5" and that of the coupled type being marked "Defendants' Exhibit U-5."

30. Question. Will you now briefly describe the sketches T-5 and U-5, identifying the parts by reference letters?

Answer. Sketch T-5 I have shown the antennae by letter A, spark gap C, and ground B. The sketch U-5 I have shown the antennae A, the secondary coupled coil as F, and the ground B; I have shown the spark gap as C, the condenser as D, and the associated coil of the coupled coil as E.

31. Question. Will you please explain generally how and where each of the two types of apparatus shown in T-5 and U-5 were used by the Marconi Co.?

Answer. That is a large question. They were used generally on ship and shore stations.

32. Question. Will you add to the two sketches, U-5 and T-5, the Rhumkorf coil or other apparatus for producing the spark as used in these transmitters?

Answer. Yes. I have done so and marked them D in the case of T-5 and G on sketch U-5.

33. Question. To what extent was it customary in practice for the operators to connect the Rhumkorf coil in the type of transmitter shown in U-5 directly between the antennae and the earth?

Answer. I do not think that is a question I can answer, except as a matter of supposition.

34. Question. Did the apparatus shown in the defendants' Exhibit U-5 displace the type of apparatus shown in Exhibit T-5?

* * * * * * *

Answer. The fact of the matter was that the same coil was used in both instances, and it would be an easy matter for an operator to connect the antennae and ground directly to it, if he desired to do so.

35. Question. Was there any reason why in practice the operator would find it advantageous to do so?

Answer. If I remember correctly, Mr. Marconi said himself it worked further.

36. Question. Will you explain in what way it worked further?

Answer. I don't know as I understand the question.

37. Question. What meaning was conveyed by Mr. Marconi's expression "worked further"?

Answer. I assume more miles with the same amount of energy.

38. Question. In the practice of the Marconi Co. did the type of apparatus shown in sketch U-5 displace the type of apparatus shown in the sketch T-5?

Answer. From the very essence of things it could not; all that was required to make T-5 was to disconnect the tuning apparatus from G in U-5. They were identically the same coil in both instances.

[fol. 957] 39. Question. In or about 1902 to what extent was the plain aerial type used by the Marconi Co.?

Answer. Which Marconi Co.?

40. Question. The American Marconi Co., of which you were chief engineer.

Answer. Not at that time.

41. Question. In your testimony in the Kilbourne & Clark case, on page 998, in answer to question 12 you testified as follows:

"The commercial apparatus used by the Marconi Co. and companies generally in those days consisted of a Rhum-

korf coil energized either from direct dynamo current or storage batteries, and the plain aerial type was almost universally used for the handling of all commercial business from ship to shore and shore to ship."

Is that in accordance with your present recollection?

Answer. Yes; the reason I could not answer your previous question was that in 1902, if my memory serves me, the Marconi Co. of America had no stations, or very few.

42. Question. To what stations were you referring in giving your testimony in the Kilbourne & Clark case?

Answer. The stations belonging to the Marconi International Marine Communications Co., which was the London company, and perhaps some of the Belgian company stations.

43. Question. What would you say as to whether or not, when the coupled circuits were added, it became common practice for the operators to connect the Rhumkorf coil directly between the antennae and the earth?

Answer. We used to hear rumors that it was done, and I have known of cases where better results were secured that way.

44. Question. Continuing your answer to question 12 in the Kilbourne & Clark case, you testified:

"Later, when the coupled circuits were added, the Rhumkorf coil, key, battery, etc., were identical, and it was common practice for the operators to connect said Rhumkorf coil directly between the antennae and the earth, because they found it very much more efficient than the coupled set that had been furnished."

Is that in accordance with your present recollection?

Answer. I would say that if I said it at that time it was my belief at that time. I have no recollection now that would help the matter.

45. Question. You further testified in the same answer:

"Practically the only time that the coupled sets were used was when from storm or damage the antennae insulation became so low as to prohibit the spark at B, as shown in Exhibit No. 13. The efficiency of these plain aerial sets was common knowledge throughout the entire Marconi service and it became quite a problem to insure that the operators did not use them as plain aerial sets even after

the coupled sets were furnished. In fact, operators were frequently reprimanded for this practice. The company found it impossible to govern their actions when at sea or even at land stations.

"The objection to the use of the plain aerial was due to the somewhat severe strain of the antennae insulation and a certain tendency of the coils to break down.

[fol. 958] "At the shore stations of the Marconi Co. for a considerable number of years after 1902 the plain aerial was used exclusively, or almost so, on account of its high efficiency.

"The station at Sagaponack, N. Y., is a particular example. This station operated with an inductance coil sparking directly into the antennae and earth up to the time the plain aerial was prohibited by law."

Did you so testify; and if so, is that testimony in accordance with your present recollection?

Answer. I would say that if I testified to it at that time it was in accordance with my belief at that time. I have not any present recollection that would help the matter, after 23 years.

46. Question. Have you any reason to believe that you did not so testify or that any of the matters stated in the testimony which I have just read to you is not true?

Answer. No.

47. Question. Did you have any personal knowledge of the reprimanding of operators and of the practice of the operators as referred to in the above extract from your testimony?

Answer. The testimony says that I did; therefore I must have had.

48. Question. How was it possible for an operator to work his transmitter, as provided by the Marconi Co., so as to bring the spark gap directly into the aerial circuit?

Answer. Usually both leads from the spark gap to the condenser and inductance were disconnected and the antenna and ground substituted in their place.

49. Question. The type of apparatus referred to in the last question was that shown by Exhibit U-5, was it not?

Answer. Yes.

50. Question. Up to that time was the plain aerial construction shown in the sketch T-5 used by the Marconi Co.?

Answer. If you will excuse me, the question is not well

put; it is rather ambiguous, because it was not a matter of construction; it was a matter of connection and use. I would be unable to say at just what time it was officially forbidden to work with the spark in the antennae or how long after such time operators made a practice of doing it.

51. Question. Was the type of apparatus illustrated in sketch T-5 still in use in 1916?

Answer. I think only as auxiliary for operation from storage batteries in emergency cases.

52. Question. Why was this?

Answer. Perhaps there were several reasons. I would put first economy, because such equipment was already on the vessels and could be utilized; second, perhaps because it was pretty efficient with comparatively small expenditure of power. I should add, however, that both types were left on the ships, if I remember rightly—both U-5 and T-5.

53. Question. Why was the type T-5 used only for emergency purposes?

Answer. They were beginning to fit ships with power apparatus in those days which operated from the ship's dynamos, and this set that you have asked about operated from storage batteries which would be available in case the ship's current supply failed.

[fol. 959] 54. Question. Was not the reason the type T-5 was used for emergency purposes only because of the radio act of 1912?

Answer. I do not remember that.

55. Question. In your testimony in the Kilbourne & Clark case, with reference to this plain aerial type, you testified in answer to question 15, page 999, as follows:

"It is still in use. I would add, however, that it is only now used for emergency purposes on some ships, on account of the radio act prohibiting its general use."

Did you so testify; and if so, have you any reason to doubt the correctness of that testimony?

Answer. I have no reason to doubt it.

56. Question. Up to 1908 or 1909 what type of transmitting apparatus was used exclusively, or substantially so, by the Marconi Co.?

Answer. I would say that both types shown in T-5 and U-5, although I am not positive about dates.

57. Question. Referring to your testimony in the Kilbourne & Clark case, in answer to question 16, having ref-

erence to the type as shown in Exhibit T–5, the plain aerial type, you testified, page 999, as follows:

"Up to what time was the plain aerial construction shown in defendant's Exhibit No. 13 used by the Marconi Co. in its commercial transmission work?

"Answer. Almost exclusively up until 1908 or 1909, and to a considerable extent after that also."

Have you any reason to doubt the correctness of that testimony?

Answer. No.

58. Question. As the apparatus of the transmitter of the type shown in defendant's Exhibit U–5 was made and used by the Marconi Co. was the inductance and capacity of the primary circuit made adjustable?

Answer. The capacity could be changed, but the inductance usually not, although both types were used.

59. Question. Was the capacity which was used an adjustable capacity?

Answer. It usually consisted of a collection of Leyden jars and, of course, more or less could be connected, if desired; in that sense it was adjustable.

60. Question. Have you any reason to question the accuracy of your answer to question 18 in the Kilbourne & Clark case referring to these sets, as follows, page 1000:

"The sets as made and used prior to 1907 or 1908 were nonadjustable, the Tesla coil had no adjustable connections. In other words, a fixed primary and fixed secondary and a tray containing a fixed number of Leyden jars was supplied and used."

Answer. No.

61. Question. Is the tray of Leyden jars represented on your sketch U–5?

Answer. Yes; under the letter D.

62. Question. What, if anything, on the defendant's Exhibit U–5 represents the Tesla coil?

[fol. 960] Answer. E and F.

63. Question. When, if ever, was the capacity and inductance of the apparatus of the type illustrated in defendant's Exhibit U–5 made adjustable by the Marconi Co.?

Answer. When they wanted to change the wave length.

64. Question. In or about what years did the Marconi Co. provide means in these sets for making the inductance and the capacity variable?

Answer. They had been made fixed in the first instance and for general ship work because it was found more convenient to put them in as units and make whatever adjustments on the antennæ that might be necessary to keep them in tune.

65. Question. Later, were the sets provided with means whereby the inductance and the capacity could be made adjustable?

Answer. Some sets were made that way; I can not remember in just what years, or whether it was later or before.

66. Question. Did the Marconi Co. at a later period provide taps on the transformers for varying the inductance and means for varying the position of the plates of the condenser in order to vary the capacity of these sets?

Answer. In certain land stations where power was used, in other words alternating current and the high-tension transformers in lieu of the Rhumkorf coil. In those instances it was usually found more convenient to make both the open and closed circuits readily adjustable without reference to their inductance and capacity.

67. Question. To the best of your recollection, when did the Marconi Co. first make the inductance adjustable by providing adjustable taps on the transformer, for example?

Answer. I think I made them adjustable myself, personally, in the early days, perhaps as early as 1903, winding them of bare wire and clipping the lead on in any desired position.

68. Question. I quote the following from your testimony, page 1060 of the record, in the Kilbourne & Clark case:

"21. Question. When, if ever, was the capacity and the inductance of the apparatus, defendant's Exhibit No. 14, made adjustable, as used by the Marconi Co.?

"Answer: To the best of my recollection, about 1907 or 1908, when a few sets were put up having adjustable taps on the secondary of the Tesla coil G, Exhibit No. 14. I remember very distinctly that one of the early sets of this nature was installed at Siasconsett, Mass., by myself."

I also show you defendants' Exhibit No. 14, referred to in this answer, which sketch appears on page 5254 of the printed record in the Kilbourne & Clark case. Does this

testimony and the exhibit refresh your recollection as to when the Marconi Co. first made the inductance adjustable in its transmitters?

* * * * * * *

Answer. I would say that perhaps in this case mentioned by you it was the first instance, or perhaps an early instance of where the inductance was made adjustable in a commercial installation. I had personally made them adjustable myself before that time, perhaps in shop or experimental work.

[fol. 961] 69. Question. Is the testimony above quoted true, according to your personal recollection?

Answer. With the amplified statement I have just made, I would say it is.

70. Question. That is, that it refers to commercial sets put out by the Marconi Co.?

Answer. Yes; to the best of my recollection; it is a long time ago.

71. Question. To the best of your recollection, how many sets of adjustable apparatus were put out by the Marconi Co. in 1909?

Answer. I would not dare hazard a guess.

72. Question. Referring again to your testimony in the Kilbourne & Clark case, page 1000, question 22 and its answer are as follows:

"22. Question. In 1909 how many sets of apparatus thus made adjustable were in use by the Marconi Co.?

"Answer. I should say not over a half dozen all told."

Have you any reason to question the giving of this testimony or its accuracy?

Answer. No.

73. Question. Were you familiar with the apparatus formerly used by the United Wireless Telegraph Co.?

Answer. I presume I was at the time. You mean receiving or transmitting apparatus, or both?

74. Question. Both.

Answer. Not very familiar with their early receivers.

75. Question. Is that company still in existence?

Answer. No.

76. Question. Do you know what became of it?

Answer. It went out of existence.

77. Question. Do you know what became of its assets?

Answer. I don't think so.

78. Question. Do you know whether or not the Marconi Co. purchased the assets of the United Wireless Co.?

Answer. They took over their ships; that I remember now; and shore stations.

79. Question. Did the Marconi Co. acquire any transmitters formerly made by the United Wireless Co.?

Answer. That I do not remember at this time, except in taking over the ships they took over all the equipment.

80. Question. Do you recollect about when the Marconi Co. acquired these transmitters from the United Wireless Co.?

Answer. I think about 1912.

81. Question. Did the United Wireless Co. use transmitters of the two-circuit coupled type?

Answer. I think that they used an autotransformer, which produced the same result.

82. Question. Did apparatus of that character come into the possession of the Marconi Co. from the United Wireless Telegraph Co. when the Marconi Co. acquired the sets above referred to?

Answer. Yes.

83. Question. Do you know how many of such sets there were?

Answer. Several hundred, I would say.

84. Question. What became of those sets?

Answer. When?

85. Question. After being acquired by the Marconi Co. [fol. 962] Answer. I guess they were used; for a while, anyway.

86. Question. What did the Marconi Co. do with the sets?

Answer. Why, on some of them I think we made two-coil transformers of them, instead of autotransformers, in order to improve the tuning.

87. Question. Were a number of these sets continued in use in the vessel and shore stations where they had been installed by the United Co.?

* * * * * * *

88. Question. As unaltered.

Answer. I don't remember.

89. Question. Were all of the sets acquired from the United Wireless Co. altered by the Marconi Co.?

Answer. A good many of them were; I don't know whether they all were or not.

90. Question. Were any of the unaltered sets in use by the Marconi Co. up to the time you left that company?

Answer. That I do not remember either.

91. Question. In your testimony in the Kilbourne & Clark case, in answer to question 26 et seq., you testified as follows:

"26. Question. Did the United Wireless Co. use transmitters of the two-circuit coupled type?

* * * * * * *

"Answer. Yes.

"27. Question. Did any apparatus of that character come into the possession of the Marconi Co. from the United Wireless Telegraph Co. when the Marconi Co. took over the assets of the United Co.?

"Answer. Yes; several hundred sets.

"28. Question. What became of this apparatus?

"Answer. It was continued in use after the vessel and shore stations where it had been installed by the United Co., and a good deal of it is still in use.

* * * * * * *

"29. Question. Was any of this apparatus obtained from the United Co. in use by the Marconi Co. when you left the latter company in 1915?

"Answer. A large quantity of it; yes."

Does the reading of this testimony refresh your recollection sufficiently to say whether or not the apparatus so acquired by the Marconi Co. and referred to in the above testimony continued in use unaltered until the time when you left the Marconi Co.?

Answer. All I can say is that the testimony given at that time was undoubtedly true.

92. Question. Did you ever make any tests or comparisons of the plain aerial transmitter, as shown in defendants' Exhibit T-5 and the coupled type shown in defendants' Exhibit U-5; and if so, what were the results of such tests or comparisons?

Answer. I may have made such tests, but they have gone from my memory now.

93. Question. In answer to question 30, at page 1002 of the printed record in the Kilbourne & Clark case, you testified:

[fol. 963] "I have personally made such tests myself and if great many tests were made under by directions, and reports of results supplied to me while I was chief engineer of the Marconi Co."

Does this refresh your recollection as to whether or not you made tests or comparisons of the plain aerial type of transmitter with the coupled type?

Answer. No.

94. Question. Have you any reason to believe that the testimony above given by you in the Kilbourne & Clark case was incorrect?

Answer. No.

95. Question. Do you recall whether or not in 1907 or 1908 it began to be apparent that the practice of sticking a coupled set and a Tesla coil between the antennæ and the earth was not proving efficient?

* * * * * * *

Answer. I do not recall it.

96. Question. Were you familiar with the tests made on the *Caronia*?

Answer. Yes; now that you recall it.

97. Question. Will you state what those tests were and what the tests showed?

Answer. In those days we had a man on the *Caronia* who was a real character; his name was H. G. Watterson; he had in those days what is now known as the D X bug, which means a mad scramble after distance. I remember onw that Watterson did some extremely extraordinary things on the *Caronia* with a 10-inch coil. It used to be said that Watterson could not hear any station that was closer than a thousand miles. He did succeed in negotiating some very long distances with a plain aerial transmitter. I saw him in Egypt only two or three years ago and he remembered them very well, as we both did. As previously stated, the tests were by means of a plain aerial transmitter, and perhaps they showed that under certain conditions or perhaps under certain handling, this type of transmitter was very efficient.

98. Question. Do you recall that with the plain aerial structure Mr. Watterson was able to negotiate distances over a thousand miles?

Answer. Yes.

99. Question. And that later, when this same vessel was furnished with a 5-kilowatt tuning set, the same operator could not secure a distance greater than that secured with the Rhumkorf coil equipment?

* * * * * * *

Answer. I would say that he said he could do it.

100. Question. The Rhumkorf coil equipment there referred to is the plain aerial type, is it not?

Answer. Yes.

101. Question. Do you recall a series of tests that were conducted in or about 1905 or 1906 directed by Mr. Bradfield, the former chief engineer of the Marconi Co., along this line?

Answer. I don't remember.

102. Question. Tests at the stations at Sagaponack and Babylon, N. Y.?

[fol. 964] Answer. I think maybe I do now, if they had reference to the loading of an antennæ and a directional antennæ.

103. Question. Do you recall that Mr. Bradfield was unable to negotiate between those two stations with the tuned set, whereas later it was found possible to work between the same stations by the use of the plain aerial?

* * * * * * *

Answer. I believe so, although that might have been due to any one of a number of causes.

104. Question. I quote the following question and answer from your testimony, beginning at page 1002 of the printed record in the Kilbourne & Clark case, and ask you to say whether or not, to the best of your recollection, the facts stated therein are true:

"30. Question. Did you ever make any tests or comparisons of the plain aerial transmitter shown in defendant's Exhibit No. 13 with the coupled type shown in defendant's Exhibit 14; and if so, what were the results of such tests or comparisons?

"Answer. I have personally made such tests myself and a great many tests were made under by directions, and re-

ports of results supplied to me while I was chief engineer of the Marconi Co.

"In 1907 or 1908 it began to be apparent that the practice of sticking a coupled set and a Tesla coil between the antennæ and earth, which in almost every case was widely different, having reference to the aerial particularly, was not proving efficient; the same Tesla coil and condenser would be used more or less regardless of the type of antennæ used. This was doubtless one reason why the plain aerial worked better, but the principal reason is that the plain aerial itself is without any possible question the more efficient.

"I remember that Mr. Marconi in his Nobel prize lecture very clearly makes the statement that the plain aerial is very much more efficient than any type of circuit in which a condenser is used, and he refers therein to certain tests made by the steamship *Caronia*.

"I am also familiar with the tests made by the *Caronia*. The operator at the time, named H. G. Watterson, and for quite a long period of time thereabouts, transmitted from the *Caronia* with a plain aerial structure and was able to negotiate extremely long distances, some of them were over a thousand miles, all of them with plain aerials.

"Later, when this same vessel was furnished with a 5-kilowatt coupled and tuned set, and the same operator placed on board, the average of distance secured was not greater than that secured with the Rhumkorf coil equipment.

"I also remember very distinctly a series of tests that were conducted, if I remember correctly, in 1905 or 1906, which former chief engineer of the Marconi Co., Mr. W. W. Bradfield, directed.

"The stations at Sagaponack, N. Y., and Babylon, N. Y., were 60 miles apart, separated by low marshes and the waters of the Great South Bay, and the first so-called tuned set, using an alternating current generator to energize it, was installed at each of these stations.

"Tests continued for many months and ended in failure. The amount of power used was from 1 to 2 kilowatts.

"Later it was found possible to work between these stations by the use of plain aerials and the simple substitution of a Lodge coil in the antennæ.

[fol. 965] "About two years ago and for some time prior thereto the Department of Commerce, which has jurisdic-

tion over the wireless installations in the United States, began to agitate with the Marconi Co. against the use of plain aerial sets for emergency purposes on shipboard, holding that mechanical troubles with the vibrators and the possible difficulty with insulation of the antennæ might prove disadvantageous in case of emergency.

"This witness personally represented to the department that if the plain aerial auxiliary sets were tuned they would be much less efficient and would therefore be unable to comply with the law requiring that they work 100 miles.

"However, a series of tests were carried out by the United States Government in which these same plain aerial auxiliary sets were tuned, and it was well demonstrated that the average percentage of efficiency when tuned was only about 60 per cent of that when they were using plain aerials. As a result, they were allowed to remain plain aerial until the contracts expired under which they had been installed.

* * * * * * *

Answer. They are.

105. Question. In this Sagaponack-Babylon test to which you have just referred, what was the relation between the power used when the tuned coupled circuits were used and when the plain aerial type was used?

Answer. If I remember right, the power type used about 2 kilowatts; I do not think so much as that was used in the Rhumkorf coil.

106. Question. Can you state approximately what these amounts were in the respective tests?

Answer. I think not.

107. Question. In answer to Question 31 in the Kilbourne & Clark case, page 1004, with reference to this Sagaponack-Babylon test, you testified:

"I personally conducted some of the tests myself under Mr. Bradfield's direction, built a large part of the apparatus myself, and was on the ground at both stations during the tests. Usually the amount of power of the tuned set, as I have said, was between 1 and 2 kilowatts. With the induction coil plain aerial, certai-ly not over one-half Kilowatt, usually less."

Does that refresh your recollection as to the amounts of power used in the tests?

Answer. I would say that if I testified to that effect at that time, it was undoubtedly true.

108. Question. You have no reason to doubt that you did so testify?

Answer. No.

[fol. 966] 109. Question. Can you give the amounts of power used in the two types of apparatus in the *Caronia* tests?

Answer. I know that Watterson had a 5-kilowatt English set on board; just how much current he put through that coil nobody but himself knew.

110. Question. By "English set," which set do you mean?

Answer. The coupled set.

111. Question. In the Kilbourne & Clark case, with respect to this matter, at page 1004 you testified as follows:

"32. Question. I ask you the same question with reference to the installations on the S. S. *Caronia*, first, when the plain aerial was used and, second, when the coupled tuned circuit was used?

• • • • • • •

"Answer. On the *Caronia* the amount of power with the plain aerial was somewhat larger than any other plain aerial ship set owing to a special form of break used by the operator. This operator reported to me regularly upon the termination of each voyage in New York and submitted to me reports signed by the captain and the chief officer of the ship, varifying the various positions and distances. The amount of power used on the vessel for the tuned set was 5 kilowatts.

"I should judge that the ratios in these cases would be about three-quarters of a kilowatt for the plain aerial and 5 kilowatts for the tuned sets."

Have you any reason to question the accuracy of that testimony?

Answer. No.

112. Question. Were you familiar with the installations of the Marconi apparatus on the steamship *Caronia*?

Answer. Fairly so.

113. Question. Was it a part of your duty to attend to the repair and upkeep of all of the Marconi wireless apparatus on all vessels coming into New York at that time?

Answer. The emergency repairs; yes.

114. Question. Would these duties include the ordinary inspection, repair and upkeep of the apparatus on the *Caronia*?

Answer. I would say emergency repairs and, perhaps, regular inspection. I mean by that that the London company did not like the size of our bills, so we would keep at a minimum all repairs.

115. Question. In your testimony in the Kilbouren & Clark case, at page 1005, in answer to question 34, you testified as follows:

"34. Question. You have spoken of tests resulting in comparative efficiency of 60 per cent; on what is this comparison of efficiency based?

"Answer. It is based upon my own personal observation in various tests that I have made at stations of the Marconi company during my long period of service with them, and also on the various results reported to me."

Does that testimony refer to the comparative tests between the plain aerial type and the coupled type, and have you any reason to question its accuracy?

* * * * * * *

Answer. I would say that it did refer to such comparison of types, and I have no reason to question its accuracy.

[fol. 967] 116. Question. Did the Marconi company while you were employed by it use transformers of the impulse excitation type?

Answer. I guess you had better describe one of those animals to me.

117. Question. Were you familiar with the type of apparatus put out by certain German companies and known as the quenched-gap type of apparatus?

Answer. Yes.

118. Question. In your answer to question 37 in the Kilbourne & Clark case, at page 1006, you testified as follows:

"37. Question. Did the Marconi company while you were employed by it use transmitters of the impulse excitation type?

"Answer. Yes."

How did the type of apparatus referred to in this testimony just quoted as the impulse excitation type compare with the so-called quenched-gap type of apparatus?

Answer. I would not dare make a comparison at this late date.

119. Question. Could you make a sketch generally illustrating the quenched-gap type of apparatus, to which reference has just been made?

Answer: I prefer not to, because I would feel that it might not be correct.

120. Question. What type of apparatus did you have in mind in answering the above-quoted testimony in the Kilbourne & Clark case with reference to impulse excitation type?

Answer. I don't remember.

121. Question. Do you recall that when you were with the Marconi company reports were heard of the efficiency of a new type of apparatus put out by some of the German companies?

Answer. Yes.

122. Question. Do you recall about what time this was?

Answer. No.

123. Question. Do you recall investigating these reports?

Answer. No.

124. —. Did you employ a young man by the name of Proctor to investigate this matter?

Answer. Yes.

125. Question. What was the nature of his investigation and report?

Answer. I don't remember accurately enough to describe it, except that he was on research work.

126. Question. As a result of this investigation did the Marconi company design and build apparatus of the quenched-gap type?

Answer. It designed and built apparatus of the quenched-gap type; but I do not know whether it was the result of Proctor's research or not.

127. Question. How did these quenched-gap sets built by the Marconi company compare in efficiency with the coupled and plain aerial types illustrated in sketches T-5 and U-5?

Answer. I do not know that I ever compared them; I don't remember that I did. It was natural, since they were [fol. 968] power sets, that they should have had a greater range than the other type, which was generally operated from storage batteries.

128. Question. Reading from the record, page 1007 of the Kilbourne & Clark case, it appears that you testified as follows:

"38. Question. To what extent was that type of transmitter used by the Marconi company, and when did it begin using them?

"Answer. About 1911 I began to hear various reports of the remarkable efficiency secured by a type of German apparatus called the 'singing spark.' I investigated some of these reports and found them to be authentic, and requested that my superiors permit me to build such sets, to which they agreed. I employed a young man named Proctor, who spent several months of long, arduous labor in perfecting a set of the impulse excitation type. Considerable difficulty was experienced in so building and designing the several units so as to overcome the inefficiency of the Marconi four-circuit tuning arrangement, whereby a very broad wave was usually emitted. Work was continued on the impulse transmitter, and finally it was developed to such a state of efficiency that a very large quantity of it was sold to the United States Government.

"Later the Marconi service began to be criticized for the large quantity of United-Wireless-Marconi type transmitters that it was using, and it finally decided to build about 200 of the impulse transmitters and to scrap or sell off at bargain prices the United Wireless apparatus, and older apparatus of that type. These 200 sets were for the most part to be installed at the various ship and shore stations of the Marconi service, and a considerable number had already been installed at the time I left the Marconi service.

"When these equipments were first tested out it was found that a half kilowatt transmitter of the impulse type would put as much current into the antennæ as would a 2-kilowatt set of the Marconi two-circuit tuned type. The result in distances also bore about the same ratio."

Did you give such testimony, and if so, have you any reason to question the accuracy of it?

Answer. I understood in your previous question that you wanted me to compare the impulse type transmitter with the plain aerial. I gave the testimony which you read, I presume, and I have no reason to doubt its accuracy.

129. Question. Is the German apparatus here referred to the type of apparatus commonly known as the quenched-gap type?

Answer. I would say so; yes.

130. Question. Which of these sets gave the greater distance? That is to say, the Marconi tuned circuit type or the quenched-gap type?

Answer. You mean for an equivalent amount of power in each?

131. Question. Yes.

Answer. I would say the quenched-gap type was more efficient.

132. Question. Approximately how much more efficient?

Answer. Considerably; I would not want to mention any exact percentage.

133. Question. Would you say that the quenched-gap type is nearly double the efficiency of the coupled-circuit type?

Answer. Under certain circumstances I would say yes.

[fol. 969] 134. Question. In referring to efficiency, do you have in mind the distances to which the sets will transmit?

Answer. Yes.

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[fol. 970] 145. Question. Are you familiar with the Fleming patent No. 803684, a copy of which I show you?

Answer. Yes, reasonably so.

146. Question. To your knowledge did the Marconi company ever make or use or sell any of the arrangements shown in the drawings of that Fleming patent?

Answer. Yes.

147. Question. Connected in circuits as shown in the drawings?

Answer. That I could not say. I had particular reference in my last answer to the manufacture of the tubes themselves.

148. Question. Did you have any knowledge of any of such tubes sold by the Marconi company in connection with the circuits such as shown in the drawings of the Fleming patent shown you?

Answer. I do not remember that I did.

149. Question. You testified as a witness in the case of the Marconi Wireless Telegraph Co. of America against the De Forest Radio & Telephone & Telegraph Co. in the Dis-

trict Court of the Southern District of New York, based on the Fleming patent, did you not?

Answer. I think so.

150. Question. I have before me a printed copy of the record in that case in the circuit court of appeals, and on page 166 I find the following testimony:

"7. Question. To your knowledge, did the Marconi company ever make or use or sell any of the arrangements shown in the drawings of the Fleming patent in suit?

"Answer. It did not.

"8. Question. At a radio receiving station or for any purpose?

"Answer. It did not."

Did you so testify, and if so, was such testimony substantially correct?

Answer. If the question refers to the tube and the exact arrangements shown in the drawings in patent 803684, I would say the answer was correct.

151. Question. I call your attention to a diagram marked "Plaintiff's Exhibit Diagram No. 1," appearing at page 2317 of the printed record on appeal in the Marconi *v.* De Forest case just referred to, and ask if the Marconi company made and sold apparatus employing the Fleming tube in the circuits shown in that diagram?

Answer. I would assume that it did; yes.

152. Question. When did the Marconi company commence to make, use, and sell apparatus embodying the circuits shown in that diagram?

Answer. I could not say from memory.

Mr. Edwards. Defendants' counsel offers in evidence the diagram referred to, and the same is marked "Defendants' Exhibit V-5."

By consent a photostat copy of the diagram will be substituted for the original and marked in evidence by the commissioner.

* * * * * * *

[fol. 971] 153. Question. In the De Forest record just referred to I find on page 166, the following:

"9. Question. I show you a blueprint marked 'Plaintiff's Exhibit, Diagram No. 1,' forming part of the stipulation marked 'De Forest Exhibit R,' and which the Marconi com-

pany admits in that stipulation that it used. When did the Marconi company first commence to use the detector organization shown on the right-hand part of the drawing, diagram No. 1?

"Answer. Early in 1910."

Does that refresh your recollection in any way as to when the Marconi company began the use of the apparatus and circuits as shown in this diagram No. 1?

Answer. Not particularly; but if I testified to that effect it was undoubtedly true.

154. Question. To what extent was the detecting organization, as shown in the diagram No. 1, used by the Marconi company, and for about how long?

Answer. I do not believe I can tell you the exact years.

155. Question. Can you say about how many of such sets were built by the Marconi company?

Answer. No.

156. Question. Can you give this number approximately?

Answer. The thing has entirely gone from my mind; it would be a guess if I did.

157. Question. Was the number large or small?

Answer. I would say it was not very large.

158. Question. I find at page 167 of the printed record in the De Forest case the following testimony:

"10. Question. To what extent was that detecting organization used and for how long about?

"Answer. To the best of my recollection the company built from 50 to 75 such sets, such organizations, and they continued in use until 1913."

Does this refresh your recollection with regard to this matter?

Answer. No.

159. Question. Did you so testify, and was such testimony correct when given?

Answer. If I gave it, it was correct when I gave it. I do not remember giving it in just those words.

160. Question. Have you any reason to suppose that you did not give the testimony in substance as just read to you?

Answer. No.

161. Question. Have you any reason to question the accuracy of such testimony?

Answer. No. In all of these questions that you are reading to me, I am assuming that they are direct quotations, and that being so, the testimony was given.

162. Question. Will you look at the diagram marked "Plaintiff's Diagram No. 2," appearing on page 2319 of the printed record of the De Forest case, and say if the Marconi company made, sold, and used apparatus like that depicted in this diagram?

Answer. I think that those were used in what was known as the "United Fruit contract."

163. Question. That is, used by the Marconi company? [fol. 972] Answer. It was a contract by which the Marconi company attempted to give certain radio service to the United Fruit Co.

Mr. Edwards. The diagram shown the witness is offered in evidence as defendants' Exhibit W-5.

By consent a photostat copy of the diagram will be substituted for the original and marked in evidence by the commissioner.

164. Question. Can you state to what extent apparatus of this type depicted in this diagram No. 2 was made or used by the Marconi company during your connection with that company?

Answer. If I remember correctly, the principal use was for the purpose previously named.

165. Question. Will you state more in detail what that purpose was?

Answer. For improving the receiving at the United Fruit stations.

166. Question. Can you recall about what time this apparatus was used in the United Fruit stations?

Answer. No.

167. Question. Can you give approximately the year?

Answer. No.

168. Question. What type of detector had previously been used in the United Fruit stations where this apparatus, like Diagram No. 2, was to be used?

* * * * * * *

Answer. I can not answer that question definitely, other than to say that I believe practically every type then in use had been used but without very satisfactory results.

169. Question. In the printed record of the De Forest case I find, at page 169, in answer to question as to when the Marconi company commenced to use apparatus like No. 2, the following testimony:

"Answer. The type of apparatus shown in diagram No. 2 was put into service in 1914, about the middle of the year, as near as I can place it, and the initial set installed at the United Fruit Co. station at New Orleans, etc."

Have you any reason to doubt the accuracy of that testimony?

Answer. No.

170. Question. Did the Marconi company ever use the carborundum crystal detector in its service while you were connected with that company?

Answer. It fell heir to the United Wireless receivers which had been using carborundum; that was the principal use, I would say.

171. Question. Had the Marconi company used the carborundum crystal detectors before that?

Answer. It is probable they were used on these same United Fruit stations.

172. Question. How long did the use of the crystal detectors by the Marconi company continue, so far as you can recall?

Answer. I can not recall.

173. Question. I quote the following testimony, at page 171 of the printed record of the De Forest case:

"24. Question. Did the Marconi company ever use the carborundum crystal detector in its service, and if so when?

"Answer. The Marconi company used the carborundum detector, yes; from about 1908 up until the present day."

Does that testimony accord with your present recollection? [fol. 973] Answer. I had not thought that that use was quite so early as that. It may be that the experiments that the London company had made in England, and which they called the balanced crystal receiver may have been in my mind when I made that answer you have just quoted.

174. Question. According to the printed record the testimony quoted appears to have been given in November, 1915. Have you any reason to doubt the accuracy of this testimony?

Answer. No.

175. Question. I also find in the record referred to, on page 172, immediately following certain statements by the court and counsel with reference to the line of examination in question 24, the following:

By the court:

"25. Question. From 1908 until when, Mr. Sammis?
"Answer. Until 1915."

Have you any reason to doubt the accuracy of this date as to how long the use of the carborundum detector continued by the Marconi company?

Answer. No.

176. Question. What was the relative sensitiveness and efficiency of the detecting organization shown in diagram No. 1 of defendant's Exhibit V-5 and the carborundum crystal apparatus?

Answer. Which carborundum crystal detector apparatus?

177. Question. I am referring to the carborundum crystal detector which you testified the Marconi company had used.

Answer. That had been used in a variety of circuits, I would say, and it would be very difficult to make a particular comparison such as you ask me to make now without more detail information about circuits and other conditions.

178. Question. At page 172 of the printed record in the De Forest case I find the following testimony:

"26. Question. Please compare that detecting organization of the diagram No. 1 of the stipulation, Exhibit R, and the carborundum crystal detector, both as used by the Marconi company, in respect of relative sensitiveness and efficiency?

"Answer. From my experience with it I should say it could be very roughly estimated to be at least 100 per cent more efficient.

"27. Question. Which is a 100 per cent more efficient?
"Answer. This type.

"28. Question. Diagram No. 1?
"Answer. Yes, sir; than the carborundum. That, of course, is an average taken from large and small, and short distances and long distances."

Have you any reason to doubt the accuracy of the testimony given by you in 1915?

Answer: No; I have not the least bit of recollection, though, of what type of circuit the carborundum was used in to which I had reference at that time.

179. Question. What type of carborundum crystal detector did you have in mind in giving this testimony?

Answer. I believe that I must have had in mind a type that has been developed in England in which two or three crystals were balanced as to their charactertistics. Such re- [fol. 974] ceiver had been used in Brazil, or it was proposed to use such a receiver there, its principal advantage being its ability to nullify static.

180. Question. Then the testimony referred to did not refer to a comparison between the organization of diagram No. 1 and the ordinary crystal detector arrangement? Is that substantially correct?

Answer. It might have. What I was trying to say there was that the vacuum-tube detector itself, somewhat regardless of its exact circuit, was a more sensitive organism.

(Direct examination closed.)

(Cross-examination waived.)

* * * * * * *

Mr. Edwards: Defendants' counsel offers in evidence the following:

File wrapper and contents of United States patent to Marconi, No. 763772 granted June 24, 1904, marked "Defendants' Exhibit X-5."

British patent to Marconi, No. 12039 of 1896, marked "Defendants' Exhibit Y-5."

File wrappers and contents of reissue patent No. 11913, granted to Marconi June 4, 1901, marked "Defendants' Exhibit Z-5."

File wrapper and contents of United States patent to Marconi No. 586193, granted July 13, 1897, marked "Defendants' Exhibit A-6."

United States patent to Marconi No. 627650, granted June 27, 1899 marked "Defendants' Exhibit B-6."

United States patent to Marconi No. 647007, granted April 10, 1900, marked "Defendants' Exhibit C-6."

United States patent to Marconi No. 647008, granted April 10, 1900, marked "Defendants' Exhibit D-6."

United States patent to Marconi No. 647009, granted April 10, 1900, marked "Defendants' Exhibit E-6."

United States patent to Marconi No. 668315, granted February 19, 1901, marked "Defendants' Exhibit F-6."

Manual of Wireless Telegraphy, by Robinson, 1911, pages 95 and 122, marked "Defendants' Exhibit G-6."

Wireless Telegraphy, by Zenneck, published in 1915, pages 84 to 86, inclusive, marked "Defendants' Exhibit H-6."

Wireless Telegraphy, by Leggett, 1921, pages 10 and 11 and 60-63, inclusive, marked "Defendants' Exhibit I-6."

Transactions of the New York Electrical Society for April 17, 1912, pages 4-29, inclusive, marked "Defendants' Exhibit J-6."

Pages 1 to 26, inclusive, of a pamphlet entitled "Marconi Wireless Telegraph Co., Ltd.," being a reprint of a lecture delivered by Mr. Marconi at the Royal Academy of Science, Stockholm, December 11, 1909, marked "Defendants' Exhibit K-6."

United States patent to Tesla, No. 649621, granted May 15, 1900, marked "Defendants' Exhibit L-6."

United States patent to Braun, No. 797169, granted August 15, 1905, marked "Defendants' Exhibit M-6."

United States patent to Braun, No. 797544, granted August 15, 1905, marked "Defendants' Exhibit N-6."

[fols. 975-976] Publications 115A, 115B, and 115C, forming Exhibit 115 shown witness Marconi on cross-examination at page 523 of the record, marked "Defendants' Exhibit O-6."

(The examination by counsel being concluded the witness, in compliance with the regulations of the court requiring him to state whether he knows of any other matter relative to the claim in question, says that he does not.)

(Deposition closed.)

(Defendant rests.)

[fol. 977] CLAIMANT'S EVIDENCE IN REBUTTAL

Proofs in behalf of claimant in rebuttal, taken commencing on Tuesday, October 6th, 1925.

Appearances:

James J. Cosgrove, Esq., Counsel in behalf of Claimant.
Clifton V. Edwards, Esq., Special Assistant to the At-

torney-General of the United States, Counsel in behalf of the Defendant.

Mr. Cosgrove reads in evidence the following stipulation entered into by counsel for the respective parties:

"It Is Hereby Stipulated that the annexed copy of the testimony of William J. Kinsley, David Sarnoff, John Bottomley, John W. Griggs, Albert Ginman, and C. H. Taylor, respectively, is a true copy of the testimony given by said persons respectively between the 9th day of March, 1916, and the 19th day of April, 1916, on behalf of the plaintiff in the suit in the United States District Court for the Western District of Washington, Northern Division, brought by the claimant herein against the Kilbourne & Clark Manufacturing Company, as defendant, for infringement of the Letters Patent in suit herein to Lodge No. 609,154 and Marconi No. 763,772; that said William J. Kinsley, David Sarnoff, John Bottomley, John W. Griggs, Albert Ginman and C. H. Taylor, if called as witnesses herein and duly sworn, would each repeat his said testimony, and that said testimony be and hereby is made a part of the evidence on behalf of the claimant herein, with as full force and effect as if each of said persons had been duly called, sworn and testified herein.

"It Is Also Stipulated that the annexed copies of exhibits are true copies of exhibits offered in evidence in said suit in connection with the said testimony of William J. Kinsley, David Sarnoff, John Bottomley, John W. Griggs, Albert Ginman and C. H. Taylor, and that said copies be and hereby [fol. 978] are made a part of the evidence herein on behalf of the claimant with the same force and effect as if the originals of said exhibits had been duly offered and received in evidence herein, and that said copies of said exhibits are hereby marked in evidence herein as claimant's exhibits as follows:

Number

150 Kinsley Photographs—Stone-Baker Letters 1, 2, 3 and 4. (Pl. Ex. 38H and 1, 2, 3 and 4, Kilbourne & Clark case.)

151 Drawing Marconi Early Tuned Transmitters and Receivers. (Pl. Ex. 39-I, Kilbourne & Clark case.)

152 Catalogue Marconi-Franklin Tuner. (P. Ex. 39-J, Kilbourne & Clark case.)

153 Photograph Marconi Tune A and B Apparatus. (P. Ex. 39-K, Kilbourne & Clark case.)
154 Diagram of Seneca Apparatus. (P. Ex. 39-L, Kilbourne & Clark case.)
155 Marconi Circular No. 37 in re Operation of Stations. (P. Ex. 39-M, Kilbourne & Clark case.)
156 Marconi Shipping Orders for Marconi Tuned Apparatus. (P. Ex. 39-N, Kilbourne & Clark case.)
157 Marconi Tune A Transmitters. (P. Ex. 27-T-1-Kilbourne & Clark case.)
158 Marconi Tune A Receiver. (P. Ex. 27-T-2-Kilbourne & Clark case.)
159 Marconi Tune B Transmitter. (P. Ex. 27-T-3-Kilbourne & Clark case.)
160 Marconi Tune B Receiver. (P. Ex. 27-T-4-Kilbourne & Clark case.)
161 Marconi Tune B Motor Set. (P. Ex. 27-T-5—Kilbourne & Clark case.)
162 Marconi Early Tuned Magnetic Detector. (P. Ex. 27-T-6—Kilbourne & Clark case.)
163 Marconi Multiple Tuner Magnetic Detector. (P. Ex. 27-T-7—Kilbourne & Clark case.)
164 Marconi Tuned Receiver—Variable Condenser. (P. Ex. 27-T-8—Kilbourne & Clark case.)
165 Marconi Untuned Plain Aerial. (P. Ex. 27-T-9—Kilbourne & Clark case.)
166 Marconi Multiple Tuner—Magnetic Detector. (P. Ex. 27-T-10—Kilbourne & Clark case.)
167 Marconi Shipping Orders for Tune B. (P. Ex. No. 28—Kilbourne & Clark case.)
168 Marconi Instructions for Tuned Apparatus. (P. Ex. No. 29—Kilbourne & Clark case.)

"It Is Further Stipulated that the objections entered and stipulations made by counsel during the taking of said testimony of William J. Kinsley, David Sarnoff, John Bottomley, John W. Griggs, Albert Ginman and C. H. Taylor in said suit shall be taken as though made as a part of the proceedings herein.

"Defendant makes the foregoing stipulation solely to avoid the expense and inconvenience of retaking said de- [fol. 979] positions, and it is stipulated that defendant shall not, by reason of making said stipulation, be deemed to

have admitted the truth of any of the matters testified to by said witnesses."

Mr. Cosgrove: Claimant's counsel offers in evidence the original of the stipulation referred to as "Claimant's Exhibit 169, Stipulation as to Testimony and Exhibits in Kilbourne & Clark Suit."

Mr. Cosgrove: Claimant's counsel reads in evidence the testimony referred to in the stipulation, which testimony is as follows:

Brooklyn, N. Y., March 10, 1916.

Proofs for final hearing taken on behalf of plaintiff at the office of the Clerk of the United States District Court for the Eastern District of New York, in the Post Office Building, Borough of Brooklyn, New York City, before Percy G. B. Gilkes, Esq., Standing Examiner in the United States District Court, Eastern District of New York (acting as Examiner by agreement of parties in the place and stead of Thomas B. Hardin, Esq., named in said order) pursuant to an order herein dated March 3, 1916, and to notice to defendant's counsel thereunder, beginning March 10, 1916, at 10:30 A. M.

Deposition of William J. Kinsley, for Claimant, taken at Brooklyn, N. Y., on the 10th day of March, A. D. 1916

Claimant's Counsel, John W. Peters, Esq., Defendant's Counsel, George F. Scull, Esq.

Direct examination.

By Mr. Peters:

Q. 1. Please state your name, age, residence and occupation.

A. William J. Kinsley; age, 50; residence, Nutley, N. J.; office, 261 Broadway, New York City; examiner and photographer of questioned documents, handwriting, typewriting, ink and paper.

Q. 2. Please state your training and experience, if any, which qualifies you as an expert examiner and photographer of questioned handwriting, typewriting, etc.

A. I took two special courses of penmanship, one in Providence, R. I., Bryant & Strattan Business College, the other under H. W. Flickinger, of Philadelphia, taking nor-

mal penmanship work under Mr. Flickinger; and for thirty-one years have been a professional penman; about twenty-nine years of that time I have given particular attention and study to questions involved in disputed documents, and for twenty-one years have been testifying in courts of law in questioned document cases. For several years I was associated with Daniel T. Ames, founder and editor of the Penman's Art Journal, and expert in handwriting, and succeeded to his practice. I studied under Mr. Ames; also wrote several chapters for his book, "Ames on Forgeries." I edited the Penman's Art Journal for seven years, a periodical devoted to penmanship in all its branches and of international circulation. I have written for that magazine and others quite a number of articles on handwriting, identification of handwriting and so on, and also have lectured some on the subject. I have had 1630 cases in 31 states of the United States and 2 provinces in Canada, and [fol. 980] have testified in several hundred of those cases, amongst these cases were 29 murder cases. In the examination and photography of documents I have done work and am still doing it for the United States District Attorneys of the Southern District of New York, Eastern District of New York, and several other districts in these and surrounding states, covering quite a number of states. I have also done work for the District Attorneys and State's Attorneys and Attorneys General in a number of states of the United States in cases extending from Maine to California and from Canada to Florida and New Orleans.

Q. 3. I show you what purport to be three letters, one dated June 30th, 1899, addressed "My dear Baker" and signed "John Stone Stone," one dated July 18, 1899, addressed "My dear Baker" and signed "John Stone Stone," and a third dated Boston, July 22, 1899, and signed "Joseph B. Baker," all enclosed in a binder marked "Marconi Wireless Telegraph Co. of America *vs.* Atlantic Communication Co. et al., Defendant's Exhibit F-1," forming a part of the records of the Clerk of the United States District Court for the Eastern District of New York. I also show you photo-lithographic copies of these three letters offered in evidence in the present suit (Marconi *v.* Kilbourne-Clark), and marked Defendant's Exhibits 1, 2 and 3 respectively,* and

* Marked in Marconi *vs.* U. S. as Defendant's Exhibits E^3, F^3 and G^3.

I ask you, if you have not already done so, to make a careful examination of the alleged original letters, paying particular attention to the date June 30th, 1899 on one letter and the correction June 20 in the letter of July 22, 1899, also to the signatures of the letters.

A. I have already made such an examination, making it for the first time May 15, 1915, and have examined the same papers on several occasions since that time. I made a careful inspection of the handwriting in the body, the date, the signature and the corrected date, June 20, in the letter of July 22, 1899, the letter signed Joseph B. Baker.

Q. 4. In your opinion, was the date, June 30th, 1899, on the first of the letters called to your attention written at the same time and under the same conditions as the body of the letter of which it forms a part?

A. In my opinion, it was not.

Q. 5. Please explain fully on what you base your opinion.

A. On three things: first, the ink; second, the pen; and third, the handwriting itself. The ink, in my opinion, in the date June 30th, 1899, is decidedly bluer than the ink in any other part of the handwriting in the letter. This ink, while it has been blotted and this would make it somewhat lighter in appearance than if it had not been blotted, yet, nevertheless, the blotting, in my opinion, cannot account for the extremely light shade and the rather brilliant blue appearance for an ink of this character, supposedly on the paper for nearly seventeen years now; and we have the comparison between the ink in this date with the ink in other parts on the several pages of this letter, so we know how the ink, if put on at the same time under the same conditions, should now appear. The ink in the body of the letter has in nearly the entire letter the greater part of the blue that was in the ink originally now covered by the darkening of age and by an iridescent sheen on the ink. In the ink in the date, June 30th, 1899, it is distinctly blue, and even the edges of the strokes have no indication of this [fol. 981] iridescent sheen. This iridescent sheen is the result of the aging of ink of this kind and base. In other parts of the document, the letter which consists of four pages, blotting paper has been applied, and even where the writing has been blotted and a large part of the coloring matter of the ink removed, this blotted writing does not compare with the ink tint in the date of June 30th, 1899. The divergence between the shade of the ink in this date,

June 30th, 1899, and the balance of the writing on the four pages of the letter is so marked as to, I think, quite clearly show that the ink in the date June 30th, 1899 has been on the paper much less time than the ink used in the body of the document.

My second reason for arriving at the conclusion that the date was not written at the same time and under the same conditions as the body writing is that the pen, in my opinion, used to write this date was a different pen from that used in writing the balance of the letter. This shows in the pen strokes, especially when magnified, shows in the line quality, and particularly on the light, or what should be light strokes.

The third reason for arriving at the conclusion that the June 30th, 1899, is a later writing than the body of the letter, than the balance of the writing in the letter, is the handwriting itself. It does not appear to be a continuous operation. There is a break in the continuity of the writing. It lacks the connection between the June 30th, 1899, and the balance of the page that we find between the "My dear Baker" in the salutation and the balance of the page. In other words, the "My dear Baker" appears to be written with the same ink, the same pen, and the handwriting seems to be continuous; that is, the "My dear Baker" and the writing following it appears to have been done at one and the same writing operation, not disconnected and no break in the continuity of the writing. The further fact that the date, June 30th, 1899, alone is blotted is a rather significant point, for the reason that in the ordinary course in writing it would not be blotted, and if a blotter was applied to the page it would be the part that had not dried, which would be the bottom part of the page. Instead of that, we find the first line blotted and the second line not blotted, and several lines down the page are unblotted; in fact, I don't see evidences of blotting paper having been applied on the page anywhere except on this date of June 30th, 1899.

These reasons, taken together, are my reasons for arriving at the conclusion that, in my opinion, the date, June 30th, 1899, was not written at the same time that the balance of that page was written, but was written at some subsequent time with another pen and another ink, and the handwriting of slightly different quality, but, in my opinion, in the same hand.

Q. 6. In your opinion, was the correction, "June 20th," in the body of the letter dated Boston, July 22, 1899, a copy of which the defendant has offered in evidence as Defendant's Exhibit No. 1 (present case as Deft.'s Ex. No. E[3]), made by the same person, with the same pen and the same ink and at the same sitting as the signature "Joseph B. Baker," forming a part of said letter?

A. In my opinion, it was not.

Q. 7. Please state your reasons for reaching this conclusion.

A. My reasons for stating that this date was not made with the same pen and ink and one continuous piece of writing at the same sitting with the signature "Joseph B. Baker" are that, first, the ink is distinctly divergent; it is another kind of ink; it is so distinctly different that I think that at even a casual inspection it shows to the naked eye [fol. 982] that two different inks were used; that is, I think inks with two different bases were used, one in the signature of Baker, the other in the June 20 alteration and the line going through the typewritten "20th" below. The ink in the correction, June 20, is a different type of blue and lacks the microscopic marginal definition which is found in the Joseph B. Baker signature. In the Baker signature the margins of the pen strokes are well defined by a black outline, and this is entirely lacking from the June 20 and the line drawn through the "20th" typewritten just below. I don't think that there can be any question but what these inks are entirely separate and distinct types of ink, and, in any event, their colors are very different.

The second reason for arriving at that conclusion that the June 20 was not written at the same time as the Joseph B. Baker signature is the matter of pen. The pen stroke and line quality in the words "June 20" are so distinctly different from the pen stroke in the Baker signature as to be apparent at a glance. The pen used in making the alteration in the date, in writing the June 20, was a coarser pen, made a heavier mark on the upstroke, and has the sort of a line quality that indicates it was a fine stub pen and not the kind of pen used by Baker in writing his name. The June 20, corrected date, has had blotting paper applied to it, and, notwithstanding that, the ink is darker in appearance than the Joseph B. Baker signature, which did not have blotting paper applied to it. I also am inclined to think that the handwriting differs quite decidedly in the

June 20 from the handwriting of Joseph B. Baker. I have not any June 20 standard of Baker's handwriting with which to compare its questioned writing in the date, but the handwriting June 20, correction, appears so different in line quality from the Joseph B. Baker signature as to cause me to think that these divergences could not all have been accounted for by change of pen and change of ink.

* * * * * * *

A comparison of the strokes in the June 20 alteration on this letter of July 22, 1899, Joseph B. Baker letter, with the pen strokes in the date "June 30th, 1899," the letter to Baker signed "John Stone Stone," shows a very close resemblance between them; in fact, the June 30th, 1899 in the one letter and the correction of June 20 in the other letter are nearer alike in line quality than are the June 30th, 1899, and the body writing of that letter, or the June 20 on the Baker letter and the Baker signature. In other words, the nearest match, so far as pen is concerned, is between the two dates, June 30th, 1899 in the one letter and June 20 in the other letter. Another thing that is significant and serves to connect these two letters in my opinion is the ink in these two dates. The June 30th, 1899 date and the corrected date of June 20 in the Baker letter are very close together in color. They are closer than any other combination that can be made in these two letters. In other words, the two dates appear to match in line quality so far as pen is concerned and, in my opinion, do match very closely, and they also match in shade in ink, and in these [fol. 983] agreements they diverge from the other pen and ink writings on their respective letters with which, supposedly, they should agree. There is also in handwriting in this June 20 correction in the Baker letter some resemblance to the handwriting in the June 30th, 1899 date.

Q. 8. Please briefly compare the correction June 20 as to handwriting, pen and ink, with the writing forming a part of the letter dated July 18, 1899, and state any conclusions which you reach.

A. I have already compared that. In my opinion it does not compare so far as ink is concerned; the ink is at present not in the same condition in two papers, and, in my opinion, the ink in the June 20 has not been on the paper so long as the ink in the July 18, 1899. The July 18, 1899 ink has much more body to it, decidedly bronzed iridescent sheen,

which is entirely lacking from the June 20 corrected date. As to handwriting I can hardly say. It is the same type of pen used by the writer of the letters of July 18, 1899, and the June 30th, 1899; the handwriting has some resemblance to that handwriting, more resemblance, in my opinion, than it has to the Joseph B. Baker handwriting.

Q. 9. Have you made photographic copies of the three alleged original letters which you have referred to above?

A. Yes.

Q. 10. Will you please produce the same and state when and under what conditions made, and what, in your opinion, the photographs show?

A. I made the photographs eight or ten months ago in this office, and I am producing a photographic album (Claimant's Ex. No. 159), which, on page 1, contains a natural size correct photographic reproduction of the first page of the June 30th, 1899, letter. Page 2 of the album is a natural size correct photographic reproduction of page 2 of that same letter. Page 3 of the photographic album is a natural size reproduction of the letter of July 22, 1899, signed Joseph B. Baker. Page 4 of the album is a comparison of the corrected date, June 20, on the Baker letter of July 22, 1899, with the portion of the date, June 30th, on the other letter, and also a portion of the first line in the body of the June 30th, 1899, letter showing the words "ckief limitation to the". These were photographed at one and the same operation and enlarged five diameters or twenty-five times. The object of these photographs, and especially in the one on page 4 showing the enlargement, was to get on the same photographic plate at one and the same exposure and one handling throughout, three comparisons; one at the top being the June 20 corrected date on the letter signed Baker; the next line being the June 30th date on the letter signed Stone; and the third line, the one at the bottom of the page, being the first line in the body of the letter proper, in the Stone letter of June 30th, 1899. This gives us an opportunity of comparing handwriting, pen and ink, so that we thus have the result of magnification and the opportunity to compare color values which are correctly represented in the three lines of writing. The comparison of the June 30th with the first line in the body of the letter shows distinctly divergent color values which cannot, in my opinion, be wholly accounted for by the fact that blotting paper was applied to

the June 30th and not applied to the words "chief limitation to the", and also to compare the width of the pen strokes and the quality of the handwriting itself. The quality of handwriting in the June 30th shows, in my opinion, that it was not done at the same sitting with the writer in the same position as was the writing in the body of the [fol. 984] letter. The width of pen strokes and the general quality of line made by the up and down strokes in the June 30th diverges distinctly from the writing in the body of the letter, although I think the same style of stub pen was used in both writings. Then, when we compare the June 20 alteration, which is the first line in this enlarged photograph, with the other lines, we find the June 20 more nearly approximates the June 30th line in line quality and in shade of ink. The same type of pen was used in writing June 20 that was used in writing June 30th, that is, a narrow pointed stub pen. This photograph, in my opinion, reinforces the conclusion arrived at from an inspection with the naked eye and with low power glasses and with ink comparison microscope. I examined all of these writings with an ink comparison microscope, which has two objectives and one eye piece. I placed one objective on one document and the other objective on the other document; for example, the June 20 and the June 30th were inspected at one and the same time; and I also compared the June 30th with other parts of the writing in the same letter. In my opinion, the photograph reinforces the conclusion arrived at from the microscopical examination that there is a distinct divergence between June 30th and the body writing, and a rather close resemblance between June 30th and June 20, and this applies to ink and to pen. I would say in regard to these photographs that a scale was put on and photographed with the object each time. On pages 1, 2 and 3 the scale comes out three inches, showing that the pages were photographed natural size. On page 4 the scale is enlarged five diameters plus, or twenty-five times. The objects were enlarged, of course, with the scale at one and the same operation.

Mr. Peters: I offer in evidence the album referred to by the witness, containing four photographs of the Stone-Baker letters, and the same is marked Plaintiff's Exhibit H-1, 2, 3 and 4, Kinsley Photographs, Stone-Baker Letters (Claimant's Ex. No. 150).

Q. 11. Please now refer to the copies of these three letters marked in the present case (Marconi *v.* Kilbourne-Clark) as Defendant's Exhibits 1, 2, and 3,* and state if you are familiar with the process of copying by which they were made, and if such process is adapted to show details and irregularities in writings such as those to which you have referred.

A. I am familiar with the process, for several years conducting a penmanship studio, where I had photo-lithography done, and we made thousands of diplomas by this identical process, and in my opinion such reproductions only show the outlines and do not represent correctly the color values and the differences existing in, for example, the June 30th, 1899, date and the balance of the writing on that page. The method by which photo-lithography works is to make what is known as a "contrasty" photographic negative first, and by that process it makes the light parts of a document, light in shade or tint, just as black, or they aim to make them just as black, as they do the very blackest part, in order to have a contrast between the lines and the surrounding white document. This kind of a negative then is transferred to the lithographic stone, and, of course, the June 30th and the June 20 writings are just as black when transferred to the stone as any other parts of their respective letters, and the Baker and the June 20 agree in blackness, [fol. 985] and the June 30th, 1899, is just as dark as the balance of that letter, and it is not a correct color value representation of the original exhibits, and I think the photographs that I have made will show that. These color values can be shown, and I have tried to show them, just as they existed in the originals, and that is noticeable in all four of the photographs, and especially so in the photograph No. 4 of Exhibit H. There are three gradations in the three lines; the bottom line, the words "chief limitation to the" is practically a dead black; the June 20 at the top is considerably lighter, the blue in the ink not taking black, while the June 30th date is even a little lighter than the June 20, just a trifle; and it shows these three gradations in color value in the three lines. The same relative gradations are shown in the natural size photographs as they appear on pages 1, 2 and 3. Now, in the other exhibits, Defendant's Exhibits 1, 2 and 3 (Present Case Defend-

* Marconi *v.* U. S.—Defendant's Exhibits E^3, F^3 and G^3.

ant's Exhibits E^3, F^3, G^3), there is not a particle of gradation between the June 30th, 1899, and the body writing so far as color is concerned. The same can be said of the June 20 alteration. It is just as black and just as light as the Joseph B. Baker; and, in fact, while, in my opinion, three different inks were used and three different pens were used in writing the date and the bodies of the letters of June 30th, 1899, and July 22, 1899, so far as ink is concerned in these Defendant's Exhibits 1, 2 and 3 all appear to have been done with one and the same ink, and that is due to the process of reproducing the original letters.

Cross-examination.

By Mr. Scull:

X Q. 12. When were you retained in this case?

A. About the middle of May, 1915.

X Q. 13. At that time had you seen the originals of Defendant's Exhibits 1, 2 and 3 (Present Case Defendant's Exhibits E^3, F^3, G^3)?

A. That is the time that I saw them, at that time, at one and the same operation. I was engaged to look at them and examine them. I saw them for the first time on May 15, 1915.

X Q. 14. What comparisons were you asked to make at that time?

A. To determine, if possible, whether or not all of the handwriting on the letter of June 30th, 1899, was put on there at one and the same time, and also when it was put on.

X Q. 15. Anything else?

A. I don't recall that I was asked in regard to the Baker letter, the June 20, although I may have been asked about that.

X Q. 16. Were you asked in reference to the Stone letter of July 18?

A. I forget whether or not I was asked about that at that time or any time; I don't recall now.

X Q. 17. Have you studied the original letter of July 18, 1899?

A. Yes.

X Q. 18. In the same way in which you have studied the other exhibits?

A. Yes.

X Q. 19. Have you compared the date, July 18, 1899, with the body of that letter?

A. Yes.

X Q. 20. Is it your opinion that that date was written at the same time as the body of that letter?

A. I was unable to determine. The ink has the same sheen, substantially, as the body and has been on the [fol. 986] paper a long time. The handwriting differs in slant a little from the balance of the writing on the page.

X Q. 21. If the ink has the same sheen, is it not evidence that the ink in the date line and in the body of the letter have been on the paper the same length of time?

A. Yes; it indicates that at least they have both been on so long, if they are the same kind of ink, that it is now difficult to differentiate between them.

X Q. 22. Do you see any reason to believe that that date line was not put on at the same time the body of the letter was written?

A. No; nothing except a little difference in the handwriting; and that was not sufficient to lead me to say it was not done at the same time.

X Q. 23. I understand that you are of the opinion that the correction, June 20, in the Baker letter of July 22, 1899, has not been on that paper as long as the ink of the signature to that letter. Is my understanding of your position correct?

A. No, I did not say that. I said it was not the same kind of ink as the signature and not written with the same pen as the signature; I don't know how long either of them have been on the paper.

X Q. 24. Then, you cannot tell, as I understand, the relative length of time which the correction, June 20, and the signature have been on this Baker letter of July 22, 1899?

A. No; the Baker signature appears to be written with an ink that does not show age at all; whereas the date is written with an ink that does and will show age progressively; but the difference between the times when they were put on I have no means of determining just by comparing those two writings themselves.

X Q. 25. Have you examined the date line, "Boston, July 22, 1899," in the typewritten letter of Joseph B. Baker of that date?

A. I just glanced at it; I did not attempt to run dow the typewriting.

X Q. 26. Were you not asked to examine that date line particularly?

A. I think not; I have just glanced at it.

X Q. 27. Do you have any recollection of having been asked to examine that date line particularly?

A. I have no recollection; I think I was not asked.

X Q. 28. Now, please examine that date line and see whether or not there is any evidence of erasure or change in it so far as you can see.

A. There is none.

X Q. 29. What is the characteristic color of the ink in the signature, "Joseph B. Baker", on the July 22, 1899 letter?

A. It is a bluish gray center, with a microscopic edge or marginal line that is a little blacker; it has a slight purple in the blue there as well.

X Q. 30. And I think you have said that that signature show evidences of having been blotted.

A. No; I said it did not show any evidences of having been blotted; the June 20, I said, I thought had been blotted.

X Q. 31. Well, what would account for the fact that the centers of the strokes in the "Joseph B. Baker" are lighter in shade than the edges, if the same has not been blotted?

A. That is caused by the character of the ink used. I am inclined to think it is a nigrosin ink, or, at least, has nigrosin in it. Nigrosin is a coal tar by-product, and produces an ink which gives that microscopic margin to which I have referred and which is entirely missing from the June 20 writing, which, I think, is an iron ink writing, iron nut-gall writing fluid. This microscopic margin clearly shows in the Joseph B. Baker signature that blotting paper [fol. 987] was not applied, and it is characteristic of a nigrosin ink to produce a marginal definition with the interior part of the stroke lighter.

X Q. 32. Do I understand that you have testified that you found evidences which cause you to have the opinion that the date, June 20, on Defendant's Exhibit 1 (present case F^3), was written by the same hand which wrote the date, June 30th, on Defendant's Exhibit 2 (present case F^3), or the originals thereof, rather?

A. Yes; there is some evidence. I am not strongly of the opinion that it was one and the same hand, because there is not enough writing there for comparison; there is some little indication.

X Q. 33. What is that little indication?

A. Its general pen movement. The same general slant of the writing, particularly in the small letters "u" and "m". There is the safe difference in proportions between the "2" and the cipher in the "June 20" and the "3" and the cipher in the "30", and also divergence in slant, the "2" being a little backhand, the cipher forward slant; the "3" being backhand and the cipher being nearly vertical. In line quality there are a number of resemblances, the movement used to produce the writing there are a number of resemblances, in pen pressure resemblances are quite marked. But that is as far as I can go.

X Q. 34. According to your art, do you say that the cipher in the "20" and in the "30", respectively, have the same slant, or approximately the same?

A. No, not the same or approximately the same. The one in the "20" slants distinctly, decidedly to the right of vertical; the one in the "30" is substantially vertical; it is kind of blurred and a little hard to get the slant of it, but they are not the same slant. However there is substantially the same divergence in slant between the "2" and the cipher and the "3" and the cipher. In the one case the "2" does not slant as much to the left of vertical as does the "3" in the other case; the cipher of the "20" slants decidedly more than the cipher of the "30".

X Q. 35. You say this does not slant as much——

A. (Interrupting): To the left of the vertical as does the "3".

X Q. 36. Now, please compare the characteristic formation of the figure 2 in the June 20 and the figure 3 in the June 30th, and tell me whether, in your opinion, those two letters belong to the same sets of numerals that one hand would ordinarily write?

A. I don't believe I could make a comparison of that kind, for the reason that I have to have a standard, and I would have to have a standard 2 which I do not have. You can't compare a 2 with a 3 for design or outline; all you could do would be to compare line quality, movement and speed of general writing, but not the outline itself. I don't know what outline the writer of the "30" would make for a 2.

X Q. 37. On the eighth page of the original of Defendant's Exhibit 3 (present case G[4]), I call your attention to the phrase, "June 30 ultimo" and ask you whether in your opinion that date was written at the same time and by the

same hand as the body of the letter, and particularly at the same time and by the same hand as the date, July 18, appearing at the top of sheet 1 of that letter?

A. In my opinion it is written with the same pen, the same ink, and in the same handwriting as the body, the balance of the letter, and by the person who write this letter. It appears to be the same time also, a continuous operation, so far as I can determine.

X Q. 38. And I asked you about the date.

[fol. 988] A. The ink appears to be the same condition, it is in the same handwriting, but whether or not done at that same time,—I have just a little doubt in regard to the July 18, 1899 date originally, but not enough to express any opinion on it. It appears to be written at one and the same operation, including the July 18th date. The handwriting is slightly different in the July 18 date from what follows; there is a slight difference in the slant.

X Q. 39. On the letter of June 30th, 1899, do you find any evidence of any erasure on the first page, and particularly at or about the place where the date June 30th, 1899 now appears?

A. No.

X Q. 40. In other words, you find no evidence that any other date has been on the paper than the one that now appears?

A. No; none whatever.

X Q. 41. Do I understand it to be your opinion that the date line, June 30th, 1899, has not been on the original of Defendant's Exhibit 2 (Present Case H[3]), for as long a time as the ink of the body of that letter?

A. Yes; that is my opinion.

X Q. 42. Can you give any idea of the relative times or period which these two inks have been on this paper?

A. No, I cannot; it is done by comparison. We have several pages of writing supposedly done at the same time as the paper is dated, June 30th, 1899, and I have a chance to compare that ink with the June 30th ink in the date, and the June 30th ink has not matured to the same extent as the ink in the body has matured; and the June 20, corrected date, in the Baker letter, matching so closely as it does the June 30th ink in the Stone letter, of course that would be the only way I could say that the Baker letter was probably not written at the same time as the date; not from a comparison by itself, but by a comparison of that

ink with the June 30th ink, and then a comparison of the June 30th ink with the body writing in that letter and also in the July 18, 1899 ink.

X Q. 43. In your opinion, the date line, June 30th, 1899, is written with a different kind of ink from that used in the body of the letter, is it not?

A. No; I am inclined to think it is much the same kind of ink, the same base of ink.

X Q. 44. Did you not find a different color value in the date line, June 30th, and the body of the letter?

A. Yes.

X Q. 45. Would that not indicate, then, that a different ink was used?

—. It might and it might not. It might be the same ink and the difference in color be due to the difference in age, the body writing having been on the paper longer than the date.

X Q. 46. Well, from your experience, can you approximate the relative times that the inks in the date line and in the body respectively of the June 30th, 1899 letter have been on that paper, assuming first that the body of the letter was written in 1899?

A. No, I don't believe I can even say approximately. I think that considerable time elapsed between the body writing and the writing of the date, but I don't know how many years.

X Q. 47. When you say a considerable time, what have you in mind?

A. Oh, five to ten years would be as near an approximation as I could give.

X Q. 48. Such difference as appears, could not, then, in your opinion, be produced by less than five years' difference in the times of writing?

A. That is only approximately; it is not at all definite. I don't do it by setting dates, but by comparison. There [fol. 989] is not any time clock on the development of ink after it gets that old, and I think the June 30th, 1899 ink has been on there long enough so that it is difficult now to determine definitely its age.

X Q. 49. And that is the nearest time, then, that you can approximate in this matter of the difference in the ages of these two inks?

A. Yes, that is as near as I could say.

X Q. 50. I think you said that the fact that the date line, June 30th, 1899 on the original of Defendant's Exhibit 2 (Present Case F[3]), was blotted, whereas the body of the letter was not blotted, that this difference was significant. In making this remark, did you have in mind the character of the contents of the body of that letter?

A. Yes.

X Q. 51. What do you understand that letter to be, so far as its contents are concerned?

A. A report on experimental investigation.

X Q. 52. Relating to wireless telegraphy, is it not?

A. Yes.

X Q. 53. Does the handwriting evidence care in writing it?

A. No.

X Q. 54. In your opinion, it was written hurriedly?

A. Yes.

X Q. 55. And without very much thought or pause on the part of the writer?

A. Yes.

X Q. 56. Did it occur to you in considering the contents of the letter that it was not at all impossible that the body of the letter was written first and the letter thereafter dated, immediately following its writing?

A. That did occur to me and that would be the only explanation for blotting if the ink was the same.

X Q. 57. Well, from your experience in examining questioned writings would that be an unusual situation in a letter of this character, consisting, as you believe, of a scientific report on wireless telegraphy?

A. Be an unusual condition to date it last?

X Q. 58. Yes.

A. I think it would be an unusual condition for anybody who wrote in this style, right off, without hesitation. The first thing I should think the average person would do would be to date it and then continue with it. Of course it would be unusual to go back and date it, although that could be done.

X Q. 59. Have you compared the character of the ink in the bodies of the two letters dated June 30th and July 18th respectively?

A. Yes.

X Q. 60. Is the ink on these two documents the same?

A. I think it is the same kind of ink.

X Q. 61. What is the evidence as to the comparative ages of the inks on these two documents?

A. The ink in the letter of July 18th, I think, has matured more, is blacker and has more nearly covered up the blue in it than has the ink on the letter of June 30th, 1899; there is a distinctly bluer cast in the body writing of the June 30th letter as compared with the July 18 letter.

X Q. 62. Then, in your opinion, the evidence is that the letter dated July 18, 1899, was written before the letter dated June 30th, 1899?

A. Either that, or else the ink, while the same kind was in a different condition when put on the paper. It might have been a fresh bottle in one case and in the other case from a bottle that had oxidized, right in the ink stand itself.

X Q. 63. What is your opinion as to the comparative ages of the writings in these two letters dated June 30th and July 18 respectively?

A. As far as I can judge from the ink itself, the June 30th has a fresher appearance than the ink of July 18. [fol. 990] There should not be any marked difference between June 30th and July 18 at this time, should not be any way by which you can tell them, supposing the ink was put on in the same condition. There must have been some difference in the conditions under which the ink was applied to the paper, although I believe it to be the same style of ink, the same base of ink on the two letters.

X Q. 64. Now, will you please state briefly which, in your opinion, of these two letters, so far as the body contents are concerned, was written first?

A. I can't say definitely, but the ink in the June 30th letter would indicate that it was written since the letter of July 18.

X Q. 65. Can you tell what the difference in the ages of these two letters is?

A. No.

X Q. 66. Can you even approximate it?

A. No.

X Q. 67. Would it be as much as a year?

A. I don't know.

X Q. 68. Would it be as much as six months?

A. I don t know.

X Q. 69. Would it be as much as a week?

A. I don't know. If the ink was in different—take the same bottle of ink, one exposed, and one bottled, might

produce variation as much as appears here, but if it is the same ink under the same conditions, some months or a year or two might have elapsed to produce this difference now, but I don't know the conditions.

X Q. 70. But you have said that in your opinion the letter dated June 30th was written subsequently to that of July 18, have you not?

A. Qualifiedly so; that the ink appears to be fresher than the ink of July 18.

X Q. 71. Then you have no opinion on the subject?

A. I have a qualified opinion on the subject; not a positive, definite opinion.

X Q. 72. And that opinion is based on the relative degree of freshness in appearance of these two inks?

A. Yes, the ink in the July 18 letter, the dark ingredients have more clearly clouded out the blue than has been the case in the June 30th letter.

X Q. 73. Now, I ask you, how long a period must elapse, in your opinion, before such a condition as that could arise?

A. I don't know, I don't believe anybody knows.

X Q. 74. You don't know whether one week would be sufficient for that?

A. No, I can't tell, because there are other conditions that we do not know anything about, whether it was a fresh bottle of ink or ink standing in an ink well exposed oxidized.

X Q. 75. In other words, then, if the difference in inks were such as you have just indicated, it might very well be that the letter of June 30th was, in fact, written before that of July 18th?

A. Yes.

X Q. 76. Did you find any difference in ink or general characteristics between the scratch marks through the figure "20th" and the correction date "June 20" on the Baker letter of July 22, 1899?

A. Yes, there is a slight difference, although, I think, it is the same ink. The difference comes in depth of color. In the crossing out mark more ink was put on the paper, the stroke was heavier, and the tint is a little deeper, although, I think, it is one and the same ink and applied under the same conditions.

X Q. 77. Was one blotted and the other not?

A. I think they were both blotted.

X Q. 78. Is not one considerably darker or heavier than the other?

A. Yes, one is. I am unable to tell, I think, definitely about the blotting of the stroke going through the type- [fol. 991] written figures; it may have been blotted and it may not; but there is no question but what the June 20 up above had a blotter applied to it.

X Q. 79. I show you an original letter marked "Defendant's Exhibit 7, A. G. Jr. Ex." (Present Case Deft's Ex. K[3]), and ask you to compare the signature on that letter with the original of Defendant's Exhibit 1 (Present Case E[3]), and tell me whether or not in your opinion, they are made by the same man?

A. I do not give off-hand opinions, as a rule, but they look very much alike.

X Q. 80. From the inspection which you have given them you have no reason to doubt they are signatures of the same hand?

A. No, they look very much the same.

X Q. 81. Will you please examine Defendant's Exhibit 7 (K[3] in Present Case), and particularly the date line, "Boston, June 3, 1902," and also particularly the dates in the last two lines, June 30, 1899 and July 18, 1899, and tell me whether, in your opinion, there is any evidence in that document of those dates having been changed or altered?

A. I could not tell off-hand; I would have to—looking at that typewriting off-hand, I don't see any evidence of any alteration.

X Q. 82. Referring now to the letter dated June 30th, 1899, the original of Defendant's Exhibit 2 (F[3] in Present Case), I call your attention to the fact that there are in a number of places thereon smears or color marks, apparently arising from the handling of the paper with a moist hand. Do you see the marks I refer to?

A. Yes.

X Q. 83. What is the color value of those marks, in tint, particularly?

A. It is blue, bluish.

X Q. 84. What is the comparison between the color of the blue from those blurs or smears and the blue in the date, June 30th, 1899?

A. That is much the same sort of tint. Of course, we have it massed in the June 30th and have it only smeared in the body.

X Q. 85. I call your attention to the photograph, Plaintiff's Exhibit H-4 (Claimant's Ex. 150), and ask you

whether the difference in the apparent color values between the date June 20 and the scratch through "20th" is not accentuated in that photograph as compared with the same color values in the original?

A. I think not; I think it is correctly represented.

X Q. 86. What is the general tint of the ink in that June 20 and the scratch?

A. Blue.

X Q. 87. And how does blue photograph in relative color values in a negative plate?

A. Somewhat light, unless a color correcting screen or filter is put on the lens and an orthochromatic plate is used to offset that, and that, of course, I did not do in this case, because I wanted to get the relative divergences in color.

X Q. 88. As I understand your last answer, different shades of blue produce different densities in the photographic plate and that such densities are not in the same ratio as the densities of the tints photographed, is that true?

A. I think it is not true; I think they are photographed in their exact ratio of density. The camera reproduces it more accurately than we see with the eye and differentiates as between these tints or shades of even the same color.

X Q. 89. Do I understand, then, that these photographic differences are differences brought out by the camera and are such as not evident to the eye?

A. No, in this case I think it is evident to the naked eye and it is certainly evidenced when they are examined even [fol. 992] under low power magnification that there are differences in the shade or depth of color in these writings.

X Q. 90. Did you not say that the camera brings out differences that are not apparent to the naked eye?

A. Yes.

X Q. 91. How did you suppress that particular function of the camera in this case?

A. I did not suppress it at all.

X Q. 92. Then, in this particular case the camera produced the same results as appear to the naked eye?

A. Substantially; that is, the eye, I think, can see everything that is shown here in all these photographs.

X Q. 93. You understand, Mr. Kinsley, my questions relate to a question of degree. What I am trying to ascertain is whether or not, in your opinion, a camera in photo-

graphing different shades of blue preserves the same relative values as are apparent to the eye, or does it accentuate them?

A. It does not preserve the same relative values if you use an ordinary plate. If you want to accentuate, if you want to reproduce those and show that the light lines are dark, of course, you have to use an orthochromatic plate and a ray filter. If you want to show the same relative conditions or to show the conditions as they appear in the camera, you use an ordinary plate.

X Q. 94. And in this particular case you used the ordinary plate and not the filter?

A. Yes, used the ordinary plate and not the ray filter.

X Q. 95. Then, again I ask you how do you account for the apparent statement that in this particular case the camera did something different from what it usually does, to wit, accentuate the difference in tints between two shades of blue?

A. Oh, the camera always accentuates the difference in degree between two shades of blue. For example, you have ink that is a deep blue and a light blue, and take the same identical ink, two dips, and put on twice as much ink on one stroke as on another, then if they are the same width of stroke one will appear darker than the other, because the camera and the photographic process that is used here reproduces only in white and black and not in colors; so we get the gradations of shade reproduced in white and black and we get color value.

X Q. 96. Is that color value in the same ratio as appears to the eye? I am asking this question generally now and not in reference to any specific exhibit.

A. Sometimes it is and sometimes it is not; it depends, of course, on the depth of the color. If you get a very light blue it would look bluer to the naked eye than it would photograph. If you get a darker blue, it might photograph about as dark as it looked to the eye.

X Q. 97. In other words, when you are shown a photograph of two specimens of writing, one of which appears dark and the other light, it does not necessarily mean to you that the originals had the same degree of difference in tints as appears by the photograph, is that correct?

A. That is true; it does not always show the same.

X Q. 98. I understand, Mr. Kinsley, that you have testified in a great many cases where questioned documents have been before the Courts?

A. Yes.

X Q. 99. And, as a matter of fact, that is your principal business, is it not?

A. That and the examination and photographing and preparation of it; not testifying. Of course, a small part of my time is spent in testifying, but the major portion of it in examination and preparation. Many cases are never tried at all and in many cases I do not testify as I decide against my clients.

[fol. 993] X Q. 100. In other words, you are a professional hand-writing expert?

A. Yes.

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Redirect examination.

By Mr. Peters:

R. D. Q. 101. Will you state the exact date when the photographs. Plaintiff's Exhibit H-1, 2, 3 and 4 (Claimant's Exhibit No. 150), were made?

A. May 28, 1915.

R. D. Q. 102. The letter of June 30th, 1899, is marked evidently by the Examiner "Marconi *v.* Atlantic, Deft's. Ex. F1 (Present Case E^3), May 14, 1915, J. L. O'Neill, Deputy Clerk." Was all of that marking on the letter when you made the photograph?

A. No.

R. D. Q. 103. Explain what part was.

A. That portion marked "Deft. Ex. F 1."

R. D. Q. 104. Please state whether or not the photographs that you have produced show substantially the same color values as the originals.

A. They do. A blue object, or blue ink, of course, has a tendency not to photograph black as it frequently appears, or dark, as it appears, to the human eye; but inks purporting to be put on with the same pen at the same time, the fairest way to show whether or not they were applied in the same condition, and if conditions now are the same, is to photograph them on the same plate, with exactly the same lighting conditions and the same magnification, as done on page 4 of this Exhibit H. The plate is absolutely un-

treated; it all had the same bath and it was handled the same way; the lighting was the same and it was exposed under the same conditions the three or four lines that appear on it, and it was developed at one and the same operation, fixed, washed and printed at the same time.

Recross-examination.

By Mr. Scull:

R. X Q. 105. What is the color in the original of the last line of Plaintiff's Exhibit H-4? (Part of Claimant's Exhibit No. 150.)

A. It is black substantially, when viewed with direct light; with transmitted light there is a slight blue tint showing in the interior parts of the stroke.

R. X Q. 106. Well, this photograph was taken with reflected light, was it not?

A. Yes.

R. X Q. 107. So that none of the blue that is in the interior of the strokes, as you say, would have any effect on this photographic plate?

A. No. Of course, had the photograph been made by transmitted light, the June 30th would be far lighter than it appears on the plate, Exhibit H-4.

R. X Q. 108. Now, how does black photograph?

A. It photographs black.

R. X Q. 109. Does it photograph practically true to tint?

A. Yes.

R. X Q. 110. But the blues don't photograph true to tint?

A. Blues don't with the ordinary plate and lens. Without a ray filter they have a tendency to come lighter, depending on the depth of color.

R. X Q. 111. And yet in the face of that statement and this you still say that Plaintiff's Exhibit H4 (Present Case G^3) shows the correct relative color values of the different lines appearing thereon?

A. As they appear and the lines are recorded on the plate of the camera there is more blue in the June 20, and the line and the June 30th, of course, than appears in the last line [fol. 994] and consequently they appear lighter to the eye, and they appear, I think, even lighter in the prints than they do to the human eye; but they are all photographed at one and the same operation, and the effort was to reproduce them accurately as they appear.

R. X Q. 112. I am not asking what the effort was nor what the process it. You said on redirect examination that plate H4 shows substantially the color values of the original. Now, is that true?

A. It does, substantially.

R. X Q. 113. What does the word "substantially' mean in that case?

A. Well, they are nearly as dark as the originals by direct light; if it was a transmitted light photograph I think they would be much lighter.

R. X Q. 114. What do you mean by that?

A. All the writings. Well, the lines June 20, the cross mark, and the June 30th would appear much lighter than they do now; but substantially, notwithstanding they are blue, they do represent the color values; to the naked eye, of course, the June 30th has a decided blue tinge that it is impossible to reproduce in the photographs; that blue tinge asserts itself in the photograph by making the lines appear a little lighter, as far as black is concerned, than in the original.

R. X Q. 115. Have you examined the color value in the signature "John Stone Stone" to the letter dated June 30, 1899?

A. Yes.

R. X Q. 116. What is the color value of that as it appears to the naked eye?

A. It is a blue black.

R. X Q. 117. Does it not have a distinct blue appearance to the naked eye?

A. I would call it a blue black to the naked eye; when examined under magnification, you can see a little more blue in it.

R. X Q. 118. Does it have the same apparent tint to the eye as the body of the letter and particularly the page immediately above it?

A. No, it is slightly lighter, progressively so, beginning with the "J". The "J" is about as dark as the "Cordially", and from there on it is progressively lighter in tint, either because the ink gave out or a blotter was applied.

R. X Q. 119. Then, is it your idea that a blotter applied to the ink of the body of the letter of June 30th, 1899, would produce a bluish appearance?

A. It would be more blue than if no blotter had been applied, that is if the color was removed, a lot of it; then when

the ink dries it would be bluer than if the ink was allowed to dry undisturbed.

R. X Q. 120. How do you account for the progressively blue and bluer appearance of the signature 'John Stone Stone''? On either one of two grounds; that the ink was gradually giving out and it did not deposit so much ink there or that he did deposit the ink and blotted it and the last writing had more ink removed than the earlier part of the writing; that is, it was dryer in the first than the last part.

R. X Q. 121. That is to say, the more quickly the blotter were applied to the ink the bluer would be the appearance?

A. Yes.

Mr. Scull: Defendant's counsel now asks Plaintiff's counsel whether or not he concedes that the originals about which this witness has been testifying this morning, to wit, the letters dated June 30, 1899, July 18, 1899 and July 22, 1899, of which Defendant's Exhibits 1, 2 and 3* are photolithographic copies, are part of the court records in the suit [fol. 995] of Marconi *v.* Atlantic Communication Company now pending in the Eastern District of New York, and cannot be removed from such records for the purpose of introduction as evidence in the present case.

Mr. Peters: Plaintiff's counsel states that the said original letters are parts of the files of the said Court and so far as Plaintiff's counsel is concerned he has no power or authority to remove them. Plaintiff's counsel has no objection to the said original letters being removed and made a part of the record in this case.

Mr. Scull: Defendant's counsel notes that the Examiner here is the Clerk of the Court for the Eastern District of New York, and now asks him to state on the record whether or not the letters above referred to are or are not part of the court records here in this District and whether they can be removed from such records for the purpose of offering them as original exhibits in a suit pending in another district.

The Examiner: The exhibits referred to and used in evidence this morning are exhibits in a case in process of trial in the United States District Court for the Eastern District of New York, as shown by the records of that Court with which I am familiar as Clerk. These papers

* Defendant's Exhibits E^3, F^3 and G^3 in Marconi *vs.* U. S.

and exhibits cannot be removed without an order of the Court or the consent of the Court.

Mr. Scull: Defendant's counsel notes that, in view of the foregoing statement of the Clerk, that the objection taken to the introduction of Defendant's Exhibits 1, 2 and 3 as secondary is apparently not well founded; but he states further that if Defendant's Exhibits 1, 2 and 3 are secondary evidence, then he wishes to make the same objection to Plaintiff's Exhibits H-1, 2, 3 and 4 (Claimant's Exhibit No. 150), as was made by Plaintiff's Counsel in reference to Defendant's Exhibits 1, 2 and 3.

Deposition Closed

March 11, 1916, 11 A. M.

Deposition of David Sarnoff, for Claimant, taken at New York, N. Y., on the 11th day of March, A. D. 1916

Direct examination.

By Mr. Peters:

Q. 1. State your name, age, residence and occupation.

A. David Sarnoff, 2063 Mapes Avenue, Bronx, New York; age, 25 years. I am at present assistant traffic manager and contract manager of the Marconi Wireless Telegraph Company of America.

Q. 2. How long have you been employed by the Marconi Company and in what capacity or capacities?

A. I joined the Marconi Company in September, 1906. I have been employed at the beginning in its executive {fol. 996} office at William Street, New York; then as wireless operator on shipboard and shore stations; as inspector in the engineering department; chief inspector of the Company; assistant to Mr. Sammis, onetime chief engineer of our Company; and, as previously testified, am now assistant traffic manager and contract manager of the Company.

Q. 3. How long have you personally been familiar with the apparatus and practices of the Marconi Company?

A. Since 1907.

Q. 4. To what extent, if at all, in 1907 and 1908 was tuned transmitting and receiving apparatus employed by the Marconi Company?

A. Tuned apparatus was employed by the Marconi Company generally at its ship and shore stations at the time referred to.

Q. 5. If untuned or plain aerial apparatus was also employed during these years, please state briefly the purpose for which it was employed.

A. Plain aerial transmitting apparatus was installed on all ship stations then equipped by the Marconi Company and also at some of the shore stations then in use. The purpose for which plain aerial was installed on ship stations was for use in case of emergency. When a ship is in distress, the plain aerial transmitter is found to be a convenient apparatus for instant use. It was also the custom of the Marconi Company at that time, and in some cases still is, to supply batteries for operating the plain aerial induction coil transmitters so that in the event of a ship being damaged and unable to furnish current from its engine room dynamo, the batteries will furnish the auxiliary source of current. At the shore stations the plain aerial transmitters were sometimes used when, for one reason or another, the main tuned equipment might have been temporarily out of commission.

Q. 6. Why did the plain aerial or untuned apparatus provide a convenient auxiliary in case of emergency or distress as I understand you state?

A. Because the plain aerial transmitter produces a highly damped wave, which is easily received on a tuner which need not be sharply tuned, and, in fact, the oscillations produced by plain aerial transmitters very often come in over a very wide range of the tuned receiving apparatus. In fact, the radio regulations of the Department of Commerce suggest, I believe, the use of highly damped waves in times of distress.

Q. 7. What ship and shore stations were operated by the Marconi Wireless Telegraph Company of America during the years 1907 and 1908?

A. The following ship and shore stations were in operation at the time referred to in your question. Shore stations: Cape Code, Mass.; Sagapenack, Long Island; Siasconset, Mass.; Sea Gate, Coney Island, N. Y.; I believe Babylon, Long Island, was still in operation at that time. Ship stations: S. S. Philadelphia, American Line; S. S. New York, American Line; S. S. St. Louis, American Line; S. S. St. Paul, American Line; S. S. Finland, Red Star Line;

S. S. Kroonland, Red Star Line; cable ship, Mackay-Bennett. There may have been one or two others, but I don't recall at this time.

Q. 8. Please describe the apparatus employed at these stations, limiting your statements to your own personal observation, either of the apparatus or the knowledge gained gained by receiving signals from the stations, during the years 1907 and 1908, and in describing the apparatus please refer to any drawings or descriptive matter which you can produce to supplement your testimony.

A. About that time there were several types of equipments generally employed. I produce a drawing (reproduced as Claimant's Ex. No. 151), I have made showing [fol. 997] the arrangements of the circuits which I will describe by referring to the figures. The apparatus then used at the ship and shore stations operated by the American Marconi Company were known as tuned apparatus, being distinguished by certain letters assigned to the different tunes, such as Tune A, Tune B, and also tuned transmitters using motor generators, which were referred to as "power sets."

Fig. 1 of the drawing submitted shows a tuned transmitter using a Tune A transmitting jigger and Tune A condenser. Letter f represents the aerial; A, the vertical wire connecting the aerial with the secondary of the Tune A jigger; d', which was connected to E, the earth. The word "jigger" stood for what we now call "oscillation transformer". d represents the primary of the jigger or oscillation transformer; e represents Leyden jars, which constituted the condenser of the closed oscillatory circuit; G, the spark gap; s, the ten inch induction coil; a, the primary source of current; b, the transmitting key.

Fig. 1-A shows the Tune B transmitting jigger and condenser; d' representing the secondary of the jigger, d, the primary of the jigger; and e (which I will label now) the Tune B condenser. The remainder of the circuit was the same as in Fig. 1, previously described.

Fig. 3 represents the tuned transmitter using a motor generator; or, in other words, the tuned power set. f represents the aerial; A, the vertical wire connecting the aerial with the loading coil g; d', the secondary of the oscillation transformer, and E the earth connection; f, A, g, d' and E being connected in series. d represents the primary of the oscillation transformer; e the condenser

of the closed oscillatory circuit; G the spark gap; c the power transformer; b the transmitting key; and a the motor generator furnishing the necessary current to the transformer.

Fig. 4 represents the receiving apparatus known as the Marconi Multiple Tuner, which was used with the magnetic detector. Describing the arrangement of circuits shown in Fig. 4, I would say that f represents the aerial; A the vertical wire connecting the aerial with the loading coil g'; h a variable condenser; j' the primary of the receiving oscillation transformer; and E the earth; the elements previously mentioned being connected in series; j^2 the secondary of the oscillation transformer; R' a variable condenser; t' an inductance; j^2 R' and t' representing the intermediate circuit of the multiple tuner; t^2 an inductance; h^2 a variable condenser; and M the magnetic detector; t^2, h^2 and M forming the detector circuit.

It was the general practice of the Marconi Company to supply both the Tune A and Tune B transmitting apparatus at the same station. The Tune A transmitter provided for a shorter wave length than the Tune B transmitting apparatus, which furnished a longer wave. Separate oscillation transformers or jiggers were supplied to each station for use with Tune A and Tune B transmitters. The condensers of the closed oscillatory circuit were varied in using either Tune A or Tune B. In the case of Tune A, the condenser consisted of six Leyden jars connected in series parallel; in the case of Tune B, the condenser consisted of a number of Leyden jars, varying from twelve to sixteen, the jars being connected in parallel. In some cases an entirely separate tray containing the Tune A condensers was supplied and a separate tray con- [fol. 998] taining Tune B condensers was supplied. In other cases provision was made for reducing the number of jars and changing the connections of the condenser when changing from Tune A to Tune B transmission or vice versa. The apparatus described in Fig. 3, namely the power sets, were then about coming into general use by the Marconi Company, this type of transmitter replacing the earlier type of induction coil transmitter. The oscillation transformers supplied with the power sets were variable as to the number of turns in the primary and secondary and the loading coil was also variable as to turns. Where the tuned transmitting power sets were installed

on shipboard, the induction coil transmitter still remained, but was connected for plain aerial use in time of emergency, as previously described and referred to. The receiving apparatus shown in Fig. 4 consisted, as I have said, of a Marconi Multiple Tuner, frequently called the "Franklin" Tuner. This tuner consisted of three circuits, namely, the open or aerial circuit, the intermediate circuit, and the detector circuit. The inductances and capacities shown and described in each of these circuits were variable.

About August of 1908 the Marconi Company was awarded a contract by the U. S. Revenue Cutter Service for the equipment of the U. S. Revenue Cutter Seneca, and I inspected the apparatus while it was in the course of construction at our shop in New York and also saw it after it was assembled and while it was tested. I produce herewith a diagram (reproduced opposite as Claimant's Ex. No. 154) showing the circuits and connections of the transmitting and receiving apparatus installed on the Revenue Cutter Seneca. This drawing shows that a tuned power transmitting set was installed using a motor generator, plate condensers in oil, an inductively coupled oscillation transformer, and that the receiving apparatus consisted of a magnetic detector and a multiple tuner, previously described.

During the years 1907 and 1908 I made frequent visits to the Marconi station at Sea Gate, Coney Island, and on several occasions operated there for short periods of time, and found that Tune A transmitting apparatus was used almost exclusively. There was no plain aerial equipment installed or used at this station during the time specified or subsequent thereto. I also made frequent visits on the vessels of the American Line previously referred to and found that the ships were equipped with Tune A, Tune B, and, of course, plain aerial sets. I should also add here that wherever a Tune A or Tune B transmitting set was used with a ten inch induction coil that it was possible to use the same coil in a plain aerial manner by simply connecting the one terminal of the secondary of the induction coil to the aerial circuit and the other terminal of the secondary of the induction coil to ground.

I should add that it was the practice of the wireless operators at ship stations to use the separate jigger supplied for Tune B when transmitting on Tune B and to use

the separate jigger supplied for Tune A when using Tune A; and similarly in the case of the transmitting condensers, either the separate bank of condensers supplied in the tray containing the Tune B condensers were used when transmitting on Tune B, and similarly the separate tray of condensers for Tune A when transmitting on Tune A, or else the change in number and connection of the jars was made by the operator where separate trays of condensers were not supplied with Tune A and Tune B transmitters. [fol. 999] Q. 9. Can you produce a photograph showing an installation of what you have defined as Tune A and Tune B apparatus?

A. Yes, sir; I produce herewith a photograph (Reproduced opposite) taken of the interior of the wireless cabin on the S.S. St. Paul of the American Line. It shows two transmitting jiggers, one of which I recognize to be the Tune A transmitting jigger and the other the Tune B transmitting jigger. It also shows two trays of Leyden jar condensers, ten inch induction coil and coherer receiving apparatus, as well as other accessories.

Q. 10. What is the apparatus shown in Figs. 2 and 2-A of your drawing?

A. The apparatus shown in Fig. 2 represents a tuned receiver with a Tune A receiving jigger. I will describe the apparatus by referring to the letters; f represents the aerial; A the vertical wire connecting the aerial with the billi condenser h; d' the primary of the receiving jigger; E the earth; s' representing the secondary of the receiving jigger and js representing a fixed condenser inserted in series with two coils and marked s'. T represents the coherer detector; c' and c^2 representing choke coils; b local battery; and B the local circuits of the relay tapper and inker, etc.

Fig. 2-A represents a Tune B receiving jigger; d' represents the primary of the Tune B receiving jigger; s' the secondary coils of the Tune B receiving jigger; and js the fixed condenser in series. I have shown in dotted lines billi condenser, which I now mark h, and the reason why I have shown this billi condenser h in dotted lines is because it could and it could not have been used in the manner shown. Some operators preferred to use it; others did not. Separate receiving jiggers were supplied for use when receiving Tune A signals and when receiving Tune B signals. These jiggers were contained in small wooden boxes and

it was the practice of the operators to remove one jigger and install in place thereof the other jigger supplied, depending on the particular tune which they desired to receive.

Q. 11. Can you produce any catalogue or circular describing the Marconi Multiple Tuner illustrated in Fig. 4?

A. I produce printed circular gotten up by the British Marconi Company, entitled "Description of the Marconi Multiple Tuner", which is the same tuner as I have previously referred to in the installation of the U. S. Revenue Cutter Seneca and other stations where it was used.

Q. 12. How does it happen that this circular is issued by the British Company?

A. Because these tuners were designed and manufactured by the British Marconi Company and were purchased by the American Marconi Company.

Mr. Peters: I offer in evidence the drawing produced by the witness, containing Figs. 1 to 4 and request that the same be marked "Plaintiff's Exhibit I, Sarnoff Drawing, Early Marconi Tuned Transmitters and Receivers" (Claimant's Exhibit No. 151).

I also offer in evidence the catalogue produced by the witness and the same is marked "Plaintiff's Exhibit J, Catalogue, Marconi-Franklin Tuner" (Claimant's Exhibit No. 152).

I also offer in evidence the photograph produced by the witness and request that the same be marked "Plaintiff's Exhibit K, Photograph, Marconi Tune A and Tune B Transmitting and Receiving Apparatus" (Claimant's Exhibit No. 153).

I also offer in evidence the blue-print produced by the [fol. 1000] witness showing the apparatus installed on the Seneca, and the same is marked "Plaintiff's Exhibit L" (Claimant's Exhibit No. 154).

Q. 13. Have you made an examination of the original records of the Marconi Company for the purpose of ascertaining the character and type of apparatus employed prior to the time you became connected with the Company?

A. I have.

Q. 14. Have you some or all of such records here?

A. I have a number of such records here.

Q. 15. When do the records show that the Marconi Company commenced commercial business?

A. About 1901.

Q. 16. Please give a list of the stations installed, from 1901 down to the time you became connected with the Company.

A. The records show that the first station was installed on the Nantucket Light Ship on August 1, 1901. Thereafter the following shore and ship stations were equipped by the Marconi Company. Shore Stations: Cape Cod, April 1902; Sagaponack, July, 1902; Siasconset, September, 1902; Babylon, September, 1902; a station at a dock in New York and called "Dock Station, New York", January, 1904; Sea Gate, January, 1906. Ship Stations: S. S. Philadelphia, American Line, November, 1902; S. S. New York, American Line, April, 1903; S. S. St. Paul, American Line, May, 1903; S. S. St. Louis, American Line, August, 1903; S. S. Finland, Red Star Line, August, 1903; S. S. Kroonland, Red Star Line, February, 1904; cable ship Mackay-Bennett of the Commercial Cable Company, June, 1905.

Q. 17. Do the original records show the type and character of apparatus installed at these early stations? If so, will you please refer to such records and state the type and character of apparatus specified in connection with the several stations.

A. I produce shipping order No. 7 dated September 24, 1902, showing the shipment to the Nantucket Light Ship which, as I have said, was equipped with Marconi apparatus, and among the items listed on this shipping order appears the following: "1 No. 35 T jigger", which I recognize to be a transmitting jigger or oscillation transformer; "1 No. 306 jigger", which I recognize to be a Tune A receiving jigger; "2 spare Leyden jars and 6 Leyden jars in portable case", which I recognize to be the transmitting condenser. The item of six Leyden jars referred to is the exact number of jars used for the transmitting condenser of the Tune A transmitter. It was customary to apply spare jars, and this is still the practice of the Marconi Company where Leyden jar condensers are used.

I produce shipping order No. 2, dated September 12, 1902, addressed to the Marconi station at Nantucket, Mass. [fol. 1001] Nantucket, Mass., stands for the station at Siasconset, Mass., as Siasconset is on Nantucket Island, and either of these names are used. Shipping order No. 2 shows the shipment of 12 Leyden jars, which represents the transmitting condenser.

I also produce shipping order No. 12, dated October 10, 1902, addressed to the Marconi station at Nantucket, showing shipment of ½ dozen No. 306 jiggers, which, as I have previously stated, is the number given to Tune A receiving jiggers.

I produce shipping order No. 22 dated November 3, 1902, addressed to the Herald station, Nantucket, Mass., which is the same as the Marconi station.

The New York Herald was interested in the Marconi station installed at Siasconset or Nantucket Island, and the records of our Company show that the station at Siasconset or Nantucket was sometimes referred to as the Herald station.

Shipping order No. 22, previously referred to, shows the shipment of a No. 306 jigger, which is the Tune A jigger.

I produce shipping order No. 71, dated April 16, 1903 addressed to the Marconi station "D.K.", American Line Dock, New York. This shipping order shows the shipment of "1 T jigger; 6 Leyden jars and tray; a No. 343 jigger," which is the Tune B receiving jigger, and also a "306 jigger", which is the Tune A receiving jigger.

I produce shipping order No. 463, dated May 10, 1905, addressed to the Marconi station at Sagaponack. The ship- [fol. 1002] ping order contains the following: "May 19th, 1 special T jigger; 2 turn primary, 10 turn secondary." I produce shipping order No. B21, dated August 22, 1905, addressed to Marconi station, Sagaponack, showing the shipment of: "50 condenser plates: 4 condenser tanks with covers, clamps and wedges; 2 KW 500 volt transformer with large balls". The condenser plates referred to were used in oil and it is still the practice of the Company to use such condenser plates in oil in transmitting apparatus and the 2 KW 500 volt transformer indicates the use of a power set instead of an indication coil. I produce shipping order B174, dated July 5, 1906, addressed to Sea Gate. This shipping order shows, "1 Tune A T jigger", T standing for transmitting jigger.

I will now refer to the ship stations equipped by the Marconi Company. I produce shipping order No. 98, dated July 27, but the year does not appear on this shipping order. However, as these shipping orders are numbered serially, I would say that No. 98 was dated prior to July 31, 1903, on which date shipping order No. 99, to be later referred to, contained a shipment of apparatus. Shipping order No.

98 shows the shipment to the S. S. Philadelphia of the American Line of "6 new Leyden (jars) only." In addition to this item there appear other items. Shipping order B-91, dated December 14, 1905, also addressed to the S. S. Philadelphia shows the shipment of "1½ kilowatt motor generator set complete; 2 tank condensers complete with 25 plates ea.; 15 spare plates for above; 1 No. 17 T jigger"; I have already described what the "T" stands for.

The next ship equipped was the S. S. New York of the American Line. I have testified that this vessel was equipped in April, 1903, and I produce shipping order No. 54, dated April 4, 1903, addressed to the Marconi Station, S. S. New York, showing the shipment, among others, of the following items: "2 bal. receiver complete with 306 jigger No. 508, relay No. 510, tapper No. 525, base No. 520; 6 Leyden jars and case; 1 T jigger No. 5; 1 billy condenser." I produce shipping order No. 55, dated April 13, 1903, showing the shipment to the S. S. New York of a number of items, among which appears the following: "1 268 jigger No. 501." I also produce shipping order No. B-27, dated September 27, 1905, showing the shipment to the S. S. New York of "1 Billy Farad"; this term has been used in place of billi condenser.

Next I refer to the S. S. St. Paul of the American Line. I produce shipping order No. 95 dated July 21, 1903, addressed to the Marconi station, S. S. St. Paul, showing the shipment, among other items, of the following: "1 306 jigger; 1 No. 5 T jigger No. 501; 1 tray 6 Leyden jars."

Next I refer to the S. S. St. Louis of the American Line. I produce shipping order B-3 dated September 13, 1905, showing as one of the items the following: "No. 1.17 T jigger (Tune B)." I also note on this shipping memorandum the following remark: "Received with thanks. William James Brooker." I also produce shipping order B-84, dated December 1, 1905, addressed to S. S. St. Louis, showing, among other items, the following: "1 tank condenser and 12 plates." I also produce shipping order B-125, dated March 3, 1906, addressed to the S. S. St. Louis, containing as one of the items shipped the following: "1 Leyden tray and 8 jars complete." There also appears a notation on this shipping order as follows: "Delivery on February [fol. 1003] 13." Next I produce shipping order No. 94 dated July 18th, the year left off, but I fix this date as being prior to July 21, 1903, on which date shipping order

No. 95 contained shipment of apparatus to the S. S. St. Paul, previously referred to. Shipping order No. 95 shows the shipment, among other items, of the following: "2 No. 306 jiggers; 1 No. 5 T. jigger; 1 tray of 6 Leyden jars; 2 spare jars only."

I also produce shipping order B-72, dated February 27, 1905, addressed to the Marconi station, S. S. Finland, showing the shipment, among other items, of the following: "1 sliding condenser."

Next I will refer to the S. S. Kroonland. I produce shipping order No. 99, dated July 31st and August 1, 1903, both dates appearing on the same shipping order, which is addressed to the S. S. Kroonland. Among other items shipped, the following appears: "306 jigger; No. 5 T jigger; 1 set 6 Leyden jars and trays; 2 spare jars only; 2 Billy Farads." Next I produce shipping order B-76, dated November 13, 1905, addressed to the S. S. Kroonland, showing, among other items, the following: "12 Leyden jars."

I have up to the present time produced records from the books containing shipping orders, but I will now refer to a letter book of the Marconi Company in which appears water copies of private letters written by Mr. John Bottemley, vice president of the Marconi Company, and also copies of business communications written by Mr. W. W. Bradfield, then chief engineer of the American Marconi Company. I am familiar with Mr. Bradfield's handwriting and recognize on page 229 of the book referred to a copy of a letter written by Mr. W. W. Bradfield in his own handwriting, which is as follows:

"Apl. 8th 2.

Marconi's Wireless Telegraph Co., Ltd.,
18, Finch Lane, S. C.

GENTLEMEN:

It was decided at a meeting at which Mr. Morse, Mr. Saunders, Mr. Marconi, myself and others were present this morning, to go ahead and equip the Long Island Station at Bridgehampton. Mr. Marconi will, upon his arrival (he leaves tomorrow on the Majestic), fully advise in this connection.

Kindly supply at once apparatus as per list appended and make chargeable to the Marconi Wireless Telegraph Co. of America.

Yours faithfully, W. W. Bradfield."

Apl. 8th 2.

Appendix.

Aerial & Fittings

6 prs. of Ebonite rod insulators
1 Bradfield type insulator
220 yds. 7 18 bare tinned Copper wire.

Transmitting

2 10" coils
1 Switch key
1 Tune A T jigger
12Q Leyden jars and 1 special box to hold 6 ditto.

[fol. 1004] *Receiving*

2 Recrs. complete in screening boxes
Unbalanced relays & 306 jiggers
1 Morse Inker with switches & bell complete
2 Boxes of 10 tested coherers
1 Set testing shunts
1 Aerial plug
3 Aerial lugs
2 Adjustable (small) condensers
2 30 ft. Recvg. Inductances.

W. W. B."

A. (Continuing.) While the figure "2" only appears after the date, Apl. 8th, it was written, as a matter of fact, in the year 1902, the letters of that time having "190" printed, and of course this did not copy.

It Is Stipulated by counsel that the foregoing read into the record is a true copy of the letter appearing in the book, and that the book need not be offered in evidence.

A. (Continuing.) I have also made a search of the Company's circulars and general orders relating to the general operation of its stations, and produce Circular No. 37, which reads in part as follows: "The following stations are directly controlled by the Marconi Wireless Tele-

graph Company of America and are 'This Line' stations." A number of ship and shore stations and their radio code letters are shown, and alongside of each station under the heading "Appar", which means apparatus, are marked the letters "TA" or "PA" or "Various" or "PA and TA". From my personal knowledge of the terms used by the Marconi Company during my employ I define "PA" to stand for "Plain Aerial"; "TA" to stand for "Tune A" and "Various" meaning that more than plain aerial and Tune A were used. Alongside of the names of the American ship and shore stations the following notations appear: "New York, TA"; "Philadelphia, TA"; "St. Louis, TA"; "St. Paul, TA"; "Finland, TA"; "Kroonland, TA"; "Sybarita, TA". Alongside of the following shore stations, Babylon, Cape Cod, Dock Station New York, Great Neck, Nantucket, Sagaponack, Siasconset, the letters "TA" are shown in each case, which shows that Tune A apparatus was installed at all of the stations previously mentioned. I also produce memorandum of the Marconi Wireless Telegraph Company of America, which is part of the general order book and dated January 3, 1905, which reads as follows:

"Marconi Wireless Telegraph Company of America

Memorandum

To Officer in Charge,
Marconi Telegraphs,
(Issued to Ship Stns. Only.)

Owing to the existence in the vicinity of Sagaponack and Babylon, N. Y. of certain apparently irresponsibly operated wireless telegraph stations, operators of Marconi ship-stations, when communicating with this Company's stations at the above mentioned points, will, under no circumstances, [fol. 1005] omit the Tune A. X-Stopping device, which in order to eliminate any possible disturbances emanating from the sources referred to, must be used in its entirety.

Marconi Wireless Telegraph Company of America,
27 William Street, New York.

January 3rd, 1905."

A. (Continuing.) I also produce memorandum No. 61, from the general order book, dated April 26, 1905, which reads as follows:

"Marconi Wireless Company of America

Memorandum 61

To the Officer in Charge,
(Issued to all stations.)

Please note that the auxiliary yacht "Valhalla" (call letters VH) is being equipped with the Marconi Wireless Telegraphs and will sail from New York, May 16th, 1905. This vessel is classed as an 'other line' station and will have all the advantages of such, but is not required to retransmit.

Ordinary private messages to and from this station will take precedence over business of a like description to or from other offices.

The "Valhalla' is equipped with tunes "A" and "B". Stations ordinarily using tune "A" will 'stand by' and communicate by this means unless otherwise instructed. Siasconset will use Tune B only.

Marconi Wireless Telegraph Company of America.
N. Y. April 26, 1905."

It Is Stipulated by counsel that the foregoing are true copies of the originals produced by the witness and that the originals need not be offered in evidence.

Mr. Peters: I offer in evidence a copy of Circular No. 37 produced and referred to by the witness, and it is stipulated that the said copy may be used instead of the original and that the original need not be offered in evidence. The same is marked "Plaintiff's Exhibit M, Marconi Circular No. 37, dated August 16, 1904 (Claimant's Exhibit No. 155).

I also offer in evidence the original shipping orders produced and referred to by the witness, the same being marked collectively, "Plaintiff's Exhibit N, Marconi Shipping Orders, Tuned Apparatus, referred to by the witness Sarnoff." In connection therewith I offer to produce for defendant's counsel all shipping orders during the period covered by those offered in evidence so far as they are now in existence (Claimant's Ex. 156).

* * * * * * *

Q. 18. Are you familiar with the so-called quenched spark gap apparatus made by the Marconi Company in recent years?

A. I am.

* * * * * * *

[fol. 1006] Q. 20. Mr. Sammis, testifying in this case at page 199 of the printed record, stated: "Practically the only time that the coupled sets were used was when from storm or damage the antenna insulation became so low as to prohibit the spark. * * * The station at Sagaponack, New York, is a particular example. This station operated with an inductance coil sparking directly into the antenna and earth up to the time the plain aerial was prohibited by law." Speaking now from your own personal knowledge, what can you say as to the truth of that statement?

A. The statement made by Mr. Sammis, to which you have just referred is untrue. Tuned apparatus was used at all ship and shore stations of the Marconi Company considerably prior to 1912, referred to in Mr. Sammis' statement. During the years 1907 and 1908 I frequently went on board the vessels of the American Line equipped with our system while these vessels were in port, and have seen tuned apparatus on these vessels. During the same time I also operated for various periods at the Marconi station at Sea Gate, where, I have already testified, tuned apparatus was used exclusively. In 1909 I was an operator at the Marconi station at Siasconset, Mass. I found tuned transmitting and receiving apparatus there and used only tuned transmitting and receiving apparatus during the time that I was there, which was about fifteen months in all. During my stay at Siasconset I received signals and messages from the Marconi station at Sagaponack, Long Island, and from the character of the signals received I know that the transmitting apparatus used at Sagaponack was tuned. In the early part of 1910 I was appointed operator in charge at the Marconi station erected on the roof of the Wanamaker Building in New York and held that position for about a year's time, during which I used tuned transmitting and receiving apparatus exclusively. The same statement as to tuned apparatus is true of the sister station on the roof of the Wanamaker Building at Philadelphia, where I made frequent inspection. I don't recall at this moment the time when I made a trip across the Atlantic on the S. S. New York, but it was only one trip, and I believe some time during 1909 or 1910, when I relieved the regular operator on the ship.

During that trip across I used tuned apparatus on the New York, and from the character of the signals received from the stations at Sea Gate, Sagaponack, Siasconset and Cape Cod, Mass., I know that the signals transmitted by these stations were tuned. It was the general practice of the Marconi Company at that time, and it still is, to supply tuned receiving and transmitting apparatus to all its stations, ship and shore. I have made numberless inspections of the various stations of this Company subsequent to 1910 and have found tuned apparatus in use at such stations as I inspected.

Q. 21. Speaking now from your own experience, how [fol. 1007] efficient, compared with the untuned apparatus, was the tuned apparatus which you have described and shown in your drawing, Plaintiff's Exhibit I (Claimant's Ex. No. 151)?

A. The Tune A apparatus which I used at Sea Gate for transmitting and which tune I received at Sea Gate from ships transmitting on this tune was superior to the plain aerial or any other untuned circuit at this point, for the reason that the Tune A signals were extremely sharp and enabled operators, including myself to receive messages while others in the same vicinity were working on different tunes or on untuned circuits. The wave length of the Tune A transmitting apparatus was, I believe, somewhere in the neighborhood of 180 meters, and I recall instances where I conducted a great volume of traffic with ships communicating with Sea Gate, while the United Wireless station situated only several blocks away from Sea Gate, namely, at "Dreamland," Coney Island, transmitted, and while also the United Wireless station on the roof of the building at 42 Broadway, New York, transmitted messages. For this reason Tune A was used exclusively at Sea Gate with the ships in its vicinity. This fact was recognized by operators generally, and is evidenced by the circulars which I have already produced, showing that with certain stations Tune A was required to be used exclusively.

* * * * * * *

During my stay at Sea Gate the more powerful apparatus was coming into general use, and the tendency of those times was to abandon Tune A, because it was specially designed to operate with the equipment described in Plaintiff's Exhibit I (Claimant's Ex. No. 151). I recall many

instances where it was impossible for me to receive messages from the ship while they were transmitting to Sea Gate except when they used Tune A. As a result of this, efforts were made by the American Marconi Company to induce the vessels of foreign registry but equipped with Marconi apparatus to still continue the use of Tune A regardless of the more powerful apparatus that they carried on these vessels. As Tune A operated on an extremely short wave length, a number of the foreign vessels referred to made provision for the continuance of Tune A, in some cases using only a portion of their antenna, and where this was not convenient special antennae were installed in addition to the regular antennae on these vessels, so that Tune A signals could be transmitted.

* * * * * * *

The witness states that all of the testimony given in the preceding answer is of my personal knowledge.

Q. 22. You have referred to different types of transmitting and receiving apparatus in your drawing, Plaintiff's Exhibit I (Claimant's Ex. 151), as tuned apparatus. In what sense was this tuned apparatus? How did you use this expression?

A. By the expression "tuned apparatus," I mean that in the case of the transmitter the closed oscillatory circuit is tuned to the same period as the aerial or open radiating circuit. The same answer applies with regard to the re- [fol. 1008] ceiving apparatus. In the case of the transmitting apparatus, sometimes the aerial or open radiating circuit was tuned to the period of the closed oscillatory circuit, and at other times the closed oscillatory circuit was tuned to the period of the aerial or open radiating circuit. This was a matter of preference.

Q. 23. Referring to the apparatus known as Tune A and Tune B transmitting apparatus what can you say as to whether or not the open and closed circuits which you have described were tuned or whether the jigger coils forming a part of these circuits were tuned?

A. In the case of the Tune A transmitting apparatus, the period of the open circuit was determined by the number of windings on the secondary of the Tune A jigger, and the aerial was specially constructed having a given dimension. The closed circuit was predetermined by having a definite value of inductance in the primary of the jigger

and by using the proper capacity. In the case of Tune B, a different jigger was used, having a predetermined value of inductance in the open circuit, and the closed circuit was tuned by varying the number of Leyden jars used in the closed circuit condenser until maximum resonance was obtained.

Cross-examination.

By Mr. Scull:

X Q. 24. In 1906, how old were you?

A. I was 15 years old.

X Q. 25. At the time your duties brought you directly into contact with the apparatus used by the Marconi Company, which, I understand, was in 1907, what had been your educational qualifications so that you could understand the apparatuses being used?

A. I had been a graduate of Public School, had taken up a term of study at De Witt Clinton High School, and from the time that I entered the employ of the Marconi Company in 1906 I devoted myself studiously to the radio art and spent as much of my time as I possibly could at the laboratory of the Marconi Company, which was then situated at Front Street, New York. I read books on electricity and such literature as was within my understanding regarding wireless telegraphy.

X Q. 26. In 1907 were all of the types of apparatus illustrated in Plaintiff's Exhibit I (Claimant's Ex. 151) used by the Marconi Company?

A. Not all of it. At that time and a year or two prior to 1907 the coherer receivers were being discarded, the magnetic detector having then taken its place, but the Tune A and Tune B transmitting apparatus was then still in use.

X Q. 27. And was the apparatus illustrated in Figs. 3 and 4 used in 1907?

A. That shown in Fig. 3 was. That shown in Fig. 4 did not, I believe, come into general use until some time in 1908.

X Q. 28. I am not asking about the general use. I am asking whether any of it was used.

A. Cut out the word "general"; came into use in 1908.

X Q. 29. To your knowledge, how long prior to 1907, if at all, had the apparatus of Fig. 3 been used by the Marconi Company?

A. Only insofar as the records that I have produced can I answer this question.

X Q. 30. What do those records show?

A. The records show that apparatus described in Fig. 3 was used at Sagaponack, Long Island and Siasconset, Mass., and I know that tuned apparatus having the circuits described in Fig. 3 were used at the high power station of the Marconi Company at Cape Cod.

[fol. 1009] X Q. 31. Do you know at what date these were put in?

A. I could tell you from the records.

X Q. 32. Do it.

A. The station at Sagaponack, Long Island,—well, I have already answered that question in my previous testimony.

X Q. 33. Well, say it again.

A. The station at Sagaponack, Long Island, was erected in July, 1902; Siasconset, September, 1902; and Cape Cod, April, 1902. These dates I am quoting from the Marconi Company's records.

X Q. 34. Do you understand that the records show that the apparatus of Fig. 3 was installed in those stations when they were erected?

A. I don't understand this to be so with respect to Fig. 3, but my answer refers now only to the dates when these stations were erected.

X Q. 35. From the records, when was apparatus like that shown in Fig. 3 installed in Sagaponack?

A. Such records as I am able to produce at this time show that on May 10, 1905, under shipping order No. 463, apparatus such as described in Fig. 3 was sent to Sagaponack. I should also add that shipping order B-21 dated August 22, 1905, shows that apparatus was shipped to Sagaponack of the character described in Fig. 3.

X Q. 36. What is there on these two shipping orders on which you base your statement?

A. The following items: "1 special T jigger having 2 turn primary and 10 turn secondary; 50 condenser plates; 4 condenser tanks with covers, clamps and wedges; 2 KW 500 volt transformer with large balls, and 1 choke coil complete."

X Q. 37. Where is this choke coil shown on Fig. 3 of your drawing?

A. Well, it is not shown in Fig. 3 of my drawing; it was the practice in some cases and still is to use a choke coil in the primary of the power transformer. I did not show it

in Fig. 3 because a choke coil was not employed at each station using a power set.

X Q. 38. Is there anything on the shipping lists which you have referred to which would show that the oscillating transformer or jigger was variable?

A. Yes.

X Q. 39. What is it?

A. Because every oscillation transformer which has a number of turns can be varied by using as many or as few of the turns as is desired. This is done by tapping off the desired number of turns.

X Q. 40. Is that true also of the coil d' in Fig. 1 of Plaintiff's Exhibit I (Claimant's Exhibit 151)?

A. That is true of coil d' in Fig. 1, excepting that I have already testified that the jigger used in Fig. 1 was predetermined as to its number of turns, and it had to be used in its entirety in order to maintain resonance between the open radiating circuit and the closed oscillatory circuit of the apparatus described in Fig. 1.

X Q. 41. But there is nothing on the shipping list to which you have referred with reference to the station at Sagaponack which shows that the oscillation transformer was variable in that case as compared with the unvariable type as illustrated in Fig. 1 of Plaintiff's Exhibit I (Claimant's Ex. 151); isn't that so?

A. Except that the jigger shown in shipping order No. 463 says "special T jigger", and it is to be understood that in 1905 jiggers or oscillation transformers then constructed for use with power sets would not be made fixed because at a shore station where apparatus is installed, it could not then be readily determined as to the exact number of turns required with the aerial.

[fol. 1010] X Q. 42. Was the transmitter of Fig. 1 installed in connection with shore stations to your knowledge?

A. It was, to my knowledge.

X Q. 43. But those oscillation transformers were sent out with fixed coils?

A. They were.

X Q. 44. In view of this, how do you know, then, that the special jiggers of Fig. 3 were necessarily variable?

A. Because a number of the jiggers shown in Fig. 3 were still in use in 1907 and 1908, when I had personal knowledge of them.

X Q. 45. You had no personal knowledge of these special jiggers at the time they were shipped in 1905?

A. I had not.

X Q. 46. You don't know what they were, as a matter of fact?

A. Those which remained in service and were still in use as of 1907 and 1908, during the time that I was employed, I have knowledge of.

X Q. 47. Do you know what was the special jigger referred to on shipping order No. 463?

A. No more than I have described previously.

X Q. 48. And you don't know, as a matter of fact, whether or not that special jigger had variable coils, do you?

A. I have not seen it.

X Q. 49. Now, referring to the apparatus shown in Fig. 1 of Plaintiff's Exhibit I (Claimant's Ex. No. 151), I think you have said that the condensers represented by the letter *c* were a set of six jars in a tray. Am I correct in so understanding your testimony?

A. Yes, sir.

X Q. 50. Was there any means supplied to the operator for varying the capacity of this condenser?

A. He could use as many less than six as he desired by simply cutting out the condenser.

X Q. 51. What would guide him in determining whether to cut out the condenser or not?

A. The operator was not required to tune the apparatus, this having been attended to by the installing engineer.

X Q. 52. As a matter of practice, was a variable number of jars connected in the circuit to form condensers of different capacities?

A. Still confining my reply to your question as it refers to Fig. 1, I would say that the number of jars used in the closed circuit of the Tune A transmitter was six.

X Q. 53. Did you ever see any apparatus constructed according to Fig. 1 in which a greater or less number of Leyden jars was used at the point *e* on Plaintiff's Exhibit I?

A. I have never seen this circuit operated with any different number of jars than six.

X Q. 54. I call your attention to shipping order No. 7, forming part of Plaintiff's Exhibit N (Claimant's Ex. 156), and ask you what the notation, "No. 5 T jigger No. 35" means.

A. It is my understanding that the item quoted by you refers to Tune A transmitting jigger.

X Q. 55. What does "No. 306 jigger" mean on the same shipping order?

A. It is my understanding that a No. 306 jigger means a Tune A receiving jigger.

X Q. 56. And what does a "No. 268 jigger" mean?

A. It is my understanding that No. 268 jigger was a special jigger used in connection with the coherer detectors.

X Q. 57. On shipping order No. 22 I see "No. 301 jigger". What was that?

A. This must have been also a special receiving jigger used in connection with coherer receivers.

X Q. 58. Am I correct then in understanding that the Marconi Company made certain standard fixed jiggers [fol. 1011] which were used in the apparatus shown in Figs. 1 and 1-A of Plaintiff's Exhibit I (Claimant's Ex. No. 151)?

A. You are correct.

X Q. 59. And were these fixed jiggers of identical construction used alike in ship and shore stations of the different Marconi installations?

A. Insofar as the circuits relate to Fig. 1 and Fig. 1-A, it is my understanding that this was the case.

X Q. 60. And does the jigger include the coils d' and d of Figs. 1 and 1-A of Plaintiff's Exhibit I (Claimant's Ex. No. 151)?

A. Yes, sir.

X Q. 61. And did the Marconi Company also have a fixed jigger of identical construction which was used alike in ship and shore stations in the receiving apparatus shown in Figs. 2 and 2-A of Plaintiff's Exhibit I (Claimant's Ex. No. 151)?

A. Yes; but I should add that the jiggers shown in Fig. 2 and Fig. 2-A were not of identical construction just the same as the jiggers shown in the transmitting circuits of Fig. 1 and Fig. 1-A were not of identical construction.

X Q. 62. Can you identify by a number used on the shipping lists which you have produced the type of fixed jigger used in the apparatus of Fig. 1 of Plaintiff's Exhibit I (Claimant's Ex. No. 151)?

A. It is my understanding that the jigger known as Type 5 was a Tune A transmitting jigger shown in Fig. 1.

X Q. 63. Please answer the same question in reference to the jigger shown in Fig. 1-A?

A. It is my understanding that the jigger known as Type 17 was used in Fig. 1-A.

X Q. 64. And please answer the same question in reference to the jiggers shown in Figs. 2 and 2-A?

A. It is my understanding that the jigger known as Type 306 was used with Fig. 2, and the jigger known as Type 343 was used with Fig. 2-A.

X Q. 65. Did the length of the wire A, and the capacity of the aerial f in Fig. 1 vary with different installations?

A. I have already testified that the aerials were specially constructed of a given length when used with apparatus described in Fig. 1.

X Q. 66. And was this length the same for all stations using the apparatus of Fig. 1, whether a land or ship station?

A. I believe not; depending upon the height of the antenna which, of course, determines its capacity.

X Q. 67. Then, was the capacity of all the aerials in ship or shore stations using the apparatus of Fig. 1 alike?

A. I should say no; but the capacity and inductance, which in combination form the period of the aerial, were made alike.

X Q. 68. How was this done?

A. By the mathematical formula which covers wave lengths, namely $\lambda = 2\pi\sqrt{CL}$ C stands for capacity in microfarads and L stands for inductance in microhenries.

X Q. 69. What gives the inductance to the aerial circuit of Fig. 1?

A. The length of the aerial f, the length of the vertical wire A, the number of turns in primary of the jigger d' and the length of the wire connecting the bottom of the coil d' with the earth E, and the manner in which the coils shown at d' are wound.

[fol. 1012] X Q. 70. I call your attention to the last part of Q. 23, in which you stated that: "In the case of Tune B * * * the closed circuit was tuned by varying the number of Leyden jars used in the closed circuit condenser until maximum resonance was obtained." Who was it who varied the number of Leyden jars in the manner which you indicate in that answer? Would it be the operator or the constructor of the apparatus?

A. Usually the man who installed the apparatus or the man who inspected the apparatus from time to time.

X Q. 71. And how many Leyden jars were normally used as the condenser in this circuit?

A. From 12 to 16 jars.

X Q. 72. You personally never saw any of the so-called Tune A and Tune B apparatus in use prior to 1907, did you?

A. I did not.

X Q. 73. Are there any records in the office of the Marconi Company that you have searched which show any more definitely than the shipping lists which you have produced the character of the apparatus which was used in making up Tune A and Tune B circuits on Plaintiff's Exhibit I?

A. There may be, but I have not been able to locate them because of the voluminous records kept by so large an organization as the Marconi Company.

X Q. 74. Were there no drawings or other specification of the construction of the different parts of the apparatus of the Tune A and Tune B circuits other than the shipping lists which you have produced in the files of the Marconi Company?

A. There may have been or there may be now, but I have not, up to the present, been able to locate them.

X Q. 75. Have you made a search for such drawings?

A. I have.

X Q. 76. At the time you received signals from the station at Sagaponack, who was the operator for the Marconi Company at that station?

A. There were three operators at Sagaponack. I recall the name of the operator in charge who was Mr. W. W. Ward, but I am not quite clear at this time as to who his assistants were then.

X Q. 77. How long was Mr. Ward in charge of that station to your knowledge?

A. I believe that Mr. Ward had been in charge of Sagaponack from 1904 or 1905 up to, I think, 1914.

X Q. 78. Is Mr. Ward now in the employ of the Marconi Company?

A. He is.

X Q. 79. Where is he located?

A. He is now in charge of the high power station of the Marconi Company at Belmar, New Jersey.

X Q. 80. And he is the man who had charge of the operation of that station during the period you have stated and

who would know what apparatus was used there, would he not?

A. He is.

X Q. 81. Is there any man now employed by the Marconi Company who personally supervised or erected any of the Tune A or Tune B apparatus of Plaintiff's Exhibit I prior to 1904?

A. I believe there is, but I cannot be certain as to this man's supervision or erection of Tune A and Tune B apparatus prior to 1904.

[fol. 1013] X Q. 82. Who is that man?

A. Mr. A. H. Ginman.

X Q. 83. And where is he now located?

A. He is now general superintendent of the Marconi Company at San Francisco, California.

X Q. 84. I call your attention to X Q's. 65 to 69 inclusive, and your answers thereto, and ask you whether in replying to such questions you were answering from your personal knowledge or from information derived from others?

A. The questions asked in X Q. 67, X Q. 68 and X Q. 69 refer to principles of wireless telegraphy and methods of constructing apparatus and tuning. The answers I have given to the questions just numbered are of my knowledge, but as to the methods employed for shortening the aerials or tuning the apparatus prior to 1907 I have only answered insofar as the information I have gained during my connection with the Marconi Company has enabled me to answer. Subsequent to 1907 I have seen the practices described in various communications and instructions.

X Q. 85. When were these communications and instructions prepared that you refer to in your last answer?

A. I don't know when they were prepared, but I have previously testified, I believe, that I was in the executive office of the Marconi Company immediately after my joining that Company, and during that time I had seen communications exchanged between the engineers of the Company and the station operators or managers referring to the tuning of apparatus.

X Q. 86. When you made the search that enabled you to produce the shipping lists which you did produce, did you also make a search for such letters or instructions that you have just referred to?

A. I did; but unfortunately a large amount of the Company's correspondence had been destroyed about a year

or two ago, for the reason that we moved into new quarters and there was so much correspondence that it took up too much room, and, as is customary with large corporations, correspondence of ordinary operations is destroyed periodically.

X Q. 87. But the corporation didn't destroy these shipping lists showing, for instance, that two Leyden jars had been shipped some time in 1904, and the like, did it?

A. It did not, and I don't know why.

X Q. 88. Then there is nothing, so far as you know, that you can produce from the records of the Marconi Company to show that prior to 1907, when your personal experience began, the Marconi Company did, in fact, by its engineers and constructors vary the inductance and capacity of the antenna to suit the fixed jiggers and the fixed oscillatory circuits which it supplied in the construction shown in Figs. 1 and 1-A of Plaintiff's Exhibit I (Claimant's Ex. No. 151), is that true?

A. So far as I know. I am not able at this time to produce any more records than I have already produced.

X Q. 89. And so far as you know, the records which you have produced are the best evidence which the records of the Marconi Company now contain of this so-called tuning which you have described?

A. So far as I know, they are.

X Q. 90. Supposing that the operator's apparatus was equipped with the separate jiggers and the separate condensers as you have testified were sometimes supplied, so that the operator could use Tune B and Tune A circuits, how long would it take an operator to shift from one to the other of these tunes?

A. I should say a minute, or possibly less, because the plugs were conveniently arranged so that all the operator [fol. 1014] was required to do was to take his leads and plug it in the proper socket as is shown in the photograph which I have previously referred to, Plaintiff's Exhibit K (Claimant's Ex. No. 153).

X Q. 91. Of course, you had no personal knowledge that the apparatus was arranged with these sockets and plugs prior to 1907?

A. Prior to 1907, I had not.

X Q. 92. Is there any evidence in these shipping lists which you have produced which leads you to believe that such sockets and plugs for such quick shifting from one

tune to the other were supplied prior to 1907 by the Marconi Company?

A. Yes.

X Q. 93. What is that evidence?

A. The evidence of the Tune A and Tune B jiggers themselves, which I had seen in use subsequent to 1907, and the method of their construction, which I had subsequently seen.

X Q. 94. I ask you whether there is any evidence in the shipping lists which you have produced of the specific construction of the jiggers referred to on such shipping lists at the time such shipments were made?

A. And my answer is yes, for the reason that when I saw a Tune B jigger or a Tune A jigger, I mean all the parts of such jiggers and part of the jiggers themselves are the connecting terminals.

X Q. 95. But you had no personal knowledge of what was actually shipped on any one of those shipping lists, have you?

A. I have already testified that prior to 1907 I had not seen the apparatus shipped.

X Q. 96. Then, when you say that you find evidence on the shipping lists of the construction of the jiggers, you are, as a matter of fact, supplying after-acquired knowledge that is to say, knowledge acquired after 1907, to a certain name which you find on those shipping lists, isn't that true?

A. Yes.

X Q. 97. Have you any knowledge of the publication date of the catalogue, Plaintiff's Exhibit J (Claimant's Ex. 152)?

A. I don't know the exact date, but believe it to be prior to 1908; and further offer to obtain the exact date of publication from the British Marconi Company.

X Q. 98. When you examined the shipping lists from which you produced those embodied in Plaintiff's Exhibit X (present case, Claimant's Ex. No. 156), did you find that about the same dates as covered by those which you did produce, such shipping lists also included items showing that plain aerial transmitting and receiving apparatus was being sent to the various stations of the Marconi Company?

A. I don't recall at this minute the contents of the shipping orders which I have not produced, but I believe that

Mr. Peters has offered to produce the books from which I took the records offered in evidence.

X Q. 99. Then, when you made this search, nothing impressed your mind except the stuff which you have produced here, is that true?

A. There were many other records showing the shipment of tuned apparatus being sent to our affiliated company in Canada, but I confined myself almost entirely to the shipping orders showing apparatus sent to the American Company's ship and shore stations.

X Q. 100. I call your attention to shipping list No. 94 of Plaintiff's Exhibit N (Claimant's Ex. 156), and particularly to an item thereon reading as follows: "1 plain aerial jigger", and ask you what that item means to you?

A. So far as I am able to interpret the particular item [fol. 1015] referred to, I should say that this was an inductance coil supplied to the station on S. S. Finland.

X Q. 101. So that coils which were used in plain aerial apparatus were also called jiggers by the Marconi Company?

A. Apparently they might have been so misterned; in this particular case it would appear so, because the term jigger stands for oscillation transformer and has been referred to ever since my connection with the Marconi Company as representing an oscillation transformer, and in plain aerial no tuned transmitters or oscillation transformers as we understand them are employed.

X Q. 102. But prior to 1907 you have no knowledge of the use of any terms by the Marconi Company. You don't know, as a matter of fact, whether or not this term "jigger" here was or was not properly or improperly used, nor do you know what it means, any more than you know exactly what the other jiggers referred to which you have specifically pointed out mean.

A. I believe I have already answered you several times that information I have obtained with regard to the Marconi Company's apparatus was obtained subsequent to 1906, when I joined them.

X Q. 103. Did you ever inspect the station at Sagaponack?

A. I did.

X Q. 104. When?

A. Not until 1913, I believe.

X Q. 105. Was the station equipped with plain aerial apparatus at that time?

A. It was not.

X Q. 106. Have you any information as to whether it ever was equipped with plain aerial apparatus?

A. I have no information at this time, but believe that it was equipped with plain aerial apparatus for emergency purposes or breakdown purposes some time or other during the existence of that station.

X Q. 107. Won't you please tell us again just why plain aerial apparatus was used by the Marconi Company as emergency or break-down apparatus?

A. Insofar as shore stations are concerned the answer is that alternating current is supplied to the power transformer and this alternating current is produced by a motor generator. At some stations, namely, Cape Cod, Siasconset and Sagaponack, the electrical current is generated at the station; therefore, if the engine breaks down or the motor generator, for one reason or another, becomes inoperative, the station is out of business except for the use of plain aerial which can be very readily set into operation by operating the coil from the batteries which are supplied at each of the stations mentioned. Insofar as ship stations are concerned, it has been the practice of the Marconi Company in America, and its affiliated companies as well, to supply a reserve source of power consisting in most cases of 12 chloride accumulators giving a voltage of about 25 or 26, and these accumulators were charged from the ship's dynamo and used in cases of emergency when the ship's dynamo, for one reason or another, failed to deliver the required amount of direct current. This was the case when the S. S. Republic sank and, I believe the same is true of the S. S. Titanic, and there are a great number of instances where these reserve batteries and plain aerial induction coils were used for distress purposes.

X Q. 108. I presume that the motor generator apparatus you are referring to is that shown in Fig. 3 of Plaintiff's Exhibit I (Claimant's Ex. 151), is that true?

A. Yes.

[fol. 1016] X Q. 109. Now the apparatus shown in Fig. 1 of Plaintiff's Exhibit I (Claimant's Ex. 151) operates with a battery, does it not?

A. It can operate with a battery, but in practice it was operated from the ship's dynamo current in the case of ship

stations and from the current supplied by the larger amount of batteries installed at shore stations, where no direct current was available from power houses.

X Q. 110. Then, as I understand your testimony, plain aerial transmission sets were used as emergency sets in connection with the apparatus shown in Fig. 1 and also in connection with the apparatus shown in Fig. 3 of Plaintiff's Exhibit I (Claimant's Ex. 151)?

A. Yes, sir.

X Q. 111. Was an apparatus like that shown in Fig. 1 of Plaintiff's Exhibit I (Claimant's Ex. 151) ever used as an emergency set in connection with the apparatus shown in Fig. 3 of Plaintiff's Exhibit I?

A. When apparatus described in Fig. 3 was installed at ship and shore stations, such induction coil transmitters as still remained at ship and shore stations would be used as plain aerial in times of distress, for the reason that plain aerial creates a more disturbing wave, this type of transmitter producing highly damped oscillations. I should also add that apparatus such as described in Fig. 3 may be employed for distress purposes if the current from the engine room is available. In fact, if current is available, it would be an advantage to use apparatus such as described in Fig. 3, because the motor generator set is of greater power and therefore would most likely negotiate much longer distances.

X Q. 112. Is the reason for using a plain aerial as an emergency set based on the fact that it sends out the highly damped waves or because it will transmit to a greater distance with the same energy as the apparatus shown in Fig. 1?

A. You are referring now to what period of time?

X Q. 113. I am referring to the period of time that you have been talking about when plain aerial was used as emergency sets in connection with Marconi Company apparatus.

A. When plain aerial was used in times of emergency, it was used because of the two reasons I have already given: First, that it could operate from batteries when the main source of power failed, and secondly because it produces a highly damped wave.

X Q. 114. Does the apparatus of Fig. 3 produce a highly damped wave or not?

A. That, of course, depends on the type of spark gap employed and the relation between the primary and secondary of the oscillation transformer, that is to say, its coupling, and, moreover, the character of the waves emitted by the apparatus described in Fig. 3 would depend upon the proper design arrangements and tuning of the apparatus shown.

X Q. 115. Well, as Fig. 3 was constructed and put up by the Marconi Company within your knowledge, was it constructed and arranged so as to produce damped or undamped waves?

A. Your term "undamped" is misleading, in that the word "undamped" is applied to what is commonly known as sustained or continuous oscillations, but I would say that the apparatus as constructed in Fig. 3 produced a wave considerably less damped than plain aerial apparatus.

X Q. 116. What was the particular advantage following from the use of plain aerials as emergency sets because they produced highly damped waves as you have said?

A. The advantage was that operators at the receiving [fol. 1017] stations would receive the damped oscillations over a much greater range of their receiving tuners. To make my answer clear, I would say that when an operator at a receiving station tunes his receiver to 600 meters, for example, he would receive messages or signals transmitted by apparatus described in Fig. 3 on the particular adjustment of his receiving tuner, but that if a message or signals were transmitted by apparatus shown in Fig. 3 on a wave length of, say, 500 meters, he probably would not receive such signals on his 600 meter receiving adjustment. In the case of plain aerial, the signals from the plain aerial would, as I have said, be received at points other than the particular adjustment for which the operator may set his receiving tuner. Therefore, in case of distress, it is a decided advantage to have distress signals promptly received and attention given.

X Q. 117. Did you ever operate an apparatus such as shown in Fig. 1 of Plaintiff's Exhibit I (Claimant's Ex. No. 151)?

A. I have.

X Q. 118. Did you ever receive on such apparatus, or, rather, on what I understand is the corresponding receiving apparatus shown in Fig. 2, messages sent out from plain aerials?

A. As I have said, I have operated apparatus shown in Fig. 1 and have received signals from transmitting apparatus such as described in Fig. 1, but I have not used for commercial purposes the receiving apparatus shown in Fig. 2.

X Q. 119. Have you ever used any receiving apparatus of the coupled circuit type in which neither the inductance nor capacity of a closed circuit was variable nor the inductance nor capacity of the aerial was variable?

A. I have not.

X Q. 120. What is the "Tune A X-Stopping Device" which appears in the instructions sheet dated June 3, 1905, reproduced in your answer to Q. 17?

A. The "X-Stopper" was an inductance coil specially arranged having various "tap offs" and used by the Marconi Company in its earlier receiving installations. It was claimed for this piece of apparatus that it considerably minimized the effect of "static" and for that reason the name of "X-Stopper" was given it.

X Q. 121. I call your attention to the apparent fact that the reason that the Marconi Company in its circular to which I have called your attention directed operators not to omit the use of this "Tune A X-Stopping Device" was not on account of static but apparently on account of interference from other stations. What have you to say as to that?

A. It has been claimed by operators that when the X-Stopper was used more selective tuning was possible.

X Q. 122. But if the apparatus shown in Figs. 2 and 2-A of Plaintiff's Exhibit I (Claimant's Exhibit No. 151) were already tuned to a definite wave length, how could they be disturbed by any other wave length?

A. I think to appreciate that one must have been a wireless operator, because even though you may have a circuit tuned to a definite wave length, nevertheless if a ship very close to your station and to the ship from which you are receiving is transmitting with a great deal of power on a wave length other than that with which you are receiving, you may still get some interference, and, as I have said, it was claimed by operators that if the X-Stopper was used this interference to which I have referred could have been eliminated; further, interference stands for not only disturbances from wireless stations, but there are peculiar [fol. 1018] local interferences often caused by surrounding

mediums, and such interferences must also be taken into account.

X Q. 123. When was plain aerial apparatus finally discontinued by the Marconi Company?

A. It was not discontinued for emergency purposes, as some of this apparatus still exists.

X Q. 124. In Q. 21 you were asked to state from your experience how efficient, compared with untuned apparatus, was the so-called tuned apparatus which you described in Plaintiff's Exhibit I (Claimant's Ex. 151), and in answer to that you said that the Tune A apparatus was superior to the plain aerial for reasons which you give, and then you state that for this reason Tune A was used exclusively at Sea Gate "with the ships in its vicinity". With what stations did Sea Gate communicate while you were there?

A. With ship stations, and these are all that Sea Gate was required to communicate with.

X Q. 125. What stations did you communicate with from Sea Gate?

A. With ship stations.

X Q. 126. Only?

A. Only; that is, ship stations were the only stations with which Sea Gate exchanged traffic.

X Q. 127. Now, I ask you whether you personally, while at Sea Gate, ever communicated with any other station than ship stations?

A. To my recollection I never sent any mesages from Sea Gate to any stations other than ship stations.

X Q. 128. And how far away were the ship stations when you sent to them? What was the farthest?

A. I could not be definite about that.

X Q. 129. Can you approximate it?

A. A distance varying from 80 to 90 miles or approximately 100, and, as you know, or should know, distances of wireless communication depend on many variable elements, and by elements I do not mean elements of apparatus but the human elements, *i. e.*, the operator, and also atmospheric conditions, etc.

X Q. 130. Where have you ever used plain aerial transmission apparatus and when?

A. I have used plain aerial transmission apparatus at ship stations when testing the emergency apparatus during my term of employment as inspector and chief inspector of the Marconi Company, and I believe that on several oc-

casions I used plain aerial transmission at the Marconi station at Siasconset when the main set was temporarily out of business. I also made a special test with plain aerial emergency apparatus on one of the Old Dominion Line boats, the report of such test having been given to Mr. Sammis, then my superior.

X Q. 131. Have you a copy of that report?

A. I have not got it here. I may say that the object of this test was to determine for the Department of Commerce the efficiency of the plain aerial transmitting apparatus for emergency purposes.

X Q. 132. Do you recall generally what your tests showed in this respect?

A. My tests in this respect showed that when the apparatus was properly operated and the antenna insulation was good, that the legal requirement of 100 miles could be negotiated; but since that time more improved emergency equipment has been supplied and installed on the majority of vessels carrying the Marconi system. By more improved apparatus I mean that a battery sufficiently large to operate the motor generator of the main transmitter has been installed on a very large number of vessels, so that in case of distress, when the ship's dynamo is unable to furnish current the motor generator is operated from the reserve power supplied by the batteries. The Marconi Company [fol. 1019] has, during the past year, removed, I should say, approximately about 175 to 200 induction coil emergency equipment, the shipping companies supplying the batteries for operation of the main set instead.

X Q. 133. Are the batteries which you are now supplying for your emergency sets more powerful than those you previously supplied for use with the induction coil plain aerial apparatus?

A. They are. In the former case the batteries consisted of 12 cells giving a voltage varying from 24 to 26, while the present batteries being supplied by the shipping companies for the operation of the Marconi main set give a voltage of about 120.

X Q. 134. Now, with the motor generator sets using this battery giving a voltage of 120, you are able to negotiate the required 100 mile distance specified by the Department of Commerce regulations, are you?

A. Yes, and more.

X Q. 135. How much more?

A. Depending, as I have said, on the variable elements, but the main sets which we have recently installed on a large number of vessels and which operate from the batteries have covered distances varying from 200 to 2,000 miles.

X Q. 136. What is the greatest distance that has been covered with plain aerial apparatus using the batteries which give approximately 25 volts?

A. I don't know definitely.

X Q. 137. In what year did you make these tests to which you referred a little while ago, for the Department of Commerce?

A. I believe in 1912; about the middle of that year.

X Q. 138. Now, when you made these 1912 tests, did you make any comparative tests of the apparatus on the ships, that is to say, did you compare the plain aerial apparatus with any coupled circuit apparatus which the ship might have had?

A. I did.

X Q. 139. What did those tests consist of generally?

A. Those tests consisted of sending and receiving signals with plain aerial and also sending and receiving signals with the tuned apparatus on board the ship.

X Q. 140. Did you use the same power in connection with the plain aerial apparatus as with the tuned apparatus?

A. No.

X Q. 141. What was the difference between the two?

A. I should say that the power used with the plain aerial apparatus was about 400 or 500 watts, while the power used with the tuned apparatus was 1,000 watts.

X Q. 142. Did you talk with the same station first with one kind of apparatus, that is to say, the plain aerial transmitter and then with the coupled circuit or tuned transmitter, and, if so, what were the apparent results so far as the distances reached efficiently was concerned?

A. I did, and in some cases it was necessary in order to obtain the attention of the station called to first use the tuned coupled apparatus, advise the operator of the test. I desired to conduct, and next use the plain aerial apparatus. There were instances where the station called could not hear the plain aerial while it could very efficiently hear the signals sent from the tuned coupled transmitter.

X Q. 143. How far away were these stations from the ship at the time you sent the messages?

A. The distances varied, in some cases being almost abeam of the radio station up to approximately 300 miles.

X Q. 144. The stations I want to include in my last question were those which you could not raise with the plain [fol. 1020] aerial but could with the tuned apparatus, and what distances were they and what specific instances were they?

A. The specific instance that comes to my mind at this time is the Marconi station at Sagaponack, Long Island.

X Q. 145. How far from the ship was it at that time?

A. I believe about 250 miles, but I could not be more definite as to the distance.

X Q. 146. Was there any instance where the reverse conditions were true, that is, where you could raise the distant station with the plain aerial but could not with the tuned transmitter?

A. There was not.

Q. 147. Did you first try to get into communication with these test stations always with the plain aerial?

A. I did.

X Q. 148. Will you produce a copy of that report?

A. If it has not been destroyed I will be glad to produce it and I will make a search for it.

X Q. 149. Am I correct in understanding that the receiving apparatus shown in Fig. 4 was variable as to inductance and capacity in the closed oscillating circuits and variable as to inductance at least in the aerial circuit?

A. Your understanding is correct.

X Q. 150. When did this receiving apparatus come into use?

A. I believe in 1908 in this country.

X Q. 151. Was that the first use, so far as you know, by the Marconi Company in this country of coupled circuit receiving apparatus in which the resonance of the circuits was under the control of the operator?

A. No.

X Q. 152. What prior apparatus of that character was used in this country by the Marconi Company?

A. Individual inductance coils or loading coils and billi condensers were supplied at ship and shore stations, and these were used with the magnetic detector and the operators could tune accordingly.

X Q. 153. Were there individual loading coils and billi condensers variable?

A. They were.

X Q. 154. And were they both used in the antenna circuit?

A. That was a matter of preference; as various hook-ups were used, but the preferred practice was, of course, the apparatus described in Fig. 4, and about the time to which I have referred the loading coils and billi condensers were being replaced with the multiple tuners.

X Q. 155. When did these auxiliary loading coils and billi condensers first come into use, so far as you know?

A. So far as I know, they were in use in 1907.

X Q. 156. My understanding of your testimony is that you are informed that it was the practice of the Marconi engineers to specially construct the antenna circuit of the apparatus shown in Fig. 1 of Plaintiff's Exhibit I (Claimant's Ex. No. 151), so that with a fixed inductance *d'* therein that circuit would be in tune with the closed oscillatory circuit, having fixed capacity and fixed inductance as shown in Fig. 1. Is that correct?

A. Your understanding is correct, with one exception: that in the case of Fig. 1 the leads from the spark gap G to the primary of the jigger or oscillation transformer *d* and the leads from the other side of the spark gap G to the condenser *e* and the leads from the other side of the condenser *e* to the remaining side of the primary of the jigger or oscillation transformer *d* could be varied as to its length, and it is my understanding that this was done at the time the installation was made.

X Q. 157. Is there any engineer or other qualified person [fol. 1021] now connected with the Marconi Company, so far as you know, who has direct personal knowledge of the method of constructing the antenna as described in your answer to Q. 23 and of varying the closed oscillatory circuit of Fig. 1 in the manner to which you have just referred?

A. I believe that Mr. A. H. Ginman, previously mentioned, is the man possessing such knowledge.

X Q. 158. Is he the only one?

A. So far as I know, at this moment.

X Q. 159. Have you been able to find, during recess, the report of the tests from the Old Dominion Line steamer about which you testified this morning?

A. I have not.

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Redirect examination.

By Mr. Peters:

R. D. Q. 160. I believe you stated on cross-examination that you never saw the circuit of Fig. 1 of your drawing, Plaintiff's Exhibit I (Claimant's Exhibit No. 151), operated with anything except six condenser jars. Will you explain what you meant a little more fully?

A. I meant by that statement that when Tune A was used only six jars comprised the condenser c of the closed oscillatory circuit, but when the apparatus shown in Fig. 1 was operating on Tune B, the condenser c was increased to a number of jars varying from twelve to sixteen, the exact number depending upon the period of the open radiating circuit.

R. D. Q. 161. You stated that you don't know when Plaintiff's Exhibit J (Claimant's Exhibit No. 152) was published. State from your recollection the best you can when you first saw catalogues of this kind in the possession of the American Marconi Company.

A. It is my recollection that I first saw catalogues of the nature described about 1908, when the multiple tuner was being placed in service. It was the custom of the Marconi Company to send instructions for operation of the multiple tuner with the instrument.

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Deposition closed.

Deposition of JOHN BOTTOMLEY, for claimant, taken at New York, N. Y., on the 13th day of March, A. D. 1916.

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Direct examination.

By Mr. Peters:

Q. 1. Please state your name, age, residence and occupation.

A. John Bottomley; age 68; residence 112 East 55th Street, New York City; occupation, vice president, secre-

tary and treasurer of the Marconi Wireless Telegraph Company of America and member of the board of directors and executive committee of the same company.

Q. 2. How long have you been connected with the Ameri- [fol. 1922] can Marconi Company and its affiliated company, the British Company, and in what capacities? Just give a brief resume.

A. In 1901, or, possibly, 1900, I was acting for the English Marconi Company, who were doing certain work out here, and in 1902 I joined the Marconi Wireless Telegraph Company of America when it was reorganized in April, 1902, and have continued with the Marconi Wireless Telegraph Company of America ever since in various capacities, first as temporary manager, secondly as treasurer and secretary, third as general manager, treasurer and secretary, and up to to-day, when I am as I described above.

Q. 3. Prior to 1908, in what capacity was Mr. F. M. Sammis employed by the Marconi Company?

A. He was stock clerk and superintendent of a little shop we had in which little parts of apparatus were put together.

Q. 4. And prior to 1908 who had active charge of the executive affairs of the Company?

A. The executive? I had.

Q. 5. And who had charge of the engineering matters?

A. William W. Bradfield was elected resident engineer in 1902 and continued until 1908, when he left this country for England.

Q. 6. Where is Mr. Bradfield now?

A. He is in England, London, England, connected with the Marconi Wireless Telegraph Company, Limited.

Q. 7. What general types of apparatus were employed by the Marconi Company in this country prior to 1908?

A. Chiefly tuned apparatus; partially plain aerial.

Q. 8. Do you remember the occasion when the Nantucket Light Ship was equipped with wireless apparatus?

A. Yes, sir; in 1901.

Q. 9. Do you recall whether or not the question came up at the time as to whether tuned or untuned apparatus should be used?

A. The question came up and it was decided that tuned apparatus should be used.

Q. 10. In what way did the question come up?

A. In general consultation as to the best method by which signals could be sent.

Q. 11. From 1901 on what did your engineers and those in charge of the operation report to you as to the character of apparatus being used?

A. They reported to me that they were using tuned apparatus.

Q. 12. I show you Plaintiff's Exhibit M, Circular No. 37 (Claimant's Ex. No. 155). Please state, if you can, what this is.

A. This is a circular which was issued to various ships and all stations from our office showing the form of apparatus which is employed upon the stations which we had equipped and also which were to communicate with our stations.

Q. 13. What did you have to do with the issuing of this circular?

A. I was in consultation with Mr. W. W. Bradfield, who not only acted as engineer but also as semi-traffic manager in those days and he and I ascertained what apparatus was being used on the various stations and embodied it in the form of this circular. We also had information from England and other points as to what their ships were equipped with and this was embodied in the circular also.

. . . . . .

Q. 14. In connection with each station listed as an Ameri- [fol. 1023] can Marconi station, and under the heading "Appar" there appear the letters "TA." State, if you can, what these letters mean.

A. "TA" represented Tune A, one of the forms of tuning.

Q. 15. What was the object in issuing this circular to each station calling attention to the type and character of apparatus used at the other stations?

A. So that each ship, as it approached the station, could prepare itself to use the Tune A, some of them having installed, besides the Tune A, plain aerial, and to notify each station of what we were prepared to communicate with or from.

Q. 16. Would it be correct to say that Mr. Sammis joined the Marconi Company as assistant chief engineer?

A. It would not.

Q. 17. Did he represent himself as being a wireless engineer when he joined the Company?

A. He did not.

Q. 18. To what extent, if at all, prior to 1908, did Mr. Sammis act as a wireless engineer?

A. He did not act at all as a wireless engineer with my sanction or permission, and until 1912 he was never called engineer. At that time he was made chief engineer at the time of the reorganization.

Q. 19. Under what circumstances did Mr. Sammis leave the employ of the Marconi Company?

A. His method of conducting the business was not satisfactory to the management. The matter was discussed between Mr. Nally, our general manager, and myself; it was discussed in the executive committee, of which I am a member, and it was decided a change should be made.

Q. 20. Was this decided before or after he had offered his resignation?

A. Before. May I explain a little?

Q. 21. Yes, go ahead.

A. He was informed that a change was about to be made, and as he had been a long time in our service he was given a chance to stay with us for about three months, pending which time he might be able to procure other employment; but he immediately felt annoyed about it and said he would not stay any longer and said he would resign. His resignation was not handed in further than that, and he was requested to send his resignation; he did not do so and he was then notified that the verbal resignation was accepted.

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Cross-examination.

By Mr. Scull:

X Q. 23. Have you any personal knowledge, Mr. Bottomley, of the specific apparatus used by the Marconi Company during any period about which you have testified here?

A. What do you mean by specific knowledge?

X Q. 24. You are not an engineer, are you, Mr. Bottomley?

A. No, sir.

[fol. 1024] X Q. 25. You have never had any personal contact with the actual apparatus used by the Marconi Company?

A. I have never set it up or anything of that nature; I have seen it in the various stations.

X Q. 26. Are you familiar enough with the art to know whether an apparatus is tuned or not when you see it?

A. No, sir.

X Q. 27. When Mr. Sammis entered the employ of the Marconi Company what were his duties?

A. Stock clerk and taking charge of a small shop we had which was then in Bridge Street.

X Q. 28. Who had direct charge of that shop?

A. Mr. Bradfield.

X Q. 29. Then, was Mr. Sammis connected with Mr. Bradfield's work until Mr. Bradfield left the Marconi Company?

A. He was working under Mr. Bradfield, yes.

X Q. 30. Would it be proper to speak of him as an assistant to Mr. Bradfield?

A. I should not say so.

X Q. 31. Whom was he an assistant to?

A. He hadn't any. Mr. Bradfield, you say?

X Q. 32. No; who was Mr. Sammis an assistant to?

A. Nobody; a storekeeper is not an assistant.

X Q. 33. But he was working under Mr. Bradfield's direction?

A. Yes, sir.

X Q. 34. And he was wholly connected with the engineering end of the Marconi Company's business, was he not?

A. Yes, sir.—I hesitated when I answered that, because I suppose you call that the engineering end.

X Q. 35. I thought you said in your direct examination that you received reports from the engineers of the Company as to the kind of apparatus that was being used? Am I correct?

A. They consulted me as to the kind of apparatus that was being used, yes.

X Q. 36. In what form does these reports come to you?

A. Verbal reports; conversations.

X Q. 37. Not in writing?

A. No, sir.

X Q. 38. Is there any employe now connected with the Marconi Company of America who has knowledge of the apparatus used by that Company prior to 1907?

A. I should say there are several, not to say many; as to their knowledge I could not tell you.

X Q. 39. Who are they?

A. Mr. Weaver, Mr. Edwards, I think Mr. Sarnoff—I am not sure whether he was there prior to 1907—Mr. Ward,

and undoubtedly there are others, but I don't recall their names at this moment.

X Q. 40. Where is Mr. Weaver located now?

A. Sea Gate.

X Q. 41. That is in New York City, is it not?

A. Yes, sir.

X Q. 42. Where is Mr. Edwards located?

A. New York City.

X Q. 43. Prior to 1908, was the apparatus used by the Marconi Company of America determined in any way by the British Marconi Company?

A. A portion of it was sent out from England and installed here and their advice was taken; but they did not control or determine anything.

X Q. 44. Was the Marconi Company of America guided in the kind of apparatus it used by the advice of the British Marconi Company prior to 1908?

A. To the extent of making the apparatus uniform on all stations.

X Q. 45. That is to say, the apparatus used by the Mar- [fol. 1025] coni Company of America was uniform with that used by the British Marconi Company. Is that true?

A. Yes, sir.

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Redirect examination.

By Mr. Peters:

R. D. Q. 46. Was Mr. Ginman connected with the Marconi Company prior to 1908?

A. Yes, sir; Albert H. Ginman.

R. D. Q. 47. For how long a period?

A. I think since 1903 or 1904.

Deposition closed.

New York, March 14, 1916, 3 P. M.

Deposition of John W. Griggs, for claimant, taken at New York, N. Y., on the 14th day of March, A. D. 1916

Direct examination.

By Mr. Peters:

Q. 1. Please state your name, residence and occupation.

A. My name is John W. Griggs, I reside at Paterson,

New Jersey; I am a member of the Bar and also am president of the Marconi Wireless Company of America.

Q. 2. What public offices have you held?

A. I was a member of the House of Assembly of the New Jersey Legislature in 1876 and 1877; I was a member of the New Jersey Senate from 1883 to 1889; I was Governor of New Jersey from 1896 to 1898; I was Attorney General of the United States from 1898 to April 1, 1901, and I was for ten years a member of the Hague Arbitration Tribunal.

Q. 3. How long have you been president of the Marconi Company?

A. I think since 1903.

Q. 4. And prior to that time had you been connected with the Company?

A. As a director, yes.

Q. 5. For how long?

A. Since 1902; I think it was in 1902 I became a director.

Q. 6. What in the past has been the condition of the wireless telegraph business in this country as affecting the necessity or expediency of prosecuting for patent infringement? Please give a brief history of the business in this country and the efforts by the Marconi Company to protect its patent rights.

A. Beginning with 1902, when my first knowledge of it was acquired, the art was in a formative state, so far as this country went, at least; there was nobody engaged in wireless operations except the Marconi Company and Mr. Marconi. They, endeavoring to establish a commercial business, undertook first the establishment of shore stations and the equipment of American ships crossing the Atlantic for the purpose of developing what is called a ship to shore business; that is, receiving messages from steamships at the shore stations and transmitting messages from the shore stations to the ships at sea. The American Marconi Company was limited in its equipment to American ships, [fol. 1026] of which, down to 1904, I think there were only four in commission, that is the four ships of the American Line; I think two others were added about that time, two Dutch ships. During this time the United States Government began to equip naval vessels and, I think, revenue cutters with wireless apparatus, and the Marconi Company supplied various apparatus to the Government and made that a part of its business.

The first indication of any competitive operation by an infringer was that of the De Forest Wireless Telegraph Company, which was a company organized by Dr. De Forest. We promptly began suit against them in 1902, and the case was decided against them by Judge Townsend, of the United States Circuit Court for the Southern District of New York in 1905, in a decision that is reported in 138 Federal Reporter 657. I made use of that decision in an effort to prevent the United States Government from purchasing apparatus of De Forest, or his Company. We had protested to the Government before that suit was decided. After it was decided I saw Admiral Manney, who was in charge of the Bureau of Construction of the Navy Department, and informed him that we had a decree adjudicating the patent rights in the Marconi Company and that we did not want them to deal any further with the De Forest Company. Admiral Manney said that the Navy Department did not recognize a decree in a patent suit rendered by an inferior Court as authoritative, and it was only when it was decided by the Circuit Court of Appeals or the United States Supreme Court that they recognized it. I replied that in this case the defendant had failed to take an appeal and we had got the decree of the last and only court that could decide it. Admiral Manney said that that did not make any difference to them, it was still an inferior court. The De Forest Wireless Telegraph Company became insolvent, so it was never worth while to have an accounting under our decree.

Then De Forest formed several companies, all for the purpose of exploiting wireless apparatus which we claimed to be infringements on the Marconi patents, and we began another suit against one of the new brood of De Forest Companies and applied for an injunction. De Forest came in and set up a lot of facts and evidence which had not been before Judge Townsend and we failed to get a preliminary injunction, but we never went on with the case because that Company was afterwards absorbed in the United Wireless Telegraph Company.

The United Wireless Telegraph Company was, I think I am justified in saying, a stock jobbing operation. Its president, Christopher Columbus Wilson, was indicted for fraud in sending through the mails circulars relative to the stock of this Company, was convicted and served a term in prison; I think he died in prison. Meantime, in 1909, we

began a suit for infri gement against this same United Wireless Company, which was subsequently terminated after the bankruptcy and dissolution of the United Wireless by a decree adjudicating infringement, which, however, was taken by consent.

The next infringement that was brought to our notice was the National Electrical Signalling Company of Pittsburgh. We began suit against that in May, 1912, and a decision against them was made by Judge Veeder on March 17, 1914, which is reported in 213 Federal Reporter at page 815, and a final decree was entered on that opinion April 6, 1914. During all this time, from 1902 to 1914, the Marconi [fol. 1027] Company had been improving its apparatus, expanding its business, equipping more and more ships, supplying more and more apparatus, and the competition that we found from infringement came, as I have said, first from the De Forests, then from another De Forest Company, then from the United Wireless, which was a combination of the De Forest enterprises, then from the National Electrical Signalling Company. Now, the National Electrical Signalling Company down to the time that we began suit against them we had hardly known to be engaged in any commercial business. Their expert and inventor was Mr. Fessenden, and we knew that he had a plant at Brant Rock, Massachusetts, where he conducted experiments, but it was not until we found that they were bidding for the supply of apparatus to the Navy Department and for the construction of a high power station at Arlington, Virginia, for the Government that they became apparent as competitors and infringers, and then we began suit against them.

Later on, in 1914, we found that the Atlantic Communication Company was carrying on business with Germany and using the Marconi patent and suit was begun against that Company on April 24, 1914. Then, in 1914, Dr. De Forest developed another company, which he called the De Forest Radio Telephone Company, and believing that to be an infringer, we began suit against that in October, 1914, and that suit is still pending. The suit against the Atlantic Communication Company was partially tried and the taking of evidence was suspended, as I recollect, because Mr. Marconi, who was testifying, was called into the service of Italy by the declaration of war which his Government, Italy, made against Austria. And I may say, generally, that the Company has promptly challenged every infring-

ing operation of a commercial kind that it has had any evidence of from 1902 down to the present time.

Q. 7. Which of the suits you have referred to were based on the patents in suit, namely, Lodge patent 609,154 and Marconi patent 763,772?

A. The suit against the United Wireless Company, commenced May 6, 1909, was on the Marconi tuning patent 763,772; the suit against the De Forest Wireless Telegraph Company commenced in 1902 was on the Marconi reissue patent No. 11,913; the suits against the National Electric Signalling Company were on the tuning patent, commonly called the "four sevens" and the other one you have mentioned I have not got the number here. The suit against the Atlantic Communication Company is on the tuning patent as I understand it.

Q. 8. Please state whether or not you obtained an injunction against the Atlantic Communication Company and whether or not it is still in force.

A. Yes; a preliminary injunction, which is still in force.

Q. 9. Do you recall a company known as the Radio Telephone Company? If so, state what its activities were and its history, so far as you know it.

A. I don't recall that as distinguished from the De Forest Radio Telephone Company. I think that the two patents involved in the National Electrical Signalling Company suit were for easy phrasing, called the "Lodge Patent," and the tuning patent; that is my recollection.

Q. 10. Do you recall a suit brought by the Marconi Company against the De Forest Radio Telephone and Tele-[fol. 1028] graph Company and the Standard Oil Company?

A. There was a suit brought in which the Standard Oil Company was involved as the user of infringing apparatus; I don't recall what corporation was defendant with them, if any.

Q. 11. What proceedings were had, so far as you know, in that suit?

A. An injunction was obtained, so we were advised, and the Standard Oil Company ceased using the infringing apparatus and obtained, as licensee apparatus from the Marconi Company to supplant it. I recall another suit now; that is one brought against a man by the name of Simon, who had obtained an order from the Navy Department to supply seventeen or more apparatus for sub-

marines. Simon set up that he was doing this for the Navy Department, and Judge Hough held that that being so, we could neither have an injunction against him, nor was he an infringer liable to account, although the pleadings admitted that he was an infringer. That case was appealed by our Company.

Q. 12. Did the Marconi Company have any knowledge at any time between 1900 and 1910 of any commercial activities on the part of the concern called the Stone Telephone and Telegraph Company?

A. It never came to the notice of the officers of the Company or Board of the Executive Committee. In fact, it was only very recently that I ever heard of a Company by that name.

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Cross-examination.

By Mr. Scull:

X Q. 13. On what patent was this suit against the United Wireless Company in 1909 brought?

A. My recollection is that it was brought on the tuning patent and on the Lodge patent; but I am not sure about the latter.

X Q. 14. What became of that suit?

A. A decree admitting infringement was taken by consent.

X Q. 15. In that suit against the National Electrical Signalling Company in the Eastern District of New York, what patents were involved?

A. The patent known as the Lodge patent which this Company acquired from Sir Oliver Lodge and the Marconi tuning patent.

X Q. 16. Any other?

A. Not that I recollect.

X Q. 17. Do you know whether or not Reissue Patent 11,913 was also involved in that suit?

A. I can't remember, no.

X Q. 18. You have said that the suit against the Atlantic Communication Company on the two patents here in suit was, as I understand you, partially tried and then suspended because Mr. Marconi had to go to Italy. Was not his testimony available in that suit so that it could have been continued?

A. I think not.

X Q. 19. Do you know that a commission to take his testimony in the present case has been issued?

A. I am so informed, but I was also informed that there was some mistake about its having been sent forward.

X Q. 20. So far as you know, was any endeavor made to take Mr. Marconi's testimony in a similar way in the suit against the Atlantic Communication Company?

A. No.

X Q. 21. In the suit in the Eastern District of New York against the National Electrical Signalling Company no appeal was taken by the defendant, was there?

A. Yes; an appeal was taken.

X Q. 22. Was that appeal ever argued?

A. No.

X. Q. 23. Do you know any reason why it was not?

A. Yes.

X Q. 24. What was that?

[fol. 1029] A. Because the National Electrical Signalling Company abandoned the appeal and took a license from the Marconi Company.

X Q. 25. Had the National Electrical Signalling Company obtained an injunction against the Marconi Company on some of its patents?

A. Yes, on what is called the high frequency patent.

X Q. 26. And did the Marconi Company take a license from the National Electrical Signalling Company under that patent?

A. It did.

X Q. 27. What was the first suit brought on the Marconi patent here in suit, the so-called "tuning patent," by the Marconi Company and when?

A. As far as I know the first suit was the one against the United Wireless Company commenced in 1909.

X Q. 28. Were any of the De Forest Companies, prior to 1909, so far as you know, infringing that patent?

A. They must have been or we would not have brought suit against them in 1909.

X Q. 29. When did you first know that the De Forest Company was infringing that patent?

A. That I cannot tell you.

X Q. 30. That Company was the predecessor of the United Wireless Company, so far as you know?

A. I think there were two or three different De Forest Companies having the word "De Forest" in the name of

the corporation, but each one of them being varied in some kind of a way.

X Q. 31. Were any of these De Forest Companies active commercially?

A. Only to a very limited extent in supplying apparatus to the Government.

X Q. 32. Did not the American De Forest Wireless Company have stations on the Coast and throughout the country prior to 1909?

A. They might have had a few so-called stations, but my recollection is that the most of the stations used subsequently by the United Wireless were built under the auspices of the United Wireless, and they undoubtedly showed a good deal of activity in putting up stations, but when the title in those stations passed subsequently to the Marconi Company we found that as a rule, they were very shabby institutions; in several instances they had no title whatever to the land on which they were built.

X Q. 33. Did not the American De Forest Company equip a number of ships, particularly on the Great Lakes, prior to 1909?

A. I think they did, some.

X Q. 34. Did the Marconi Company have any ships equipped on the Great Lakes with its apparatus prior to 1909?

A. I cannot answer that; I don't remember.

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Redirect examination.

By Mr. Peters:

R. D. Q. 35. What can you say as to whether or not the De Forest Companies prior to 1912, and any other companies engaged in commercial work prior to that time, were engaged in legitimate commercial work as distinguished from erecting stations for stock jobbing purposes?

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A. In my opinion, from what I know of the attempts of the De Forest Companies and the United Wireless Com- [fol. 1030] pany to sell their stock to the public and the success with which they sold it and the subsequent disclosure of the fact that their entire material organization was nothing but a shell, the latter fact having come to my knowledge

as an officer of the Company when we acquired their material property,—from those facts I think I am justified in saying that their operations were only carried on to a sufficient extent to impress the public with the belief that they were a genuine commercial enterprise likely to become profitable to stockholders, and that there was no bona fide attempt to establish a real commercial enterprise that would be profitable to stockholders; in other words, I think they were what are known as stock-jobbing companies.

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Recross-examination.

By Mr. Scull:

R. X Q. 36. The assets of the United Wireless Company were bought by the Marconi Company, were they not?

A. Yes; the physical assets.

R. X Q. 37. In what year?

A. Why, I think it was 1912; I am not quite sure of these years.

R. X Q. 38. At the time the Marconi Company took over the physical assets of the United Wireless Company did it not also take over operating contracts with ship stations which the United Wireless Company had?

A. Just whether it took over the contracts and assumed them or not I cannot say, but at any rate it took over the apparatus that were on the ships that the United Wireless had equipped.

R. X Q. 39. And did it not continue to operate that apparatus for the ships?

A. Generally speaking, I think yes, but I think that other apparatus was substituted as soon as it conveniently could be.

R. X Q. 40. How many of such ship stations were taken over by the Marconi Company from the United Wireless Company when the former bought the assets of the United Wireless Company?

A. I cannot tell you from recollection; I have nothing here to refer to that would show me.

R. X Q. 41. Well, do you know whether or not at that time the United Wireless Company had equipped more ships that had, up to that time, been equipped by the Marconi Company of America?

A. I think they had, but they were not Atlantic liners; they were coasting ships, or on the Great Lakes; I am not sure which.

R. X Q. 42. So that this stock jobbing company had, as a matter of fact, put out more apparatus at the time you took over its assets than the Marconi Company had, is that true?

A. Well, I could not tell you because I have not the data here, but they had put out a considerable amount, on all of which they were losing money.

R. X Q. 43. But, I ask you, Governor, what the relation between the number of stations equipped by the United Company was as compared with the number equipped up to that time by the Marconi Company?

A. All I can say is that my recollection is, and it would be subject to correction by looking at the figures, that there were more ships of all kinds that were equipped with the United Wireless apparatus than were equipped with Marconi apparatus.

Deposition Closed.

[fol. 1031] *Deposition of Albert Ginman, for claimant, taken at New York, N. Y., on the 14th day of March, A. D.* 1916.

Mr. Betts:

Q. State your name.

A. Albert Ginman.

Q. What is your occupation, Mr. Ginman?

A. General superintendent, Pacific Coast division, Marconi Wireless Telegraph Company.

Q. How long have you occupied that position?

A. Since the fall of 1911.

Q. What territory is included within the Pacific Coast division of the Marconi Company?

A. All the Coast line of the Pacific Coast of the United States, and the territory of Alaska, and Hawaii.

Q. Where are your offices located?

A. The division offices are in San Francisco. The district office of the Northern district is in Seattle, from which the territory from Oregon north is served.

Q. What is the character of the business conducted by the plaintiff Marconi Company?

A. The manufacture of wireless telegraph apparatus, its sale to the various departments of the United States government, to railroads, to the owners of private yachts, and to individuals or corporations who desire to erect stations for their semi-commercial purposes. We also lease wireless equipments to owners of vessels in the maritime service. A general telegraph service is also conducted between ship and shore stations, likewise a trans-oceanic service between Honolulu and San Francisco. We also conduct a general telegraph service between points in Alaska, Seattle and Astoria, Oregon.

Q. In your last answer you referred to some shore stations; what is the purpose of having these shore stations, and about how many are maintained by the plaintiff company?

A. You refer now to shore stations in the marine service, Mr. Betts?

Q. In the marine service.

A. I cannot tell the exact number of shore stations in the marine service throughout the entire organization, but they extend on the Atlantic Coast from Boston to Galveston, and there is quite a chain on the Great Lakes. But on the Pacific Coast I can tell the number and their location.

Q. Well, will you please refer to the map, Plaintiff's Exhibit 30 (Marconi *v.* Kilbourne & Clark), and point out to the court where the shore stations for marine service are located.

A. (Indicating to the court on map.) All the shore stations on the Pacific Coast are marked in red ink, one being at Juneau, in Alaska, one at Ketchican, in Alaska, one at Seattle, Washington, one at Astoria, Oregon, one at Marshfield, Oregon, one at Eureka, California, one at San Francisco, California, one at San Pedro, California, and another at Avalon, on Catalina Island, California—nine stations, altogether.

Q. On the Pacific Coast?

A. On the Pacific Coast.

Q. What is the character of the apparatus used in these shore stations?

A. Coupled tuned circuits.

Q. With what ships are the Marconi land or shore stations required to communicate?

A. With all ships, regardless of the flag carried or the system of wireless telegraphy used.

Q. Why are they required to communicate with all ships? [fol. 1032] A. That is the United States government regulation, and I believe it is also required by International law.

Q. State, if you know, approximately what is the amount of investment involved in the erection and equipment of the land Marconi stations on the Pacific Coast, and the cost of maintaining them?

A. The cost of investment is approximately two million dollars, and the cost of operating those stations about $180,000 per annum. But those figures include not only stations in the marine service, but also in the trans-Pacific and Alaskan service. The investment charges against the marine stations of the Pacific Coast is approximately seventy thousand dollars, and the annual cost of operating those stations about nineteen thousand dollars.

Q. Are the marine stations on the Pacific Coast of the plaintiff company operated at a loss or a profit?

A. At a loss of about nine thousand dollars per annum.

Q. Why does the plaintiff company maintain these land stations in operation?

A. Because under our contract with ship owners we agreed to provide a free telegraph service within certain limits, and the chain of shore stations is necessary to maintain that service.

Mr. Betts: You may cross examine.

Cross-examination.

Mr. Farnsworth:

Q. Did you, as head of the Pacific Division of the Marconi Company, ever ask leave of any officer of the defendant to inspect defendant's apparatus?

A. No, sir.

Q. Not prior to the commencement of this suit last August?

A. No, sir.

Q. Not prior to the commencement of this trial in March last?

A. No, sir.

Q. Are there any government land stations operating in commercial business in the Pacific Division of the Marconi Company?

A. There are.

Q. How many?

A. I could not say the number that are open for commercial business.

Q. Approximately, in your division?

A. But I know there is one at Point Loma, and there is one at San Francisco, or, rather, Mare Island, but I am not sure that there are any others.

Q. How many leased sets of radio apparatus has the Marconi Company in your division?

A. Ninety-eight at present.

Q. How many Marconi sets are sold outright in your division?

A. That have been sold since 1911?

Q. Yes.

A. That I could not say.

Q. Do your Marconi stations in your jurisdiction here charge regular rates for transmission and receipt of commercial messages?

A. Yes, sir.

Q. The land stations do?

A. Yes, sir.

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[fol. 1033] *Deposition of C. H. Taylor, for claimant, taken at New York, N. Y., on the 14th day of April, A. D. 1916*

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Mr. Betts:

Q. What is your occupation, Mr. Taylor?

A. A radio engineer.

Q. Have you ever testified in court before?

A. No, sir.

Q. You have never testified before?

A. No, ir.

Q. Where have you recently been?

A. I have just returned from Honolulu.

Q What was the purpose of your being in Honolulu?

A. I was there for the purpose of conducting some tests from Honolulu to a wireless station built by the Japanese government.

Q. In whose employ are you at present?

A. I am in the employ of the Marconi's Wireless Telegraph Company, Limited.

Q. How long have you been in this country this time?

A. Since October of 1912.

Q. And why were you sent to this country in 1912?

A. For the purpose of installing and erecting the long distance high-power stations to be built by the American Marconi Company.

Q. What long distance or high-powered stations do you refer to?

A. I refer to the Honolulu station, from which I have just returned, which was to work to the Japanese government station, and to the station erected in California by the American Company, that California station, and the station erected in New Jersey to work to England, and a station erected in Massachusetts to work with the station to be erected by the Norwegian government in Norway.

Q. And you have been in charge of the erection and installation of apparatus on these American high-powered stations?

A. Yes, sir.

Q. Are the Honolulu and San Francisco stations completed?

A. The stations to work from Honolulu to San Francisco are complete and operating.

Q. What is the distance between those stations?

A. So far as I can remember, it is about twenty-three hundred miles.

Q. They are in daily communication, or intermittently?

A. They are in daily communication.

Q. Carrying on commercial traffic?

A. Carrying on commercial business, yes.

Q. Were you ever in the employ of the American Marconi Company?

A. Yes, I was in the employ of the American Marconi Company from 1902 to 1909.

Q. When first in 1902 did you enter the employ of the American Marconi Company?

A. In August, 1902.

Q. You came from where?

A. I came from London.

[fol. 1034] Q. On what ship?

A. On the "S.S. Minnetonka".

Q. And what was your purpose of coming to New York at that time?

A. My purpose was to endeavor to join the American Marconi Company, that company having just been formed.

Q. Had you had any previous experience in wireless teleggraphy before that time?

A. Yes, I had joined the English Marconi Company in 1899, but I had left them in 1901.

Q. Can you describe the wireless apparatus on the Steamship "Minnetonka", on which you came over, in August, 1902?

A. The "S.S. Minnetonka" was fitted with tuned apparatus that we called Tune A. In the transmitting circuit there was a spark-gap, inductance and capacity, and in the receiver they had a tuned oscillation transformer connecting the coherer circuit with the antenna.

Q. Have you prepared and will you produce a diagram showing the Tune A apparatus to which you have referred?

A. Yes, sir (reproduced opposite). That is the Tune A transmitting apparatus and that is the Tune A receiving apparatus (producing).

Q. Well, just give the court a copy, will you?

A. (Witness handed copy to the court.)

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Q. Have him make his explanations so that the reporters get them as to each one of the figures.

A. Figure 1 is the tuned transmitter, with Tune A transmitting jigger.

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(Blue print referred to was marked Plaintiff's Exhibit "27, T-1".) (Claimant's Ex. #157.)

Q. Now, Mr. Taylor, proceed and describe the transmitting Tune A. I will have you describe, Mr. Taylor, the Fig. 1, the transmitting Tune A apparatus.

A. The oscillation transformer used with the Tune A apparatus comprises a secondary of fifteen turns and a primary of less than one turn. This secondary was wound on a square former and the primary was wound around

three sides of it and the connections brought out on the fourth, but it did not make one complete turn. The capacity used in conjunction with this primary consisted of a tray containing six Leyden jars. The total capacity of that was approximately .002.

Q. Now, how is the capacity, which you have said was six Leyden jars, illustrated on Fig. 1?

A. The capacity is shown there by two parallel lines.

The Court:

Q. What letter do you mean, what letter designates it?

A. There is no designation against it.

Mr. Betts:

Q. Well, will you put some letter, say e?

A. It is designated in Figure 1 by the letter e.

. . . . . .

[fol. 1035] Mr. Betts:

Q. Now, you have spoken of the primary, Mr. Taylor, in the Tune A transmitter, as being of less than a turn. How is that primary shown in Figure 1?

A. It is shown there as a single loop.

Q. I mean what is the letter?

A. I have not got a blue print of that, Mr. Betts.

(Blue print handed witness.)

A. Thank you. It is shown by the loop marked "d" in Figure 1.

Q. And the secondary of the Tune A transmitter is indicated in Fig. 1 by what letter?

A. By the letter d^1.

Q. d^1. And how many turns were in the secondary of the Tune A apparatus?

A. There were fifteen turns.

Q. Now, will you describe the receiving apparatus used on the Steamship "Minnetonka", and produce any drawing illustrating it?

A. I have already shown the drawing.

Q. That is marked how?

(Handing blue print to witness.)

A. The drawing showing the receiving apparatus on board the "Minnetonka" is shown in Figure 2. This comprises an antenna circuit f, a variable capacity, marked h, in the antenna circuit, and the primary of the oscillation transformer, marked d^1. The secondary of the oscillation transformer is marked s^1, with a fixed condenser j s.

Q. What is the element marked T in your Fig. 2?

A. T is the coherer.

Q. What are the elements marked s^1 in your Figure 2?

A. The element marked s^1 is the secondary coil of the oscillation transformer.

Q. What is the element marked j s in Fig. 2?

A. The element marked j s is the fixed condenser used in connection with the oscillation transformer.

Q. Were there any means by which an operator could adjust either the capacity or the inductance of the detector circuit in the Tune A receiving apparatus?

A. No, sir.

Q. What is illustrated in d^1 in Fig. 2?

A. d^1 in Fig. 2 is the primary inductance used in the antenna circuit.

Q. And what is h in Fig. 2?

A. h is the variable condenser in the antenna circuit.

Q. What is the purpose of variable condenser h?

A. The purpose of the variable condenser h is to vary or tune the antenna circuit to the fixed secondary circuit containing the coherer.

Q. Now, referring back to your Figure 1, marked "Tuned Transmitter with Tune A transmitting jigger," was there any apparatus in the antenna circuit which was adjustable by the operator, on the "Minnetonka"?

A. No, there were no adjustments made in the antenna circuit on the "Minnetonka".

Q. Was there any adjustment of the spark circuit on the "Minnetonka", of the Tune A apparatus, by the operator?

A. There was nothing provided by which that circuit could be varied.

Q. What does the letter g in Fig. 1 indicate?

A. g indicates the spark-gap.

[fol. 1036] Q. What kind of a spark-gap was used on the "Minnetonka"?

A. A stationary type, comprising two brass balls.

Q. What does s indicate on Fig. 1?

A. s indicates a ten-inch induction coil.

Q. Was the Tune A transmitting and receiving apparatus illustrated in Figs. 1 and 2, which you have referred to, the only wireless apparatus on the "Minnetonka"?

A. Yes, that was the only appara-us supplied to the "Minnetonka" while I was on board.

Mr. Betts: I offer in evidence Fig. 2, referred to by the witness, and ask that it be marked plaintiff's exhibit.

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(Paper referred to was marked plaintiff's exhibit "27, T-2".) (Claimant's Exhibit #158.)

Q. Now, when you arrived in New York on the "Minnetonka", what did you do?

A. After obtaining employment from the American Marconi Company, I was sent to Newport, Rhode Island.

Q. For what purpose?

A. For the purpose of installing some Tune A apparatus, which was to be used in conjunction with the combined Army and Navy maneuvers.

Q. How long did you remain at Newport?

A. Approximately a month.

Q. While at Newport, did you actually set up any wireless apparatus?

A. Yes, I set up the Tune A apparatus.

Q. For whom?

A. For the Army.

Q. And how did that tuned apparatus which you set up for the army differ from the tuned apparatus which you have already described?

A. There was no difference.

Q. After you left Newport, what next did you do?

A. I returned to New York and was sent to their station at Sagaponack, Long Island.

Q. Where is this station?

A. It is on the eastern end of Long Island, about ninety miles from New York.

Q. I will show you a map and ask you to point out to the court where that station was?

(Handing map to witness.)

A. (Witness indicates on map to court.)

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A. The name is Sagaponack Station. Shown in red letters on the map.

Mr. Betts:

Q. Was the Sagaponack Station completed and operating when you arrived there?

A. Yes, sir.

Q. Will you describe the transmitting apparatus at the [fol. 1037] Sagaponack Station when you arrived there?

A. The transmitting apparatus was the Tune A apparatus recently described in regard to the "Minnetonka".

Q. How about the receiving apparatus at Sagaponack when you arrived there?

A. That was the coherer receiver, with the Tune A oscillation transformer.

Q. How long did you remain at Sagaponack at this time?

A. I remained there approximately seven months.

Q. Were you the operator there, or what?

A. I was in charge of the station and operated it.

Q. While you were at the Sagaponack station, did you use any other wireless apparatus than the Tune A transmitting and receiving apparatus which you have described?

A. Yes, we used some tuned apparatus which we called Tune B.

Q. Where did you get that apparatus from?

A. The parts of it were set down from the New York office.

Q. Of what company?

A. Of the American Marconi Company.

Q. Can you describe this Tune B apparatus?

A. The Tune B apparatus had an oscillation transformer and a battery of condensers. The value of the condensers was approximately .02 microfarad. The oscillation transformer had a secondary of nine turns wound on a square former, and a primary of one turn, comprising two wires in parallel, making just less than one turn.

Q. Now, I will show you two drawings (reproduced opposite) and ask you if they diagrammatically illustrate the Tune B transmitting and receiving apparatus which you have described? (Handing drawings to witness.)

. . . . . .

A. Yes, these two drawings illustrate the Tune B apparatus that I have just described.

Mr. Betts: I offer the blue prints in evidence and ask that they be marked plaintiff's exhibit "27, T-3" and "4".

* * * * * * *

Blue prints referred to were marked, respectively, plaintiff's exhibit "27, T-3", and plaintiff's exhibit "27, T-4". (Claimant's Exhibits Nos. 159, 160.)

Q. * * * Now, referring to the tuned transmitter for Tune B, will you explain to the court what d^1 was?

Q. What is j?

(Blue print handed to witness.)

A. d^1 is the secondary of the oscillation transformer, it is the secondary inductance of the oscillation transformer.

Q. How many turns did it have?

A. That had nine turns.

Q. And what is the element marked d in this exhibit?

A. d is the primary coil of the oscillation transformer.

Q. How many turns did that have?

A. That had approximately one turn, but less than one turn.

Q. What is the element not marked but indicated by a square?

A. That is the battery of condensers.

[fol. 1038] Q. Will you mark that with the letter e?

A. I mark that e. (Marking.)

Q. How many condensers were there in this battery?

A. Fifteen Leyden jars.

Q. What is the part marked g?

A. g is the spark-gap.

Q. What is the part marked s?

A. s is the ten-inch induction coil.

Q. Were there any elements of a spark-gap circuit which could be varied by the operator?

A. No variation was provided in this circuit.

Q. Were there any elements in the antenna circuit which the operator could vary or adjust?

A. No. No provision was made for varying the component parts of the antenna circuit.

Q. Now, referring to the drawing marked "Tuned Receiver for Tune B", what is d^1?

A. d^1 is the primary of the oscillation transformer.

Q. What is s^1?

A. s^1 is the secondary inductance of the oscillation transformer.

Q. What is j?

A. j is the fixed condenser.

Q. And what is T?

A. T is the coherer.

Q. What is c^2 and c^1?

A. c^1 and c^2 are choke coils.

Q. What is b?

A. b is the primary battery.

Q. And what is r?

A. r is the relay.

Q. Any adjustable elements in the detector circuit in Tune B apparatus?

A. No.

Q. Any adjustable elements in the antenna circuit of Tune B apparatus?

A. No, none whatever.

Q. Now, referring to the oscillation transformers at the transmitters of Tunes A and B, were they identical or were they different?

A. The oscillation transformers of Tunes A and B were different.

Q. In what way did oscillation transformers Tune B differ from those of Tune A?

A. The number of turns in the secondary, and, consequently, its inductance was different.

Q. And as to the oscillation transformers in Tune B, as contrasted with Tune A, were they the same at the receivers?

A. At the receivers, no, they were different. The windings had a different inductance in Tune A than in Tune B.

Q. What was the purpose of providing Tune B apparatus instead of Tune A apparatus, at Sagaponack?

A. Tune B apparatus was provided for the purpose of enabling the station to work to two or more ships when the adjacent station at Babylon was working probably to another ship within the range of that station.

Q. Did you have both Tune A and Tune B apparatus at Sagaponack?

A. Not when I originaliy went there.

Q. At any time did you have Tune A and Tune B apparatus at Sagaponack while you were there?

A. In my second visit. Tune A and Tune B were there, and we carried out experiments, as I said before, between Babylon and Sagaponack, with Tune B apparatus.

Q. How did the wave-length of Tune B apparatus com- [fol. 1039] pare with the Tune A apparatus?

A. Tune B was much longer than Tune A.

Q. Have you stated, Mr. Taylor, whether the receiving oscillation transformer of Tune B was the same or different from that of Tune A?

A. The oscillation transformer for Tune B was different from that of Tune A.

Q. How did it differ?

A. It differed in the amount of inductance in the secondary circuit.

Q. What values of condenser were used in the receiving detector circuits of Tune B?

A. The value was fixed at the Marconi works and was not changed at the station, and I could not tell you what the exact value was.

Q. And how about the value of the capacity in the detector circuit of Tune A apparatus?

A. That also was fixed in the oscillation transformer, and I have no knowledge of the exact value of it.

Q. Can you state whether or not the values were the same in the Tune A and the Tune B, from your experience?

A. No, I could not.

Q. After you had been at Sagaponack for the length of time that you have mentioned, what next did you do?

A. I returned to New York and was sent to Chicago.

Q. For what purpose?

A. For the purpose of erecting a station at Chicago, and one at Milwaukee.

Q. Do you remember when this was that you went to Chicago?

A. It was in the spring of 1903.

Q. State whether or not you erected the two stations you have mentioned?

A. Yes, I erected the two stations, one at Chicago and one at Milwaukee.

Q. What apparatus did you put into those stations?

A. We put in Tune B apparatus.

Q. How did Tune B apparatus, which you put into the Chicago and Milwaukee stations, compare with that which you have described as being present at Sagaponack?

A. It was identical, except that the condenser, instead of being built up of Leyden jars, was made up of glass plate condensers in oil.

Q. What was the idea of using oil condensers, rather than Leyden jar condensers?

A. We were supplying a greater power at the Chicago station than at the Sagaponack station.

Q. What was the source of power at the Milwaukee and Chicago stations?

A. Motor generator set.

Q. Will you produce and identify a drawing showing this motor generator set?

A. (Witness produces drawing; reproduced opposite.)

Q. Give it to the court?

A. (After handing drawing to the court.) Figure 3 shows the motor generator set.

Mr. Hughes: It will be shown in the record, by the reporters, that what the witness has referred to as Figure 3 is a designation appearing upon the blue print, the print itself being marked plaintiff's exhibit "27, T-5". (Claimant's Exhibit #161.)

[fol. 1040] Mr. Betts:

Q. Go ahead, Mr. Taylor.

A. What is the question?

Q. Will you please describe the motor generator transmitting apparatus illustrated in this diagram?

A. The motor generator set is illustrated by the portion marked a. The operating key is shown marked b, the transformer is shown marked c, the spark-gap marked g, the condenser the portion marked e, the primary of the oscillation transformer marked d, the secondary of this oscillation transformer is marked d^1, the loading coil is marked g, and the antenna marked A.

Q. What is the antenna circuit shown in this figure?

A. The antenna circuit is the portion marked f a g d^1 e.

Mr. Betts:

Q. What do the arrows on various part of that circuit indicate?

A. Indicate variability in the connections.

Q. And what is the spark-gap circuit?

A. The spark-gap circuit is the circuit marked g, e, d.

Q. Was e a fixed condenser or a variable condenser?

A. e was a fixed condenser.

Q. What does the arrow at d indicate?

A. d indicates that the inductance of that coil could be varied.

Q. What kind of a spark-gap was used at Chicago and Milwaukee stations?

A. Plain spark-gap between two brass spheres.

Q. How long were you in Chicago and Milwaukee installing these two stations?

A. I was there installing and operating them until October of that year.

Q What year was that?

A. October of 1903.

Q. And what did you next do?

Mr. Hughes: Well, one moment. The blue print just described by the witness is offered in evidence as plaintiff's exhibit "27, T-5".

Blue print referred to was marked plaintiff's exhibit "27, T-5". (Claimant's Ex. =161.)

A. I returned to New York.

Q. And after returning to New York, what work did you next do?

A. I was sent to the Marconi station at South Wellfleet, Mass.

Q. Will you point out to the court where that station is, upon the map which has already been referred to?

A. The station is marked here on the map, South Wellfleet, in red.

Q. Is that South Wellfleet station known by any other name?

A. Yes, it is frequently referred to as the Cape Cod station.

Q. Was the Cape Cod station erected when you first went there?

A. Yes, sir.

[fol. 1041] Q. Radio apparatus there?

A. Radio apparatus was all installed.

Q. Had the station been operating?

A. Yes, the station had been operating.

Q. In what way was the Cape Cod station used, for what purpose?

A. The station was then being used to test with the station erected by the Marconi Company in Nova Scotia, at Glace Bay.

Q. What kind of wireless apparatus was at the Cape Cod station in 1903?

A. The apparatus was of the tuned type.

Q. Can you refer to any of the drawings which you have produced as illustrating the Cape Cod station?

A. The drawings showing the Tune B apparatus would be diagrammatically correct for the Cape Cod station.

Mr. Hughes:

Q. You refer to the drawing shown in exhibits "T-3" and "T-4" (Showing).

A. Yes.

Mr. Betts:

Q. Now, Mr. Taylor, referring to the transmitter at Cape Cod station in 1903 while you were there, how many turns were there in the spark-gap circuit oscillation transformer?

A. There was less than one turn. The primary was usually built up on a separate former and wound around the three sides of a square former or if circled around almost to a complete turn and then the ends brought out for connections.

Q. And what can you say as to the condensers in the spark-gap circuit at Cape Cod, in 1903, while you were there?

A. They were of the glass plate in oil type, and their connections could be made, or broken, if necessary; but there was no provision made for altering these.

Q. Did they have at Cape Cod an induction ten-inch coil?

A. No, sir.

Q. What did they have?

A. They had two transformers.

Q. A motor generator circuit?

A. No, it was an alternator driven by an oil engine.

Q. How long did you remain at Cape Cod station this time?

A. Until March of 1904.

Q. What was the height of the antenna at Cape Cod station at that time?

A. The antenna was supported by four wooden towers, each of which was 210 feet high, and by two wooden masts, each of which was approximately 105 feet.

Q. How did the number of turns in the transmitting oscillation transformer at the Cape Cod station at this time compare with the Tune B oscillation transformer at Sagaponack?

A. We varied the number of turns in the oscillation transformer secondary, and each turn would be wound on a larger former than on the Tune B apparatus previously described.

Q. What kind of a spark-gap was used at Cape Cod in the fall of 1903 until March, 1904, when you left?

A. The spark-gap was what is usually known as the stationary type. It comprised two discs of iron, the face of each of which was approximately two inches wide, and the diameter was about eight inches, and each of these was kept revolving at a very slow speed. I should say from memory that they revolved once every two minutes.

[fol. 1042] Mr. Hughes:

Q. Every two what?

A. Every two minutes, so that, for all practical purposes, they were stationary gaps.

Mr. Betts:

Q. Now, referring to the receiving apparatus at Cape Cod, how did that differ, as to value, with the Tune B receiving apparatus at Sagaponack?

A. The oscillation transformer secondary was wound to be used for longer waves than for the Tune B, but, otherwise, it was the same.

Q. And the condensers in the receiver at Cape Cod and Sagaponack, were they of the same value?

A. The fixed condenser in the oscillation transformer was boxed and I could not tell you what its value was relative to the Tune A or Tune B condenser.

Q. What elements were in the transmitting antenna at Cape Cod station, which the operator could use to vary or adjust, in operation?

A. He could vary the inductance of the antenna circuit.

Q. And what elements were in the other transmitting circuit which the operator could vary?

A. Well, nothing was provided in the other circuit, but we always varied the condenser.

Q. How?

A. By breaking connection or making connection with

more or less rows of these tanks containing the condenser in oil.

Q. Did you finish your testing with the Glace Bay station before you left Cape Cod?

A. Yes, sir.

Q. And what was done, if anything, with the Cape Cod station then?

A. We started testing with the mercantile marine, ships that were leaving New York and sailing towards England.

Q. For what purpose?

A. For the purpose of establishing a news service to ships at a longer range than could be obtained at the stations at Sagaponack and Babylon.

Q. You say a longer range than Sagaponack and Babylon. What range?

A. About a thousand to thirteen hundred miles.

Q. Now, when you left Cape Cod in the spring of 1904, what next did you do?

A. I returned to New York and was sent to Alaska.

Q. For what purpose?

A. For the purpose of taking over some stations that had been erected for the company by Mr. Pfund.

Q. What kind of apparatus was at the Alaska stations?

A. It was the tuned apparatus of the Tune B type.

Q. Such as you have already described and illustrated in the drawings?

A. Yes, sir.

Q. Can you mention what those Alaska stations were?

A. The names or places at which these stations were erected were Fort Gibbon, Tolvana and Chenoa.

Q. How long were you up in Alaska on this job?

A. I came out of Alaska during February and March.

Q. Of what year?

A. 1905.

Q. And what did you do then?

A. On returning to New York, I was sent to Siasconset station and Babylon, and then went on a holiday.

Q. Now, will you point out to the court, on the map which you have already used, where the Siasconset station and where the Babylon station is?

A. The Siasconset station is on Nantucket Island off the [fol. 1043] coast of Massachusetts, and Babylon is at the New York end of Long Island. (Indicating on map to the court.)

Q. What kind of apparatus did you observe was at the Babylon and Siasconset stations when you were there in the spring of 1905?

A. Babylon had the Tune A and Tune B apparatus set up, and Siasconset had the Tune B apparatus.

Mr. Hughes:

Q. As you have described it in this diagram?

A. As I have described.

Mr. Betts:

Q. Now, after you had been to these two stations, what did you do?

A. I went to England on a vacation.

Q. On what ship?

A. On the "S.S. St. Paul".

Q. What kind of apparatus did the "St. Paul" have?

A. The "St. Paul" had Tune A apparatus set up.

Q. When, if ever, did you return to the United States?

A. I returned the same year. I believe it was the end of July or beginning of August that same year.

Q. And when you returned to the United States in August of 1905, what did you do?

A. I was sent down to the Sagaponack station.

Q. How long were you there at Sagaponack?

A. Approximately a month.

Q. What kind of apparatus did you see in use at Sagaponack in 1905?

A. Sagaponack was then using Tune A apparatus.

Q. After you had been at Sagaponack for a month, what did you next do?

A. I returned to New York and was sent to the South Wellfleet station again.

Q. That is the Cape Cod station?

A. The Cape Cod station.

Q. What apparatus was in use at Cape Cod station when you arrived there?

A. The same as that which I have previously described in my first visit there.

Q. How long were you at Cape Cod station?

A. I was there until 1909.

Q. In charge there?

A. In charge of that station.

Q. And during this period from 1905 to 1909, what kind of apparatus was used at the Cape Cod station?

A. The tuned apparatus such as I have already described.

Q. Tunes A and B or Tune B?

A. No, a larger tune,—it was a longer wave-length than Tune B, but the apparatus was substantially as shown for Tune B on the diagrams.

Mr. Hughes:

Q. You say the larger tune?

A. It was a longer wave-length.

Mr. Hughes:

Q. A long tune, not a large tune. I didn't understand what you said. I wanted the reporter to get it correctly.

Mr. Betts:

Q. And after you left Cape Cod station in 1909, what next did you do?

A. I was employed by the English Company to erect stations in the Amazon Valley in Brazil.

Q. And you were in their employ for that purpose for how long?

A. I was in their employ until 1912.

Q. When you came to the United States?

A. When I came to the United States, yes.

Q. Now, Mr. Taylor, during the period when you were [fol. 1044] in the employ of the American Marconi Company, from 1902 to 1909, did the American Marconi Company use any other kind of detector than the coherer which you have described?

A. Yes, we used the magnetic detector.

Q. Well, now, can you produce a diagram showing how the magnetic detector was used instead of the coherer? Go ahead, if you can.

A. A magnetic detector was used in a tuned circuit connected with the antenna circuit, such as I have shown in the tracing that I have here.

Q. Show that to the court, please.

A. (Witness shows tracing to the court.)

Mr. Betts: I offer a blue print of the tracing in evidence and ask that it be marked plaintiff's exhibit "27, T-6" (claimant's exhibit No. 162).

Blue print referred to was received in evidence and marked plaintiff's exhibit "27, T-6".

Mr. Betts:

Q. Did the Marconi Company use a magnetic detector in any other circuit than that which you have just illustrated or identified by the diagram?

A. Yes, they have used it in a third circuit with an intermediate circuit between the antenna and the detector circuit.

Q. Can you produce a diagram of that circuit arrangement?

A. Yes, that is shown in diagram marked 7.

Q. Show it to the court.

Witness hands diagram to the court.

Q. Now, referring to this diagram having the words "Marconi multiple tuner with magetic detector", please describe the apparatus, beginning with f.

A. f is the antenna, g^1 is the variable inductance used in series with that antenna, h is a variable condenser also used in series with that antenna, j^1 is the primary of the oscillation transformer, and E is the earth connection.

Q. Was h a variable or a fixed condenser?

A. h is a variable condenser.

Q. Now, describe the next circuit, please.

A. The next circuit comprises the secondary of the oscillation transformer marked j^2, a variable capacity marked r^1, and an inductance marked t^1.

Q. Now, describe the next circuit?

A. The next circuit comprises an inductance marked t^2, a variable condenser marked h^2, and a magnetic detector marked m.

Mr. Betts: I offer this drawing in evidence and ask that it be marked plaintiff's exhibit "27, T-7".

Drawing referred to was received in evidence and marked plaintiff's exhibit "27, T-7" (claimant's exhibit =163).

Q. At what stations, Mr. Taylor, was the magnetic detector used and connected in diagram such as you have illustrated in exhibits "27, T-6" and "7"?

A. In "T-6" and "7"? At Sagaponack, at Milwaukee and at Cape Cod.

Q. Mr. Taylor, I show you four sheets of paper and ask [fol. 1045] you if you can identify them and state what they are? (Handing papers to witness.)

A. These are duplicates of shipping orders of material sent to Sagaponack station in the fall of 1902. One marked number "1" refers to transmitting jigger sent to me while I was at that station. One marked "13" refers to a Tune B transmitting figure sent to me. One marked "17" refers to a receiving jigger of Tune B type, and one marked "39" contains, among other things sent to that station, two magnetic detectors. That is in 1902 and 3.

Mr. Hughes:

Q. When you say marked you mean having at the top the numbers?

A. The reference number.

Mr. Hughes:

Q. The reference number.

A. Having reference numbers 1, 13, 17, 39.

Mr. Betts:

Q. In whose handwriting, if you know, are any of these papers?

A. Every one of them is in the handwriting of Mr. F. M. Sammis.

Mr. Betts: I offer these four sheets of paper in evidence and ask that they be marked plaintiff's exhibit "28".

* * * * * * *

Papers referred to were received in evidence and marked plaintiff's exhibit "28". (Claimant's Exhibit #167.)

Q. I show you another paper and ask you if you can state what that is? (Handing paper to witness.)

A. This is a copy of instructions issued by the Marconi's Wireless Telegraph Company, Limited, for the use of Marconi tuned apparatus for wireless telegraphy. This is dated the first of January, 1904.

Mr. Betts: I offer in evidence this paper and ask that it be marked plaintiff's exhibit "29".

* * * * * * *

Paper referred to was marked plaintiff's exhibit "29". (Claimant's Exhibit #168.)

Q. Now, Mr. Taylor, while you were employed by the American Marconi Company from 1902 to 1909, what instrumentalities did you use in endeavoring to ascertain whether the transmitting circuits of the Tune A or Tune B apparatus which you have described were or were not in tune or in resonance?

A. We used to use a straight filament lamp placed in the antenna circuit, or else a hot wire volt-meter shunted across a small portion or small part of the antenna circuit.

Q. Explain a little more fully how, when you used the lamp, it showed whether the circuits were in resonance, or not?

A. The antenna circuit inductance would be varied until the lamp glowed at its maximum, and that point would be taken as the point of resonance.

Q. And what instrumentalities were used to determine whether the spark circuit of the transmitter was in tune or resonance?

A. In tune, what with?

[fol. 1046] Q. With the antenna.

A. Well, the variation was all done in the antenna, there was no variation made in the primary circuit or spark circuit of the transmitter.

Q. Now, referring to the receiving apparatus of tunes A and B, what instrumentalities were used to determine whether the aerial or antenna circuit was in tune or resonance with the detector circuit?

A. A small buzzer was used in the antenna circuit.

Q. Any instrumentalities used in the detector circuit?

A. None whatever.

Q. That was all done by the manufacturer?

A. Yes, that was fixed.

Q. When did wave-meters come into use, Mr. Taylor, I mean portable wave meters, so that you could measure wave lengths of radio circuits?

A. As far as I can recollect, they did not come into general use until 1908.

Q. Did you use wave meters while you were in the employ of the American Marconi Company?

A. No, we never used any portable wave meters in the tuning up of the various stations with which I was connected

in the employ of the American Marconi Company at that time.

Q. Are you familiar with the employment of wave meters at the present time to determine the wave-length of radio circuits?

A. Yes.

Q. What is the advantage of using wave meters over the use of your incandescent lamp that you have described?

A. The advantage is that with the wave meter you can tune your primary circuit independently of the secondary; you can tune your secondary independently or to the primary circuit, and it is possible to get a much closer adjustment of the tuning than you can get with the single tuning obtained by the lamp or voltmeter.

Q. Do you recall whether or not at any time, while you were in the employ of the American Marconi Company, any means was provided for getting sharp tuning in the detector circuit of the receiver?

A. Towards the end of the use of the coherer detector for commercial purposes, we used to put a variable condenser across the coherer itself, but that was only done occasionally, it was not general practice.

Q. Could you make a drawing showing this occasional practice?

A. Yes (reproduced opposite).

* * * * * * *

Mr. Betts:

Q. Mr. Taylor, can you now produce the drawing which I asked you to make before the recess?

A. This is the drawing referred to.

Q. Give the original to the court.

A. (The original drawing was handed to the court by the witness.)

Mr. Betts: I ask that this be marked plaintiff's exhibit "27, T-8".

Drawing referred to was received in evidence and marked plaintiff's exhibit "27, T-8". (Claimant's Exhibit #164.)

[fol. 1047] Q. Mr. Taylor, will you now explain the drawing "T-8"?

A. The drawing "T-8" shows the tuned receiving apparatus used by the Marconi Company. The antenna circuit

is shown, marked f and d^1, and the secondary circuit is shown marked S J S^1 T, T being the coherer, and the variable condenser J^1, dotted, connected across that coherer.

Q. Where was such a receiving circuit used by the American Marconi Company while you were connected with it from 1902 to 1909?

A. We used such a circuit at Cape Cod or Sagaponack.

Q. Why did you use it at all?

A. It was used if the transmitting circuit was not directly in tune with the coherer circuit on the receiving apparatus, and this variable condenser J^1 enabled us to put the receiving circuit containing the coherer in better tune with the transmitting circuit.

Q. While you were with the Marconi Company from 1902 to 1909, were any other forms of transmitters used than that which you have called Tune A and Tune B?

A. Yes, we used plain aerial.

Q. Can you produce a drawing illustrating that?

A. Yes. (Producing.)

Q. Give it to the court.

A. (Witness handed drawing to the court.)

Mr. Betts: Mark it "T-9", please.

Drawing referred to was received in evidence and marked plaintiff's exhibit "27, T-9". (Claimant's Exhibit #165.)

Q. Will you now explain to the court your sketch "T-9"?

A. The exhibit "T-9" shows the early type of Marconi transmitter, in which the antenna circuit is marked f to E, and the spark-gap S.G. directly on it. This spark-gap is connected across the secondary of a ten-inch induction coil marked "induction coil" and the primary circuit is shown energized by a battery marked b, and the manipulating key is shown, marked k.

Q. What was the transmitter shown in your exhibit "T-9" used for?

A. It was used for emergency purposes.

Q. What do you mean by emergency purposes?

A. When the ship that we were working with could not receive on Tune A or Tune B apparatus.

Q. Now, Mr. Taylor, I call your attention to your drawing "T-5", entitled "Tuned transmitter using motor generator" set. This drawing shows some clips on the coils of the transmitters. Will you state whether or not such sets were used or worked?

A. This drawing has reference to the set that was used at the Milwaukee and Chicago stations. That was not a commercial set, and was installed with clips for the purpose of carrying out experimental work.

Q. Now, in the Cape Cod, Babylon and Sagaponack stations that you have referred to, how many turns were in the primary of the transmitting oscillation transformer?

A. There was just less than one turn in each of the oscillation transformer primaries on each of those stations whilst I was there.

[fol. 1048] Q. That was the universal practice?

A. That was the universal practice of the Marconi Company.

Q. Now, when you were at Cape Cod from 1905 until 1909, what was that station doing, if anything, in a commercial way?

A. It was transmitting news from the shore to the commercial ships that were fitted with Marconi apparatus.

Q. To what distance was this communication?

A. The communication was to the limit of thirteen hundred miles.

Mr. Farnsworth:

Q. You know that of your own knowledge?

A. Yes.

Mr. Betts:

Q. I now show you an exhibit marked plaintiff's exhibit "K" (Claimant's Ex. 153) and ask you if you can identify that exhibit and state to the court what it is? (Handing paper to witness.)

A. This shows the interior of a Marconi wireless station, showing ten-inch induction coil, with two trays of Leyden jars, one of which is the six used for the Tune A apparatus, and the other the fifteen used for the Tune B, and besides them is the coherer type of receiving apparatus.

Q. Just point that out to the court on the photograph, please.

A. This is the ten-inch induction coil, and here is the battery of six Leyden jars for the Tune A apparatus, and here is the battery of fifteen for the Tune B, and these are the coherer receivers.

Q. Whose photographs or pictures appear in that exhibit, if you know?

A. In the foreground here is Mr. Chavlier, who was at Sagaponack with me, and this man is Mr. Brennan, who was in the Marconi Company's stores or workshop in New York, and the third man I do not know, or I do not recognize him.

* * * * * * *

Mr. Betts:

Q. I now show you another exhibit, marked plaintiff's exhibit "J" (Claimant's Exhibit No. 152), and ask if you recognize that, and, if so, state what it is, exhibiting the same to the court.

A. This is a print of the Franklin multiple tuner such as was used at the Marconi shore stations at Sagaponack, Babylon, Siasconset and Cape Cod, at which I was employed.

* * * * * * *

Q. Referring to plaintiff's exhibit "29" (Claimant's Ex. 168), Mr. Taylor, which you have already identified, what can you say further as to that?

A. These are the instructions issued by the English Marconi Company for use with Tune A and Tune B apparatus, and were copied by the American Company and issued to their stations, and a copy of which was sent me while I was on one of their stations in 1904.

Q. From your practical experience, Mr. Taylor, what are the advantages of using coupled tuned circuits at the transmitter and coupled tuned circuits at the receiver?

A. For the same initial energy we get a louder signal at the distant receiving station, and the reception is easier because the circuits are more selective.

[fol. 1049] Q. In your experience as a radio engineer, particularly in long distance wireless work, what can you say as to whether or not continuous communication could be maintained between San Francisco and Honolulu without the use of tuned circuits of the transmitter and tuned circuits of the receiver?

A. In my experience, I would say that if the circuits of the transmitting station were not tuned and the circuits of the receiving station were not tuned and had no harmonious relation with one another, the amount of energy required at the transmitting station would make such a combination commercially impossible.

Q. Is there any other advantage than that of long distance communication with a small amount of power in the

use of coupled tuned circuits of the transmitting and receiving stations, from your practical experience?

A. Well, we are able to work duplex at our transmitting stations, for instance, the station at Honolulu can work to Japan or to San Francisco at the same time as San Francisco and Japan stations are working to it, and the station at San Francisco can work to Honolulu at the same time as the Honolulu station is working to San Francisco.

Q. From your own practical experience, can you state as to whether or not messages have been actually received and sent from San Francisco to Honolulu with the use of coupled tuned circuits at both stations?

A. The Marshall station of the Marconi Company has received messages from the Funabashi station in Japan by the use of coupled tuned circuits, but the Marshall station has not engaged in any test for transmitting to Funabashi.

Q. The Marshall——

A. The Marshall station has not engaged in any transmitting test to the Funabashi station of the Japan government.

Q. Well, now, as between Honolulu and San Francisco, what can you say as to the use of coupled tuned circuits between those two stations?

A. The coupled tuned circuits are always used between the Marconi stations at Honolulu and San Francisco.

Q. What is the distance between the Japanese government station and the Marshall station you have referred to?

A. I have never measured it out or calculated it, but I should imagine it was about five thousand miles; probably slightly under.

Q. From your experience with radio telegraphy, what is the minimum and maximum wave-length used commercially?

A. The maximum wave-length that we have employed in the Marconi long distance stations is approximately 16,000 meters, and the smallest wave-length that I am aware of that has been used is 100 meters.

Q. Mr. Sammis has testified for the defendant that "Practically the only time that the coupled sets were used was when from storm or damage the antenna installation became so low as to prohibit the spark. * * * The station at Sagaponack, New York, is a particular example. This station operated with an inductance coil sparking directly into the antenna and right up to the time the plain

aerial was prohibited by law." What can you say, Mr. Taylor, from your own personal knowledge, as to the truth of Mr. Sammis' statement?

A. From my own personal knowledge, I know that the Sagaponack station used Tune A all the while I was there. [fol. 1050] The only time that the spark-gap was put in the antenna was, as I said before, in case of emergency.

Mr. Betts: I want to introduce in evidence the map referred to by the witness during the direct examination as plaintiff's exhibit "30".

. . . . . .

Map referred to was marked plaintiff's exhibit "30". (Not offered in present case.)

Cross-examination.

By Mr. Farnsworth:

Q. Mr. Taylor, what is the power of the transmitters of the Marconi Company at Hawaii and San Francisco?

A. The alternator used for energizing the condenser bank has a rated capacity of 300 kilowatts.

Q. At each transmitter?

A. Yes, at each transmitter.

Q. The Federal Company, with the Poulsen system, also operates between Hawaii and San Francisco, does it not, or between Honolulu and the Pacific Coast?

A. So I understand.

Q. A regular commercial communication?

A. So I believe.

Q. What power have their transmitters in that communication?

A. I do not know. I never have been in their station.

Q. You don't know whether or not it is as large as the Marconi power?

A. No, I have no knowledge of it.

Q. You know, do you not, that the system of the Poulsen type, applied by the Federal Company, is that employing a single oscillating circuit at each station and not coupled tuned circuits, don't you?

A. No, I do not.

Q. What is the shortest wave which the regular receivers at Marshall's, in Honolulu, Marconi High-power station, can receive?

A. Those receivers are adjustable in every particular and we can arrange to make them tune to almost any wave.

Q. What is the shortest?

A. The shortest wave that we have actually tuned to is about 2,000 meters.

Q. In your experience in radio telegraphy, which type of transmitter will transmit the longest distance, the old plain aerial type or the coupled tuned circuit type, other conditions being the same as to power and so forth at the transmitter?

A. That will depend on the type of receiver that was used.

Mr. Farnsworth:

Q. What form of Marconi apparatus was used on the steamship on which you returned from England to the United States, in 1905?

A. I returned in the Steamship "St. Paul", and that station was equipped with Tune A and Tune B apparatus.

Q. In your experience in this country with the American Marconi Company you didn't have much opportunity to become acquainted with the plain aerial or single oscillating circuit transmitters used by the American Marconi Company, did you?

A. Not while I was in their employ.

Q. Those were mostly used on the ships, rather than on the land stations?

A. That I could not say.

Q. Referring to plaintiff's exhibit "27, T-7" (Claimant's [fol. 1051] Ex. 163), will you please step to easel and make a drawing of the circuits of that receiver employing a magnetic detector, in which you will show the circuits of the magnetic detector in full, as indicated only diagrammatically at M in said exhibit?

A. The whole?

Q. The whole receiver?

A. (After drawing.) There is the drawing, Mr. Farnsworth.

Q. Mark it, Mr. Taylor, with your initials.

(Drawing referred to was marked "T-10".)

Mr. Farnsworth: "T-10". That is offered as defendant's exhibit.

(Received in evidence and marked plaintiff's exhibit "27, T-10".) (Claimant's Ex. =166.)

Q. Explain, please, with the letters of reference on the chart "T 10", just where the magnetic detector is and what its parts of the circuit are.

A. This is the magnetic detector. This part is——

Q. Mark it, please, and specify it.

A. M 1 shows the primary coil of the magnetic detector, and M 2 shows the secondary coil of that detector, and T shows the telephones.

Mr. Hughes:

Q. The letter "T"?

A. The letter "T".

Mr. Farnsworth:

Q. Mr. Taylor, referring to your drawing at "T-9", you have marked that "Early Marconi transmitter untuned plain aerial." State, please, what you mean by untuned.

A. I mean that there were no coupled circuits, there is only one circuit in which the frequency is a radio frequency.

Q. When you show two coupled circuits in your other diagrams, that is why you call them tuned?

A. The two coupled circuits. The transmitter shows that the two coupled circuits are those in which we have tuned relation between the two circuits.

Q. Yes, and when there is only one circuit at transmitter or receiver, you call that an untuned receiver?

A. There is only the single circuit there, and there are not two circuits, no, untuned in the radio frequency.

Q. You never in your experience knew of the plaintiff's aerial, such as in your T-9, being tuned to the aerial of the other station.

A. I am referring to the tuning of the transmitting apparatus in itself.

Q. Yes, and two circuits together.

A. The two circuits——

Q. I will ask you if you ever have known in your experience whether or not, with a plain aerial transmitter and receiver, where there was a single oscillatory circuit—whether you have ever known of one aerial of one station being tuned to the aerial of another station, as in your T-9?

A. No, I don't think so, as far as I can recollect.

Q. You don't know of any cases where two stations were tuned to each other, where at each station there was only one radio circuit, such as the antenna?

A. A single radio station in each circuit?

Q. In each station.

A. Not as far as I am aware of, no.

Q. Before wave-meters came into use, which I think you said was about 1908, how did you practitioners in the art manage to get, in each of the two circuits at each station, [fol. 1052] that is, four circuits at the Marconi system, the product of the inductance and capacity in each circuit exactly the same as the product of inductance and capacity in the other circuits?

A. In my experience, I could not say that we did get the product of those two quantities identical in both stations but we got it as near as we possibly could.

Q. You constructed or adjusted until you got the best results in practice?

A. Yes. We altered the antenna circuit until we got the maximum relation between the two, as far as we could.

Q. Yes, the adjustment or construction being empirical until you got the best results?

A. To a large extent, yes.

Q. Well, just what was shown to your satisfaction by the instruments you did use prior to the time you began to use the wavemeter? That is, I think you said they were a lamp and a hot wire——

A. A hot wire volt-meter or a lamp.

Q. Describe fully the use of those for that purpose in aiding you in making those empirical adjustments to get the best results?

A. We put the indicating instrument, whether it was a hot wire voltmeter or lamp, in the lower part of the antenna circuit, varying the inductance of the antenna circuit until this lamp or voltmeter gave us maximum indication showing that the indication was a maximum on the instrument, where the lamp glow was brightest. The final tuning was done by having the receiving station correct that adjustment, if necessary.

Q. So that if you did not get the two circuits of the transmitter into tune with each other, you could remedy that defect by adjusting the distant receiver?

A. We could get the best effect out of that circuit.

Q. And the adjustment you made, or construction, at the receiver, were *impirical*, as indicated by the best results you got at that receiver?

A. By the best results, yes, sir.

Q. Now, when the maximum indication was shown by the lamp or instrument, hot wire instrument, that indicated, did it not, as you understand it that the maximum current was flowing in that circuit?

A. Yes, it——

Q. Or energy?

A. It gave the indication of maximum flow of energy.

Q. It was due to that flow in the circuit of the maximum energy or current that you got the best results in transmission of radio communications?

A. No. The instructions showed that the best point very [fol. 1053] often was the slightest bit off to one side of that maximum.

Q. It was very near that maximum?

A. It was near that maximum, yes.

Q. As to any of your drawings that you have submitted today, in addition to giving the operation of some of the parts in those cases, can you state the wave-length or frequency of those circuits?

A. I have never measured them for wave-length or frequency of those circuits. I have never measured them for wave-length or frequency when we had a wave meter.

Q. Can you state whether any of those circuits of your sketches today, as specified to exemplify the ancient practice of the Marconi Company—can you state whether or not, as a matter of fact, in practice, the circuits in two or more of them ever did have substantially the same wave length or frequency as the others?

A. Yes. The majority of those for Tune A had the same frequency, or very approximately the same frequency; and the same with Tune B.

Q. How do you you know that?

A. Because the secondary circuit in the coherer circuit was fixed and had a definite period of its own.

Q. How do you know that, were you constructor?

A. Yes, I was constructor for part of the time.

Q. That is the fact, is it, that as on your drawing T-2 and T-4, namely that the secondary or coherer circuit of those receivers had substantially the same frequency or period as the antenna or aerials?

* * * * * * *

A. T-2 and T-4, or T-2 and T-5?

Q. Mine is marked 4.

(Question read.)

Q. The antenna circuit in both instances was tuned to the fixed circuit at the receiver containing the coherer.

Q. The coherer in the coils s^1 s^1 and the condenser j?

A. Yes, and condenser j.

Q. What is it, j s?

A. j^1 and j s. J^1 in exhibit "4" and j s in exhibit "2".

Q. Yes, that is, you state that as a fact, do you, both as [fol. 1054] being a constructor of that apparatus and as a practitioner with it?

A. Yes, we constructed the antenna to correspond to the secondary circuit of the coherer.

Q. Yes. You are absolutely certain of that, namely, that in T-2 and T-4 the two receiving circuits, namely, the aerial and the secondary circuit, including the coherer, did have substantially the same wave frequency or tune or period?

A. So fas as our apparatus would inform us.

Q. So far as what?

A. So far as our apparatus would let us know.

Q. So far as your apparatus would let you know?

A. Yes.

Q. Just explain what you mean by that. I don't quite get that.

A. Well, we had no means of finding out the definite periodicity of the circuit like we have nowadays with the wave meter, and, so far as the indications would go, the two circuits were in resonance.

Q. Namely, the indications being what?

A. The indications, in case of the transmitter, would be the hot wire voltmeter or the lamp, and in case of the receiver, it was the maximum signals in response to the buzzer on the antenna circuit.

Q. Yes. Then, as I understand you, as to the transmitter, you used the instruments you have mentioned, the lamp and the hot wire instrument, to obtain substantially the greatest current in the transmitter, and then, to get the best conditions at the receiver, you adjusted or constructed the receiver so that you got the best results at the receiver from such a transmitter?

A. Yes.

Q. And you never knew, otherwise, whether or not the product of the inductances and capacities of those circuits, or any of them, were substantially the same in each and all of the circuits?

A. So far as I am aware, I had no knowledge of the product of the capacity and inductance in each of these stations.

Q. Now, Mr. Taylor, you said, I think, that the wave meter used nowadays had an advantage over the use of the lamp instrument and hot wire instruments, in that you thereby get closer tuning of these four circuits. Can you now go further and state what advantage arises from obtaining closer tuning?

A. Well, closer tuning would cause a greater amount of energy in the antenna circuit.

Q. At the transmitter?

A. At the transmitter, and that would cause a better signal on the receiving instruments.

Q. Yes. That is, when you were able to get a condition of closer and closer approximation to the same periods in the primary of the closed circuit of the transmitter and the antenna, then you got better conditions of the radiation from the transmitter?

A. Yes.

Q. And, similarly, at the receiver, when you can get the receiving antenna into closer and closer approximation to the exact tuning between the antenna and the closed secondary circuit, then you get the best results at the receiver?

A. Yes.

Q. The wave meter is, you think, quite useful for the purpose of getting such closer tuning of those two circuits in each station and the four circuits at both stations?

A. Yes, I believe that we can get nowadays, with the wave meter, a much better tuning relationship than we could get in the old days without it.

[fol. 1055] Q. Well, now, as to the receiver, can you tell me, as between T-2 and T-4 on the one hand, compared with T-8 on the other, you can get closer tuning in the receiver secondary, that is, in T-2 and T-4 there is no condenser, variable or otherwise, around the detector; but in T-8 there is.

A. I would not say that the T-8 form gave us closer relationship, but at that time there were so many ships being

equipped and the transmitting apparatus was not as well tuned as it should be, and in some instances the additional condenser was used in order to make that circuit more responsive to the improperly tuned transmitting apparatus.

Q. Yes.

Mr. Betts:

Q. You are referring now to which sketch?

A. T-8.

Mr. Farnsworth:

Q. Then I take it that with T-2 and T-4 the tuning of that secondary circuit, including the coils, the condenser between them and the coherer detector, you could get in that secondary just substantially as close tuning as you could in a secondary like T-8 where the coils s and the condenser J have also a condenser J^1 included in that circuit.

A. The results obtained with the circuit as shown in Figure 2 were sufficient for the commercial work that we were doing at that time.

Q. Yes, but could you get just as close tuning with that secondary as you could with the one at T-8, where it was a variable condenser in shunt?

A. I have not made a comparative test of that.

Q. The matter of difference was not of sufficient importance to investigate it, so far as you know?

A. No.

Mr. Farnsworth:

Q. As to this variable condenser of T-8 in the secondary, I think you said that you found it was advisable to use that because by an adjustment of that variable condenser you could get better results at the receiving station from the transmitter when the tuned circuits of the transmitter were out of tune with each other; is that correct?

A. I said that was what was done; not that I could do it.

Q. Well, that was what was done, you have seen it done?

A. Oh, yes, I have seen it done.

Q. Now, do you know, have you any knowledge, as a matter of fact, of just what happens there in practice?

A. I don't quite understand your question.

Q. When the two circuits of the transmitter are out of tune, do you know, as a matter of fact or observation, what

happens in the radiation from that transmitter, whether one wave or more? What did you see, observe at the times you have testified you used this apparatus?

A. From personal observation, I never thought that that condenser was any use possibly, and very seldom used it in any station I was at.

[fol. 1056] Q. You are stating an answer I didn't ask for. I am asking for facts. What do you say you observed in those stations, at the stations where you worked?

A. There was nothing to take any measurement.

Q. Didn't you measure the waves emitted from a transmitter out of tune?

A. There was no wave meter in those days.

Q. You didn't have any wave meter?

A. No.

Q. Even in the experiments you could not tell the character of radiation from the transmitter, where the two circuits of the transmitter were out of tune with each other?

A. We had means of telling whether we got a received impulse or not.

Q. That is all?

A. That was all.

Q. When a transmitter had its two circuits out of tune, you could not tell, without any wave meter, what the character of the radiation was from that transmitter?

A. We could tell, from the hot wire meter. If we put that in and tested it over the whole range, we probably could have told the——

Q. I mean of course as to whether there were one or two waves?

A. Not in commercial stations, we could not in commercial operation.

Q. You had no means of telling whether, from such a transmitter having two circuits out of tune, there were more than one wave emitted?

A. No, we could not tell in the receiver in those days.

Q. Then I take it you do not know the fact, if it be a fact, that that variable condenser in the secondary of the receiver T-8 had any useful effect in adjusting that receiver so as to receive transmission from a transmitter where the two circuits were out of tune, you don't know the facts as to that?

A. No, I don't know.

Q. And you don't know because you had no means of giving the emitted waves?

A. We had no means of measuring the waves.

Q. In those circuits of those various sketches to which you have referred today, couldn't you calculate, from the dimensions of the reactances, namely, the condensers and inductance, what the periods of frequency of the various circuits were?

A. They got that clearly, yes.

Q. Did you ever do it?

A. No.

Q. Why not?

A. I was employed in construction work most of the time.

Q. You never did that even in your construction work?

A. No.

Q. You constructed these apparatuses containing these supposed tuned circuits without any calculating, or having calculated for you, the periods or frequency of those circuits?

A. We received instructions as to what to use for Tune A and Tune B and we carried those out.

Q. Yes, and if you varied them in constructing or use in operating them, you didn't know what the periods or frequencies were in those circuits?

A. No, we didn't know.

Q. Referring to your various drawings which you have offered today, could any one of those transmitters, that is, [fol. 1057] Tune A or Tune B, radiate at different times more than one wave-length?

A. Yes, they could both radiate more than one wave-length.

Q. How is that?

A. With two coupled circuits you can get two wave-lengths.

Q. At the same time you mean?

A. Yes.

* * * * * * *

A. At the same time, yes, with coupled circuits you can get two waves at the same time from a transmitter.

Q. Coupled tuned circuits?

A. Coupled tuned circuits.

Q. How is that an advantage as observed by you at the receiving stations at which you worked.

. . . . . .

A. We had no knowledge that two waves were being emitted at those stations.

Q. Yes; I think you really misunderstood me, Mr. Taylor. I asked you, or tried to ask you, whether those old transmitters, Tune A or Tune B, either of them, could be or were changed for the purpose of changing the emitted wave-length to a different one?

A. Were changed?

Q. Yes.

A. I don't quite understand you.

Q. By the operator, say.

A. No, in the Tune A and Tune B apparatus nothing was provided for making any changes by the operator.

Q. Yes. Now, then, the operator of such a transmitter as either Tune A or Tune B was limited to one wave-length in the use of that transmitter?

A. Yes, he could only use the wave-length as set up by the engineer.

Q. Yes. And the same is true, as you have just stated, also in respect of the Marconi receivers Tune A or Tune B respectively?

A. He could make no alteration in the secondary circuit of that coherer receiver.

Q. Do you know as a matter of fact, from your experience as a practitioner at the various stations at which you have been employed, whether you could receive efficiently, at a receiver such as Tune A or Tune B, an emitted complex wave of two frequencies?

A. No.

Q. Why couldn't you?

A. Not knowing what the radiated wave was, I had no means of telling.

Q. Because you had no wave meter?

A. We had no means of telling what the radiated wave was, whether it was, whether it was simplex or complex.

Q. Well, in one of those Tune A or Tune B receivers, could you in either one of those at one time receive messages from two distant and different transmitters each having a different wave-length?

A. We could receive the radiation from the Tune A station, and if a station was using another wave within a [fol. 1058] very short range, it would probably impulse the aerial and cause a signal on the receiving current.

Q. Answer the question without referring to very short range.

A. At long range the Tune A receiving apparatus would receive only on the Tune A.

Q. Yes.

A. Using the same power for the two sets.

Q. Yes. Is that why, on occasions, at the place where one receiving operator was, he was provided with two complete receivers, that is, Tune A and the Tune B?

A. I could not say what the object of the Marconi Company was in providing more than one receiver.

Q. Well, the result, as you practically observed it, was that when he had both the Tune A and Tune B receiver he could then work, as I take it, with a distant Tune A and Tune B transmitter?

A. He could work with a distant Tune A, and Tune B transmitter, certainly.

Q. And not with any other transmitted waves of different length than those emitted from Tune A and Tune B transmitter?

A. Well, he would have no knowledge of waves other than those——

Q. Yes.

A. (Continuing)—emitted by Tunes A and B.

Q. He would have no means at the place where he was of knowing whether waves of any other frequency were being transmitted from anywhere?

A. No. In working on the coherer, he would have no knowledge of such things.

Mr. Betts:

Q. How?

A. Working on the coherer.

Mr. Farnsworth:

Q. His senses then would be closed to any third station or distant transmitter at any different wave-lengths from either Tune A or Tune B transmitters?

A. Yes.

(Witness excused.)

Mr. Cosgrove: Claimant's counsel offers in evidence the exhibits referred to in the stipulation and the testimony, and the same are marked as specified in the stipulation.

Mr. Cosgrove also reads in evidence the following stipulation entered into between counsel:

"It is Stipulated and Agreed that the annexed copy of the pleadings and evidence under the supplemental bill in the suit in Equity No. 12 31, in the United States District Court for the Southern District of New York, of Marconi Wireless Telegraph Company of America, the claimant herein, against DeForest Radio Telephone & Telegraph Company, on the Fleming patent No. 803,684, is a true copy of the original of such pleadings and evidence, and may be offered in evidence herein, subject to the objections of the defendant, with the same force and effect as the original of said pleadings and evidence, or a duly certified copy thereof.

It is further Stipulated that a copy of said pleadings and evidence was marked for identification herein by the claimant in the taking of the evidence of Frank X. Waterman, a witness called on behalf of the claimant (Vol. 1, Record p. 264) and that such evidence is referred to in the evidence of John M. Miller, a witness called on behalf of the defendant herein and quotations made therefrom.

[fol. 1659] Mr. Cosgrove: Claimant's counsel offers in evidence the last-mentioned stipulation as "Claimant's Exhibit No. 170 Stipulation in Record Suit of Marconi *vs.* De Forest".

Claimant's counsel also offers in evidence the Pleadings and Evidence annexed and referred to in the last-mentioned stipulation, and the same is marked "Claimant's Exhibit No. 171. Pleadings and Evidence in Case of Marconi Wireless Telegraph Company of America *vs.* De Forest Radio Telephone & Telegraph Company".

Deposition of John J. Brennan, for claimant, taken at New York, N. Y., on the 8th day of October, A. D. 1925

First interrogatory by the Notary: State your name, your occupation, your age and your place of residence; whether you have any, and if any, what interest direct or indirect, in the claim which is the subject of inquiry; and whether, and in what degree, you are related to the claimant.

Answer: My name is John J. Brennan; age, 53 years; residence, 219 Harrison Avenue, Jersey City, N. J.; occupa-

tion, Foreman of the Maintenance and Repair Division of the Sales Service of the Radio Corporation of America; I have no interest direct, or indirect, in this claim and am not related in any way to the claimant.

Direct examination.

By Mr. Cosgrove:

Q. 1. Are you the same John J. Brennan who testified in this case in April 1917?

A. I am.

Q. 2. How long have you been in the employ of the Radio Corporation of America?

A. Since 1919, when the Radio Corporation of America took over the Marconi Wireless Telegraph Company of America.

Q. 3. What department of the Marconi Company referred to in your last answer did you work in from 1909 to 1916, inclusive?

A. The Maintenance and Repair Department.

Q. 4. What work did you do in or for that department during those years?

A. We manufactured transmitters and receivers and also the Marconi valve receivers, rotary gaps, oscillation transformers and parts necessary for the manufacture of complete wireless equipment.

Q. 5. What position did you hold in that department during the years 1909 to 1919, inclusive, and what work did you do in that position?

A. I was Foreman of that department; it was my duty to see that all orders were carried out.

Q. 6. What kind of orders?

A. Such as repairs to equipment on vessels when orders were issued that there was trouble on any vessel.

Q. 7. What work did you do in connection with manufacturing any of the wireless apparatus for the Marconi Company?

A. I looked after personally myself the manufacturing of the various parts of these apparatus.

Q. 8. Did you do any repair or maintenance work at the shore stations of the Marconi Company or on vessels equipped with its wireless apparatus, and if so, during what period was the work done?

[fol. 1060] A. Yes, between the period of 1909 and 1912 I visited the vessels as they came into port and tried out the apparatus, such as the Marconi valve receivers, and if possible, made the repairs while there; I also visited the John Wanamaker Station of New York City, at various times, upon complaint of trouble, and made the repairs.

Q. 9. Do you remember about what month and year you visited the John Wanamaker Station in New York City?

A. I visited that station from the early part of 1910 to about 1912, at various times.

Q. 10. What kind of a station was this John Wanamaker Station?

A. This was a Marconi wireless telegraph station of 5 KW output, conducting business between the Wanamaker stores in New York and Philadelphia.

Q. 11. Whose wireless apparatus was this Wanamaker station equipped with?

A. This was equipped with the Marconi Wireless Telegraph Company of America set.

Q. 12. During the period from 1909 to 1916, inclusive, did you visit any other shore station of the Marconi Wireless Telegraph Company of America?

A. Yes, I visited our station at Sea Gate, Coney Island, New York.

Q. 13. Do you recollect about when you visited the Sea Gate station?

A. Yes, it was around 1911; how many times I visited the station I cannot definitely state now, but it was at various times.

Q. 14. Where did the Marconi Company manufacture the wireless apparatus which you stated in your answer to Q. 4 was manufactured by that Company?

A. 27 Water Street, 125 Front Street, 29 Cliff Street, Edison Building, 27 Elm Street, New York City.

Q. 15. During the period between 1909 and 1916, inclusive, what, if any, stock of wireless apparatus did the Marconi Company keep on hand?

A. We kept a more or less complete line of parts for manufacturing purposes, such as valve tuners, rotary gaps, oscillation transformers and all parts pertaining to the complete manufacture of wireless equipment.

Q. 16. Did the Marconi Company keep on hand any types of detectors during this period, and if so, what types of detectors?

A. Yes, we kept large quantities of Fleming valves; also the magnetic detector parts and crystals.

Q. 17. When you speak of Fleming valves, what kind of a device have you in mind?

A. This is a lamp similar to the incandescent bulb, with a filament inside and a metal plate alongside of the filament, with leads coming through the glass to the outside of the bulb.

Q. 18. What disposition did the Marconi Company make of the wireless apparatus manufactured by it?

A. We equipped ship and shore stations with this apparatus manufactured by us.

Q. 19. Did you sell any of the apparatus?

A. Yes, we sold this to commercial companies and individuals as well; we also rented same to them.

Q. 20. What did you have to do, if anything, with receiving and shipping Marconi valve receivers and Fleming valves during the years from 1910 to 1915, inclusive?

A. This was a part of my work, and upon receipt of orders from the main office we would place orders through my assistants to ship these to the various Marconi shore stations and vessels.

Q. 21. Did the Marconi Company manufacture the Flem- [fol. 1061] ing valve referred to?

A. No, we had these manufactured for us by various companies; we also received a number from the English Marconi Wireless Telegraph Company.

Q. 22. State, if you know, by whom the Fleming valves were manufactured for the Marconi Company.

A. We had them manufactured for us by the General Electric Lamp Works, of Harrison, New Jersey, Tungsten Lamp Repair Company of New York City and the McCandless Lamp Works of New York City.

Q. 23. In your answer to Q. 21 you stated that you had received a number of Fleming valves from the English Marconi Company. Can, and will you produce a specimen of the Fleming valve received from that Company?

A. I can, and do.

Q. 24. Will you state, if you can, when this Fleming valve was received from the English Marconi Company?

A. I cannot state positively when this particular valve was received, but we received a number of the same kind between the early part of 1910 and up to 1911.

Q. 25. How long has this Fleming valve you have produced been in your possession?

A. This valve has been in my possession from about 1912 until two or three years ago, when I turned it over to Mr. George Clark, and obtained it from him a short while ago.

Q. 26. I notice an inscription on the bulb of the Fleming valve you have produced, and which appears to be etched into the bulb. Please read it.

A. "Fleming Oscillation Valve 12 Volts", and on the other side of the bulb it is marked "Royal Ediswan".

Q. 27. Do you know what the word "Ediswan" refers to?

A. To an English Company who manufactured the valve for the English Marconi Wireless Telegraph Company.

Mr. Cosgrove: Claimant's counsel offers in evidence the Fleming valve produced by the witness and the same is marked "Claimant's Exhibit No. 172, English Fleming Valve."

Q. 28. In your former deposition you referred to and produced a Fleming valve marked "Plaintiff's Exhibit 29, Fleming Valve". Will you please state for whom, and by whom, this valve was made, if you know?

A. This valve was manufactured for the Marconi Wireless Telegraph Company of America by the General Electric Lamp Works of Harrison, New Jersey.

Q. 29. Can you state about when that valve was received by the American Marconi Company from the General Electric Lamp Works?

A. No, not that particular valve; but I have seen numerous ones of the same type between 1910 and 1912.

Q. 30. I show you six articles. Will you state if you know, what they are?

A. These are Fleming valves.

Q. 31. For how long past have you known of the existence of these six Fleming valves?

A. These valves have been in my possession from 1910 up to the present time. Some of these valves are of the manufacture of a slightly later date than 1912 and 1913.

Q. 32. One of the six valves you have produced has a small tag attached to it, marked "O. K. 10 - 19 - 12. 10 V. Fair H. E. H.". Please state if you know what that inscription or marking means?

A. This refers to the date when this valve was tested by our inspector, Mr. Halberg and the marking "10-19-12"

means October 19th, 1912, and apparently wor[illegible]ost on 10 volts on test.

Q. 33. Do you know in whose handwriting the inscription [fol. 1062] on the tag is?

A. Only from seeing Mr. Halberg's signature at various times; I would say that this is his own handwriting.

Q. 34. Do you know where Mr. Halberg is at the present time?

A. Mr. Halberg is now connected with the engineering department of the Radio Corporation of America; I don't just know what branch.

Mr. Cosgrove: Claimant's counsel offers in evidence the Fleming valve last referred to by the witness and requests that the same be marked "Claimant's Exhibit No. 173, Fleming Valve".

(Said exhibit so marked by the Notary.)

Q. 35. Another one of the six valves you have produced has a tag attached to it, on which appears the following "Tested Fair 4/30/13 C. L. H." "12 V." and a word which I cannot read. Will you please state, if you know, what that word is, and what the entire marking means?

A. This shows that this valve was tested on April 30, 1913, and the marking is "12 V. Carbon"; it shows that this valve is a 12-volt carbon filament. Marked "Tested Fair". The signature I cannot make out.

Q. 36. Do you know what the words "Tested Fair" mean on that tag?

A. This means that this valve did not come up to the tests of our standard.

Mr. Cosgrove: Claimant's counsel offers in evidence the Fleming valve last referred to by the witness and requests that the same be marked "Claimant's Exhibit No. 174, Fleming Valve".

The Notary does as requested.

Mr. Cosgrove: Claimant's counsel also offers in evidence the remaining four of the six Fleming valves produced by the witness, and requests that the same be marked respectively "Claimant's Exhibits Nos. 175, 176, 177 and 178, Fleming Valve".

(The Notary does as requested.)

Q. 37. In your former deposition you referred to and produced a receiver marked "Plaintiff's Exhibit No. 28, Fleming ——— Valve Receiver" and stated that it was received in October, 1910, from the British Marconi Company, and that at the time of its receipt it was accompanied by six 12-volt Fleming valves. Can you produce a specimen of the type of Fleming valve which accompanied this receiver when received by you?

A. I can.

Q. 38. Will you please do so?

A. This is one of the type of valves received with the tuner from the British Marconi Company.

(Witness produces "Claimant's Ex. 172, English Fleming Valve").

Q. 39. When did the Marconi Wireless Telegraph Company of America begin to have manufactured for it in this country the Fleming valves, of one or more of the types like "Claimant's Exhibits 173 to 178", inclusive?

A. We began having these valves manufactured in the latter part of 1910 up to 1913, inclusive.

Q. 40. State, if you know, about how many of the various types of Fleming valves you have referred to in your last answer, were manufactured for the Marconi Company from the latter part of 1910 up to 1913, inclusive?

A. We had more than a thousand of these valves manufactured for us, but I have no records to show at the present time just how many, as they are very incomplete.

Q. 41. How do you know that the Marconi Company had [fol. 1063] manufactured for it more than one thousand valves?

A. From the records which I have gone over, which are very incomplete, and the number of valves which I received from the manufacturers it was more than a thousand.

Q. 42. Have you made a search for, and been able to find, any of the records of the American Marconi Company which would show the receipt of Fleming valves and Marconi valve tuners?

A. I have.

Q. 43. What did you find in the way of such records?

A. I have the large receiving book; also bills from the General Electric Lamp Works, and bills of the Tungsten Lamp Repair Company.

Q. 44. Will you please produce the Receiving Book and the bills referred to in your last answer?

A. I produce the books and bills.

Q. 45. What, if anything, did you have to do with the book which you have produced and which has pasted on it a label "Marconi Co. Large Account Book, Book No. 1"?

A. Upon receipt of material it was my duty to check the items as entered, to see that they conformed to the material actually received.

Q. 46. For how long past has this book you have produced been in your possession?

A. This book has practically been in my possession or in the shop at least since 1904.

Q. 47. What periods does this book cover?

A. September 22, 1902 to November 30, 1905; May 18, 1907 to July 15, 1907; December 2, 1910 to December 30, 1912.

Q. 48. Is this the only book that you have been able to find covering the receipt by the Marconi Company of Fleming valves?

A. Yes, this is the only book; I have been unable to find the others.

Q. 49. Have you made an examination of the entries in this receiving book to ascertain the number of Fleming valves and Marconi valve receivers received by the Marconi Company, as shown by the book?

A. I have done so.

Q. 50. Have you made, or had made, a correct transcript from this book of the Fleming valves which were received at the New York City shops of the Marconi Company?

A. Yes, I have had a transcript made.

Q. 51. Will you please produce it?

A. (Witness hands same to counsel.)

Q. 52. Is this transcript a correct copy of the entries from the large receiving book relating to the receipt of Fleming valves?

A. Yes, it is.

Mr. Cosgrove: Claimant's counsel offers in evidence the receiving book produced by the witness, with particular reference to Fleming valves and Marconi valve receivers, and requests that the same be marked "Claimant's Exhibit No. 179, Marconi Receiving Book No. 1".

(The Notary does as requested.)

Mr. Cosgrove: For the convenience of Court and counsel Claimant also offers in evidence the transcript of the entries of the receipt of Fleming valves from this book produced by the witness and requests that the same be marked "Claimant's Exhibit No. 180, Transcript No. 1, Fleming Valves".

(The Notary does as requested.)

Q. 53. How many Fleming valves were received according to the entries in "Claimant's Exhibit No. 179, Marconi [fol. 1064] Receiving Book No. 1" and as shown in the transcript which you have produced?

A. There is a total of 702 valves.

Q. 54. In your answer to Q. 43 you produced five bills of the General Electric Company for the manufacture of Fleming valves. How many Fleming valves do these five bills call for?

A. These five bills show a total of 222 valves in all.

Q. 55. Are these 222 valves included within the 702 Fleming valves previously mentioned by you?

A. Yes.

Q. 56. Please give the dates of the five General Electric bills?

A. December 29, 1911; February 10, 1912; November 16, 1911; November 17, 1911; and February 15, 1912.

Mr. Cosgrove: Claimant's counsel offers in evidence the five bills produced and referred to by the witness, and the same are marked "Claimant's Exhibit No. 181, General Electric Company Bills".

Q. 57. Referring to the bills of the Tungsten Lamp Repair Company for the manufacture of Fleming valves, will you please state how many Fleming valves those bills call for?

A. These bills call for a total of 825 valves.

Q. 58. Are the valves called for by these bills in addition to the 702 valves shown by "Claimant's Exhibit No. 179, Marconi Receiving Book No. 1"?

A. These are in addition to those shown in the book.

Q. 59. In other words, the incomplete records which you have produced show that the Marconi Company had manufactured for it 1527 Fleming valves; is that correct?

A. Yes, 1527.

Mr. Cosgrove: Claimant's counsel offers in evidence the bills of the Tungsten Lamp Repair Company produced by

the witness and requests that the same be marked "Claimant's Exhibit No. 182, Tungsten Lamp Repair Company Bills".

(The Notary does as requested.)

Q. 60. Did the Marconi Company, in addition to manufacturing the Marconi valve receivers, have those receivers manufactured for it by others?

A. Yes, the Electrical Industries Manufacturing Company manufactured a number of these for us.

Q. 61. Does "Claimant's Exhibit No. 179, Marconi Receiving Book No. 1" show the receipt of Marconi valve receivers or tuners received by the Marconi Company during the period covered by that book?

A. No; this does not cover it, only a part,—as we manufactured large numbers ourselves.

Q. 62. What does "Claimant's Exhibit No. 179, Marconi Receiving Book No. 1" refer to in the way of Marconi valve receivers or tuners?

A. That book merely covers the ones manufactured outside of our own shop and also those shown as credits returned from vessels, and so forth.

Q. 63. Have you made an examination of the entries in "Claimant's Exhibit No. 179, Marconi Receiving Book No. 1" to ascertain the number of Marconi valve receivers or tuners received by the Marconi Company as shown by that book?

A. I have done so.

Q. 64. What number of Marconi valve receivers or tuners were received by the Marconi Company according to the entries in this book?

A. A total of 58 valve tuners.

[fol. 1065] Q. 65. Have you made, or had made, a correct transcript from "Claimant's Exhibit No. 179, Marconi Receiving Book No. 1", showing the entries of the receipt of these 58 tuners?

A. Yes, I have done so.

Q. 66. Will you please produce it?

A. (The witness produces transcript.)

Mr. Cosgrove: For the convenience of Court and counsel, Claimant's counsel offers in evidence the transcript just

produced by the witness and requests that the same be marked "Claimant's Exhibit No. 183, Transcript No. 2, Valve Tuners".

(The Notary does as requested.)

Q. 67. What was done with the Fleming valves which the Marconi Company had made for it?

A. We shipped these to our Marconi shore stations and ships for use with the Marconi valve receivers.

Q. 68. What kind of use—was it commercial or otherwise?

A. These were used for commercial purposes for the reception of messages between ship and shore stations and ship to ship stations.

Q. 69. Was any other disposition made by the Marconi Company of these Fleming valves; if so, what was done with them?

A. Yes. We sold them to commercial companies, private individuals and amateurs.

Q. 70. What disposition did the Marconi Company make of the Marconi valve tuners or receivers you have referred to?

A. On receipt of orders from our head office we shipped the Marconi valve tuners to our ship and shore stations; also sold them to commercial companies and individuals.

Q. 71. How do you know that the Fleming valves and Marconi valve tuners were shipped to ship and shore stations for use at those stations?

A. I myself shipped many of these Marconi valve receivers in conjunction with my assistants.

Q. 72. During what years were these Fleming valves and Marconi valve receivers shipped by the Marconi Company to ship and shore stations, commercial concerns and individuals?

A. We shipped the valve receivers from the period of the latter part of 1910 to 1915, and the valves from 1910 until 1915.

Q. 73. Please state, if you know, about how many of the Fleming valves were shipped by the Marconi Company from its New York City shops during the years from 1910 to 1915, inclusive.

A. We shipped a total of 649 valves, as shown by our records. These records, of course, are very incomplete and do not cover the total hipments made by us.

Q. 74. Have you here, and can you produce, the records of the shipments of Fleming valves referred to in your last answer?

A. Yes, I have and can produce them.

Q. 75. Will you please produce such records and state just what the records are? I am referring to any shipping books or other records you have.

A. I produce five shipping books showing shipment of Fleming valve receivers, and valves. I also produce pencil copies of loose sheets made by myself, from shipping books which are at the present time missing. I also produce loose shipping orders taken from shipping order books, covering the shipment of valves and valve tuners.

Q. 76. Will you please state what period is covered by the shipping books which you have produced, and which I notice are marked respectively "Shipping Books 2, 3, 4, 5 and 6"?

A. Shipping Book No. 2, July 10, 1911, to October 4, 1911; Shipping Book No. 3, November 11, 1912, to January [fol. 1066] 9, 1913; Shipping Book No. 4, January 26, to May 25, 1912; Shipping Book No. 5, June 10, 1913, to July 6, 1916; Shipping Book No. 6 (marked "Cash Book"), October 7, 1912, to June 13, 1913.

Q. 77. Have you been able to find any shipping books or shipping records of the Marconi Company after 1915?

A. I have not been able to find any books after that date, as they are missing at the present time.

Q. 78. Did you make a search for them?

A. Yes, I made a search for them and am unable to find them.

Q. 79. What, if anything, did you have to do with keeping these five shipping books that you have produced?

A. I was in touch with these books, as it was necessary for me to see that all material shipped checked up with the entries in the books.

Q. 80. How long have these five shipping books been in your possession?

A. These have been in the shop and in my possession more or less at all times.

Mr. Cosgrove: Claimant's counsel offers in evidence the five shipping books produced by the witness, with particular reference to the entries therein relating to the shipment of Fleming valves and Marconi valve receivers or tuners, and requests that the same be marked respectively "Claimant's Exhibit No. 184, Shipping Book No. 2", "Claimant's Exhibit No. 185, Shipping Book No. 3", Claimant's Exhibit No. 186, Shipping Book No. 4". "Claimant's Exhibit No. 187, Shipping Book No. 5" and "Claimant's Exhibit No. 188, Shipping Book No. 6".

(The Notary does as requested.)

Q. 81. In your answer to Q. 75 you produced pencil copies of loose sheets made by yourself from shipping books which are at the present time missing; when did you make those notes and from what books did you make them?

A. These were copied by me from old shipping books in 1915, but these books at the present time cannot be found; these entries are at least ten years old.

Q. 82. What do the pencil notes refer to?

A. These pencil notes refer to the shipment of Fleming valves and valve receivers shipped to our Marconi shore stations and vessels.

Q. 83. In your same answer you produce some loose shipping orders. To what do these shipping orders refer?

A. These refer to shipments of Marconi valve receivers and Fleming valves to vessels and stations.

Q. 84. State, if you know, where these loose shipping orders came from?

A. These shipping orders were removed by me personally from old shipping books in 1917.

Q. 85. Have you made a search for the books from which these loose shipping orders were taken?

A. Yes, I have made a very thorough search and have been unable to find any of them.

Mr. Cosgrove: Claimant's counsel offers in evidence the loose shipping orders referred to by the witness and re-

quests that the same be marked "Claimant's Exhibit No. 189, Loose Shipping Orders".

(The Notary does as requested.)

Q. 86. Can you state the number of Fleming valves and Marconi valve receivers shipped or disposed of by the Marconi Company as shown by these loose shipping orders [fol. 1067] and your pencil notes that you have referred to?

A. I can; the number of valves in the pencil copies is 63 valves and 5 Marconi valve tuners; in the loose shipping orders, 15 valves and 3 Marconi valve tuners.

Q. 87. Is the number of Fleming valves shipped, according to these loose shipping orders and your pencil notes included within, or in addition to the 649 valves which you previously stated had been shipped by the Marconi Company?

A. They were included in the 649 previously mentioned.

Q. 88. Will you please state the total number of Marconi valve receivers or tuners shipped by the Marconi Company to its ship and shore stations and to commercial companies and individuals from 1910 to 1915, inclusive, as appears by the records you have produced?

A. We shipped a total of 649 valves and 117 valve tuners, as shown by my records.

Q. 89. How do you account for the difference in the number of Fleming valves which the Marconi Company had made for it and the number it shipped and disposed of, according to your records?

A. This is due to the incompleteness of my records at the present time, as many of my shipping books are missing.

Q. 90. Have you had made from the shipping books and other shipping records that you have produced, a correct transcript showing to what vessels the Fleming valves were shipped by the Marconi Company, the names of the vessels and the number of valves shipped to such vessels respectively?

A. I have.

Q. 91. Will you please produce this transcript?

A. I will produce the transcript.

Q. 92. Will you please read this transcript on the record?

A. It is as follows:

Fleming Valves Shipments

Fleming Valves were shipped to the following vessels:

Abangary	6	Dakotan	6
Adeline Smith	6	El Alba	6
Aloha	6	El Secunda	6
Avon	1	Relay	6
Bantu	6	Rescue	6
Borgstad	6	Restorer	18
California	6	St. Louis	2
Cassandra	6	Santa Cruz	6
Chalmotte	6	Surmane	6
Kentra	6	Excelsior	6
Laurentic	2	F. G. Pettibone	6
Lenape	6	Florence	12
Louisiana	2	Freida	6
Maracas	8	Georgian	6
Molke	2	Grendader	3
New York	5	Gulfoil	6
Oceana	5	Hamburg	2
Philadelphia	2	Heroine	6
Corsair	4	Virginia	6
Curytyba	1	Wakiva	6
		Warrior	6

41 vessels with 225 valves

[fol. 1068] Q. 93. You handed me in response to Q. 91 a sheet headed "Fleming Valve Shipments"; will you please explain what this sheet is?

A. This is a copy of the distribution of Fleming valve shipments to Marconi wireless stations, Marconi Division offices and so forth, commercial companies and individuals, of the total number of valves copied from my shipping books.

Q. 94. Will you please read that memorandum on the record?

A. It reads as follows:

Fleming Valve Shipments

Distribution among stations, divisions, companies, etc.:

Marconi Wireless Stations

Cape May, N. J.	7	Siasconsett, Mass.	5
Palm Beach, Fla.	5	So. Wellfleet, Mass.	14
Sagaponack, N. Y.	6	Virginia Beach, Va.	11

Marconi Divisions, Offices, etc.

Cleveland, Ohio	3	New York City, N. Y.	51
Jersey City, N. J.	12	San Francisco, Cal.	78
Montreal, Canada	2		

Commercial Companies

Manila, P. I.	12	Phila., Pa.	8
Hamilton, Ohio	1	Pittsburgh, Pa.	2
Boston, Mass.	4	——, Hawaii	6
Harrison, N. J.	24	New York City, N. Y.	18
Detroit, Mich.	6	New Orleans, La.	26
Guancia Centralle, Porto Rico	12	Santa Marta, Colombia	7
		Swan Id., Honduras	12

Individuals

Albany, N. Y.	1	Chicago, Ills.	3
Atlantic City, N. J.	6	Derby, Conn.	2
Athens, Ga.	2	Elizabeth, N. J.	1
Boston, Mass.	2	Fargo, No. Dak.	1
Burliagton, Iowa	1	Fort Worth, Tex.	1
Cambridge, Ohio	1	Harrison, N. J.	1
Chester, Pa.	1		

Q. 95. Please look at the typewritten paper now handed you, and state what that is.

A. This is a copy of the distribution of Fleming valve shipments made from my old shipping books.

Q. 96. Is this a continuation of the previous typewritten sheet you have produced and read from?

A. Yes, it is.

Q. 97. Will you please read that on the record?

A. It is as follows:

[fol. 1069] *Fleming Valve Shipments*

Distribution among stations, divisions, companies, etc. (continued):

Individuals

Ithaca, N. Y.	1	Pulaski, Mich.	1
Lamoni, Iowa	1	Reading, Pa.	2
Lincoln, Neb.	1	Rutland, Vt.	1
Moline, Ill.	1	Salt Lake City, Utah	2
New Orleans, La.	2	Scranton, Pa.	1
New York City, N. Y.	2	Seattle, Wash.	1
Oklahoma City, Okla.	1	Stanislaus, Cal.	1
Orono, Me.	1	Toledo, Ohio	1
Phila., Pa.	1	Watsonville, Cal.	1

Schools, Colleges, etc.

New York City, N. Y.	1	——, So. Dak.	1
Valparaiso, Ind.	1	——, Minn.	1
——, Mont.	2		

Government

New York City, N. Y.	29	Wash., D. C.	3

Uncertain or Unknown

9

Total 424

Q. 98. Please look at the pamphlet now shown you and state, if you know, what it is.

A. This is a Marconi catalogue showing the various types of apparatus and instruments for amateur purposes.

Q. 99. If you know, will you please state when this catalogue was issued by the Marconi Company?

A. To the best of my recollection this was around the early part of 1913.

Q. 100. Do you find any reference in this catalogue to the Fleming valves; if so, please state the page where the reference is found and read it.

A. I do, on page 6 (Reproduced Opposite); it reads as follows:

"The Fleming Oscillation Valve

This is the type of detector with which the Marconi Transatlantic reception is accomplished. Operates on four to six dry cells.

Detector complete with base. Price, $3.50 each. Extra valves, $2.50 each. Add 10c. for postage."

Mr. Cosgrove: Claimant's counsel offers in evidence page 6 of the catalogue referred to and produced by the witness, and the same is marked "Claimant's Exhibit No. 190, Page 6 of Marconi Catalogue."

Q. 101. Do any of the shipping books you have produced contain any entries relating to the shipment of Fleming valves to the John Wanamaker store in the City of New York; I mean the wireless station at the John Wanamaker store in the City of New York?

A. Yes, these shipping books show numerous entries of valves shipped to the John Wanamaker wireless station in New York City.

[fol. 1070] Q. 102. Will you please read from the shipping books the entries of the shipments of these Fleming valves to the John Wanamaker store in New York City?

A. They are as follows:

Shipments to John Wanamaker's New York Store

Valves

Pencil Copies

Date	*Page*	*Items*
April 12, 1913	B-	2 12-volt tungsten valves
May 13, 1913	B-7151	5 12-volt carbon valves

Shipping Book No. 2

July 24, 1911	A-206	1 12-V carbon valve 1 12-volt tungsten valve G. E. type
July 25, 1911	A-209	2 12-V carbon valves
Sept. 1, 1911	A-258	1 4-vlt. valve 1 4-vlt. valve sample

Shipping Book No. 4

Feb. 28, 1912	B-857	2 12-V G. E. tungsten valves
Apr. 16, 1912	B-921	1 G. E. Tungsten 12-V valve

Q. 103. Referring to "Claimant's Exhibit No. 186, Shipping Book No. 4", I call your attention to shipping order No. B-857, dated February 28, 1912, being a shipment of two 12-volt G. E. tungsten valves to the Marconi Station, John Wanamaker, New York; also shipping order B-921, dated April 16, 1912, being the shipment of one G. E. tungsten 12-volt valve to the Marconi Wanamaker station, New York. Both of these shipping orders refer to D. Sarnoff. Will you please state what that reference to D. Sarnoff means in these shipping orders?

A. These shipping orders show that the Marconi Company delivered to the Marconi Station, John Wanamaker, New York, two 12-volt G. E. tungsten valves, and they were delivered to D. Sarnoff. The second order, B-921, shows that I personally made out this shipping order for the Wanamaker Station, New York, one G. E. tungsten 12-volt valve and two pieces of quarter inch by five inch copper rod, and the signature is signed by Mr. D. Sarnoff.

Q. 104. What was Mr. Sarnoff doing at this station at that time?

A. Mr. Sarnoff was the wireless operator at the Wanamaker station at that time.

Q. 105. Were the valves in those orders delivered to Mr. Sarnoff?

A. I delivered the B-921 order personally to Mr. Sarnoff according to the record 1 G. E. tungsten 12-volt valve.

Q. 106. To whom were the valves referred to in the order of February 28, 1912 delivered?

A. These two 12-volt valves were delivered to Mr. D. Sarnoff.

Q. 107. Who is the D. Sarnoff referred to in these records?

A. The Mr. D. Sarnoff referred to in these records was the operator at the John Wanamaker store station in New York City, and is now Vice-President and General Manager of the Radio Corporation of America.

Q. 108. State, if you know, with what device or apparatus [fol. 1071] the Fleming valves were first used in this country by the Marconi Wireless Telegraph Company of America?

A. These were used with British Marconi valve receivers shipped to us from England.

Q. 109. I show you two bills; will you please state what these are, if you know?

A. These are bills for 2 Special 6000 foot wave valve receivers Nos. 5015 and 5014; 1 set with two valves only, the other with two valves also, and one pair of high resistance telephones. This bill is dated the 10th of May, 1909. The second bill is for 1 valve receiver with intermediate circuit No. 7434, 4 12-volt carbon valves; 4 12-volt tungsten valves, 2 high tension resistances and 1 telephone transformer No. 6864.

Q. 110. Whose bills are they?

A. These are the bills of the Marconi Wireless Telegraph Company, Limited, Hall Street Works, Chelmsford, showing shipment of these two Special 6000 foot wave tuners to the Marconi Wireless Telegraph Company of America.

Q. 111. Do you know whether or not the valve tuners and valves referred to in these two bills were actually received by the American Marconi Company?

A. Yes.

Q. 112. How do you know it?

A. I received them myself.

Q. 113. When did you receive them?

A. These were received by me in the middle part of the year 1909.

Mr. Cosgrove: Claimant's counsel offers in evidence the two bills referred to by the witness, and the same are marked "Claimant's Exhibit No. 191, British Marconi Bills."

Q. 114. Do any of the valve tuners referred to in either of those bills bear any relation to the type of tuner marked herein "Plaintiff's Exhibit No. 28, Fleming Valve Receiver"?

A. Yes, this long wave receiver No. 5015 is one of the two received by me from England.

Q. 115. Do you know what became of the British Marconi short wave Fleming valve receiver called for in the bills you have produced?

A. When we first received these tuners, we shipped them to various shore stations to be tried out as to their availability to compare with our tuners in use at that time.

Q. 116. Can you produce one of these British short wave tuners?

A. Do you refer to the original tuners?

Q. 117. I do.

A. I cannot produce one of the original of that type at the present time, as I do not know what became of them.

Q. 118. Please look at the photograph now shown you and state, if you know, what it is a photograph of.

A. This is a photograph of the first valve tuners received from the British Marconi Company of England.

Q. 119. Is it a photograph of the first British short wave or long wave valve tuners?

A. This is a photograph of the short wave receiver.

Mr. Cosgrove: Claimant's counsel offers in evidence the photograph identified by the witness and requests that it be marked "Claimant's Exhibit No. 192, Photo of British Short Wave Valve Tuner".

(The Notary does as requested.)

Q. 120. If this photograph shows any Fleming valves, will you please indicate those valves with the letter X on the photograph in black ink?

A. I have done so.

Q. 121. Were any of the British long wave and short wave valve receivers equipped with the Fleming valves used commercially in this country to your knowledge?

A. Yes.

[fol. 1072] Q. 122. How do you know this?

A. On my visit to British vessels in the Port of New York I have seen these mounted in their place on the apparatus table; I have also tried these out to see if they were functioning properly.

Q. 123. Can you state about what year you saw these British valve receivers on British ships in the Port of New York?

A. Between 1911 and 1912.

Q. 124. When did the American Marconi Company first begin to manufacture Marconi valve tuners?

A. We began to manufacture the valve tuners in the latter part of 1910, and continued until 1913.

Q. 125. How do you fix those dates?

A. When we received the Marconi valve tuners from England and gave them a try-out at our stations, they proved so satisfactory, according to reports received at the main office, that we decided to manufacture them ourselves.

Q. 126. How soon after you received the valve tuners from England did the American Marconi Company begin to manufacture Marconi valve tuners?

A. We began the manufacture of these valve receivers in the late Fall of 1910.

Q. 127. I show you a piece of apparatus having a tag marked "Plaintiff's Exhibit No. 101, U. S. Dist. Court, S. D. of N. Y., June 7, 1916. Please state if you recognize this apparatus, and if so, state what it is.

A. This is the American Marconi Valve Receiver manufactured by the American Marconi Wireless Telegraph Company.

Q. 128. Have you any recollection of having seen this particular Marconi valve receiver before?

A. I won't say that I have seen that particular one, but I have seen many others like it.

Mr. Cosgrove: Claimant's counsel offers in evidence the apparatus just identified by the witness and requests that the same be marked "Claimant's Exhibit No. 193, Marconi Valve Receiver or Tuner".

(The Notary does as requested.)

Mr. Cosgrove: Claimant's counsel states that this receiver or tuner is an exhibit in the suit in the United States District Court for the Southern District of New York in the case of the Claimant against the De Forest Company for the infringement of the Fleming patent, and therefore requests counsel for the Government to stipulate that it may remain in the possession of claimant's counsel until the close of the case.

Mr. Edwards: Defendant's counsel states that he has no objection to this being done.

Q. 129. What type of detecters were used with the Marconi valve tuners?

A. The Fleming valves.

Q. 130. Referring to "Claimant's Exhibit No. 193", please state what the sockets on this receiver were used for.

A. These bayonet sockets on this tuner were used for the reception of the valves.

Q. 131. What was the purpose of what appears to be a disk condenser mounted on the left hand side of the top of this receiver?

A. It is an aerial tuning condenser.

Q. 132. What is the purpose of what appears to be a disk condenser on the right hand side of the top of this Marconi valve receiver?

A. This is the condenser for the tuning of the tuned circuit or intermediate circuit.

[fol. 1073] Q. 133. What is the purpose of the knob marked "Aerial Tuning Inductance" mounted on the front of this Marconi valve receiver?

A. That was used for the purpose of tuning the antenna and known as a "tuning inductance".

Q. 134. What was the purpose of the use of the sliding device mounted on the top of this Marconi receiver?

A. That was used for fine selective tuning in conjunction with the tuned circuit.

Q. 135. Just what do you mean by your last answer?

A. I don't quite understand your last question.

Q. 136. What was the sliding contact on the top of the Marconi valve receiver called?

A. This was called a "Billi Condenser".

Q. 137. What is the knob on the right hand side of this Marconi receiver? That is, what function does it perform?

A. This is a loose coupling used in the secondary circuit or tuned circuit to give selective tuning.

Q. 138. What was the purpose of the 3-pole double-throw switch mounted on the top of this Marconi receiver?

A. This 3-pole switch shown on the top of the Marconi receiver in the left hand position was in the aerial circuit or stand-by, and when thrown to the right hand side, was then in the tuned circuit.

Q. 139. I show you a book entitled "Text-Book on Wireless Telegraphy" by Rupert Stanley and call your attention to the illustration Fig. 144, on page 252 of that book. Will you please state, if you know, what the illustration represents?

A. This is an illustration of the British Marconi short wave valve receiver.

Q. 140. How does it compare with "Claimant's Exhibit No. 193, Marconi Valve Receiver"?

A. This Marconi valve receiver is very similar in construction, aside from a few mechanical changes, to the American Marconi valve receiver manufactured by us.

Q. 141. In the same book I call your attention to a diagram 143, page 251. Do you know what that diagram represents?

A. The diagram represents circuits of a Marconi valve receiver, as we had many of these in use for our tuners of the same type.

Mr Cosgrove: Claimant's counsel offers in evidence pages 250 to 253 inclusive (Reproduced Opposite) of the book referred to by the witness and requests that the same be marked "Claimant's Exhibit No. 194, Extracts from Stanley Book".

(The Notary does as requested.)

It Is Agreed that photostats of these pages may be marked and used in evidence instead of the original pages of the book in question.

* * * * * * *

Q. 142. In your answers to questions 134 and 136 you [fol. 1074] state that the Billi condenser was for fine tuning. In what circuit is this condenser?

A. My recollection of this Billi condenser is that it is in the plate circuit of the Fleming valve.

Q. 143. Then, as I understand you, this Billi condenser is for fine tuning in the valve circuit?

A. Yes.

Q. 144. When the three-pole 2-throw switch is in the stand-by position, how do the signals get into the valve circuit?

A. The signals get into the valve circuit through a variable condenser and then through a coupled primary in inductive relation to the secondary.

Q. 145. When the 3-pole 2-throw switch is in the tuned position, how do the signals get into the valve circuit?

A. Through the loose coupling of the intermediate circuit.

Q. 146. Please look at the diagram marked "Defendant's Exhibit V-5" and if you recognize it, state what it represents and what you know about that diagram.

A. This print shows it to be an elementary diagram of a Marconi receiver, and numerous ones of the same kind were sent out by us when we sold valves to the amateurs. It shows them how to hook up the circuit for use with the valve.

Q. 147. Can you state approximately when the first of the diagrams marked "Defendant's Exhibit V-5" was sent out by the Marconi Company?

A. This was somewheres in the early part of 1913, to the best of my recollection.

Q. 148. Were the Marconi valve tuners which were sold in 1910 accompanied by any circuit diagram or diagrams showing the circuit arrangement or hook-up of the tuners?

A. Yes, we sent a diagram with these tuners, of the valve circuit.

Q. 149. Have you any copies of these diagrams?

A. Not at the present time.

Q. 150. Did you ever see any of the Marconi valve tuners manufactured by the claimant herein, and equipped with Fleming valves in commercial use in this country, and if so, where?

A. Yes, I have seen these in use at the John Wanamaker station in New York City and aboard the American Line Steamers New York, St. Paul and Philadelphia.

Q. 151. Do you recollect about when you saw these Marconi valve tuners equipped with Fleming valves in the wireless station in the John Wanamaker store in New York City?

A. To the best of my recollection this was during the period of 1911 to 1912.

Q. 152. Referring to "Claimant's Exhibit No. 184, Shipping Book No. 2", order A-296, October 3rd, 1911, and to the item on that order "J. J. Brennan 3 Hr." What does that mean?

A. This shipping order A-296 shows that we received the report of trouble at the station of John Wanamaker's, New York City, and that I in person went there to make repairs to an A. C. armature.

Q. 153. I call your attention to the same shipping book and to shipping order A-272, dated September 13, 1911; will you please state what type of apparatus is referred to in that shipping order, and if you know, where such apparatus was to be installed?

A. This was a Marconi valve receiver complete with six 4-volt G. E. tungsten valves and two pair of telephone receivers, and was shipped to J. R. Irwin, care of Vaniman, The Inlet, Atlantic City, New Jersey; this was for use on the Airship America.

Q. 154. Do you know whether or not this apparatus was [fol. 1075] installed in the airship America?

A. Only from the report from Mr. Irwin, who was operator of the airship, that it worked very satisfactorily while in use.

Q. 155. Have you had made from the incomplete shipping book and records of the Marconi Company covering the period from 1910 to 1915, inclusive, which you have produced, a correct transcript or copy which will show to what shore stations or other places on land Marconi valve tuners were shipped by the Marconi Company, the number of such tuners and where the shore stations and other places were located?

A. I have.

Q. 156. Will you please produce and read it?

A. I will; it reads as follows:

Marconi Valve Tuner Shipments.

Distribution among stations, divisions, companies, etc.:

Marconi Wireless Stations

Palm Beach, Fla	1	So. Wellfleet, Mass	1
Point Judith, R. I.	1	Virginia Beach, Va	3
Savannah, Ga	1		

Marconi Divisions, Offices, etc.

Aldene, N. J.	1	Norfolk, Va	1
Baltimore, Md.	2	Port Arthur, Texas	1
Boston, Mass	1	San Francisco, Cal.	12
Galveston, Texas	1	Seattle, Wash	2
Jersey City Shop, N. J.	2		

Commercial Companies

, Arizona	1	, Newfoundland	1
Manila, P. I.	12	Baltimore, Md	1
New York City, N. Y.	1	, Hawaii	1
Boston, Mass	2	New Orleans, La	4
Guanica Centralle, Porto Rico	6	Swan Island, Honduras	1

Individuals

Atlantic City, N. J.	1	New York City, N. Y.	1
New Orleans, La.	1	Point Lomas, Cal.	1

Government

Washington, D. C.	1

Uncertain or Unknown

	3
Total	58 Tuners.

Q. 157. Have you had made a similar transcript showing the vessels to which Marconi valve tuners were shipped and the names of the vessels and numbers of the tuners?

A. I have.

Q. 158. Will you please produce and read it?

A. I will; it reads as follows:

[fol. 1076] *Marconi Valve Tuners Shipments*

Marconi Valve Tuners were shipped to the following vessels:

Adeline Smith	1	Oceana	1	St. Louis	1
Admiral Dewey	1	Pan American	1	St. Paul	1
Admiral Sc[illegible]ley	1	Philadelphia	1	San Sylvester	1
Aleaza	1	City of Bangor	1	Santa Catalina	1
Aloha	1	City of Rockland	1	Santa Clara	1
Aranmore	1	Clan Murray	1	Santa Cruz	1
Avon	1	Comet	1	Saramaca	1
Bantu	1	Commewijne	1	Surmane	1
Borgstad	1	Copyrenaime	1	El Valley	1
Buena Ventura	1	Emiline	1	F. G. Pettibone	1
California	1	El Alba	1	Finland	1
Cassandra	1	El Secundo	1	Florence	1
John Hooper	1	El Siglo	1	Francisco	1
Kentra	1	Ransome B. Fuller	1	Georgian	1
Laurentic	1	Relay	1	Gulfoil	1
Lenape	1	Rescue	1	Trinidad	1
Maine	1	Richmond	1	Trinidadian	1
Maracas	1	Washington Irving	1	Vesta	1
Wana	1	St. Cecelia	1	Virginia	1
Molke	1				

59 vessels with 59 tuners

Q. 159. It appears from your evidence and the incomplete records of the Marconi Company that you have produced, that that company had over 1,500 Fleming valves manufactured for it; that they shipped over a thousand of these valves to their ship and shore stations and to commercial companies and others during the period from 1910 to 1915, inclusive. It also appears from your testimony

and the records you have produced, that the Marconi Company shipped 117 Marconi valve tuners to its ship and shore stations and to commercial companies and others during the same period. Was that a large or small number of Fleming valves and valve tuners for that period?

A. Yes, that was a very large number for that period, as wireless telegraphy was practically in its infancy in those days.

Q. 160. Did you ever personally use any Fleming valves and if so, for what purpose and under what circumstances?

A. I have tried these out at various times on board ships in the Harbor of New York, to see if they were functioning properly; I have also tried them out in our shop testing out valve receivers at various times.

Q. 161. During what years did you use the Fleming valves or try them out in the valve receivers?

A. It covered a period from 1910 to 1913.

Q. 162. Did you ever use or test any crystal detectors, and if so, for what purpose and under what circumstances?

A. Yes, I have tested out crystals at different times in our shop.

Q. 163. Did you test or use crystals on board vessels in the Port of New York in the ordinary course of your inspection on wireless apparatus on these vessels?

A. No.

[fol. 1677] Q. 164. What was the character of the crystals of the crystal detectors which you tested?

A. Carborundum and cerusite.

Q. 165. In using and testing the Fleming valves and the crystal detectors, what signals did you work with?

A. We used the signals transmitted by some of the stations around the City of New York and vessels.

Q. 166. About when did you make the tests with the crystal detectors?

A. This was around between 1910 and 1911.

Q. 167. In testing and using the Fleming valves and crystal detectors, how did you find they compared in sensitiveness and tuning?

A. The signals from near-by stations, with the crystals and valves were about of equal strength, but on some very weak signals the valves were more sensitive and seemed to tune much sharper than the crystals.

Q. 168. In your experience with the Fleming valves and crystal detectors, how did they compare in reliability?

A. The valves were much more reliable than the crystals, as it was not so easy to knock them out of adjustment, and therefore were more staple.

Q. 169. From your testimony it appears that the Marconi Company was shipping Fleming valves in 1915. Can you state about when that company discontinued the use and shipment of these valves?

A. We discontinued the shipping of these valves in 1915, to the best of my recollection.

Q. 170. Can you give any of the reasons why the Marconi Company discontinued the shipment of Fleming valves?

A. Yes; we found that the valves were very costly on account of the fragile filament and breakage of filaments and bulbs in shipment.

Q. 171. Was there any breakage, to your knowledge, of the filaments or bulbs after they were put into use?

A. Yes, the life of the filament was of very short duration, due to the operators not understanding how to properly take care of them, and they would burn out in a very short while, due to the operators not understanding how to use the same.

Q. 172. What was used in the way of a battery to light the filament of the Fleming valve?

A. We used a storage battery of 6 and 12 volts for use in lighting up the filament of the valve.

Q. 173. Did you find it difficult to educate operators in the use of these batteries, and if so, what were the difficulties?

A. Yes; we found that it was very hard to educate the operators to keep their storage batteries charged up and keep them in condition so that they would properly light the filament.

Q. 174. State, if you know, what was the nature or character of the filaments of the Fleming valves in those early days.

A. The first valves that were in use were a carbon filament, but we found that this was not satisfactory, as after a short while of use with the filament lit up the signals would fade and then we began the manufacture—or had manufactured for us—the tungsten filament, which we found was very satisfactory, as the signal strength remained constant, and did not fade.

Q. 175. I show you a photograph which is "Complainant's Exhibit No. 153" in this case. Please state what that photograph represents, if you recognize it, and who the individuals are pictured in that photograph, if you know.

A. This is a photograph of myself, Mr. Ballam and Mr. Chevelier, showing the interior of the wireless telegraph room and of the apparatus of the S. S. St. Paul, about 1905.

[fol. 1078] Cross-examination.

By Mr. Edwards:

X Q. 176. Did the Marconi Company, at any time provide crystal detectors with holders adapted to fit into the lamp sockets of these Fleming valve receivers?

A. Yes. We began to have manufactured for us at Aldene, New Jersey, in the year 1914, adaptors to be used in the sockets of the Fleming valves.

X Q. 177. Were these crystals with adaptor sockets sent out to the Stations to which the valve receivers had been sent originally?

A. The crystal was mounted in a separate cup from the adaptor and was shipped to our various stations for use with the valve receivers.

X Q. 178. This was about 1914?

A. Yes.

X Q. 179. What was the reason for sending out these crystals.

A. We discontinued the Marconi valves because we found the up-keep of the valves very costly from a maintenance point of view, as the filaments would be broken in shipment and burned out by the operators, through misuse, and therefore we were compelled to adopt some substitute, which was the crystal, to cut our maintenance cost down.

X Q. 180. How long did the use of crystal detectors continue by the Marconi Company?

A. That is, in general, or with the valve receiver?

X Q. 181. Both.

A. We have been continually using crystals since 1914 and, I believe, some are in use at the present time on vessels with various types of tuners manufactured by us.

X Q. 182. When did the Marconi Company begin to use three electrode vacuum tubes?

A. I cannot answer that question, as I am no longer connected with the Marine Division; I am in another depart-

ment entirely separate from it, known as the Sales Service Section.

X Q. 183. Did any of the stations of the Marconi Company employ three electrode vacuum tubes to your knowledge?

A. No.

X Q. 184. Then you have no knowledge of any use of the three electrode vacuum tubes by the Marconi Company?

A. No.

X Q. 185. Have you any knowledge as to how long all or any of the fifty-eight Marconi valve receivers or tuners remained in use?

A. These Marconi valve receivers, to the best of my recollection, were in use on various stations and vessels from the latter part of 1910 and continued in use after 1914 and up to 1916 or 1917, with the adaptor in use with the crystal.

X Q. 186. In the Stanley book, "Claimant's Exhibit No. 194", reference is made to wire gauze shields put over the valves to protect them from static charges. What experience did you have, or have reported to you, concerning the effect of static charges in connection with these Marconi valve receivers?

A. I have never heard any report, to my knowledge, that static had any effect on the Fleming valve.

X Q. 187. Were gauze shields put over the valves in any of the Marconi valve receivers concerning which you have testified here?

[fol. 1079] A. No; only in those valves which were received from the British Marconi Company; some of these had a copper wire gauge shield around the outside, but we did not make use of that shield in our Marconi valve tuners; that is, we never grounded them.

X Q. 178. In operating the valve receivers, was it necessary for the operator to adjust the filament voltage?

A. Yes; in adjusting the filament voltage through a 6-ohm rheostat and then by adjusting a potentiometer of 480 ohms, which was alongside of the rheostat, we found a point where maximum signals were received.

X Q. 179. When this adjustment was arrived at did the operator find it necessary to make readjustments for receiving other stations, or for best reception from the same or different stations?

A. I cannot speak of the use by the operators, only from my own personal experience.

X Q. 180. Will you state your own experience?

A. I found that by varying the rheostat back-and-forth in conjunction with the potentiometer, that there was one point where the signals would be very sharply defined in the head receivers.

X Q. 181. And was this point the same for all wave lengths, distances and stations?

A. That would hold true in regard to the signals received, some being weak and some being strong, but the point would be noticeable just the same, by moving the potentiometer back-and-forth.

X Q. 182. In picking up a station was it not customary to adjust the filament voltage somewhat analogous to adjusting a crystal, until the point of best reception is attained?

A. Yes.

Last Question by the Notary: Do you know of any other matter relevant to this claim?

Answer. I don't recollect any at this time.

Deposition Closed.

It is Hereby Stipulated and Agreed, by and between the attorneys for the respective parties herein, that if John J. Brennan were recalled as a witness on behalf of the claimant herein, he would testify as follows:

1. That from an examination of the incomplete records of the claimant, including Plaintiff's Exhibits No. 186, shipping book No. 4, and No. 187, shipping book No. 5, he finds that the claimant shipped to the defendant, the United States, on or about the following dates, at the following places, the following wireless telegraph apparatus:

January 30, 1912, General Storekeeper Navy Yard, Brooklyn, New York, twelve four-volt Fleming valves.

March 22, 1912, Navy Department Bureau of Steam Engineering, Washington, D. C., One 4-volt Fleming valve.

March 25, 1912, General Storekeeper Brooklyn Navy Yard, five 4-volt Fleming valves for five Marconi valve tuners or receivers.

April 8, 1912, Bureau Naval Supply, account of Navy Yard, Washington, D. C., one Marconi valve tuner or receiver, and two 4-volt Fleming valves.

October 27, 1913, General Storekeeper, Navy Yard, Brooklyn, New York, twelve Fleming valves.

[fol. 1080] 2. That the shipments of valves on January 30, 1912, and March 22, 1912 above referred to, were made on account of contract No. 251, dated December 29, 1911, between the claimant and the defendant, calling for one quenched gap wireless telegraph set complete the receiver to be provided with a valve detector and 12 spare valves.

3. That the shipment of valves above referred to of March 25, 1912, was made on account of contract No. 221, dated January 3, 1912, between the claimant and the defendant, calling for five quenched gap wireless telegraph sets complete, the receiver to be provided with a valve detector and 12 spare valves.

4. That he is unable to state whether or not the shipment above referred to of April 8, 1912, of a valve tuner or receiver and Fleming valves, and the shipment of October 27, 1913, of Fleming valves were made under any contract or contracts between the claimant and the United States.

Claimant's counsel offers in evidence the contracts above referred to, and the same are marked respectively Claimant's Exhibit No. 198, Marconi-Government Contract of December 29, 1911, and Claimant's Exhibit No. 199, Marconi-Government Contract of January 3, 1912.

Deposition of CLARENCE S. RICE, for Claimant, taken at New York, N. Y., on the 29th day of October, A. D. 1925.

First Interrogatory by the Notary: State your name, your occupation, your age and your place of residence; whether you have any, and if any, what interest, direct or indirect, in the claim which is the subject of inquiry; and whether, and in what degree you are related to the claimant.

Answer. My name is Clarence S. Rice; age, 31; residence, 236 South Fifth Avenue, Mount Vernon, New York; occupation, Technician in the National Service Department, Radio Corporation of America, 326 Broadway, New York. I have no interest, directly, or indirectly, in this claim and I am not related in any way to the claimant.

Direct examination.

By Mr. Cosgrove:

Q. 183. How long have you been connected with the Radio Corporation of America, and in what capacities?

A. Since 1919, when the Radio Corporation of America took over the Marconi Wireless Telegraph Company of America, as Chief Radio Operator on ship and shore stations, until 1921.

Q. 184. When did you assume your position as Technician in the National Service Department of the Radio Corporation of America?

A. About September 5th, 1925.

Q. 185. What was your business or occupation between 1909 until 1921?

A. Commercial Wireless Telegraph Operator.

Q. 186. By whom were you employed as such operator during that period?

A. In the early part of 1909 by the Massie Wireless Telegraph Company for a brief period; then by the National Electric Signaling Company; later by the United Wireless Telegraph Company, and then by the Marconi Wireless Telegraph Company of America, and then by the Radio Corporation of America following that.

[fol. 1081] Q. 187. During what period were you employed as a wireless operator by the Marconi Wireless Telegraph Company of America?

A. From 1912 to 1919.

Q. 188. Where were you employed as a wireless operator by the claimant herein (Marconi Wireless Telegraph Company of America)?

A. Various steamships sailing out of New York.

Q. 189. Did you also act as wireless telegraph operator at radio shore stations?

A. Yes, in a relief capacity; by that I do not mean continuous service.

Q. 190. Did the steamships on which you were employed as wireless operator by the claimant herein, include the S. S. Camagney of the Ward Line?

A. Yes.

Q. 191. During what period did you act as a wireless operator on that steamship?

A. From April, 1914, until January, 1916.

Q. 192. Was there more than one wireless operator on this ship while you acted as an operator on it?

A. Occasionally when we had a full passenger list, two operators were carried.

Q. 193. Was the S. S. Camagney a freight and passenger vessel?

A. The S. S. Camaguey was rated as a freight steamer provided with accommodations for about twenty-four passengers.

Q. 194. About how many passengers did the vessel usually carry during the period you were an operator on her?

A. Do you desire an average in those two years?

Q. 195. Yes, you might give the average. I mean the usual number of passengers on each trip.

A. Well, it was only seldom that we carried any passengers at all; that is why I asked the question.

Q. 196. Then on most of the trips during the two years you were operator on the S. S. Camaguey you were the sole operator?

A. That statement is correct.

Q. 197. Between what ports did the S. S. Camaguey ply while you were her wireless operator?

A. Between New York and the South Coast of Cuba and all of the principal Mexican ports on the Gulf Coast.

Q. 198. Was the S. S. Camaguey equipped with wireless receiving apparatus, and if so, will you please state generally what type of wireless receiving apparatus she carried while you were acting as her wireless operator?

A. When I joined this steamer she was equipped with the old United Wireless Telegraph Company's type D receiver; later equipped with the same company's improved receiver, being the inductively coupled type E receiver, with carborundum crystal detector, and later she was equipped with the Marconi Company's inductively coupled tuner for use with the Fleming two-electrode valve.

Q. 199. Will you briefly describe the Fleming valve referred to in your last answer?

A. The Fleming valve in physical appearance resembled the ordinary incandescent bulb, except for its having sealed in the same vacuum in which the filament was contained, a metal plate. It was provided with a special base through which contacts were brought out from its different elements.

Q. 200. I show you an article, and if you recognize it, please state what it is.

A. I recognize this article as a Fleming valve similar to that used by myself aboard the steamship Camaguey. (Witness was shown "Claimant's Exhibit No. 172, English Fleming Valve" and identified same.)

Q. 201. I also show you another article, and if you recog- [fol. 1082] nize it, state what it is.

A. I recognize this as the Marconi inductively coupled tuner for use with the Fleming valve, which is identical; that is, as to type, used by myself aboard the S. S. Camaguey.

(The article referred to and identified by the witness is "Claimant's Exhibit No. 193, Marconi Valve Receiver or Tuner".)

Q. 202. Did you personally use the Marconi valve tuner equipped with the Fleming valve during the period you were operator on the S. S. Camaguey?

A. Yes, as I was the only operator aboard ship during the time this receiver was used.

Q. 203. For what purposes did you use this apparatus on board the S. S. Camaguey?

A. For commercial wireless telegraph correspondence.

Q. 204. What, if any, press communications did you receive with the Fleming valve and "Marconi Valve Tuner" while you were operator on the S. S. Camaguey?

A. Daily press dispatches were received from Arlington, Va., Miami, Fla., and others; also weather reports and storm warnings from various naval stations.

Q. 205. Was any detector, other than the Fleming valve, furnished with the Marconi valve tuner installed on the S. S. Camaguey while you were operator on that ship, and if so, what type of detector, and how was it adapted to the Marconi valve tuner?

A. Yes; a carborundum crystal mounted on a special adaptor to fit in the Fleming valve socket was provided for use as an emergency detector in case the valve became broken or otherwise unless through accidental cause.

Q. 206. Did you ever use this carborundum crystal detector with the Marconi valve tuner while you were an operator on the S. S. Camaguey?

A. Only experimentally, to compare the sensitivity of the carborundum crystal with the valve detector.

Q. 207. From what shore or coast stations did you receive wireless communications with the Marconi valve tuner and Fleming valve, while you were operator on the S. S. Camaguey?

A. Commercial wireless telegraph communications were received using the Marconi tuner and Fleming valve be-

tween the following points: Sea Gate, New York; Cape May, New Jersey; Virginia Beach, Virginia; Cape Hatteras, North Carolina; Charleston Naval Station, Charleston, South Carolina; Savannah, Georgia; Jacksonville, Florida; St. Augustine, Florida; Miami, Florida; Nassau in the Bahama Islands; Key West, Florida; Havana, Cuba; Tampa, Florida; Progresso, Yucatan; Tampico, Mexico, Vera Cruz, Mexico; Tuxpam, Mexico; Swan Island and New Orleans. That is all that I recall just now.

Q. 208. In your ordinary commercial work under normal conditions with the Marconi valve tuner and the Fleming valve aboard the S. S. Camagney, over what distance were messages received with that apparatus?

A. Between twenty-five to eighteen hundred miles.

Q. 209. What was the distance you received with the Fleming valve and the Marconi valve tuner aboard this ship Camagney under static conditions found in Southern waters?

A. Between seven hundred and nine hundred miles could be relied upon, except in cases of extremely severe static conditions.

Q. 210. What was the power of the transmitters at the stations from which you received messages with the Fleming valve and the Marconi valve tuner, say from five hundred to eighteen hundred miles?

A. To the best of my knowledge the station at Swan [fol. 1083] Island was a high-power transmitter using about 20 Kilo Watt, 500 cycle transmitter; New Orleans using about 10 K.W., 500 cycle. The Marconi stations which I used to route commercial messages and correspondence through were of 5 K.W. power, using a 60 cycle source of current supply with the non-synchronous rotary gap, such as the stations at Cape May, New Jersey; Miami, Florida, and Tampa, Florida.

Q. 211. Can and will you cite any instances which will show the character of the work done by the Fleming valve and the Marconi valve tuner, and the distances covered in such work while you were using such valve and tuner on the S. S. Camagney?

A. I recall work carried on between the Aztec of the Pacific Mail Steamship Company and the steamship Camagney, during which commercial messages were received by me from the Aztec for re-transmission or delivery to American Coast Stations which I was in communication

with, while the Azetc was approximately forty hours from her point of destination, which was Honolulu, my vessel being about twenty-four hours out of Vera Cruz, Mexico. The approximate distance of this communication was four thousand miles. This instance convinced me of the value of the Fleming valve over the carborundum or crystal detectors, because of a direct comparison made between the valve and crystal detectors on account of weakening signals from the distant ship.

Q. 212. How long was the communication carried on between the S. S. Aztec and the Camaguey in the instance referred to in your last answer?

A. From a little before midnight until sunrise in the latitude and longitude in which the Camaguey was located.

Q. 213. Can you cite any other instances which you consider as showing the value of the Fleming valve as a detector?

A. I recall working with Cape May, New Jersey, while in the Gulf of Mexico, an approximate distance of eighteen hundred miles. Also the receiving of distress signals from a vessel whose name I do not recall now.

Q. 214. How far were you from the vessel from which you received the distress signal?

A. To the best of my knowledge about four hundred miles.

Q. 215. While you were aboard the S. S. Camaguey using the Marconi valve tuner equipped with the Fleming valve, did that ship have any reputation for clearing traffic, or what was its reputation in that respect?

. . . . . .

A. Yes, the Camaguey was known to many ships in the Gulf and several Coast stations, for her ability to handle traffic through heavy atmospheric disturbances.

Q. 216. For how long a period while you were aboard the S. S. Camaguey did you use the Marconi valve tuner equipped with the Fleming valve in ordinary commercial work?

A. For about seven or eight months.

Q. 217. Can you state between what months and years such use took place?

A. From about April, 1915, to September, 1915.

Q. 218. After the period of this use was another detector or tuner used by you on the S. S. Camaguey?

A. Yes, the Marconi inductively coupled type 106 tuner with crystal detector replaced the Marconi tuner and Fleming valve receiver.

[fol. 1084] Q. 219. Do you know why this replacement took place?

. . . . . .

A. I do not.

Q. 220. Do you know by whose order this replacement was made?

A. By the company's order.

Q. 221. What company's?

A. The Marconi Company's.

Q. 222. Did you ever personally see any Fleming valves and Marconi valve tuners in use on any other ships than the S. S. Camaguey, and if so, on what ships and about what date?

A. I have seen several ships equippeed with the Marconi tuner and Fleming valve while in Puerto, Mexico and Vera Cruz, during 1915 and 1916; I couldn't give the approximate dates at present; I don't recall exactly what months.

Q. 223. Did you ever see the Fleming valves in use on any British ships, and if so, when and where?

A. On one occasion I visited a British steamer that was equipped with this receiver while laying in port at Brooklyn, New York, in the latter part of 1915.

Q. 224. Do you recollect the name of the ship?

A. I do not.

Q. 225. In your answer to Q. 189 you stated that you acted as wireless telegraph operator at radio shore stations. Did you ever, when acting as such, use or see the Fleming valve and the Marconi valve tuner in use; if so, please state when and where this was.

A. Yes, at the Coast station located at Galveston, Texas, and Tampa, Florida.

Q. 226. What company operated these stations?

A. The Marconi Wireless Telegraph Company of America.

Q. 227. Did you personally use the Marconi valve tuner equipped with the Fleming valve at either one of those stations; and if so, please state at what station, and when you so used that apparatus?

A. I used the Marconi valve tuner and Fleming valve at the Galveston, Texas, station on various occasions while relieving members of the regular staff.

Q. 228. Was the Marconi tuner at the Galveston station equipped with the adaptor and crystal detector you have referred to in one of your answers?

A. Yes.

Q. 229. Did you ever personally use the Marconi valve tuner and the crystal detector?

A. Only experimentally.

Q. 230. What experience have you had in the use of crystal detectors in commercial wireless work, other than as stated in your last answer, and the experience you had with such detectors on the S. S. Camaguey?

A. I used the crystal detector from 1916 until 1921.

Q. 231. From your experience in the use of the crystal and Fleming valve detectors in commercial wireless telegraph work, will you please state how they compared in sensitiveness and reliability?

A. From personal experience I preferred the valve detector because of its permanency of adjustment and ability to stand up under fairly severe atmospheric conditions.

Q. 232. How did the two detectors compare in sensitiveness?

A. I found the valve the more sensitive of the two.

* * * * * * *

Cross-examination.

By Mr. Edwards:

X Q. 233. What kind of detector was employed in the type 106 tuner which replaced the Fleming valve tuner?

A. Cerusite.

X Q. 234. Have you ever used crystal detectors other than carborundum and cerusite?

A. No, I have not.

[fol. 1085] X Q. 235. Do you agree that it is generally understood in the radio art that carborundum is the most insensitive of the crystal detectors and that next to carborundum, cerusite is also considered relatively insensitive?

A. In some cases I do agree with this statement relative to carborundum when used in its raw, untested and unmounted state; however, the Marconi Wireless Telegraph Company was particular to see that no untested crystals

were provided for operators' use in their stations; these crystals were mounted in Wood's metal, I believe, and from personal experience I can say that some of them were very sensitive. Cerusite was found to run comparatively uniform in sensitiveness and matched up favorably with carborundum, although its adjustment was not nearly as permanent.

X Q. 236. Did you have any personal knowledge of the steps taken by the Marconi Company in selecting the carborundum crystals for use in its detectors?

A. None other than the fact that these crystals I have mentioned were supplied from our stock rooms in small boxes which were marked "Tested O. K."

X Q. 237. What was the height and character of the antenna on the Camaguey?

A. The height was approximately one hundred feet above water line, four-wire inverted L type.

X Q. 238. That would be considered a good antenna?

A. Yes.

X Q. 239. Do you agree that the distance from which signals can be received depended very largely upon the skill of the operator?

A. To some extent, yes.

X Q. 240. That is to say, some operators with a given installation, would be able to receive messages from greater distances than other operators could receive with the same installation. Is that statement substantially correct?

A. That statement *is* substantially correct, inasmuch as the intelligent handling of a radio set or any other piece of machinery is dependent upon that machine's efficient operation.

X Q. 241. Did you ever make any comparison with regard to sensitiveness between the Fleming two-electrode valve and a good galena or silicon or other well-known sensitive type of crystal detector?

. . . . . .

A. I made no comparison between the Fleming two-electrode valve and the galena or silicon detectors because of the fact that the only crystal detectors we were permitted to use were the carborundum and the cerusite crystals.

. . . . . .

Last Question by the Notary: Do you know of any other matter relevant to this claim?

Answer: No, I do not.

Deposition closed.

[fol. 1086] Deposition of DAVID SARNOFF, for Claimant, taken at New York, N. Y., on the 19th day of November, A. D. 1925.

* * * * * * *

First Interrogatory by the Notary: State your name, your occupation, your age and your place of residence, whether you have any, and if any, what interest, direct or indirect, in the claim which is the subject of inquiry, and whether, and in what degree, you are related to the claimant.

Answer: My name is David Sarnoff; age 34 years; residence Mt. Vernon, New York; occupation, Vice-President and General Manager of the Radio Corporation of America. I have no interest, direct or indirect, in this claim, except that I own some scrip of the claimant, and am not related in any way to the claimant.

Direct examination.

By Mr. Cosgrove:

Q. 242. How long have you been connected with the Radio Corporation of America?

A. Since its organization in the Fall of 1919.

Q. 243. With what company were you connected from the years 1916 until the Fall of 1919, inclusive?

A. With the Marconi Wireless Telegraph Company of America.

Q. 244. It appears from a deposition given by you and stipulated into this case, that in 1910 you were appointed operator at the Marconi station erected on the roof of the Wanamaker Building in New York City, and that you held that position for about a year. Can and will you please state the dates when you acted as wireless operator at this Wanamaker station?

A. Yes. I was appointed operator at this station on May 22, 1911, instead of in 1910, and continued to act in that capacity at that station until August, 1912.

Q. 245. What was the general character of the wireless communication conducted at this Wanamaker station while you were operator there?

A. Commercial Wireless telegraph communication between ships at sea and with the Wanamaker station in Philadelphia.

Q. 246. What type of wireless receiver or tuner and detector did you use in receiving wireless communications at this Wanamaker station?

A. During the period when I was operator at this station I used exclusively what is known as the Marconi valve tuner and a detector which was known as the Fleming valve.

Q. 247. Please generally describe the Fleming valve.

A. It consisted of a glass bulb somewhat like the incandescent lamp, except that, in addition to the filament, it had sealed within the bulb a metal plate adjacent to the filament, and was provided with leads extending from the filament and plate to the outside of the bulb.

Q. 248. If you recognize the article handed to you, state what it is.

(Witness handed "Claimant's Exhibit No. 173, Fleming Valve".)

A. It is a Fleming bulb similar to those I used at the Wanamaker Station in New York City.

Q. 249. Please look at Claimant's Exhibit No. 193, and [fol. 1087] if you recognize it, state what it is.

A. I recognize this as a wireless receiver similar to the Marconi valve receiver used by me with Fleming bulbs during the period I acted as operator at the Wanamaker station in New York City.

Q. 250. From your experience in the use of the Fleming valve, how efficient did you find it in commercial radio work?

A. I found the Fleming valve more sensitive and efficient in radio work than the magnetic or carborundum crystal detectors which I had also used.

Q. 251. Can and will you refer to any instance in your personal experience illustrating the character of the work done with the Fleming valve while you were an operator at the Wanamaker station in New York City?

A. Yes; I received radio messages at that station with the Fleming bulbs under difficult and trying circumstances

at the time that the steamship "Titanic" ran into an iceberg in April, 1912.

At the time of this disaster I was on duty as a radio operator at the Wanamaker station in New York City practically continuously for 72 hours, and during that period I was in direct radio communication with all the ships that were rushing to and about the scene of the disaster, and I directly received, without difficulty, their radio messages at such station with the two-electrode Fleming bulb referred to.

Notwithstanding the fact that many were working wireless apparatus in an attempt to get in touch with ships which might be near the scene of the disaster, I was the first to receive, and to receive directly with this two-electrode Fleming bulb, the confirmation from the steamship "Olympic" of the report that the "Titanic" had been sunk. I also received radio messages directly with this two-electrode Fleming bulb from the rescuing ships having aboard survivors from the "Titanic", including lists of the names of survivors.

Q. 252. Approximately how many miles was the Olympic and other ships from the Wanamaker station at the time you received the messages and reports from them referred to in your last answer?

A. Approximately 1,300 or 1,400 miles from New York.

(No cross-examination.)

Last question by the Notary: Do you know of any other matter relative to this claim?

Answer: No.

Deposition closed.

* * * * * * *

It is hereby stipulated and agreed, by and between the attorneys for the respective parties herein, that if David Sarnoff were recalled as a witness on behalf of the claimant, he would testify as follows:

That the claimant herein, Marconi Wireless Telegraph Company of America, has at all times borne true allegiance to the Government of the United States, and has not in any way voluntarily aided, abetted, or given encouragement to rebellion against the Government of the United States.

[fol. 1088] Deposition of CHARLES J. WEAVER, for Claimant, taken at New York, N. Y., on the 20th day of November, A. D. 1925.

* * * * * * *

First Interrogatory by the Notary: State your name, your occupation, your age and your place of residence, whether you have any, and if any, what interest, direct or indirect, in the claim which is the subject of inquiry, and whether, and in what degree, you are related to the claimant?

Answer: My name is Charles J. Weaver; occupation, Traffic Superintendent of the Radio Corporation of America; my age is 53; residence, 150 Beaumont Street, Manhattan Beach, New York; I have no interest, direct or indirect in the claim which is the subject of inquiry, and I am not related in any degree whatever to the claimant.

Direct examination.

By Mr. Cosgrove:

Q. 253. How long have you been connected with the Radio Corporation of America, and in what capacity?

A. Since 1919, as Assistant Superintendent and Superintendent of Traffic.

Q. 254. What is the nature of the Radio Corporation of America's business in which you are engaged?

A. Trans-Atlantic communication by radio.

Q. 255. Have you ever had any experience as a wireless telegraph operator?

A. Yes.

Q. 256. For how long a time did you act as a wireless telegraph operator?

A. From 1903 to 1917 as an operator and station manager.

Q. 257. By "station manager", you mean manager of a wireless station?

A. Yes, manager of a wireless coast station.

Q. 258. For what company did you act as wireless telegraph operator and station manager?

A. Marconi Wireless Telegraph Company of America.

Q. 259. Did you ever serve as a wireless telegraph operator on the steam yacht Atalanta?

A. Yes.

Q. 260. During what period did you act as an operator on this yacht?

A. From May, 1910, to September, 1911.

Q. 261. What type of receiving apparatus was installed on the Atalanta and used by you during the period you served as an operator on that vessel?

A. Marconi tuner fitted with the Fleming valve. We also used a magnetic detector for short-distance work.

Q. 262. What sort of a device was the Fleming valve which you used on the Atalanta?

A. It was an evacuated glass tube similar to an incandescent lamp with a filament and surrounded by a cylinder of platinum.

Q. 263. Did the valve have any terminals extending through the tube?

A. Yes, at the top.

Q. 264. I hand you two devices and if you recognize them, state what they are?

A. That looks like the Fleming valve as near as I can remember it; (referring to "Claimant's Exhibit No. 173, Fleming Valve"); this one, I know what it is, but I never used it (referring to "Claimant's Exhibit No. 172, English Fleming Valve").

[fol. 1689] Q. 265. When did you first see a Fleming valve in use?

A. When I joined the Atalanta, in May, 1910.

Q. 266. Was the tuner fitted with the Fleming valve installed on the Atalanta when you joined that vessel?

A. Yes.

Q. 267. During the period that you acted as an operator on the Atalanta, in whose and what service was that vessel engaged?

A. Mr. George J. Gould, her owner, cruising in foreign waters.

Q. 268. For what kind of work was the valve tuner and Fleming valve used on the Atalanta by you?

A. For the reception of private and press messages, by wireless.

Q. 269. Will you name some of the wireless stations from which you received messages with the tuner and the Fleming valve while you were aboard the Atalanta?

A. Sea Gate, New York; Sagaponack, New York; Siasconset, Massachusetts; South Wellfleet, Mass.; Cape Sable and Sable Island, Nova Scotia; Cape Race, Newfoundland;

Crook Haven Island, The Lizard and St. Catherine's Point and Poldhu, England; Ushant, Marseilles, France; Venice and Messina, Italy; Algiers; I think that will cover the most of them.

Q. 270. In using the valve tuner and Fleming valve on the Atalanta, what was the range or distance from which you received messages?

A. In the day time approximately two hundred and sixty miles; at night, on the ship's or shorter-wave, approximately seven hundred miles; with the longer wave, between fifteen hundred and two thousand miles.

Q. 271. State if you recollect the circumstances under which you received messages, either private, commercial or press, from a distance of one thousand or more miles, while using the tuner and Fleming valve aboard the Atalanta.

A. I received press dispatches from: South Wellfleet, Mass., up to Wednesday night after leaving New York the previous Saturday morning, the ship's cruising speed being about fifteen knots per hour. On several other occasions I received press messages from Poldhu, England, and while in the Mediterranean, off the Island of Malta.

Q. 272. If you recollect, will you please state how long a period you received the press messages from South Wellfleet, Mass., and from Poldhu, England, which you have referred to in your last answer?

A. I should say for approximately six months, every night.

Q. 273. Can you estimate and give us the number of words you received with the valve tuner and the Fleming valve while you were acting as an operator on board the Atalanta?

A. Approximately one hundred thousand words; I would estimate this as received within about an hour every night, at a speed of sixteen to eighteen words a minute; that is about as near as I can remember.

Q. 274. When you left the service of the Atalanta, was the tuner fitted with the Fleming valve still in use on that ship?

A. The ship went out of commission and all apparatus was closed up by myself, or covered up.

Q. 275. After you left the Atalanta, where did you next [fol. 1090] serve as a wireless operator?

A. On Colonel Astor's yacht, the Noma, during his honeymoon trip to the Bermudas.

Q. 276. During what period were you acting as an operator on the Noma?

A. Late September until November, 1911.

Q. 277. What type of wireless receiving apparatus did you use while aboard the Noma?

A. Marconi tuner fitted with the Fleming valve.

Q. 278. What was the character of the messages received with this tuner and Fleming valve aboard the Noma?

A. Private messages.

Q. 279. After you ceased acting as an operator on the Noma, where did you next serve as a wireless operator?

A. Rejoined the American Liner Philadelphia.

Q. 280. When and for how long a time did you act as an operator when you rejoined the Philadelphia?

A. From the end of November, 1911, to the end of July, 1912.

Q. 281. In what service was this vessel engaged during that period?

A. Passenger service between New York and Cherbourg and Southampton.

Q. 282. What type of wireless receiving apparatus did you use when acting as an operator aboard the steamship Philadelphia from the end of November, 1911, to the end of July, 1912?

A. The Marconi tuner fitted with the Fleming valve and magnetic detector.

Q. 283. Which of the detectors, the magnetic or the Fleming valve, was normally used by you on the Philadelphia?

A. Both were used.

Q. 284. What was the character of the messages or work done with the Marconi valve tuner and Fleming valve from the end of November, 1911, to the end of July, 1912, on the Philadelphia?

A. Official ship's messages, private messages and press messages.

Q. 285. Which apparatus was used for long distance work aboard the Philadelphia?

A. At the time I was on the Philadelphia the American Line did not subscribe for long distance press dispatches; therefore it was not necessary to receive from either South Wellfleet or Poldhu.

Q. 286. What was your experience when using the Fleming valve aboard the Philadelphia?

A. The Fleming valve installed on the Philadelphia I found not as efficient as the one that I used on the Atalanta, and it was only slightly better than the magnetic detector until I borrowed two valves, previously used on the Atalanta, which increased the signals two-fold, making the valve far superior to the magnetic detector.

Q. 287. For how long a period did you use the borrowed Fleming valves on the Philadelphia?

A. For one voyage only.

Q. 288. Was that voyage the end of your service on board the Philadelphia?

A. Yes, I made a report on my findings to the Company, and as I did not go to sea again in the capacity as an operator, I never had a chance to make any further tests with the Fleming valve.

Q. 289. Did you ever make any comparison as to sensitiveness or reliability between the Fleming valve and any crystal detectors?

A. None whatever.

[fol. 1091] Q. 290. Please look at the apparatus now shown you, and if you recognize it, state what it is.

A. Yes, that is a Marconi tuner similar to what I used on the Atlanta, Noma and Philadelphia (referring to "Claimant's Exhibit No. 193, Marconi Valve Receiver or Tuner"). This exhibit is the same size as the one on the Noma and Philadelphia; but the one on the Atalanta was slightly smaller in build; I am stating this from memory, I am not saying it is so.

Cross-examination.

By Mr. Edwards:

X Q. 291. Did the Atalanta have any detector device other than the Fleming valve?

A. Yes, the magnetic detector.

X Q. 292. Did you use it?

A. Yes, when close in-shore.

X Q. 293. Did she have a crystal detector?

A. No.

X Q. 294. What if any other detecting device was used on the Noma?

A. None.

X Q. 295. That is, none other than the Fleming valve?

A. None other than the Fleming valve.

X Q. 296. Did the Philadelphia have a crystal detector?

A. Not in my time.

X Q. 297. Have you a copy of the report which you made to the company concerning the performance of the Fleming valve on the Philadelphia?

A. No. It was just made in a rough note. In those days we did not go into lengthy reports, just scribbled it down.

X Q. 298. In what circuit did you use the Fleming valve on the Atalanta, Noma and Philadelphia? That is to say, in what kind of electrical connection or circuit diagrams?

A. I can't remember.

X Q. 299. Could you make a sketch of the diagram or hook-up in which you used the Fleming valve?

A. No; not at the present time.

X Q. 300. Did you use a battery for the filament current of the valve?

A. Yes.

X Q. 301. Were any batteries used other than the battery or batteries for lighting the filament?

A. No.

X Q. 302. When you brought the two valves from the Atalanta to the Philadelphia, and increased the signals two-fold, how did you measure this increase in signal strength?

A. By making a comparison between the tubes already installed on the Philadelphia and the tube valves borrowed from the Atalanta.

X Q. 303. What did you do to make the comparison?

A. When I heard a ship or shore station with very weak signals on the valves belonging to the Philadelphia, for comparison purposes I changed over to my borrowed tubes.

X Q. 304. How do you know that the borrowed tubes gave signals twice as strong as signals from the Philadelphia tubes?

A. Because I received them.

X Q. 305. Did you have any other way of measuring the increase in signal strength than by listening and estimating the increase?

A. None whatever.

X Q. 306. Then when you say that the signals increased twofold, you mean that it is your present-day recollection that the signals which you heard with the Atalanta valves

[fol. 1092] were twice as strong as those which you heard from the Philadelphia valves. Is that correct?

A. Yes.

* * * * * * *

Last question by the Notary: Do you know of any other matter relative to this claim?

Answer. No.

Deposition Closed.

Deposition of ALEXANDER E. REOCH, for Claimant, taken at New York, N. Y., on the 20th day of November, 1925.

* * * * * * *

First Interrogatory by the Notary: State your name, your occupation, your age and your place of residence, whether you have any, and if any, what interest, direct or indirect, in the claim which is the subject of inquiry, and whether, and in what degree, you are related to the claimant.

Answer. My name is Alexander E. Reoch; age, 41 years; residence, 94 Elliott Place, East Orange, New Jersey; occupation, Assistant Chief Communication Engineer of the Radio Corporation of America; I have no interest, direct or indirect, in this claim, and I am not related in any way to the claimant herein.

Direct examination.

By Mr. Cosgrove:

Q. 308. How long have you been with the Radio Corporation of America and in what capacities?

A. Since the date of its formation in 1919, in the capacities first, Plant Engineer; second, Assistant Chief Engineer; third, Assistant Chief Communication Engineer.

Q. 309. By communication, do you mean radio communication?

A. Sometimes.

Q. 310. Is most of your work in the radio field?

A. Yes.

Q. 311. Prior to 1919, what work were you engaged in, and for what company?

A. I was engaged in radio engineering work from 1902 to 1919. 1902 to 1905, with the English Marconi Company;

1905 to 1917, with the Canadian Marconi Company; 1917 to 1919, with the American Marconi Company.

Q. 312. Where were you employed and in what capacity, from December 1908, to May, 1909?

A. At the Glace Bay Station of the Canadian Marconi Company, as Assistant Radio Engineer.

Q. 313. Was this a Trans-Atlantic wireless station?

A. Yes.

Q. 314. During the period you were employed at the Glace Bay Trans-Atlantic station was there any other Trans-Atlantic wireless station in North or South America, to your knowledge?

A. There was not.

Q. 315. During the period you were employed at the Glace Bay Station, did you ever act as a wireless telegraph operator, and if so, under what circumstances?

A. During the whole of the period I supervised the performance of the wireless telegraph operator on duty during my watch, which was eight hours daily, and occa- [fol. 1093] sionally, in cases of emergency, performed the duties of wireless telegraph operator.

Q. 316. What was the character of the messages you received at the Glace Bay station while acting as an emergency operator, and from where were they received?

A. The messages were ordinary business or press messages for delivery in Canada or the United States; they originated in the British Isles and were transmitted by the wireless telegraph station at Clifden, Ireland.

Q. 317. What type of receiving apparatus and detector did you use in receiving these Trans-Atlantic wireless messages at Glace Bay from Clifden, Ireland?

A. The receiving apparatus consisted of an elevated antenna and ground and tuned circuits, and the detector was the two element Fleming valve.

Q. 318. Will you describe the Fleming valve referred to in your last answer?

A. The Fleming valve consisted of an evacuated glass vessel with a filament contained therein, which could be heated to incandescence by an electric current, and a metallic plate held in close proximity to the filament with a connection brought from the plate through a seal in the glass to the outside.

Q. 319. I show you some exhibits in this case and ask you if you can pick out from them any that resembled the Fleming valves used by you at the Glace Bay station?

A. This one very closely resembles the Fleming valves used at the Glace Bay station, but is somewhat larger in size (witness refers to "Claimant's Exhibit No. 172, English Fleming Valve").

Q. 320. During the period you were at the Glace Bay station, how extensively was the Fleming valve used in receiving wireless messages from the Clifden, Ireland?

A. Entirely.

Q. 321. How satisfactory was the Fleming valve in this transatlantic work?

A. It made a reception possible during the major portion of the day at times at speeds as high as 40 words a minute.

Q. 322. Can you approximate the number of messages received at Glace Bay from Clifden, Ireland, using the Fleming valve during the period you were at that station?

A. I would estimate roughly some 5000 messages, many of which were long press dispatches for the New York Times.

Q. 323. Can you state now how many of these messages were actually received by you personally?

A. About 50 or 100.

Q. 324. By whom were the other messages received?

A. By the three wireless telegraph operators who did 8 hours' watch each per day.

Q. 325. Do you recollect their names? If so, please give them.

A. I remember the names of three who were there most of this time. They were Samuel Currie, Gordon Rabbits and Walter Gray.

Q. 326. What was the approximate distance between the Glace Bay station and the Clifden, Ireland station?

A. About 2300 miles.

Q. 327. When you left the Glace Bay station was the Fleming valve still in use there in transatlantic work?

A. Yes.

Q. 328. Do you know if the Canadian Government owned or operated a wireless station at Cape Race and Cape Ray Canada?

A. The Canadian Government owned wireless telegraph stations at Cape Race, Newfoundland, and Cape Ray, Newfoundland. These stations were operated for the Canadian Government by the Canadian Marconi Company. [fol. 1094]

Q. 329. By whom was the wireless apparatus installed in these two Canadian Government stations and about when was it installed, if you know?

A. The apparatus was installed by the Canadian Marconi Company in about 1905, and was enlarged by the Canadian Marconi Company about 1907.

Q. 330. What, if any, connection did you have with designing or installing, or using the wireless apparatus at these two Canadian Government stations?

A. I had nothing to do with the design or installation of the apparatus, but observed the use of the apparatus while stationed at Cape Ray for short periods during 1906 and 1907, and by inspections of the stations which I made in 1908 and subsequently.

Q. 331. What type of wireless receiving apparatus and including detectors was installed and used at the Cape Ray and Cape Race Canadian Government stations?

A. The original installations included Marconi coherer and Marconi detector receivers with the usual grounded antenna system, and the two element Fleming valve receiver was added when the stations were enlarged.

Q. 332. Do you remember about what time the Fleming valve was added to these stations?

A. About 1907.

Q. 333. Why was the Fleming valve added to the equipment of these two Canadian Government stations?

A. Because it was desired that they should communicate between one another and it was impossible to do this with the other types of receiving apparatus.

Q. 334. Why was it impossible to communicate with the other apparatus?

A. It was not sufficiently sensitive.

Q. 335. Will you please state what the distance was between these two Canadian Government stations, and whether it was over land or water?

A. The distance was about 250 miles, about half over land and about half over water.

Q. 336. At the time the Fleming valve was used at these two Canadian Government stations, what was the character of the service these stations was engaged in?

A. Communication between these stations consisted in the transmission of weather reports, fog and ice reports and steamship reports for the Canadian Government Signal Service.

Q. 337. Did the Canadian Government own any wireless stations on the Great Lakes in which the Fleming valves were used?

A. Yes, the two-element Fleming valve was used at stations located at Midland, Tobermory and Sault Ste. Marie, all in the Province of Ontario.

Q. 338. Can you approximate the dates when the Fleming valves were used at these stations?

A. Stations were constructed in 1912 and the Fleming valve was used at that time and during 1913 and 1914 also.

Q. 339. Please look at the apparatus now shown you and if you recognize it, state in a general way what it is. (Witness shown Claimant's Exhibit No. 193.)

A. The apparatus is a two-element Fleming valve, detec- [fol. 1095] tor and tuner of the type that was being manufactured by the American Marconi Company about 1910.

Q. 340. How do you know this?

A. I handled several sets of this description for the Canadian Marconi Company when I was acting as Chief Engineer for that company, which sets had been purchased from the American Marconi Company and the general handiwork of the instrument made it possible to recognize it as of their manufacture.

Cross-examination.

By Mr. Edwards:

X Q. 341. Was any other type of detecting apparatus besides the two-element Fleming valve employed at any of these Canadian stations to which you have referred in your direct examination, during the time these stations were under your observation?

A. Yes. The Marconi coherer, the Marconi magnetic detector, carborundum crystals and three-element Fleming valves.

X Q. 342. Which of these types of detectors, other than the Fleming two-element valve, were employed at each of the stations named by you and during what periods?

A. The Glace Bay station, during the period I was stationed at that point, had installed a Marconi magnetic detector, which I tested several times, but which was never used commercially. At the Cape Ray and Cape Race stations the coherer receiver was used occasionally in the early years. The magnetic detector was used regularly for short

distance communication. At the Midland, Tobermory and Sault Ste. Marie stations, to the best of my recollection the magnetic detector was also installed, in which cases it would be used for short distance communications. No other receivers were employed at any of these points until about 1911, when we commenced to use crystals at Glace Bay and 1912 when we commenced to use three-element Fleming valves at Glace Bay, and until 1914 when we commenced to use crystal detectors at Cape Ray, Cape Race and the Ontario stations.

X Q. 343. When was the use of the two-element Fleming tube discontinued at each of these stations?

A. At or about the date when the crystal detectors were first installed.

Redirect examination.

By Mr. Cosgrove:

R. D. Q. 344. Were you at Glace Bay in 1911?

A. To the best of my recollection I made one short visit to Glace Bay in 1911.

Last Question by the Notay: Do you know of any other matter relative to this claim?

Answer: No.

Deposition closed.

[fol. 1096] *Deposition of Edwin M. Hartley, for claimant, taken at New York, N. Y., on the 25th day of November, A. D. 1925.*

First Interrogatory By the Notary: State your name, your occupation, your age and your place of residence, whether you have any, and if any, what interest, direct or indirect, in the claim which is the subject of inquiry, and whether, and in what degree, you are related to the claimant.

Answer: My name is Edwin M. Hartley; occupation, Manager of Service Station, Radio Corporation of America, 326 Broadway, New York City; my age is 30; residence 14602 130th Avenue, South Ozone Park, Queens County, Long Island, N. Y.; I have no interest either direct or indirect in this claim; I am related in no way to the claimant.

Direct examination.

By Mr. Cosgrove:

Q. 345. For how long have you been employed by the Radio Corporation of America, and in what positions?

A. I have been employed by the Radio Corporation of America since January 16, 1920 to the present date, and from January 16th, 1920 to March 1st, 1922, District Manager of the Marine Department, Philadelphia. From the first of March, 1922 to November the first, 1924, I was Assistant Superintendent, Maintenance, Repair and Inspection Department, 326 Broadway, New York City. From the first of November, 1924 to the present time in charge of the Sales Service Division of the Sales Department at 326 Broadway.

Q. 346. Did you work for the Radio Corporation of America with relation to radio communication and radio apparatus, generally speaking?

A. Yes, it related to radio communications in so far as ship communication is concerned, and the maintenance of the equipment aboard vessels controlled by the Radio Corporation of America and its affiliated companies.

Q. 347. In whose employ were you between 1912 and 1920, and in what capacities?

A. In 1912, from May 19, 1912 to April 6, 1917, I was employed by the Marconi Wireless Telegraph Company of America as wireless telegraph operator. From April 7, 1917 until Jan. 15, 1920, I was in the United States Navy, with the exception of the last five months, when I was employed in the Philadelphia Navy Yard as radio laboratorian.

Q. 348. While you were in the employ of the claimant, did it maintain and operate a wireless telegraph station at Virginia Beach, Virginia?

A. It did.

Q. 349. Were you ever employed as a wireless telegraph operator at that station, and if so, at about what period?

A. I was, from about November 5, 1913, until June 5, 1914.

Q. 350. State in general what types of wireless receiver and detector were used by you while you served as an operator at this Virginia Beach wireless station.

A. I used the Marconi Company's coupled circuit receiver, commonly known as a Marconi valve tuner, together

with the Fleming two-electrode valve as the main detector and the carborundum detector as the auxiliary.

Q. 351. Will you describe in a general way the Fleming [fol. 1097] valve referred to in your last answer?

A. The Fleming two-electrode valve consisted of an evacuated bulb, into which had been placed a filament, together with a plate adjacent to the filament or a cylinder entirely around the filament, with leads protruding from the bulb.

Q. 352. If you recognize the device shown you, will you state what it is?

A. It is a Fleming two-electrode valve, similar to the type which we used at the Virginia Beach station. (Witness shown Claimant's Ex. No. 177, Fleming Valve.)

Q. 353. I also show you a piece of apparatus and if you recognize it, state generally what it is.

A. It was one of the Marconi Company's coupled circuit receivers with which the Fleming valve was used.

Q. 354. How does it compare with the receiver used by you while acting as an operator at the Virginia Beach station?

A. Its general appearance is identical with that receiver which we used at Virginia Beach.

Q. 355. Were you familiar with the circuits of the receiver used by you at Virginia Beach, and how did you become familiar with them?

A. I was familiar with the circuits as used in this receiver and became familiar with the circuits at various times when it became necessary to make minor repairs. In order to facilitate this work a schematic diagram had been furnished to the station.

Q. 356. I show you Defendant's Exhibit V-5 and ask how this diagram compares, according to your recollection, with the schematic diagram referred to in your last answer?

A. This diagram is essentially a schematic diagram of the receiver, and the circuit is fundamentally the same as the circuit within the receiver.

Q. 357. When you arrived at Virginia Beach station to serve as a wireless operator there, was the Marconi tuner, fitted with the Fleming valve, installed and in use at that station?

A. Yes, a number of Fleming valves had previously been supplied to the station for use with this receiver.

Q. 358. What was the character of the wireless work for which you used the Marconi tuner and Fleming valve, while you were an operator at the Virginia Beach station?

A. For general commercial work, with ships at sea, with the Cape Hatteras station, and included press messages, position reports, S. O. S. calls, and general ship's business between the vessels and their owners.

Q. 359. What company operated the Cape Hatteras station?

A. Marconi Wireless Telegraph Company of America.

Q. 360. In your personal experience with the Marconi tuner fitted with the Fleming valve, what was the range in miles covered in receiving wireless messages?

A. Our average working range was approximately 250 miles during daylight hours, and 1200 miles at night.

Q. 361. In your answer to Q. 350 you referred to a carborundum detector as an auxiliary detector. Just what do you mean by that?

A. The auxiliary detector in this case was used mostly for short distance work and was also kept handy in case we should have at any time trouble with the valves. It was the policy of the company to furnish auxiliary detectors and other auxiliary equipment for use in emergency.

[fol. 1098] Q. 362. What distance do you have in mind by "short distance work"?

A. Short distance work at Virginia Beach was approximately within the radius of 75 miles.

Q. 363. In your use of the Fleming valve and carborundum detector at Virginia Beach, how did they compare in sensitiveness, reliability and general usefulness?

A. The Fleming valve detector was not only more sensitive, but was more stable in operation, in that it did not require adjustments after each time the transmitter had been in operation and did not require frequent adjustments during heavy atmospheric conditions.

Q. 364. What effect did the operation of the transmitter have on the crystal?

A. The transmitter caused the crystal detector to become out of adjustment whenever it was used, and it was necessary to readjust the crystal each time before reception could be had.

Q. 365. In using the Fleming valve with the Marconi tuner at Virginia Beach, was a battery employed, and if so, what was the voltage of the battery?

A. Yes, the filament lighting battery was employed. The voltage ranged from 4 volts to approximately 15 volts, according to the type of tube in use.

Q. 366. In using the Fleming valve at Virginia Beach was any voltage or potential placed on the plate of the valve?

A. Yes, this potential was taken from the filament lighting battery and regulated by means of a potentiometer.

Q. 367. What are the two sliding devices on one end of the Marconi vaive tuner Claimant's Exhibit No. 193, and what was the function of these devices?

A. The upper device, containing the heavy wire, was known as the filament voltage regulator, and served to regulate the voltage being supplied to the filament. The lower device containing the fine resistance wire, was known as the potentiometer, and regulated the voltage supplied to the plate of the valve from the filament battery.

Q. 368. Was the Marconi receiver fitted with the Fleming valve in use at the Virginia Beach station when you ceased to act as an operator at that station?

A. It was.

Q. 369. Have you ever seen the Fleming valve in use at any wireless telegraph station other than the Virginia Beach station, and if so, please state what stations, and when you saw it installed at such stations?

A. Yes, I have seen Fleming valves used at the John Wanamaker station at Philadelphia; the Marconi station at Baltimore, Md., and the Marconi station at Savannah, Georgia, during periods in 1915 and 1914, to my best recollection.

* * * * * * *

Cross-examination.

By Mr. Edwards:

X Q. 370. In operating the Fleming valve, was it necessary, in order to get the best reception, to adjust the filament voltage and the potentiometer to adjust the plate voltage?

A. It was necessary to adjust the potentiometer to obtain the plate voltage, but it was not necessary to adjust the filament regulator to do this.

X Q. 371. Was the potentiometer the same for all incoming signals?

A. The potentiometer adjustment was the same for all incoming signals during a certain period. I mean by that [fol. 1099] it was not necessary to readjust the potentiometer for each individual signal, but could be left with one adjustment for a considerable period of time.

X Q. 372. Was it customary each time the set was put in operation to adjust the potentiometer?

A. It was not necessary to adjust the potentiometer after each time the transmitter had been in operation and the receivers put back in use.

X Q. 373. If the set stood idle for a time, was it customary to adjust the potentiometer at the time the set was put back into use?

A. If the battery being used had the same voltage it would not be necessary to readjust the potentiometer. However, any fluctuation in battery voltage would require a readjustment.

X Q. 374. It is true, is it not, that the batteries in use run down, and that as they did run down it was customary to readjust the potentiometer in accordance with the reduction in battery voltage?

A. Large sized storage batteries were in use and the voltage remained almost constant for a considerable period of time, thereby requiring but few readjustments.

X Q. 375. What period of time do you refer to as a "considerable period"?

A. During a normal watch which was of 8 hours' duration.

X Q. 376. When you state in answer to Q. 365 that the filament voltage ranged from 4 volts to approximately 15 volts, does this mean that different voltages were selected for different tubes?

A. Tubes employing the same length of filament wire required the same voltage, and the voltage used was entirely due to the type of tube in use, of which we had three different types.

X Q. 377. What voltage was used with each type?

A. One type, as exhibited, used, to the best of my knowledge, from 4 to 6 volts, and we had two other types, one using in the neighborhood of 10 volts and the other around 15.

X Q. 378. How was the voltage adjusted for each type of tube?

A. By means of a switching arrangement external to the receiver, together with a filament regulator on the receiver.

X Q. 379. Was it necessary to adjust the filament voltage each time a new tube was put in the set?

A. Each new type of tube would naturally require a different adjustment on the voltage regulator; but tubes of one type were fairly constant.

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Redirect examination.

By Mr. Cosgrove:

R. D. Q. 380. What were the differences in the three types of tubes used at Virginia Beach?

A. The type most regularly used was of the single plate construction, Claimant's Ex. 177; the second type almost similar in construction employed a plate on each side of the filament, both plates being connected together; the third type having one large single plate with a very large filament.

R. D. Q. 381. I show you a collection of tubes which are exhibits in this case; can you pick out from them any tubes resembling the second and third types referred to in your last answer?

A. Exhibit No. 177 is on the order of the first type men-
[fol. 1100] tioned; Exhibit No. 178 is constructed along the same lines as the second type; while Exhibit No. 173 resembles more or less the third type.

* * * * * * *

Last Question by the Notary: Do you know of any other matter relative to this claim?

Answer: No, I can't say as I do.

Deposition Closed

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Deposition of Arthur A. Isbell, for Claimant, taken at New York, N. Y., on the 11th day of December, A. D., 1925

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First Interrogatory by the Notary: State your name, your occupation, your age and your place of residence; whether you have any, and if any, what interest, direct or indirect, in the claim which is the subject of inquiry; and

whether, and in what degree, you are related to the claimant.

Answer:-My name is Arthur A. Isbell; occupation, Assistant Traffic Manager Radio Corporation of America; my age is 51; residence, 85 Hicks Street, Brooklyn, New York; I have no interest either direct or indirect in this claim; I am not related in any way to the claimant.

Direct examination.

By Mr. Cosgrove:

Q. 382. What kind of traffic did you refer to in your last answer?

A. Wireless telegraph traffic.

Q. 383. How long have you been connected with the Radio Corporation of America, and in what capacity?

A. I have been connected with the Radio Corporation of America since November, 1919, at which time it took over the Marconi Wireless Telegraph Company of America. In the capacity first, as General Superintendent of the Pacific Division; later, Manager of the Pacific Division; at this date, Assistant Traffic Manager, New York Office Radio Corporation of America, and for the past six months.

Q. 384. By whom were you employed prior to November, 1919?

A. From the summer of 1912, until November, 1919, by the Marconi Wireless Telegraph Company of America at San Francisco, and in that vicinity.

Q. 385. What position did you hold with the Marconi Company?

A. Superintendent of Construction for the Pacific Division, from the summer of 1912, until August, 1915.

Q. 386. What business was the Marconi Company engaged in during the period you were employed by that company?

A. In the manufacture, sale and rental of wireless telegraph apparatus and in the wireless telegraph communication business.

Q. 387. Are you a wireless telegraph operator?

A. I am.

Q. 388. When you became connected with the Marconi Company in 1912, were they installing any wireless tele- [fol. 1101] graph receiving apparatus on any vessels in and about the Port of San Francisco, under your direction?

A. They were.

Q. 389. What type of wireless telegraph receiving apparatus were they installing on these vessels at that time?

A. In the summer of 1912, when I became Superintendent of Construction, the Marconi Wireless Telegraph Company of America was installing Marconi tuners fitted with the Fleming valve detectors.

Q. 390. Look at the apparatus now shown you, and if you recognize it, state what it is.

("Claimant's Exhibit No. 193" shown witness.)

A. It is a Marconi wireless telegraph receiver fitted for the use of Fleming valve detectors.

Q. 391. In what, if any, respects does it resemble the Marconi valve tuners fitted with Fleming valves which were installed under your direction or supervision in 1912, on vessels in and about San Francisco?

A. To the best of my recollection it is an exact replica of those tuners installed in 1912.

Q. 392. I show you two devices, and if you recognize them, state what they are.

(Witness shown "Claimant's Exhibits Nos. 174 and 175, Fleming Valves".)

A. Fleming two-element valves.

Q. 393. How do they compare with the Fleming valves fitted into the Marconi valve tuners that you have referred to?

A. In appearance, I should say that the comparison is exact.

Q. 394. From what source did you obtain the Marconi valve tuners and Fleming valves which were installed on the vessels referred to?

A. From the New York headquarters of the Marconi Wireless Telegraph Company of America.

Q. 395. For about how long a period did you continue to receive and install these Marconi valve tuners fitted with Fleming valves?

A. From the summer of 1912 until I departed for Alaska, in May, 1914.

Q. 396. About how long a time were you in Alaska?

A. Fifteen months; I left Alaska in August, 1915.

Q. 397. What work were you connected with after you returned from Alaska, and where was that work being done?

A. After a vacation in San Francisco, I became Engineer in Charge of the Trans-Pacific Transmitting Station at Bolinas, California.

Q. 398. Were the Marconi valve tuners fitted with Fleming valves, which you have referred to, examined and tested by you or under your supervision, before or after they were installed on the vessels?

A. The Marconi tuners fitted with Fleming valves were almost always tested in the San Francisco shop for the purpose of determining whether both the receiver and the valve would function properly. These tests consisted of placing the valves in the tuners, connecting the same to a battery and connecting the tuner to an antenna and ground, making the usual adjustments of the controlling devices, so that wireless telegraph messages or signals could be received from the various commercial stations, merchant vessels and Naval Radio stations in the vicinity of San Francisco Bay. After checking and testing, the tuners fitted with the valves were installed on vessels and, if necessary, again tested on the ship or ships.

Q. 399. Did you ever personally receive any wireless telegraph messages with any of these Marconi valve tuners [fol. 1102] fitted with Fleming valves, and if so, what kind of messages and under what circumstances?

A. I did, many times; under the circumstances described in my previous answer.

Q. 400. Can you give us the names of some of the lines on which these Marconi valve tuners fitted with the Fleming valve were installed?

A. Matson Navigation Company and the Pacific Mail Steamship Company.

Q. 401. Do you recollect, and if so, will you state the names of any of the vessels on which these tuners fitted with Fleming valves were installed?

A. To the best of my recollection, Marconi tuners and valves were installed and successfully operated on the steamers Enterprise, Lurline, Hyades, San Juan, San Jose and Newport.

Q. 402. If you recollect, will you please state what service these vessels were engaged in and between what ports this service was carried on?

A. The first three named plied between San Francisco and ports in the Hawaiian Islands; the last three named

above between San Francisco and the Isthmus of Panama, and Central American ports between those two points.

Q. 403. Were the Marconi valve tuners fitted with the Fleming valves installed on these vessels supplied with a battery; if so, for what purpose was the battery used?

A. Batteries were supplied for the purpose of lighting the filaments of the Fleming valves in order to make the Fleming valves act as detectors of wireless telegraph signals.

Q. 404. Do you recollect what the voltage of these batteries was?

A. As I remember, these batteries were six volts.

Q. 405. When the Fleming valve fitted into these tuners was adjusted for the best signal on one wave length, was it necessary to change the adjustment in order to receive on other wave lengths, and if so, what adjustments were necessary?

A. Subsequent to adjusting the tuner to a different wave length, it was necessary to vary a little the potentiometer and rheostat of the circuit supplying current to the valve.

Q. 406. When the valve tuners fitted with a Fleming valve or valves were received and installed by you, were they fitted with any additional detector than the Fleming valve and, if so, what type of detector?

A. I think that in 1913, tuners were shipped to us together with adapters holding carborundum crystals that could be inserted in either one of the two sockets on the Marconi valve tuner.

Q. 407. For what purpose, if you know, was the additional carborundum crystal detector supplied for these valves tuners?

A. For the purpose of more economical maintenance and operation, and as an emergency detector. We frequently were confronted with the loss of valves, breakage of valves and improper or insufficient charging of the batteries supplying current to the valves.

Q. 408. Do you know for about how long a period these Marconi valve tuners fitted with the Fleming valve continued in use on the vessels you have referred to?

A. Vessels continued to be equipped with Marconi vaive tuners up to the time I left for Alaska in May, 1914.

Q. 409. Have you any personal knowledge now as to just how long the valves were used on the vessels you have mentioned?

A. Do you mean those vessels I specifically named?

[fol. 1103] Q. 410. Yes.

A. No.

Q. 411. Up to the time when you left for Alaska do you recollect whether there were few or many of the adapters with the carborundum crystals received by you for use with the valve tuners?

A. I believe that every Marconi valve tuner at the time I left San Francisco for Alaska had been supplied with a carborundum adapter.

Q. 412. And this carborundum adapter was fitted into one of the sockets of the valve tuner?

A. Yes.

Q. 413. Were the Fleming valves which you received at San Francisco uniform in quality and performance?

A. No; the valves varied some in their detecting characteristics; in other words, in the degree in which they were able to detect wireless signals. However, when the valve was once adjusted, it was quite stable in its operation.

Q. 414. Did you ever make any direct comparison between the Fleming valves and the carborundum crystals supplied to you by your company under substantially the same conditions; and, if so, what were the results of the comparisons?

A. Many comparisons were made; probably every tuner fitted with the valve and a carborundum adapter had this comparative test in actual operation. It was a simple matter to actuate a double-throw switch while making a comparative test. Almost invariably it was found that the valve was the more sensitive detector and more stable in its operation.

Q. 415. Have you any personal knowledge of the use of the Fleming valve on any other vessels than those you have mentioned and, if so, please state what vessels these were and how you acquired such knowledge?

A. Vessels under the control of the English Marconi Company plying to San Francisco were fitted with Marconi valve tuners and, occasionally, these tuners were brought to the San Francisco shop for repairs. I have a very distinct recollection of an English oil tanker operated by the Standard Oil Company between San Francisco and the Orient, the Marconi valve tuner on which the San Francisco shop men sometimes repaired and tested.

Q. 416. What types of detectors were fitted in the valve tuners referred to in your last answer?

A. Fleming valve detectors.

. . . . . .

Mr. Edwards: No cross-examination.

Last Question by the Notary: Do you know of any other matter relative to this claim?

Answer. I do not.

Deposition Closed

Deposition of Gordon B. Rabbitts, for Claimant, taken at New York, N. Y., on the 11th day of December, A. D. 1925.

. . . . . .

First Interrogatory by the Notary: State your name, your occupation, your age and your place of residence; [fol. 1104] whether you have any, and if any, what interest, direct or indirect, in the claim which is the subject of inquiry; and whether, and in what degree, you are related to the claimant.

Answer. My name is Gordon B. Rabbitts; occupation, Radio Operator; my age is 40; residence, Cosmopolitan Hotel, Chambers Street, New York, N. Y.; I have no interest, direct or indirect, in the claim which is the subject of inquiry, and I am not in any way related to the claimant herein.

Direct examination.

By Mr. Cosgrove:

Q. 1. By whom are you employed as a radio operator?

A. The Radio Corporation of America.

Q. 2. For how long have you been employed as a radio operator by that corporation?

A. Since they reorganized in 1919.

Q. 3. By what other companies have you been employed as a radio operator, and when?

A. About five years with the Canadian Marconi Company and the Marconi Company of America, from the spring of 1911 until 1919.

Q. 4. During about what period were you employed as radio operator by the Canadian Marconi Company?

A. From 1906 until the spring of 1911.

Q. 5. Did you ever act as a radio operator at the Glace Bay, Nova Scotia, Wireless Station of the Canadian Marconi Company?

A. Yes.

Q. 6. About when did you act as a radio operator at this Glace Bay Station?

A. I went down there shortly after they started commercial work in the fall of 1907, about November, I think it was.

Q. 7. Between what points was the commercial operation of the Glace Bay station carried on?

A. Between Clifden, Ireland, and Glace Bay.

Q. 8. For about how long a time did you continue to act as a wireless operator at the Glace Bay wireless station?

A. About a year and a half.

Q. 9. That is, a year and a half from November, 1907?

A. From November, 1907 to the spring of 1909.

Q. 10. Did you act as an operator at that station at any other time, and if so, during about what period?

A. In the spring of 1911 I went back there for about three weeks.

Q. 11. What type of detectors were used by you at the Glace Bay station when you first acted as an operator at that station?

A. The magnetic detector and a detector known as the Fleming valve.

Q. 12. What type of detectors did you use during the second period in which you acted as an operator at this Glace Bay station?

A. The detector known as the Fleming valve.

Q. 13. What did the detector known as the Fleming valve, and which you used at the Glace Bay wireless station, look like?

A. It looked like a small incandescent bulb (indicating), with two elements—a plate and filament.

Q. 14. Look at the two articles which I show you, and if you recognize them, state what they are and how they resemble anything used by you at Glace Bay. (Witness shown "Claimant's Exhibit 172" and "Claimant's Exhibit 173".)

A. We were using something like that at times (Witness [fol. 1105] refers to "Claimant's Exhibit No. 172"); this is the one we used continuously (witness referring to "Claimant's Exhibit No. 175").

Q. 15. Did you use a battery with the Fleming valves at Glace Bay, and if so, for what purpose did you use it?

A. Yes, to light the filaments.

Q. 16. About when did you first begin to use the Fleming valve in regular service at the Glace Bay station?

A. After about the first six months that I was there.

Q. 17. After your first six months at the Glace Bay station, to what extent was the Fleming valve thereafter used by you in receiving wireless messages at that station?

A. Continuously, except that at times we would switch over to the magnetic detector.

Q. 18. For what purpose did you switch over to the magnetic detector?

A. Just for comparison and try-outs.

Q. 19. What kind of messages did you receive during the period you used the Fleming valve at the Glace Bay station, and from where were those messages received?

A. General commercial messages and press, received from Clifden, Ireland.

Q. 20. About how many hours a day or night did you act as an operator at the Glace Bay station, using the Fleming valve to receive messages?

A. Four hours a day.

Q. 21. About how many other operators worked with you at Glace Bay in receiving messages with the Fleming valve, and how was the operators' time generally divided up?

A. The first part of my time there I had three operators; the time was split up, four hours each, four on land wire, four on radio. It was limited service, you know, for the first few months I was there, and we didn't have any night watch.

Q. 22. On an average about how many messages did you personally receive with the Fleming valve from Clifden, Ireland, during your four-hour watch?

A. I should say about thirty messages. Sometimes we were receiving press, and that would mean one continuous message.

Q. 23. About what time or times did it take to receive or copy these press dispatches or messages?

A. That would depend on the length of them, there were some longer than others, but if it was continuous copying, about eight hundred words an hour.

Q. 24. Did you ever take most of your four-hour watch to copy these press despatches?

A. Yes, often.

Q. 25. Can you roughly estimate the number of words received by you from Clifden, Ireland at Glace Bay, with the Fleming valve during an average watch of four hours, when press despatches were coming in?

A. Well, allowing for breaks in transmission, I would say at least twenty-five hundred words.

Q. 26. Will you also give us a rough estimate of the number of words you received at Glace Bay with the Fleming valve from Clifden, Ireland, during the period when you first acted as an operator at the Glace Bay station?

A. I should say over two hundred and fifty thousand.

Q. 27. In your experience with the Fleming valve in receiving wireless messages from Clifden, Ireland, and also from your experience with the magnetic detector in that [fol. 1106] work, how did the two detectors compare in usefulness?

A. The Fleming valve was a great improvement; at times when we couldn't hear at all on the magnetic, it came in good on the valve.

Q. 28. When you left the Glace Bay wireless station, after your first service there, was the Fleming valve still in use?

A. Yes, it was.

Q. 29. For about how long a time did you use the Fleming valve at the Glace Bay station on your return to service as operator there in the spring of 1911?

A. We used it continuously,—about three weeks.

Q. 30. For what purpose was the valve used during these three weeks?

A. For the receiving of the regular messages, press and services.

Q. 31. From where were these messages received?

A. Clifden, Ireland.

Q. 32. How did the wireless traffic between Glace Bay and Clifden, Ireland, compare at the time of your second service at Glace Bay, in 1911, with the wireless traffic at the time of your first service at Glace Bay?

A. There was quite an increase; we were handling about double the business.

Q. 33. About how many radio operators were handling the traffic at Glace Bay at the time of your second service there?

A. Ten or twelve operators; some of them were on clerical work and things like that.

Q. 34. Do you recollect about how many were engaged in actually receiving from Clifden, Ireland?

A. There were six during the twenty-four hours.

Q. 35. Did you use the magnetic detector during your second service at Glace Bay?

A. No, not for commercial purposes.

Q. 36. When you left the Glace Bay station, after the period of your second service there, was the Fleming valve still in use in receiving messages from Clifden, Ireland?

A. Yes.

Q. 37. Did you ever make use of the Fleming valve as a wireless detector aboard any ships?

A. Yes, on the S. S. Philadelphia, of the American Line.

Q. 38. About when did you first use the Fleming valve as a detector aboard the S. S. Philadelphia?

A. When I joined her in August, 1912.

Q. 39. For how long a period did you continue to use the Fleming valve as a detector on the S. S. Philadelphia?

A. All the while I was on there, from August, 1912, to the spring of 1913, somewhere about May, I think.

Q. 40. Do you recollect the name of the operator whom you relieved aboard the S. S. Philadelphia when you first joined that ship?

A. Yes; Mr. Charles J. Weaver.

Q. 41. During the period you acted as an operator and used the Fleming valve on the S. S. Philadelphia, in what service was that ship engaged?

A. In the passenger service between New York and Southampton, England, and Cherbourg, France, in the Trans-Atlantic passenger service.

Q. 42. What was the character of the messages you received with the Fleming valve, while you acted as an oper-
[fol. 1107] ator aboard the Philadelphia?

A. Regular commercial messages, ship's business and press.

Q. 43. Did you ever receive any long-distance messages with the Fleming valve while you acted as an operator

aboard the S. S. Philadelphia, and if so, what was the character of the messages and from where were they received?

A. Yes, from Cape Cod and Poldhu, they were press messages.

Q. 44. And about what was the distances over which these messages were received by you?

A. We held both stations about half-way across.

Q. 45. Did you ever receive with the Fleming valve while aboard the Philadelphia, from any other vessel, at a distance of over a thousand or fifteen hundred miles, and if so, when and what vessels?

A. Yes, we exchanged messages with one of the Kaiser boats. I forget just which one it was—a distance of fifteen or eighteen hundred miles we were east of Cape Race at the time.

Q. 46. Did you ever receive any distress signals with the Fleming valve while you were an operator aboard the Philadelphia, and if so, when and under what circumstances?

A. Yes, during the winter I was on the Philadelphia. We received distress signals from an English cargo ship. I think she was called the Wanderer. We handled some of the correspondence connected with the distress call.

Q. 47. While you acted as an operator on the Philadelphia, was she equipped with any other type of wireless detectors than the Fleming valve?

A. Yes, we had the magnetic detector as a standby.

Q. 48. What do you mean by "stand-by"?

A. I mean "stand-by" or "emergency".

Q. 49. Which detector, the magnetic or the Fleming valve, was normally used on the Philadelphia?

A. The Fleming valve.

Q. 50. Please look at the apparatus now shown you and if you recognize it, state what it is, and if you ever used it. (Witness shown "Claimant's Exhibit No. 193, Marconi Tuner or Receiver".)

A. This is the old Marconi tuner which was used with the Fleming valve; it looks very much like it.

Q. 51. Do you mean that this apparatus looks like the tuner used with the Fleming valve aboard the Philadelphia?

A. Yes, it looks like it.

Q. 52. When you left the Philadelphia, was the Fleming valve still in use aboard that ship?

A. Yes.

Q. 53. After leaving the Philadelphia, at what wireless station did you next serve as a wireless operator?

A. At Sagaponack, Long Island, New York.

Q. 54. By whom was this Sagaponack wireless station operated?

A. The Marconi Wireless Telegraph Company of America.

Q. 55. How soon after you left the S. S. Philadelphia did you begin work as an operator at the Sagaponack station?

A. Immediately after.

Q. 56. During what period of time did you continue to act [fol. 1108] as an operator at the Sagaponack station?

A. From the spring of 1913, to the fall of 1915.

Q. 57. How do you fix the date as the fall of 1915, when your services as an operator ended at the Sagaponack station?

A. Because it was the second year of the War and I dismantled the station, and it was cold weather.

Q. 58. Do you know why the Sagaponack station was dismantled at that time?

A. Through lack of business owing to war conditions.

Q. 59. During the period you acted as a wireless operator at the Sagaponack station from the spring of 1913, to the fall of 1915, what type of receiver and detector were used by you at that station?

A. The receiver was something like this, with the Fleming valve (witness refers to "Claimant's Exhibit No. 193").

Q. 60. Was this receiver fitted with the Fleming valve in use at the time the Sagaponack station was dismantled?

A. Yes.

Q. 61. What was the character of the messages you received with the Fleming valve at the Sagaponack station?

A. General commercial messages and press from ships at sea.

Q. 62. How important a wireless station was the Sagaponack station?

A. It was considered very important, second to the Sea Gate station.

Q. 63. On what part of Long Island was the Sagaponack station located?

A. On the Eastern end of it, about thirty-five miles West of Montauk Point.

Q. 64. In your experience with the Fleming valve how satisfactory was it as a wireless detector.

A. It seemed to work very satisfactorily.

Q. 65. In your experience with the Fleming valve did you find all of the Fleming valves uniform in sensitiveness; if not, how did they differ?

A. No; some were more sensitive than others.

Q. 66. In your experience with the Fleming valve, what adjustments did you have to make in the valve circuit in changing from one wave length to another?

A. No adjustment of the valve itself; sometimes varied the filament battery.

* * * * * * *

Mr. Edwards: No cross-examination.

Last Question by the Notary: Do you know of any other matter relative to this claim?

Answer: No.

Deposition closed.

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Deposition of Cyril D. Reinhard, for Claimant, taken at New York, N. Y., on the 29th day of December, A. D. 1925

* * * * * * *

First Interrogatory by the Notary: State your name, your occupation, your age and your place of residence, whether you have any, and if any, what interest, direct or indirect, in the claim which is the subject of inquiry, and [fol. 1109] whether, and in what degree, you are related to the claimant.

Answer: My name is Cyril D. Reinhard, my age is 45; residence, Borough of Manhattan, New York City; I have no interest whatever in the claim; I am not related in any way to the claimant.

Direct examination.

By Mr. Cosgrove:

Q. 1. Are you a wireless telegraph operator?

A. I am.

Q. 2. Do you hold any license as such operator, and if so, from whom, and what grade?

A. I hold a First Class First Grade license issued by the Department of Commerce of the United States.

Q. 3. For about how long have you held such license?

A. Ever since the United States has issued such licenses.

Q. 4. Do you know when they began to issue such licenses?

A. 1910 or 1911.

Q. 5. Please state in a general way what practical experience you have in wireless work.

A. My first knowledge of wireless was gained in the United States Navy in 1903. After my discharge from the Navy I was employed by various wireless companies as operator, engineer, sales manager and in practically all capacities except that of financing in connection with wireless work.

Q. 6. When did you enter and leave the Navy?

A. 1903 to 1907.

Q. 7. Were you ever employed by the United Fruit Company, and if so, when and where and in what capacities?

A. Yes, from I think in March, 1911, until April, 1915. First I was senior operator on the Steamship Limon, running between Boston and Puerto Limon, Costa Rica. I was afterwards transferred to the S. S. Metapan of the same company, running between New York and Central and South America, on which ship I served as senior operator until transferred to Santa Marta, the Republic of Columbia, to be the United Fruit Company's representative during the erection of the 50-kilowatt station at that point. After the station had been completed by the Marconi Wireless Telegraph Company of America, I was the operator in charge of this station for approximately three years.

Q. 8. Were you ever employed either by the claimant herein or the Radio Corporation of America?

A. I was employed by the Marconi Wireless Telegraph Company of America for one voyage only on the S. S. Seguranca from New York to Buenos Ayres and return. I have never been employed by the Radio Corporation of America.

Q. 9. What if any experience have you had in the use of a wireless device known as the Fleming Valve?

A. I used the Fleming valve for handling commercial traffic while I was stationed at the Santa Marta station of the United Fruit Company.

Q. 10. Will you describe generally the Fleming valve or valves used by you at the Santa Marta wireless station?

A. We had many types of Fleming valves supplied us, but in general they were usually cylindrical glass tubes about ¾ of an inch in diameter and 4 inches long, provided with the necessary base for making electrical connections to the filament.

Q. 11. What elements were inside of the cylindrical glass tube?

A. A filament or heating device and another element called the plate.

Q. 12. I show you half a dozen devices and if you recognize any of them, please state what they are.

[fol. 1110] A. These objects are Fleming valves. I note that the filaments are broken in some of them; and they are quite similar in appearance to those supplied me at Santa Marta, especially these three which are not marked. Those tubes which we had were more like these than the small fat ones.

Mr. Cosgrove: (It is noted that the witness was shown Claimant's Exhibits Nos. 173, 175, and 176 Fleming Valves, and three unmarked devices, which the witness has identified as Fleming Valves.)

The latter devices are offered in evidence and marked respectively "Claimant's Exhibits Nos. 195, 196 and 197, Fleming Valves.

Q. 13. During what period or about what time did you serve as wireless operator at the Santa Marta station of the United Fruit Company?

A. From 1912 to 1915.

Q. 14. Do you recollect the month of 1912 when you first began to serve as an operator and the month in 1915 when you ceased to serve as such operator at that station?

A. To the best of my recollection, it was in March, 1912, until April, 1915.

Q. 15. Were you the only wireless telegraph operator serving at Santa Marta station during the period mentioned in your last two answers?

A. For the first two and a half years, yes; until I became ill and was sent to the hospital, which necessitated the closing of the station until a relief operator was sent to Santa Marta, who afterwards acted as my assistant.

Q. 16. Do you know from whom the Fleming valves which you used at the Santa Marta station were received?

A. Yes, from the Marconi Wireless Telegraph Company of America.

Q. 17. How do you know this?

A. Because it was necessary for me to sign the receipts or shipping vouchers which were afterwards returned to the shippers. I unpacked the cases.

Q. 18. With what type of receivers did you use the Fleming valve while you served as an operator at the Santa Marta station?

A. With those receivers which we knew as the Marconi Ship-Type Valve Receiver, and the Marconi Balanced Crystal-Valve Receiver.

Q. 19. Please look at the apparatus now shown you and state what it is, if you know. (Witness shown Claimant's Exhibit No. 193.)

A. This is a Marconi Ship-Type Valve Receiver, very similar to the one which I used at Santa Marta. It might be the same one, it looks just like it.

Q. 20. Were you supplied with any detector other than the Fleming valve to use with this Marconi ship valve receiver while you were at Santa Marta?

A. No.

Q. 21. Will you please describe to the best of your recollection the Marconi balanced crystal valve receiver referred to in your answer to Q. 18?

A. We had two of these receivers which were identical, and as I remember they were flat structures about 18 inches by 11 and 2 or 2½ inches high with valve sockets and crystal holders mounted on the surface together with rheostats for controlling the filament voltage.

Q. 22. Were these balanced valve and crystal receivers long wave receivers?

A. They were.

Q. 23. Will you please state how the Fleming valves and [fol. 1111] crystals functioned in this balanced receiver—that is, did the valves and crystals function independently or in combination?

A. In combination.

Q. 24. That is both the crystals and valves must be operative in order to receive signals?

A. Yes, both.

Q. 25. Just what do you mean by calling this receiver a balanced receiver?

A. A receiver in which the static is minimized or balanced out so that the signals can be received.

Q. 26. Can you describe or illustrate the details of the circuits of these balanced receivers?

A. No, I cannot, because it is more than ten years since I have seen or used them.

Q. 27. Do you know who manufactured these balanced receivers?

A. Yes, they were made by the Chelmsford Works of the Marconi Company in England.

Q. 28. For what kind of work were the Marconi ship valve receiver fitted with the Fleming valve, and the balanced receiver fitted with those valves and crystal detectors used by you at the Santa Marta station?

A. The Marconi ship type receiver used with the Fleming valve for detector was employed for communication with the various vessels of the United Fruit Company and for communication with the Naval Station at Colon, the Republic of Panama. The balanced receivers were used for point to point communication—that is, between Santa Marta and Port Limon, Costa Rica, Swan Island, Honduras, Cape San Antonio, Cuba, and New Orleans, Louisiana.

Q. 29. While at Santa Marta did you regularly receive wireless messages from New Orleans, and other points, with the Marconi ship valve tuner fitted with the Fleming valve?

A. The Marconi ship type valve receiver was used at Santa Marta as a standby, and it was usual at scheduled time with one of the more distant stations to shift over to the balanced receiver, as these had been preadjusted for the particular wave length of the distant station. It was, however, possible and practicable to communicate with any of our stations using only the ship type receiver.

Q. 30. Was it the practice to pick up the distant station with the ship valve tuner and then shift to the balanced receiver?

A. No, because we adhered very rigidly to exact scheduled time and unless the traffic with one station was particularly heavy and we overran the schedule time, we usually shifted to the balanced receiver when one of the distant stations was due to communicate with us; if we did run over of course we could hear the other stations calling us on the ship type receiver.

Q. 31. While at Santa Marta, using the ship type of receiver fitted with the Fleming valve or valves, did you ever actually receive messages from New Orleans?

A. Yes.

Q. 32. Will you please state the approximate distances from Santa Marta to New Orleans, to Swan Island, to Port Limon, and to Colon?

A. Approximately the air line distance from Santa Marta to New Orleans is 1,470 miles. To Swan Island 685. To Port Limon 547, and to Colon 325.

Q. 33. How were the static conditions at Santa Marta during the time you served as an operator there?

A. The static was worse in Santa Marta than I have ever experienced in 20 years of service as a radio operator.

Q. 34. How successful or efficient were the Fleming valves [fol. 1112] used by you at Santa Marta as detectors under static conditions?

A. Efficient enough to handle the United Fruit Company's important traffic, except at such times as the static was so strong that signals could not be heard with any type of detector.

Q. 35. What kind of crystals were furnished you while at Santa Marta for use in the balanced receiver?

A. Carborundum.

Q. 36. While at Santa Marta did you ever make any direct comparison between the Fleming Valve and any crystal detector, and if so, what type of crystal detector, and what is your recollection of the comparison made?

A. Yes. I have made direct comparisons between the Fleming valve and the carborundum detector and a silicon detector; the sensitivity of the three types of detectors was about the same, but the reliability of the valve was greatly superior to that of either of the crystal detectors.

Q. 37. Will you please state what you mean by "reliability" as stated in your last answer?

A. That quality in a detector of wireless signals which enables the receiving operator to hear and record accurately the greatest number of signals from the transmitting stations.

Q. 38. In your experience, which quality have you found more desirable in a wireless detector—sensitiveness or reliability?

A. Reliability.

Q. 39. Is reliability essential in order to handle commercial wireless traffic, and if so, why?

A. It is absolutely essential and in order to explain why, or rather to point out so that those not familiar with telegraphing can understand more readily, take for instance the telegraphic correspondence of the United Fruit Company, which is almost invariably in code. By code I mean artificial words. The United Fruit Company's code is made up of unpronouncable groups of ten letters. If the receiving operator has not a detector which is reliable and should miss one dot in a letter of the Morse code, for instance changing a B to A D or an H to an S, it would change the entire meaning in translation of the received word.

Q. 40. In what respects or why were the crystal detectors more unreliable than the Fleming valve?

A. Because in severe static the crystal detector is more easily "knocked out" of adjustment or par-lyzed, and does not recover as quickly as the valve type detector.

Q. 41. In your experience with the Fleming valves did you find that they were all of the same order of sensitiveness, and if not, generally speaking, how did they differ in this respect?

A. The Fleming valves supplied to me at Santa Marta varied greatly in their characteristics, principally in their sensitivity and length of useful life.

Q. 42. In using the Fleming valves at Santa Marta was any battery employed and if so, for what purpose?

A. Yes, for heating the filament of the valve.

Q. 43. Did you ever receive any distress calls while at Santa Marta while using the Fleming valve as a detector? If so, please state about when and under what circumstances?

A. Yes; while listening in for one of the regular schedules with one of my corresponding stations, I received distress signals from W. K. Vanderbilt's steam yacht "The Warrior" which had gone aground between Puerto Colombia and Santa Marta. The exact date of this I am unable to recall, but it can easily be ascertained because it is a matter of record. It was probably in 1913.

[fol. 1113] Q. 44. While at Santa Marta were you supplied with, and did you use a type of detector known as the "magnetic detector", and if so, to what extent was the magnetic detector used by you?

A. Yes, I was supplied with two magnetic detectors, one made in England at Chelmsford, and the other made in the United States. These magnetic detectors were used infrequently, because of the superiority in sensitivity of the valve detectors.

Q. 45. Did you continue to use the receivers fitted with the Fleming valves in commercial work at Santa Marta up to the time that you left that station?

A. Yes.

Q. 46. Were you supplied with any other receiver than the ones fitted with the Fleming valve while you were at Santa Marta, and if so, what was the type of receiver and what detector was used with it?

A. As I said before, we had two magnetic detectors which could be used with the tuning devices supplied in the form of the ship type receiver or the balanced crystal receiver, and about January, 1915, I was supplied with a new type of receiver made at Aldene, which employed a three-element valve.

Q. 47. What use was made of this type of receiver fitted with the three-element valve at Santa Marta before you left there?

A. It was used experimentally, because having successfully handled commercial traffic on the receivers and detectors originally supplied, we felt more safe in depending upon them and the new receiver and detector were tried out on communications less important than our regular schedules.

Q. 48. What vessels did you serve on while in the United States Navy, in what capacities did you serve on these vessels, and state, if you recollect, about the time of each service on the vessels respectively?

A. I served aboard Diamond Shoals Light Vessels, No. 81 and 82, as a radio operator after my graduation from the Electrical School at the Brooklyn Navy Yard for about eight months. This was 1903-4, that is the fall of 1903-4. I was then transferred to the U. S. S. Iowa, and served as a wireless operator and electrician. This was about 1905. From the U. S. S. Iowa I was transferred to the U. S. S. New Jersey, where I served in the same capacity until my four years in the Navy had expired.

Q. 49. Where were the two Lightships you have referred to located at the time you served as an operator aboard those ships?

A. Off Cape Hatteras, Virginia.

Q. 50. How important were these lightships in coastwise traffic?

A. Second in importance to Nantucket Shoal Light vessels, as Cape Hatteras or Diamond Shoals is the point at which North and South bound steamers change their courses.

Q. 51. Will you please state your recollection of the type of transmitter and receiver installed on the Diamond Shoals Lightships at the time you served as an operator on those ships?

A. The wireless apparatus on the Diamond Shoals Lightships was manufactured by the National Electric Signaling Company and known as the Fessenden System. The power for the transmitter was supplied from a bank of storage batteries to a one-kilowatt rotary converter. The transmitting circuit was a tuned coupled circuit in which the spark gap was partially enclosed and cooled by a blast of air. The receiving circuit was the standard Fessenden circuit employing tuned coupled circuits and using an electrolytic detector.

[fol. 1114] Q. 52. What do you mean by "tuned coupled circuits" in your last answer?

A. A circuit in which the primary and secondary are in resonance, or nearly so.

Q. 53. Referring to the blast of air on the spark gap, referred to in your answer to Q. 51, from what source was this air supplied?

A. From a small blower actuated by a motor especially installed for that purpose.

Q. 54. Please describe the transmitting set installed on the Iowa when you served as an operator on that ship?

A. A mercury turbine interrupter supplying interrupted direct current to a large Rulmkorff coil which charged the Leyden jars, the Leyden jars discharging through an inductance which we called the auto-transformer, and a fixed open spark gap to the antenna circuit.

Q. 55. What was the character of the circuits of the Iowa transmitter?

A. Both the transmitter and receiver were tuned coupled circuits.

Q. 56. Was the spark gap of the transmitter of the Iowa ventilated in any way, and if so, in what way?

A. Yes, by a small electric fan, which was mounted underneith the jar rack.

Q. 57. Will you generally describe the receiver you operated aboard the Iowa?

A. The receiver used on the Iowa when I was first assigned to that ship was a coherer set made by the Slaby-Arco Company of Germany. The coherer was shunted across the auto-transformer receiving inductance and actuated by a battery, also employing a Morse printer for recording of received signals.

Q. 58. While you acted as an operator aboard the Iowa, what was the longest distance you were able to receive using the coherer as a detector?

A. 90 miles.

Q. 59. How do you happen to remember this?

A. Because it was out of the ordinary to communicate over such a distance with a coherer and all the operators in the fleet commented upon this performance.

Q. 60. Did you use any other type of transmitter while you acted as an operator aboard the Iowa than that mentioned in your answer to Q. 54, and if so, what type of transmitter?

A. Yes, the mercury turbine interrupter was replaced by an alternating current motor generator, which supplied alternating current to the Ruhmkorff coil instead of interrupted direct current.

Q. 61. If you recollect, will you state what the character of the circuits of this transmitter were?

A. It was a tuned coupled circuit.

Q. 62. Will you please state what type of transmitter and receiver were installed aboard the Battleship New Jersey while you served as an operator aboard that ship?

A. It was a Standard Shoemaker set.

Q. 63. What was the character of the spark gap of this transmitter and the character of its circuits, and those of the receiver?

A. Both the transmitter and receiver had tuned coupled circuits. The transmitter was supplied with alternating current from the motor generator, using a transformer which charged the Leyden jars or condensers discharging across a fixed spark gap through an inductance coupled to the antenna circuit. The receiver circuit was a tuned coupled circuit using an electrolytic detector with glass enclosed detector points.

Q. 64. Were either one or both of the coupled tuned circuits of the transmitters or receivers operated by you while you were in the Navy provided with any means for adjusting or varying the capacity or inductance of the circuits, [fol. 1115] and if so, which circuit could be varied and how?

A. In both the Slaby-Arco and Shoemaker transmitting circuits, the inductance could be varied by means of a sliding contact so that more or less inductance would be inserted in the primary and secondary circuits. The capacity could also be varied by cutting out of circuit some of the Leyden jars. In the receiving circuits there was no means provided for changing the capacity and tuning was done by changing the inductance by means of siders which permitted the operator to increase or decrease the number of turns of inductance in the receiving circuit.

Q. 65. Did you have any wave meters on board the vessel on which you served as an operator while in the Navy?

A. No.

Q. 66. While you were operating coupled tuned sets in the Navy how did you determine that the coupled circuits were in tune—I am referring to the circuits of the transmitter?

A. By the fatness and quality of the spark in the anchor gap.

Q. 67. What do you mean by the "anchor gap"?

A. The small spark gap in the antenna which cut off the transmitter from the receiver while receiving on the antenna.

Q. 68. Referring to the sets installed on the Diamond Shoal Lightships, what means, if any, were provided for adjusting or varying the capacity and inductance of the coupled tuned circuits?

A. The transmitting condensers were not variable and tuning was accomplished by changing the number of turns of wire in the transmitting inductance. The receiving set was tuned in the same way, that is, by varying the number of turns of wires in the tuning inductance. There were no variable receiving condensers employed in these sets.

Cross-examination.

By Mr. Edwards:

X Q. 69. After you left the Santa Mara station in 1915, what was your occupation?

A. I did not do anything for almost a year. I had not had a vacation all the time I had been in Santa Mara, and I had saved my money and took life easy in New York.

X Q. 70. What was your next occupation?

A. In the fall of 1916 I made a trip as operator on the SS. Seguranca.

X Q. 71. What line?

A. It was independently owned.

X Q. 72. What kind of receiver did you have on that ship?

A. An old United Wireless receiver with a carborundum detector.

X Q. 73. What kind of transmitter did that have?

A. A United Wireless transmitter.

X Q. 74. Did it have a loading coil in the antenna?

A. Not as I recall, no.

X Q. 75. How was its waves length adjusted?

A. At that time ships were not required to work on any predetermined wave length, and all ships and stations used that wave length by which the greatest radiation was obtained. We made no adjustment for any particular wave length.

X Q. 76. What was the wave length of the United Wireless transmitter?

A. I don't know.

X Q. 77. What was the wave length of the transmitter at the Diamond Shoals Lightship?

A. I don't know.

X Q. 78. What was the wave length on the transmitter of the Iowa?

A. I don't know.

[fol. 1116] X Q. 79. Did the transmitter at the Diamond Shoals Lightship, or that on the Iowa, have a loading coil?

A. Not as I recall, no.

X Q. 80. Was any adjustment of the wave length of the transmitter ever made at either of these stations to your knowledge?

A. Yes, on the Lightship.

X Q. 81. How was this done?

A. By a Naval expert radio aide, or as I remember he was called an electrical aide.

X Q. 82. What did he do to change the wave length?

A. Adjusted the transmitter inductance.

X Q. 83. By transmitter inductance do you mean the inductance in the antenna circuit?

A. By the transmitting inductance I mean the primary and secondary of the transmitter circuit.

X Q. 84. Can you not explain in detail just what changes the Naval Expert made in order to adjust the wave length?

A. It would be perhaps more accurate to say that the wave length was changed, rather than "adjusted" to any particular length. This was done by electrically varying the number of turns of wire in the primary and secondary circuits of the transmitter.

X Q. 85. Did he explain to you why he made the change?

A. No.

X Q. 86. Did you know the reason for the change?

A. No.

X Q. 87. Do you know that the changes that he made changed the wave length?

A. Yes.

X Q. 88. How do you know this?

A. Because I had read Fleming's book and knew that changing the length of wire or amount of wire in the primary or secondary circuit would change the wave length.

X Q. 89. Can you explain why this is so?

A. No, I cannot explain myself, I simply accept the usual explanation as given by radio and wireless authorities.

X Q. 89. Did the Naval Expert change the inductance in the primary or the secondary circuit, or in both circuits?

A. In both.

X Q. 90. Did not changing the adjustment in both circuits merely change the degree of coupling without necessarily changing the wave length?

A. I don't know.

X Q. 91. Are you now engaged in wireless telegraphy or telephony?

A. No at this exact time.

X Q. 92. What is your present occupation?

A. I am on a vacation.

X Q. 93. How long have you been on a vacation?

A. Since about November 1.

X Q. 94. What was your occupation before that time?

A. Sales Manager for Otto R. Gischow, Inc.

X Q. 95. How long has it been since you ceased work as an operator in the wireless telegraph field?

A. April, 1925.

X Q. 96. After 1915 did you have any occasion to use any of the two-element Fleming valves in your work as an operator?

A. No.

X Q. 97. Did you see any of them in use in commercial stations.

A. No.

X Q. 98. Were you occupied more or less continuously as a wireless operator between 1915 and 1925?

A. Yes.

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Redirect examination.

By Mr. Cosgrove:

R. D. Q. 99. Were you ever in the employ of Emil J. Simon, if so, during what period and in what capacities?

[fol. 1117] A. Yes, I was Chief Engineer for Emil J. Simon from 1917 to 1920, and during part of 1920 was General Superintendent of the Radio Communication Company, which was owned by Emil J. Simon, and in 1921 was General Traffic Manager for the Intercity Radio Company, which was also controlled by Emil J. Simon.

R. D. Q. 100. What business was Emil J. Simon engaged in in 1917 and 1918?

A. The manufacture of radio telegraph transmitting and receiving apparatus for the United States Navy, Army, and the French Government.

R. D. Q. 101. In general what was the character of these transmitting and receiving sets?

A. The transmitters were the quenched spark type using a coupled tuned circuit. The receiving sets employed tube detectors and coupled tuned circuits.

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Last Question by the Notary: Do you know of any other matter relative to this claim?

Answer: No.

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Deposition of Wilson Aull, Jr., for Claimant, taken at New York, N. Y., on the 21st day of May, A. D. 1926

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First Interrogatory by the Notary: State your name, your occupation, your age and your place of residence, whether you have any, and if any, what interest, direct or indirect, in the claim which is the subject of inquiry, and whether, and in what degree, you are related to the claimant.

Answer: My name is Wilson Aull, Jr.; age, 30; residence, 88 Goodrich Street, Astoria, Long Island, New York; occupation, Radio Engineer; I have no interest, directly, or indirectly, and I am not related in any way to the claimant.

Direct examination.

By Mr. Vaill:

Q. 1. Where are you located in the practice of radio engineering?

A. I have an office at 41 Park Row, New York City. I am engaged in experimental and research work.

Q. 2. What practical experience have you had in qualifying you to conduct tests on radio receiving apparatus of the coherer and crystal detector types?

A. I entered the radio field in 1908 as a radio amateur; at this time I was attending school. I read what radio periodicals I could find, subscribed to some and read what books and radio literature I could find in the Public Library. I also supplemented this reading with the construction of practical wireless transmitters, and receivers and experiments regarding them, and assisted my friends and others who became interested in the subject. I continued in this way until about 1913, when I organized a radio company at East St. Louis, Illinois, specializing in radio receiving and transmitting equipment. I also obtained a first grade [fols. 1118-1119] operator's license with the grade of "Excellent" at about this period. Later I studied at Columbia University and from tutors in this country and abroad, specializing in mathematics and engineering subjects.

In the spring of 1917, while at Columbia University, I also served as an instructor in a school in which Merchant Marine Officers were inducted into the United States Naval Reserve.

In June, 1917, I entered the Navy and continued in the Navy until March, 1919. In the Navy I was assigned to radio duties at various stations and Naval bases in this country and abroad, and was commissioned an Officer in the Naval Reserve.

In 1919 I entered the employ of the International Radio Telegraph Company as a radio engineer, in which capacity I served until the summer of 1920, when the International Company was acquired by the Westinghouse Electric and Manufacturing Company. I continued with them as a Radio Engineer until the Fall of 1921, at which time the International Radio Telegraph Company was merged with the Radio Corporation of America.

Since 1921, I have been doing radio engineering and consulting work, up to the present time.

I have operated and constructed several forms of coherers, my interest in the coherer being chiefly in connection with its use as a scientific instrument. I have also come across several types in various laboratories, and have used them also. The types I have used include the ordinary iron filings coherer, the nickel and silver coherer and later forms of the so-called auto coherer, containing carbon granules and similar types of microphone coherers, such as the sharpened arc carbon type, with the needle laid across them. I have also used and operated many forms of crystal detectors, and other forms of receivers in general use.

[fols. 1120-1121] Deposition of FRED H. KROGER, for Claimant, taken at New York, N. Y., on the 4th day of June, A. D. 1926.

* * * * * * *

First Interrogatory by the Notary: State your name, your occupation, your age and your place of residence, whether you have any, and if any, what interest, direct or indirect, in the claim which is the subject of inquiry, and whether, and in what degree, you arer elated to the claimant.

Answer: My name is Fred Hutton Kroger; age, over 30; residence, Hempstead, Long Island, New York; occupation, Division Radio Engineer; I have no interest, directly or indirectly, and I am not related in any way to the claimant.

Direct examination.

By Mr. Vaill:

Q. 1. Is your occupation as Division Radio Engineer in connection with the Radio Corporation of America?

A. Yes.

Q. 2. From about when have you been connected with practical operation of radio transmitting and receiving apparatus?

A. From 1906.

* * * * * * *

[fol. 1122] Deposition of Ernest R. Cram, for Claimant, taken at New York, N. Y., on the 7th day of October, A. D. 1926.

* * * * * * *

First Interrogatory by the Notary: State your name, your occupation, your age and your place of residence; whether you have any, and if any, what interest, direct or indirect, in the claim which is the subject of inquiry; and whether, and in what degree, you are related to the claimant.

Answer: My name is Ernest R. Cram; of legal age; temporary residence, Clarendon Hotel, Brooklyn, New York; occupation, Radio Engineer, with the Radio Corporation of America; I have no interest direct or indirect, in this claim, and I am not related in any way to the claimant herein.

[fol. 1123] Direct examination.

By Mr. Vaill:

Q. 1. How long have you been connected with the Radio Corporation of America, and in what capacity?

A. Since the Fall of 1924, as Radio Engineer.

Q. 2. What was your occupation previous to being connected with the Radio Corporation of America?

A. Radio Engineer in the Signal Corps U. S. Army.

Q. 3. Were you familiar with the receivers used by the Signal Corps in radio pack sets, referred to by Mr. Loftin on pages 1116 and 1117 of the printed record, and else-

where in the record, and if so, during what period does your knowledge of these sets cover?

A. Yes, beginning in 1911 and continuing until some time after the United States entered the World War.

Q. 4. What type of receivers constituting these pack sets were you familiar with during that period?

A. The early type as made by the Foote-Pierson Company and the later types A, B, C and D.

Q. 5. Will you please state what circumstances allowed you to become familiar with these sets?

A. The Foote-Pierson type was the one in use in the Signal Corps when I entered its service and I designed either wholly, or in part, the types A, B, C and D.

It was a part of my duty to visit the plants of the manufacturers who were making these various types of sets; on these occasions I tested the sets, either in parts, or as a whole, and almost always tested the sets before final acceptance by the Signal Corps.

Q. 6. Please state the names of the manufacturers who manufactured the types A, B, C and D sets, as referred to in your last answer.

A. The National Electrical Supply Company, Washington, D. C.; the Electrical Industries Manufacturing Company and the Foote-Pierson Company, both of New York City; the American Radio and Research Corporation, Medford, Mass.; the General Electric Company, Schenectady, N. Y., and others that I do not now recall.

Q. 7. Referring to the receiving sets of the Atlantic Communication Company, mentioned on printed pages 1116 and 1117, and elsewhere in the record, what types of sets were furnished to the Signal Corps by that Company?

A. The same types of sets as had previously been furnished by the Telefunken Company, except that the Atlantic Company did not furnish any radio wagon sets.

Q. 8. Please designate the types of sets supplied by the Atlantic Communication Company?

A. These were station and ship sets, types E-4, E-5 and GAHU.

Q. 9. Referring now to the Telefunken Company's receiving sets mentioned on printed page 1119 and elsewhere, what types did they furnish to the Signal Corps?

A. Type GEK-2 in the radio wagon sets and also the station and ship sets, types E-4, E-5 and GAHU.

Q. 10. What were the general circuit arrangements of these Telefunken and Atlantic Communication Companies' receiving sets?

A. The circuits of the Telefunken and Atlantic Companies' sets were the same, in general, as the types A and B which, as I stated in an earlier answer, I had designed.

There were two tuned circuits inductively coupled by [fol. 1124] an oscillation transformer with variable coupling and provided with crystal detectors and high impedance or high resistance telephones. The primary circuit consisted of the antenna, an adjustable or variable part of the inductance or primary coil of the oscillation transformer, a variable condenser put either in shunt or in series with this inductance by means of a switch, or else a series condenser which could be put into circuit or cut out of circuit by a switch, and the ground or counterpoise. The coupling between the circuits was varied by moving the secondary coil of the oscillation transformer toward, or away from, the primary coil. The secondary circuit consisted of the secondary coil of the oscillation transformer, the crystal detector and a telephone or stopping condenser, all in series, and having the high resistance telephones in shunt to the condenser. The secondary coil was adjustable in steps, either by a variable switch arm moving over a set of contacts connected to different points on the coil, or else by a plug which could be inserted in any desired one of several sockets that likewise were connected to several points on the secondary coil.

Q. 11. How were these sets mentioned in your last answer adjusted or tuned to the required wave length?

A. The primary circuit was tuned either by changes of inductance by small steps, or by the variable condenser, or by both changes of inductance and changes of variable condenser. The secondary circuit was tuned by steps of inductance in the secondary coil, which coil had both inductance and distributed capacity. The tuning in the secondary by means of steps of inductance and distributed capacity was broader than when a variable condenser was used in the secondary circuit so that, at any one secondary contact, the circuit was really tuned not to a single wave length, but a certain range or band of wave lengths. Thus the first contact or socket would be tuned to and give a substantially equal response to wave lengths say between

300 and 450 meters and at the second contact between 450 meters and 700 meters, and at the third contact from 700 meters to 1200 meters, and so forth.

Q. 12. Will you please explain how the kinds of coils used in the secondary circuit permitted tuning through inductance and distributed capacity, referring to the Signal Corps sets types A and B, mentioned by you in your previous answers?

A. If a single layer cylindrical coil is wound to a certain number of turns and if a variable condenser is connected to the terminals of this coil, and if this circuit is provided with a detector and telephones, this circuit can be tuned to some given wave length. If now, the number of turns in the coil is progressively increased, then, the wave length remaining constant, it will be found that the variable condenser will have to be progressively decreased in capacity. If again, the number of turns in the coil is further increased, a point will be reached at which no variable condenser at all is necessary to tune the circuit to the given wave length; in fact, the variable condenser can be entirely removed and the circuit will be tuned to the given wave length. Under these circumstances this coil has not only inductance, but also a distributed capacity and such a coil, when connected to a suitable detector, can be tuned broadly [fol. 1125] to certain ranges or bands of wave lengths, as I have previously mentioned.

If contact should be made at points along this coil say at every fifty turns, it will be found that at each one of these contacts the circuit will be tuned to a different band of wave lengths. If, instead of making contact at a certain number of points, a sliding or continuously variable contact is made, then there will be a continuous tuning or adjustment to all the wave lengths within the range of the coil. The method of separate contacts was the method used in the Telefunken, Atlantic Communication, and Signal Corps sets types A and B. The method of the continuous adjustment is that used, for example, in the Foote-Pierson set, wherein the so-called double-slide tuning coil is used.

Q. 13. You have stated that the secondary coil can be tuned to a desired wave length through the inductance and distributed capacity. Can you refer to any literature indicating that this fact is recognized in the radio art?

A. Yes. In "Circular of the Bureau of Standards", No. 74, Radio Instruments and Measurements, Government

Printing Office 1918, pages 62 and 63, Section 19, "Capacity of Inductance Coils", I find the following:

"19. Capacity of Inductance Coils

"The small capacities between the turns of a coil are of such importance in radio design and measurements that a coil can seldom be regarded as a pure inductance. The effect of this distributed capacity is ordinarily negligible at low frequencies, but it modifies greatly the behavior of a coil at radio frequencies. For most purposes a coil can be considered as an inductance with a small capacity in parallel as shown in Fig. 45. This fictitious equivalent capacity is called the capacity of the coil. Investigations have shown that in ordinary coils its magnitude does not vary with frequency. Thus a coil may in itself constitute a complete oscillating circuit even when the ends of the coil are open."

In the 1924 edition of the same Circular, I find substantially the same description of the capacity of inductance coils on pages 62 and 63, which I will not read.

In "Robison's Manual of Radio Telegraphy and Telephony for Use of Naval Radiomen" by Admiral S. S. Robison and revised by Commander S. C. Hooper, both U. S. Navy, 6th Revised Edition, published in 1924, on pages 337 and 338, I find the following:

"Distributed Capacity of Inductance Coils

"All types of inductance coils possess capacity in addition to the inductance of the coil. This capacity is composed of a number of capacities which exist between turns of wire on the coil, between the ends, between taps or binding posts on the coil, or between the high-potential end of the coil and the walls of the room, or grounded bodies.

"The capacity of an inductance coil is called the "Distributed Capacity C_0 of the coil."

[fol. 1126] (There is now omitted the rest of this paragraph.)

Continuing with the next paragraph, I find:

"The distributed capacity of a coil cannot be ignored when the coil is used in a radio-frequency circuit, nor can the coil be considered as a pure inductance, but must be

treated as if it were an inductance with a small capacity across its terminals. Each coil, therefore, has a definite resonant frequency even when nothing is connected across its terminals, this resonant frequency being determined by the pure inductance L and the distributed capacity C_0. This is shown, figure 218, where the distributed capacity can be considered as a capacity C_0 across the whole coil."

I omit the following short paragraph.

Mr. Vaill: Counsel for claimant offers in evidence a photostat print of the pages from the Circular of the Bureau of Standards, No. 74, referred to by the witness, including the diagram referred to in the quotation in the last answer as "Fig. 45" and requests that the same be marked "Claimant's Exhibit No. 203".

(Said exhibit marked as requested.)

Q. 14. According to your experience with these sets concerning which you have been testifying, what if any advantage does the presence of the inductance and distributed capacity have in tuning these sets?

A. It permits the usual variable secondary condenser to be omitted, thus economizing space and doing away with an otherwise additional adjustment. In field and portable sets this permits of quicker tuning of the set and a more prompt reception of the incoming signals or message.

It has the additional advantage which I have stated in my previous answers, of providing a circuit that is broadly tuned, rather than sharply tuned, and this is one advantage in the quick picking-up of signals which is to be considered as included in the first part of my answer.

Q. 15. According to your experience, how do you know that the secondary circuit of the Telefunken type GEK 2 receiver was tuned by means of the inductance and distributed capacity?

A. One such set had been returned to Washington for repair and general examination, and during this time I tested and measured the secondary circuit and found that it was tuned by inductance and distributed capacity by measuring the wave length at each of the six contacts. The secondary circuit in this set consisted of the secondary coil of the oscillation transformer, the crystal detector, and a stopping condenser, all in series with two pairs of telephones

that could be connected in shunt to the condenser. A variable switch-arm made contact at any desired one of these six contacts. At each one of these contacts there was a small tab or marker giving the range or band of wave lengths to which the circuit was thus tuned at the contact in question. I measured the natural wave length at each of these six contacts and found that it was in general approximately at the middle of the band or range of wave lengths marked at each tab.

[fol. 1127] Q. 16. Do you know whether or not the Telefunken Company has ever issued any instructions as to how to use this type GEK-2 set?

A. Yes, I know that they issued a set of instructions for tuning and operating this set as a part of the instructions for tuning and operating the Signal Corps radio wagon set, of which this receiver was a part.

Q. 17. Can you produce a copy of such instructions?

A. Yes, I produce them herewith.

Q. 18. Will you please point out in these instructions that you have produced any sentence or other matter which is in accordance with your testimony in answer to Q. 15?

A. The instructions which I have produced are for a radio wagon set with a transmitter and a receiver and are entitled "Instructions for Operating Telefunken Wireless Telegraph Field Wagon Set Supplied on Signal Corps Order #9648." On Sheets 3 and 4 of these Wagon Set instructions, I find the following:

"Receiver

• • • "To receive, close the large double pole switch at the top of the receiver.

The plug holes marked with Roman numbers (at the right on the receiver) are connected to taps on the aerial or primary coil.

The wave range on this coil is approximately as follows with a proper aerial."

I omit a short table.

Continuing to quote:

"The turns on the detector or loose coupling coil are variable by means of the switch located on its top, the wave range for each tap being marked.

Either of the two detectors can be used by means of the switch located between them.

For receiving a signal of a known wave-length, the following procedure can be recommended:

1. Use tight coupling.
2. Plug in on the aerial coil.
3. Set the switch on the detector coil at about "λ = 500/1000".
3. Set the switch on the detector coil at about '500-1000'.
4. Turn the condenser very slowly over the entire scale.
5. Change the plug on aerial coil and repeat No. 4. When signals are finally heard, the coupling and the position of the switch on the detector coil are varied until the best results are obtained."

I omit the note of six lines at the bottom of page 4.

Q. 19. Will you please state the source from which these instruction sheets were obtained?

A. I asked for and received the instruction sheets which I have produced, from the late Mr. Richard Pfund, at the time when he was the representative of the Telefunken Company and I note that on the back of each sheet there occurs the following:

[fol. 1128] "The Telefunken Wireless Telegraph Company of the United States,

111 Broadway—New York, N. Y."

This is a marking put on by a rubber stamp and each sheet was so stamped when I received them from Mr. Pfund.

Q. 20. Have these sheets, which I note are in the form of blueprints, been continuously in your possession since they were given to you by Mr. Pfund?

A. Yes.

Mr. Vaill: Counsel for claimant offers in evidence a photostat print of the sheets of the Telefunken Company instructions produced by the witness, consisting of four sheets of reproductions of typewritten matter and two sheets of diagrammatic drawings, and requests that the same be marked "Claimant's Exhibit No. 204".

(The said exhibit marked as requested.)

Mr. Vaill: Counsel for claimant also offers in evidence a photostat print of pages 337 and 338 of the "Manual of Radio Telegraphy and Telephony" referred to by the witness in his answer to Q. 13, and requests that the same be marked "Claimant's Exhibit No. 205."

(Said exhibit marked as requested.)

Q. 21. Have you found the same or similar instructions for the operation of this radio wagon set of the Telefunken Company in other publications?

A. Yes. In "Plaintiff's Exhibit No. 90, 'Radio Telegraphy 1914'", pages 91 to 93, inclusive; in "Plaintiff's Exhibit No. 91, 'Radio Telegraphy 1915'", pages 92 to 94, inclusive; and in "Plaintiff's Exhibit No. 92, 'Radio Telegraphy'", date not given on the exhibit marking but noted to be from the publication "October, 1916", pages 93 to 95, inclusive; I find the set of instructions similar to that which I have produced in the blueprints "Claimant's Exhibit No. 204".

Q. 22. What is the basis of your statement that the secondary circuits of the type E-4, E-5 and GAHU sets were tuned by changes in inductance and distributed capacity?

A. Sets of these three types had been purchased both by the Signal Corps and by the Navy Department and, on various occasions, were available for use, test and measurement in Washington. On these various occasions I measured and tested the secondary circuits of these receivers. I found them tuned circuits, being so tunable by inductance and distributed capacity.

Q. 23. Why did you have occasion to make the measurements of wave length of the secondary circuits of the Telefunken Company receivers types GEK-2, E-4, E-5 and GAHU?

A. For two reasons; the first was that it was a part of my duty to know the various types, connections and methods of tuning, and methods of using the Signal Corps sets and, in general, the sets of that time; the second reason was that while designing Signal Corps sets types A and B, I planned to use a secondary circuit that was to be tuned by inductance and distributed capacity. During the course of this work there was some discussion in the Signal Corps as to whether or not this method of tuning could be used; al- [fol. 1129] though I knew that the Telefunken sets had

secondary circuits that were tuned by inductance and distributed capacity for different wave lengths by the suitable selection of the contact points along the secondary coil, there were some men who believed that this choice of contact was made for some purely mechanical reason and not for any electrical reason. And in order to confirm the facts which I had noted in the design of these various sets, I proceeded to measure and test the secondary circuits of all of these types of receivers.

In every case I found that they confirmed my belief that these secondary circuits were thus tuned by inductance and distributed capacity.

Q. 24. What knowledge have you of instruction sheets issued by the Telefunken Company relating to receiving sets of the type E-4, E-5 and GAHU?

A. There were instruction sheets issued by the Telefunken Company for the operation of these sets, including circuit drawings, and so forth.

Q. 25. Can you produce such sheets and, if so, please state the source from which you obtained them?

A. I can produce some parts of these instructions, which I hand you herewith. These instructions were obtained by me from Mr. Pfund of the Telefunken Company, during the last of 1911 or the early part of 1912. The sheets have been continuously in my possession ever since.

I may add that the sheets in question refer to the receiver type GAHU, not specifically to E-4 and E-5; however, these latter two sets had circuit connections practically the same as GAHU.

Mr. Vaill: Counsel for claimant offers in evidence the six photostatic prints produced by the witness in answer to the last question, and requests that the same be marked "Claimant's Exhibit No. 206."

(The exhibit is marked as requested.)

Q. 26. Will you please point out in these sheets you have produced, "Claimant's Exhibit No. 206", anything that confirms your testimony as to the operation and tuning of this GAHU type set?

A. On the second sheet, No. 167, there is, on the right hand third of this sheet, a circuit diagram of the GAHU receiver. The primary circuit is shown as consisting of the antenna, a variable inductance and the ground, all con-

nected in series, and a variable condenser, which may be connected either in series or in shunt to the primary variable inductance. Thus the primary circuit can be tuned by changes in inductance, or variable condenser, or both. There are two secondary circuits shown on this sheet, one of which is indicated by an arrow by the words "Detector Coil" and the other, or alternative secondary circuit is indicated just below, and to the right of the other, by an arrow with the words "Secondary Coil". The latter secondary circuit, to-wit, the one marked "Secondary Coil", is tuned both by a variable inductance and a variable condenser and is not the type of circuit to which I have referred mostly in my previous answers in describing secondary tuning by inductance and distributed capacity. The secondary circuit to which I have repeatedly referred, with inductance and distributed capacity, is the one shown marked with the [fol. 1130] words "Detector Coil". This secondary circuit is seen to consist of a variable inductance, either one of two detectors and a telephone condenser, all connected in series with one or two pairs of telephones in shunt to the condenser.

Referring to sheet No. 162A the same two secondary circuits are shown on a somewhat enlarged scale; on these two sheets the secondary circuit diagram shows connection is made by an arrow resting on one of the turns of the secondary inductance. This is the conventional way of indicating a variable inductance.

Referring now to the left hand side of sheet 162A and near the top and center of this part, is seen an arrow marked "Sec. Coil" and on the lower parts of this secondary coil are indicated six holes, three on one side and three on the other side of the center line, and to two of these holes there is indicated a line with an arrow, thus indicating in another slightly different manner that there are six holes for the contacts, and that contact may be made at any one of these six holes of the secondary coil. From my knowledge of this set and its actual practical use, I know that the variable contacts shown in the "Detector Coil" circuit of sheets 167 and 162A were really sockets which were connected to six different points on the secondary coil, and that the variable contact on these sheets was actually a plug-connection at the end of a flexible wire. Referring now to the last of the unnumbered sheets showing a receiving set, which I recognize as being type GAHU, I recognize the coil which

is shown lying at an angle with the horizontal line, as being the "Detector Coil" which I referred to on the other sheets of this exhibit. On the upper side of this coil, and at the left, near the edge, can be seen a short piece of the flexible wire and the plug for making the variable contact on this coil; and both on the upper and lower edges of the frame of this coil can be seen three, at least, of the variable sockets previously mentioned in this answer. In other words, I recognize that the secondary circuit of this receiver as being one tuned by inductance and distributed capacity and that there are six contacts on this coil, made by plug and socket, covering six adjacent bands or ranges of wave length.

Q. 27. Can you produce instruction sheets relating to type E-4 and E-5 sets, and if not, for what reason?

A. No, I cannot produce these sheets, for the reason that although both sets of instructions for E-4 and E-5 were given to me by Mr. Pfund, together with those for GAHU, I have been unable to find these sheets in my personal files from which I drew the sheets included in "Claimant's Exhibit No. 206".

Q. 28. Which, if any, of the sets of the Atlantic Communication Company were capable of having the secondary circuits tuned by changes in inductance and distributed capacity?

A. The same sets as had been previously furnished by the Telefunken Company, to-wit, E-4, E-5 and GAHU. By this answer I mean the same kinds of sets.

Q. 29. Will you please describe the general circuit arrangement and the manner in which the secondary circuit was tuned, as to the Signal Corps pack sets 1915 type, re- [fol. 1131] ferred to by Mr. Loftin on page 1116 of the printed record?

A. This set is more correctly known as the type C receiving set. I may add at this point that there was a later and slightly improved set of the same kind that was known as type D receiving set; the circuit arrangements of the two sets are practically the same, and a description of type C will really suffice for both sets.

Type C set has two tuned and coupled circuits provided with crystal detector and high-resistance telephones. There are two kinds of connections provided for this set, one for the shorter wave lengths and another kind for the longer wave lengths.

Referring only to the shorter wave lengths, the primary circuit consisted of the antenna, a variable part of the primary inductance of the oscillation transformer and the ground or counterpoise. This circuit was tuned by means of two variable switch-arms, one making contact on any one of twenty-four contacts having large changes or steps in inductance, and the other making contact on any one of twenty-four contacts making the small changes in inductance in between the large changes. The secondary circuit was coupled to the primary circuit by means of two condensers, and for this reason this type of coupling has long been known in the art as a "condenser coupling". The secondary circuit consists of the secondary inductance coil of the oscillation transformer, the crystal detector, the stopping condenser, all in series, and having the telephones in shunt with the condenser. This secondary coil was designed to have inductance and distributed capacity similar to that described in types A and B of the Signal Corps sets, and others mentioned in my testimony, and was tapped at twenty-four points along its turns, thus permitting tuning by inductance and distributed capacity to twenty-four adjacent bands or ranges of wave lengths.

Referring now only to the longer wave lengths, change was made by a switch to another kind of connection. The primary circuit and its method of tuning is the same as that for the shorter wave lengths. The secondary circuit is now directly coupled to the primary or directly-connected, as it is sometimes known, using the auto-transformer type of circuit, in which the ratio of turns is one-to-one. The secondary circuit now consists of the same turns as are in the primary circuit, in series with the two coupling condensers, the telephone condenser, and the detector and telephone in shunt to each other. The secondary circuit then has inductance and some distributed capacity which is in series with three other local capacities and the telephones in shunt to the detector. The secondary circuit is thus tuned at the same time that the primary is tuned, and by the same means; that is, the two variable switch-arms.

Q. 30. What circumstances led up to the construction where the kind of connection at long wave lengths was different from that at short wave lengths?

A. When the condenser type of coupling between the primary and secondary circuits was extended to the longer

wave lengths of this set, it was found that such a set was somewhat inefficient. For this reason an effort was made to design, for the longer wave lengths, a magnetically coupled [fol. 1132] set. Thus, at the shorter wave lengths the circuits would be condenser coupled and at the longer wave lengths magnetically coupled. During the comparisons between the condenser coupled and the magnetically coupled circuits at the longer wave lengths, it was found as a matter of experimental discovery, that the direct-connected circuits which I have just described, were more efficient than either the condenser coupled or magnetically coupled circuits within the space allotted for this receiving set. It was for this reason that the directly-connected type of set which I have just described was finally adopted for both the type C and type D receiving sets.

Q. 31. Can you refer to any exhibits in this case which confirm your understanding of the circuit connections of the type C set which you have referred to in your preceding answers?

A. Yes. I refer to "Plaintiff's Exhibit No. 91", page 119 and "Plaintiff's Exhibit No. 92", page 125. These two pages are apparently identical, and in the upper half of both there are the circuit connections for the short wave lengths which I have described, and in the lower half the circuit connections for the longer wave lengths, as I have described.

Q. 32. Now referring to the Foote-Pierson Company type of Signal Corps pack sets, will you please describe the general circuit arrangements and the method of tuning the secondary circuit of this set?

A. This set is of the type known as a "double slide tuning coil set" and consists of two tuned circuits that are directly-connected or directly coupled. The primary circuit consisted of the antenna, a variable or adjusted part of the inductance coil and the ground or counterpoise, all in series. The secondary circuit is directly coupled by the auto-transformer type of connections, in which the ratio of the turns is variable. The secondary circuit consisted of an adjustable or variable part of the inductance coil in series with a crystal detector and a stopping condenser, and having the telephones and potentiometer in shunt to this condenser. By using a large number of turns in the secondary circuit, there was provided inductance and distributed capacity such that the secondary circuit could be tuned to a continuous band or range of wave lengths. This tuning by

inductance and distributed capacity was limited to a narrower band or range than the later types of Signal Corps sets which I have described, to-wit, types A and B.

I may add that this early type of set, with its single inductance coil, is the most rugged and compact type of set that could be built, and it was for this reason that it was used in the early Signal Corps field or pack sets. Later it was replaced by sets using the oscillation transformer, which were more useful and tunable over a wider range or band of wave lengths.

Q. 33. Referring again to the receiving sets of the Atlantic Communication Company and to the Signal Corps pack sets of 1915, which you have also designated as type C sets, what facts, within your experience, have a bearing upon the following statement made by defendant's witness Loftin, found on page 1116 of Volume 3 of the Printed Record beginning just above the middle of the page:

[fol. 1133] "In some of the above types I find that at the receiving station the secondary circuit is of the type known as 'untuned'. That is, there is no provision made for varying the time period of the secondary of the receiving circuit to correspond to the frequency of the incoming signal, the receiver depending upon tuning the primary or open circuit only. Of the above types the following have untuned secondary circuits at the receiver.

"Atlantic Communication Co. type.
"Signal Corps pack set, 1915 type."

A. From my experience with, and knowledge of, these sets, as amply described in my previous testimony, I know that the statement is wrong in that the secondary circuits are tuned, there is a provision for varying the time period, and that the receiver does not depend only on the tuning of the primary circuit.

Q. 34. Will you also refer to the following statement made by defendant's witness Loftin, as found on page 1117 of the Printed Record, near the top of the page, regarding the same sets mentioned in the previous question, and state what facts, if any, within your experience, have a bearing on said statement:

"I have also named two types in the above group which have a secondary circuit at the receiving station which is

not tunable. That is, the secondary circuit is designed to remain fixed in frequency or natural time period to be used with a primary or absorbing circuit which is tunable through a wide range of natural time periods."

A. From my experience with, and knowledge of, these sets, I know that the statement is wrong, in that the secondary circuits of these two sets are tunable, and they are not designed to remain fixed in frequency.

Q. 35. Will you please refer to the following statement of defendant's witness Loftin, found on page 1117 of the Printed Record, and state what facts, if any, within your experience, have a bearing on said statement; particularly as concerns the Signal Corps pack set of 1915:

"In the 'long wave' type illustrated in plaintiff's Exhibit 91, the secondary circuit is in no wise tunable," * * *

A. From my experience with, and knowledge of, this set, as amply described in my previous answers, I know that this statement is wrong, in that the secondary circuit is tunable.

Q. 36. Please refer to the following statement by defendant's witness Loftin, found on page 1119 of the Printed Record and state what facts, if any, within your experience, have a bearing thereon:

"I also find that in the following types of the group now under discussion, the receiving stations have untunable secondary circuits:

"Telefunken type.

"Foote-Pierson type.

"These two types having untunable secondary circuits at the receiving station are therefore subject to the same com- [fol. 1134] ments of mine in connection with the previous group, wherein a number of receivers had tunable secondary circuits."

A. From my experience with, and knowledge of, these two kinds of sets, as amply shown in my previous answers, I know that the statement is wrong, in that both types of sets have tunable secondary circuits.

Q. 37. In addition to the Signal Corps sets and the sets of the Telefunken and Atlantic Communication Companies,

to which you have referred in your previous answers as having secondary circuits which were tunable and were actually tuned to the incoming signals, did the Signal Corps have sets in which the secondary was untuned and untunable?

A. In my experience in Signal Corps work, which has covered a period of at least a dozen years and more, I know of no receiving set in which the secondary circuit was untuned and untunable.

I may add that there was one, and only one, set in which the secondary circuit was untunable in the sense that there was no variation provided for changing the wave lengths. This occurred in the 1909 Telefunken two-trunk pack set. Part of this set had been returned to Washington for a general overhauling and I examined and tested the secondary circuit of this set. The secondary circuit consisted of an inductance coil of fixed inductance as the secondary of an oscillation transformer, crystal detector, and stopping condenser, all in series, and having the telephones in shunt to the condenser. I measured the natural wave length of this secondary circuit and found it to be slightly over 300 meters and also found that the most useful range of wave lengths of the transmitting part of the set was from 250 to a little less than 400 meters. In other words, the secondary circuit of this receiver was tuned by inductance and distributed capacity to a single band of wave lengths approximately within the center of the most useful band of transmitting wave lengths. Under these circumstances this secondary circuit is not an untuned circuit, but is tuned by fixed adjustments to the best wave lengths of a transmitter of another pack set with which it is in communication.

Q. 38. Will you please refer to "Claimant's Exhibit No. 204" which you produced, and which is entitled "Instruction for Operating Telefunken Wireless Telegraph Field Wagon Set Supplied on Signal Corps Order No. 9648" and state whether or not you ever saw and operated such a set?

A. I saw the Field Radio Wagon Set referred to at Fort Myer, Virginia, in the late Fall of 1909, just before the set was shipped to the West.

The receiving set was provided with two pairs of telephones and the Signal Corps operator in charge wore one pair and I wore the other, and I tested this receiving set with him, listening to such stations as could be heard at that time.

Later the Signal Corps operator demonstrated for me the operation of the engine and the transmitter, but I did not, personally, operate either part.

Q. 39. Were the instruction sheets for the corresponding instructions of "Claimant's Exhibit No. 204" adopted by the Signal Corps as evidenced by publications referring to [fol. 1135] Signal Corps work; if so, will you kindly refer to them?

A. Yes, I refer to "Plaintiff's Exhibit No. 90", pages 91 to 93, inclusive, which is "Circular No. 1, Office of the Chief Signal Officer, 1914, Radio Telegraphy U. S. Signal Corps 1914". I refer also to "Plaintiff's Exhibit No. 91", pages 92 to 94, inclusive, which is practically a later edition of "Circular No. 1", being dated May, 1915. I further refer to "Plaintiff's Exhibit No. 92", pages 93 to 95, inclusive, which is entitled "War Department Office of the Chief Signal Officer, 1916 Radio Telegraphy U. S. Signal Corps Revised October, 1916".

Q. 40. Will you please refer to "Claimant's Exhibit No. 206", which was produced by you, comprising "Diagrams and Instructions for Type 0.5 T.K. (1 KW) Telefunken Set" and state whether or not you ever saw and operated a set similar to the one illustrated in said exhibit?

A. Yes, I saw this set, or the same type of set, in the Coast Artillery Station at Fort Monroe, Virginia, in the Summer of 1912, and I operated both the receiving part and the transmitting part.

Q. 41. In operating this set, to what extent did you vary the adjustable portions to tune to the wave lengths desired?

A. I simply followed the Telefunken Company's instructions as contained on sheet 167 of "Claimant's Exhibit No. 206", contained within the insert entitled

"Directions for Operating

"1. Set the plugs on primary inductance at points indicated on drawing =152.

2. This will result in a certain definite wave length or period in the primary circuit and all that remains to be done is to put the aerial circuit in resonance with the primary circuit by means of the aerial variometer (V).

3. This is done by varying the number of turns and relative position of coils X and Y both of which turn about axis C.

4. To reduce the energy (range) of the transmitter reduce the number of operative gaps in the spark-gap (G) at the same time reducing the generator voltage.

5. As the clearest signals are obtained with a certain definite generator voltage at the terminals of the spark-gap (G) great care must be taken to neither make this voltage too high (which would tend to produce an arc) or too low (which results in imperfect signals)."

I did not use the instructions of paragraph 6, which only concerns the maintenance of the set.

Q. 42. Testimony has been given in this case by defendant's witnesses to the effect that the primary and secondary or antenna circuits of a quenched spark transmitter are not tuned to resonance, but are slightly detuned. Will you please state your experience in this regard as concerns any of the Signal Corps, Navy or Coast Artillery sets which you have seen or operated? You may also refer to any printed matter on this subject which may contain instructions for the operation of such sets.

A. I know of no such detuning in any of the sets men- [fol. 1136] tioned in the previous question. I have made hundreds of measurements of the wave lengths of quenched spark transmitters and I have never noted this detuning.

Referring specifically to the matter of instructions concerning detuning, I refer to the book "Robison's Manual of Radio Telegraphy and Telephony for Use of Naval Radiomen" by Admiral Robison and Commander Hooper, both U. S. Navy, Sixth Revised Edition, 1924, pages 539 and 540.

I refer to the following:

"*It is very important* that (a) both circuits be in resonance; (b) proper voltage for the number of gaps used be supplied; (c) best coupling exist between the primary and secondary. *In no case should the antenna circuit be detuned* (thrown out of resonance with the primary), because (a) there will be a reaction between the two circuits and two waves will be radiated which can be found on a wavemeter coupled to the antenna circuit; (b) the gap will not quench properly, thereby heating, and power will be retransferred from the antenna to the primary, and back again to the antenna, and the decrement will be increased due to this retransfer of power. In other words, the utility and efficiency of the quenched-spark system will be entirely lost.

"Whenever it is desired to transmit on *maximum power*, special adjustments should always be made with a view to obtaining maximum output and maximum efficiency, thereby reducing injury to the transmitter. The voltage number of gaps, coupling, and tuning of the antenna circuit to the primary circuit should be carefully adjusted" (italicized matter is in heavy type in original text.)

* * * * * * *

Q. 43. In the measurement of the wave lengths of quenched gap transmitters by you in connection with the Signal Corps work, to what extent did you find that detuning between the primary and secondary circuits of the transmitter was necessary?

A. I have made hundreds of measurements of wave lengths of quenched spark transmitters and have never noted that there was any detuning, or that detuning was necessary; in other words, the circuits were in resonance.

* * * * * * *

[fol. 1137] Cross-examination.

By Mr. Edwards:

X Q. 44. In your direct examination you referred to certain Telefunken sets and certain Signal Corps sets to which reference was made by Mr. Loftin in his testimony at printed pages 1116 to 1119, inclusive. Do you understand that Mr. Loftin was referring to sets previously described by claimant's witness Waterman in this case?

A. Yes, in part.

X Q. 45. Do you understand that he was referring to any sets other than those described by Mr. Waterman?

A. Without having read the testimony of other claimant's witnesses for a very considerable length of time, it is my understanding that the sets included at least some of those mentioned by other witnesses.

X Q. 46. Are the sets referred to by you in your direct examination, the same sets as the ones referred to by Mr. Waterman?

A. In part, yes.

X Q. 47. Have you made reference to any other sets or types of apparatus than those referred to by Mr. Waterman?

A. I have referred to types of sets such as I remembered from witness Waterman and others, and, without having read Mr. Waterman's testimony for a long time, I consider that the types mentioned by Mr. Waterman include those of the other witnesses, and with this understanding, I consider the types mentioned by Mr. Waterman as including also the types mentioned by the other witnesses.

X Q. 48. Which, if any, of the types referred to by you, were referred to by Mr. Waterman?

A. Without having read Mr. Waterman's testimony for a long time, I consider that I have included the same types as were included by Mr. Waterman.

X Q. 49. Referring to the Telefunken Company's apparatus, specified by you in answer to Q. 9, will you state wherein any of the types mentioned by you differ from the schematic representation of circuits "Plaintiff's Exhibit No. 79", introduced by Mr. Waterman and printed opposite page 180 of the Printed Record?

A. The circuits mentioned in "Plaintiff's Exhibit No. 79", marked "E-4 Receiver" are of the same type as in the Telefunken sets in question.

X Q. 50. Do you mean that the receivers of all of the Telefunken sets referred to in your answer to Q. 9, were like the type E-4 receiver illustrated in "Plaintiff's Exhibit No. 79"?

A. Of the same general type.

X Q. 51. You will note that in his exhibit "No. 79", Mr. Waterman illustrates the E-5 receiver as having a condenser h', whereas said condenser is not present in the E-4 receiver as illustrated by Mr. Waterman. Do you understand that the types GEK-2, E-5 and GAHU, referred to in your answer to Q. 9, did, or did not, have this condenser?

A. As stated in my direct examination, types E-5 and [fol. 1138] GAHU had two types of secondary receiving circuits, one type with a secondary tuning condenser as h', and the other a different secondary coil without the tuning condenser; that is, the secondary circuit was therein tuned by means of the inductance and distributed capacity of the secondary coil without the secondary variable tuning condenser.

X Q. 52. Do you mean that some of the GEK-2, E-5, and GAHU receivers had the condenser h' and some did not?

A. The type GEK-2 did not have the secondary variable

tuning condenser h', but as stated in my previous answers, E-5 and GAHU were furnished with two different types of receiving circuits. That is, each set had the equivalent of both E-4 and E-5, as shown in "Plaintiff's Exhibit No. 79".

X Q. 53. Will you explain what you mean by "equivalent" in your last answer?

A. The same general type of circuit, E-5 being tuned by a variable condenser and E-4, not being so tuned.

X Q. 54. Take the case of the E-5 receiver, was that provided with both of the circuits illustrated by Mr. Waterman; that is to say, both of the receiver circuits illustrated by him?

A. Yes, in the sets that I saw.

X Q. 55. Was the condenser h' present in these sets?

A. Yes.

X Q. 56. Will you explain how the set was so arranged that it sometimes used the circuit of the E-5 receiver and sometimes the circuit of the E-4 receiver?

A. One set of coils was used as in E-5, and one other coil for use as in E-4, and the necessary connections were made by plugs and sockets.

X Q. 57. And the set was provided with two different coils j^2 and j^2; is that correct?

A. No, there was a set of coils for j^2 of E-5 and only one coil j^2 for E-4, and it was the coil of j^2 of E-4 that had the band of wave lengths marked by a tab or marker at the several sockets.

X Q. 58. And in the same set there would be present the set of coils and condenser h' for the E-5 hook-up, and another coil, j^2, in the E-4 hook-up, without the condenser h'; is that correct?

A. They would not be present in the sense of being connected into circuit, but were separate units to be into circuit one at a time.

X Q. 59. Then, am I correct in understanding that the type E-5 receivers were provided with two units, one of which had the circuit arrangement as shown in the E-5 receiver of Mr. Waterman's diagram, "Plaintiff's Exhibit No. 79", and the other of which had the circuit of Mr. Waterman's diagram marked "E-4 Receiver" in the same exhibit, and that these units were adapted to be used alternately?

A. Yes.

X Q. 60. And is the same true of the GAHU receiving sets?

A. Yes.

X Q. 61. Referring to your answer to Q. 32, is the Foote-Pierson set there referred to, the same as the one diagrammatically illustrated by Mr. Waterman in his "Plaintiff's Exhibit No. 102" opposite page 196 of the Printed Record?

A. It is the equivalent of that set, with the understanding that the coil in black and the coil in red are actually one and the same coil, and with the further understanding that the coil in black represents the tuning of the primary [fol. 1139] circuit and the coil in red the tuning of the secondary circuit, which in the actual set, was directly coupled as stated in my direct examination. I further note that there is a slight error in the green circuit in the diagram, wherein the condenser in the green circuit has evidently been misplaced in the reproduction.

X Q. 62. Will you explain how this condenser has been misplaced and where it should be?

A. Short circuit condenser in green as it is shown, insert another condenser in red just below the detector marked in black with T, change the green line wherein the condenser in green has been short-circuited to the point just underneath the base of the detector; this will correct the minor mistake which I have pointed out.

X Q. 63. In your answer to Q. 4, and in other parts of your deposition, you refer to later types, A, B, C and D of receivers used by the Signal Corps; are they the same types that are referred to by Mr. Waterman in his answer to Q. 23, at page 203 of the Printed Record?

A. In the first line of the answer as printed on page 203, I note an apparent mistake in printing, in that it reads "model L913"; I assume this means "1913" and, if so, the 1913 and 1914 receiving sets are the same as type B referred to in my previous answers. In answering this question I assume that only these two receiving sets are inquired about and, if so, my answer is as already given.

Q. 64. Mr. Waterman's answer to Q. 23, you will note, states that this set which you identify as "type B" is the same in all substantial particulars as the National Electric Supply Company set illustrated by him schematically in "Plaintiff's Exhibit No. 80", opposite page 192 of the

Printed Record; is this in accordance with your recollection?

A. Types A and B are like the receiving station of "Plaintiff's Exhibit No. 80", opposite page 192.

X Q. 65. How did the types C and D compare with the set illustrated in "Plaintiff's Exhibit No. 91", opposite page 204 of the Printed Record?

A. Types C and D are correctly represented by "Plaintiff's Exhibit No. 91", opposite page 204.

X Q. 66. To what band of frequencies were the type E-4 Telefunken receivers, the Foote-Pierson receiver illustrated in "Plaintiff's Exhibit No. 102" and the long wave length types C and D Signal Corps receivers tuned respectively?

A. I do not now exactly recall the band of E-4, but it was about 300 to at least 2400 meters. The Foote-Pierson receiver was tuned to a very much narrower band, from wave lengths of 250, or slightly more, to nearly 400 meters, and for types C and D from about 1,000 to a little over 2,000 meters.

X Q. 67. Do you not consider that if the long wave length type C receiver is receiving wave lengths of 500 meters, that the receiving circuit tuned to from 1,000 to 2,000 meters would be out of tune with the incoming frequencies?

A. Your question presupposes a condition never realized in practice because, for short waves, as 500, the long-wave circuit arrangement was never used.

X Q. 68. Please disregard the matter of whether or not this condition would be realized in practice, and with that [fol. 1140] understanding, answer the preceding question.

A. I do not see how I can answer that question, inasmuch as it presupposes a condition which I have never encountered in my experience; that is, I have never attempted to receive a wave length of 500 meters with the circuit arrangement of the long wave circuit.

X Q. 69. If the receiving circuit is tuned to a band of frequencies ranging from 1,000 to 2,000 meters, at what wave length was the circuit most resonant?

A. It would be most resonant to a succession of bands of wave lengths, depending upon where the variable switch-arms made contact; and I cannot now tell the band wave length for each of these various contacts; that would involve at least several hundred combinations.

X Q. 70. If one circuit is tuned to a wave length of 500 meters and another circuit is tuned to a band of frequencies ranging from 1,900 to 2,000 meters, do you consider that they are in resonance?

A. No.

X Q. 71. How close should the frequencies approximate in order to be in resonance, in your opinion?

A. The wave length of one circuit had best be within the band of the other circuit; in some cases the band or range on either side of the first-mentioned band might give very nearly equal results; that would depend, to a considerable extent, on the type of transmitter; thus, if the transmitter is very broadly tuned as to its radiated wave lengths, nearly equal response might be found on two adjacent bands of wave lengths.

X Q. 72. In your direct examination you mentioned having tested certain of these Telefunken sets; did you make any written report of these tests?

A. Yes, although they may have been somewhat informal, being given in a memorandum.

X Q. 73. Were any of these reports of an official nature?

A. All official.

X Q. 74. Were they of such character as could be found in the files of the Signal Corps?

A. Yes.

X Q. 75. To whom were they rendered, and when?

A. Either to the Chief Signal Officer, or to the Officer in Charge, immediately following the tests.

X Q. 76. Do you recall the name of the officer or officers to whom the reports were rendered?

A. Only in part, because there were many officers in charge at different times.

X Q. 77. Were the reports delivered to the Chief Signal Officer in person?

A. No.

X Q. 78. What was the official title of the officer to whom the reports were delivered?

A. They might be according to several different titles as Chief Signal Officer, Assistant to the Chief Signal Officer, Officer in Charge, Signal Corps Laboratory and doubtless, in many cases, simply in the form of a memorandum to lieutenant, captain, major, so and so.

X Q. 79. To what officer did you report during the time that these reports were being made?

A. To several officers, all of whose names it would be difficult now to recall.

X Q. 80. Can you give the names of any of them?

A. Yes. The then Major Squier, now Major-General U. S. Army, retired; Brig.-General Allen, U. S. Army, now [fol. 1141] retired; the then Major Russel, later Major-Gen. Russel, U. S. Army, retired, who has recently died; the then Capt. Wallace, now Colonel Wallace; the then Lieut. Olmstead, now Major Olmstead; the then Capt. Voris, now Colonel Voris; the then Major Saltzman, now Major-Gen. Saltzman, the present Chief Signal Officer of the Army; the then Capt. Black, now Major Black; and many others whom I do not now recall.

X Q. 81. Can you not recall the name of the particular officer, or the time when you reported the results set forth in your answer to Q. 11?

A. To the best of my knowledge it was the then Major Russel, later Major-Gen. Russel.

X Q. 82. Can you reproduce the resonance curves for the wave lengths as set forth in your answer to Q. 11?

A. No, I have no material whereby I could give this information; and I may add that both galvanometer deflections and telephone tests were used in this work, but that no galvanometer measurements were made in the tests when the telephone was the detecting instrument.

X Q. 83. When the telephone was used, did the tests consist in listening in at different wave lengths and determining that there was no observable difference between 300 and 450 meters, 450 and 700 meters and 700 to 1200 meters?

A. There was an observable difference, but so slight that the circuit was considered tunable over the band in question.

X Q. 84. How was this observable difference determined?

A. By two observers listening in and noting the change over the band in question.

X Q. 85. At what frequency was the loudest response heard in each of the band of frequencies mentioned in your answer to Q. 11?

A. In general, about in the middle of the band.

X Q. 86. Was there a marked difference in the response above and below the limits of the respective bands?

A. In some cases yes, and in other cases no; thus in the type D receiver at short wave lengths, there were 30 studs instead of 24, as in type C, it was not always possible to

adjust to the same stud, but it might vary by a stud or two, particularly if the transmitter was broadly tuned.

X Q. 87. Could you not draw resonance curves illustrating approximately your present recollection of the degree of response obtained at each of the contacts as referred to in your answer to Q. 11?

A. No, I couldn't undertake to do it so many years after the time of the tests.

X Q. 88. And these tests were about how many years ago?

A. There were a great many tests, beginning in 1911, and continuing from time to time, until 1914 or 1915.

X Q. 89. Is it not fair to say that your present testimony is merely your recollection, after upwards of ten years, as to the degree of response from each of the settings of contacts referred to in your answer to Q. 11?

A. It is my best recollection, but a recollection that, in some respects, is very vivid; thus type D was an improvement essentially over type C, in that, as the transmitters improved we found it necessary to improve the receivers, and for that reason the number of studs for the short wave connection was increased from 24 to 30.

[fol. 1142] X Q. 90. Can you produce any documentary evidence in support of your recollection as testified to in this case?

A. I have produced "Claimant's Exhibit No. 204", which supports my recollection.

X Q. 91. Can you produce any documentary evidence in support of your recollection as expressed in your answer to Q. 11?

A. "Claimant's Exhibit No. 204" is part of such evidence and also "Claimant's Exhibit No. 206".

X Q. 92. Can you produce any other documentary evidence in support of the statements in your answer to Q. 11?

A. In general it would be contained in "Plaintiff's Exhibits Nos. 90, 91 and 92" which are publications of the Signal Corps.

X Q. 93. Referring to your answer to Q. 11, and assuming that at the third contact the point of greatest response is about midway between 700 and 1200 meters, that is to say, at 950 meters, if the instrument is receiving frequencies of 700 meters, do you consider that the receiving circuit is in resonance with the incoming frequencies?

A. Inasmuch as the tuning in that band is broad, resonance exists over a considerable number of wave lengths

or, at least, approximate resonance and, under the conditions existing in the actual set, the circuits were substantially in resonance.

X Q. 94. I notice that you refer to "approximate resonance" and "substantially in resonance"; can you give us any idea as to how you determine whether two circuits are in approximate or substantial resonance?

A. Referring specifically to these receiving sets, if the secondary circuit gave the same, or nearly the same, intensity of signal over a certain range or band of wave lengths, then, being thus broadly tuned, it would be approximately or substantially in resonance over its band of wave lengths.

X Q. 95. Is it your understanding that with any adjustment of the Telefunken E-4 receiving circuit, the Foote-Pierson pack set, "Plaintiff's Exhibit No. 102", or the long wave length type C receiving set, the product of the inductance and capacitance of the antenna circuit is exactly the same as the product of the inductance and capacitance of the receiving set?

A. In the sets in question, I have never measured the product of the inductance and distributed capacity of the secondary circuit, but I did measure only its wave length and that wave length was not sharply defined, but rather was broad, and for that reason would receive over a range of wave lengths of the primary circuit where the product of the inductance and capacitance was varied over some width of band of wave lengths; in other words, I cannot, categorically, answer your question yes or no.

X Q. 96. Do you wish to be understood as testifying or expressing any recollection of whether or not the product of the inductance and capacitance of the antenna circuit was equal to, or approximately equal to, the product of the inductance and capacitance of the receiving circuit in any of the types referred to in X Q. 95, at all settings of the receiving circuit.

A. As I have stated in my previous answers, I did not measure the inductance and distributed capacity of the secondary circuits of the receivers, but I did measure the wave lengths, and I can only express my answer in terms [fol. 1143] of my experience with these sets by stating that these secondary circuits were in tune broadly, or within a certain band or range of wave lengths, with the incoming signals.

Redirect examination.

By Mr. Vaill:

R. D. Q. 97. Referring to your answer to X Q. 62, will you please consider the circuit connections indicated in "Claimant's Exhibit No. 98", and state whether or not the corrections which you suggest being made in "Plaintiff's Exhibit No. 102" are in accordance with the circuits indicated on "Claimant's Exhibit No. 98"?

A. I intend the correction to "Plaintiff's Exhibit No. 102" to make it the same as the circuit indicated in "Claimant's Exhibit No. 98".

R. D. Q. 98. Referring to Mr. Loftin's testimony on page 1116 of the Printed Record, particularly the part quoted in connection with Q. 33 on your direct examination, will you state whether or not any of the pack sets which you referred to on your direct examination were not included within the said sets referred to by Mr. Loftin?

A. The quotation refers only to "Signal Corps pack set, 1915 type", but in my direct examination I referred to types A and B which, if I understand your question, must be additional to the so-called 1915 type.

R. D. Q. 99. Please state whether or not, according to your recollection, the types A and B sets, just referred to by you, were such sets as mentioned by Mr. Loftin on page 1116 of the Printed Record as "National Electric Supply Company Type, Field Radio Pack Set, Plaintiff's Exhibit 80"?

A. In my answer to X Q. 64 I stated, "Types A and B are like the receiving station of 'Plaintiff's Exhibit No. 80', opposite page 192."

Last Question by the Notary: Do you know of any other matter relative to this claim?

Answer: No.

Deposition closed.

Deposition of Frederick W. Lehr, for Claimant, Taken at New York, N. Y., on the 13th day of October, A. D. 1926

Appearances: Same as before.

First Interrogatory by the Notary: State your name, your occupation, your age and your place of residence,

whether you have any, and if any, what interest, direct or indirect, in the claim which is the subject of inquiry, and whether, and in what degree, you are related to the claimant.

Answer: My name is Frederick W. Lehr; my age is 44 years; my residence is 21 Victory Boulevard, St. George, Staten Island, New York; occupation, with the Radio Cor- [fol. 1144] poration of America; I have no interest, direct or indirect, in this claim, and I am not related in any way to the claimant herein.

Direct examination.

By Mr. Vaill:

Q. 1. Were you ever connected with the United States Navy, and if so, where, and during what period?

A. I was connected with the United States Navy as a Civilian Radio Electrician, at the Norfolk Navy Yard, Virginia, from April, 1917, to July, 1922.

Q. 2. What were your duties at the Norfolk Navy Yard?

A. My duties at the Norfolk Navy Yard were the installation, repairs and calibration of transmitters and receivers on the U. S. war ships.

Q. 3. What experience did you have with open-gap short-wave transmitting sets while connected with the Norfolk Navy Yard during the years 1917 and 1918?

A. My experience with short-wave spark transmitters during the years 1917 and 1918 was the installation of the inter-fleet 126 meter sets which were placed on the war ships to be used with the Grand Fleet in Foreign Waters.

Q. 4. What was the wave length at which these sets you have referred to, were intended to be used?

A. These sets were calibrated to be used with the wave length of 126 meters.

Q. 5. How many of these short-wave transmitting sets did you install or had already been installed on U. S. war ships while you were at the Norfolk Navy Yard?

A. I installed two or three complete transmitters while at the Navy Yard during the years 1917 and 1918, and also made repairs and calibrations to a number of other sets that had been installed previously in other Yards, including the Utah, Nevada, Oklahoma and Arkansas.

Q. 6. To what extent did you have occasion to operate these short-wave transmitting sets installed on United States war ships while at the Norfolk Navy Yard?

A. I had occasion to operate these sets after installation and repairs had been made, as each set had to be calibrated to the wave length of 126 meters; this was done by means of a standard wave meter, and by pressing the key we could then detect if the transmitter was in resonance.

Q. 7. On page 1137 of the Printed Record in this case defendant's witness, Mr. Loftin, states as follows:

"I have in recent years examined the records of purchases of radio apparatus of both the United States Army and the United States Navy since 1910, and while an extremely large number of sets were purchased since that date, particularly during the war, I do not recall a single instance of purchases of the open-gap type in the records which I have examined, and in fact, am familiar with the use of the open-gap type in but a few instances since 1910, these instances being in the case of the battleship division of the United States Fleet which joined the British Fleet in its North Sea operations." • • • "The ships of the American division were promptly equipped with this type of apparatus obtained from the British in order that their communication scheme would conform to that of the fleet which they had joined."

Regarding the sets which you installed on the war ships at the Norfolk Navy Yard, to which you have testified, who provided you with these sets for installation?

A. These transmitters were placed on the floor of the shop and turned over to me to be installed in each case. [fol. 1145] I have no way of determining whether these transmitters were in stock in the Norfolk Navy Yard, or if they had been shipped from some other point for installation at the Yard.

Q. 8. Please state whether or not you saw any inscription or indication that the sets which you installed were obtained from the British Government, or came from England?

• • • • • • •

A. There was no indication, as far as I know, whether these sets had been made or shipped from England.

Q. 9. Can you produce any diagrams relating to the 126 meter transmitting sets that you saw or installed at the Norfolk Navy Yard?

A. Yes, I produce two such diagrams (Reproduced Opposite).

Q. 10. Who made these diagrams, and when?

A. These diagrams were made by myself from the actual apparatus as I was working on this type of transmitter.

Q. 11. At about what time did you make these diagrams?

A. These diagrams were made about 1917 or 1918.

Q. 12. Please state the essential features of the apparatus indicated in these diagrams.

A. The essential feature was the use of a straight-gap enclosed in a wooden air-tight box, and which was provided with a powerful blower and electric motor; the primary inductance consisted of two upright angle copper rods, secured to each side of the gap box; these rods were provided with a cross rod which slipped over the right angle rods, so that the wave length could be adjusted at any point in the primary circuit. This primary circuit was then loosely connected by condensers to a coupling condenser board, which was also made up of small fixed condensers manufactured from mica and tinfoil; this condenser board also contained a variable condenser which was on the order of a pump, by which slight adjustments could be made to the antenna; the antenna loading coil consisted of a spiral tubing about twelve inches in diameter, from which the antenna-period could be adjusted. In the primary power transformer circuit, which consisted of a break-in relay so that signals could be simultaneously sent and received; this circuit also contained a motor generator starting resistances and switches for the adjustment of the primary power circuit.

Q. 13. At what input power were these transmitting sets rated?

A. The rating of these sets was 1 K. W. input.

Q. 14. Did you measure the antenna radiation from these sets and, if so, what did you find it to be?

A. The antenna radiation of the 126 meter set was about three-tenths of an ampere.

Q. 15. Will you please describe a little more fully the variable condenser which you have stated "was on the order of a pump"?

[fol. 1146] A. This condenser was made up of two pieces of brass tubing, one of which was insulated and was made to slide on the inside of the larger tubing, the inner tube being supported on insulated rods, with a handle on the front for the operation or degree of sliding.

Q. 16. Will you please point out and identify by any words you may find, the variable condenser you have just

referred to, as indicated in the diagrams which you have produced?

A. The variable condenser referred to in the diagrams has the wording "Coupler Located in Middle of Board".

Q. 17. Will you also please point out and refer to by any designation you may find, the primary inductance referred to in your answer to Q. 12?

A. The primary inductance on the diagram is referred to as "P. P."

Q. 18. What do the letters "C C" indicate in these diagrams?

A. The letters "C C" are used to designate two mica insulated condensers of a small capacity.

Q. 19. What was the order of the capacity of these condensers which you have referred to as having small capacity?

A. I cannot exactly tell the capacity of these condensers marked on the diagrams as "C C".

Q. 20. Will you please state the effect of the powerful blower and electric motor which you referred to in answer to your Q. 12?

A. This blower was used to cool the gap and to keep the spark steady.

Q. 21. In tuning these short-wave transmitters to the desired wave length, will you please state what you did as actual operations, referring to the parts of the diagrams, if you will, as indicating the adjustments that you made?

A. In tuning this transmitter to 126 meters we would first make adjustments at "P P" on the primary inductance, and then, by holding a standard wave meter within two or three feet at this point, we could determine if this part of the circuit would measure 126 meters; if not, these sliding pieces would be again adjusted until the desired wave length was found; then the antenna would be adjusted on the loading coil and the variable condenser or coupler on the coupling board would be adjusted to maximum radiation on the meter marked "H A" in the diagrams; the wave meter would then again be placed near the antenna and the set again checked for the wave length of 126 meters. The current during this operation being placed in the circuit by the pressing of the sending key, as shown in the circuit. After all adjustments were made, a record of the inches on the primary inductance would be placed on a tuning chart, also the inches of the coupler on the coupling

board and also the number of turns in the antenna loading coil, together with the amount of power used on the input and the amount of radiation in the antenna. These charts were then turned over to the Yard Radio Officer and a copy left on board the vessel.

Q. 22. When these sets were adjusted to a wave length of 126 meters did you find that they radiated waves of any other wave lengths at the same time?

A. My experience in adjusting these sets to 126 meters was that they admitted no harmonics or other wave lengths than the one desired, that being 126 meters.

Q. 23. Referring in the diagrams to the abbreviation "Trans." and to the letters "P" and "S", will you please state the construction of this transformer, as well as the voltage and the periodicity of the current applied thereto?

A. The words "Trans." as noted on the diagram, means [fol. 1147] "Transformer": this transformer was the main power transformer for the complete set; this transformer consisted of a primary and secondary, which are designed on the diagram as "P" and "S". These coils were wound on a closed iron core and the input of primary voltage was rated at 100 volts, the secondary voltage was probably around 12,000 volts. This transformer was enclosed in a wooden box with terminals on the top for connections to the circuit.

Q. 24. Will you please describe a little more fully the parts indicated in these diagrams as "Horn Gap" and "Gap"?

A. The words "Horn Gap" were given this type of gap, due to the fact that all straight gaps resembled a horn. It has no particular bearing on this special gap.

Q. 25. What was the shape and material of the terminals constituting these gaps?

A. These gaps were made up of about three-eighths brass rod with a round copper ball screwed on one end of each rod, one of the rods was fastened by insulation to the inside of the box, while the other worked with an adjustable screw-handle, so that the distance between the gap balls could be adjusted.

Q. 26. On one of these diagrams I notice the words "For Yard Station". Why was this put on the diagram by you?

A. The words "For Yard Station" were used in the case where I had installed one of these sets at the Yard Radio Station, which was located in the Yard, for experimental

purposes. This set was intended to be used with the Fleet, while laying at anchor in Hampton Roads; this transmitter and circuit is the same as was installed on the war ships by me at the Navy Yard.

Q. 27. Did you operate this particular set?

A. I operated this set and checked it for wave length.

Q. 28. To what extent was set installed at the Norfolk Navy Yard, used for actual transmission to war ships at Hampton Roads?

A. I do not believe that this set was actually used for transmission to the Fleet, due to the fact that all these sets in the Navy Yard Station were remote-controlled from the Naval Base which was a distance of about seven miles; the antennas at the receiving station were so long that it was impossible to get down to this wave band. I made tests with this set by adjusting the wave length to around 300 meters, and it was heard very distinctly at the receiving station, and when the wave length was brought down below 200 meters, the signals were lost, this showing that the receiving station was not properly adjusted to receive this wave band.

Q. 29. Where was this transmitting station you have just mentioned, in relation to the Norfolk Navy Yard?

A. The transmitting station was in the Navy Yard and the receiving station was located in the Administration Building at the Naval Base, the reason being that when an operator was sending a message from the receiving station to a ship, he could hear his own signals while sending, as well as any other ship that wanted to call him at the same time he was operating one of the transmitters. This operation is called "remote-control."

Mr. Vaill: Counsel for claimant offers in evidence a photostatic copy of the two diagrams produced by the witness in answer to Q. 9, and requests that the same be marked "Claimant's Exhibit No. 207".

(Said exhibit marked as requested.)

[fol. 1148] Cross-examination.

By Mr. Edwards:

X Q. 30. Do the two drawings forming part of "Claimant's Exhibit No. 207" both represent the same type of set?

A. The two drawings both represent the same type of transmitter of the 126 meter type, with one exception: on one diagram marked "For Yard Station", the magnetic key has been left out, due to the fact as using it on remote control this key was not necessary in this case.

X Q. 31. In what units of measurement was the scale of the measuring instrument "H A" in the antenna calibrated?

A. I don't remember those.

X Q. 32. I mean in amperes, or kilo-watts, or what?

A. In amperes, but I don't remember the scale of the meter.

X Q. 33. You mentioned in answer to Q. 14, that the antenna radiation was about three-tenths of an ampere; how much energy would that represent in watts?

A. To measure the antenna current in watts, would be a difficult matter for me to explain as the voltage at this point is so high and special instruments would have to be made to determine the voltage, whereby with the amperes the watts could be determined.

X Q. 34. Can you state what was the amount of energy radiated from the antenna?

A. I cannot state the amount of energy radiated from the antenna, only what was radiated in the antenna, which was three-tenths of an ampere.

X Q. 35. But can you not give an expression of how much energy that three-tenths of an ampere represented?

A. Do you mean in watts?

X Q. 36. Yes.

A. No, I have no way to determine.

X Q. 37. Well, you understand, do you not, that merely stating the amperage of a current is nothing more than stating in effect, quantity, without expressing the amount of energy?

A. The amount of energy leaving the antenna would be very hard for me to determine, due to the absorption of the radiated current, due to the guys and stays in the rigging.

X Q. 38. Well, you understand, do you not, that when you give only the amperage in the antenna, you are not even stating the energy in the antenna?

A. The three-tenths ampere radiation, to my knowledge, expresses the excitation of the antenna to that degree.

X Q. 39. Do you understand that it expresses the energy in the antenna?

A. I do.

X Q. 40. Do you understand that merely expressing measurement of a current in amperes is sufficient to express the energy of the current?

A. In some cases energy is expressed in watts and horsepower, but in this case where only one value is known, it is impossible for me to express further what energy or wattage is applied in this case to the antenna. Most transmitters of my experience are expressed by watts or kilowatts input, which is easily determined; considerable loss from this point is customary in a circuit of this type, or any other type of transmitter, due to heat and insulation.

X Q. 41. Will you please answer the preceding question?

(X Q. 40. repeated.)

A. As far as I know, yes.

X Q. 42. Do you not understand that the unit of measurement "watt" is a product of the voltage and amperage of a current?

A. I understand Ohms law quite well, and that the amperes multiplied by the voltage will determine the watts.

X Q. 43. In your answer to Q. 13 you stated the input [fol. 1149] power of these sets as being 1 k.w., that would mean 1,000 watts, would it not?

A. The input as determined by me as 1 k.w., would equal 1,000 watts power.

X Q. 44. Do you not recognize that when you give the input as 1,000 watts and only state the amperage in the antenna, that you are not giving any information as to the comparative input energy, and energy in the antenna?

A. As my tests and technical education extend to only a certain point, it would be impossible for me to determine the output in watts as applied to the 126 meter transformer.

X Q. 45. Can you state the voltage of the current in the antenna, or the resistance of the antenna?

A. The only measurements taken on these sets during calibration were the wave length and the antenna current. The resistance and capacity of the antenna were never placed on the records; in some cases the natural period of the antenna alone would be taken and placed on the record.

X Q. 46. Do you know the range of transmission of these sets?

A. I have never transmitted with this type of set to any given point so, therefore, have no way of determining the distance that these sets would transmit.

X Q. 47. In calibrating these sets, within what limits of accuracy would the wave lengths be adjusted?

A. The wave lengths of the 126 meter sets were adjusted as near as possible to 126 meters; in one or two cases it was impossible to adjust the set any lower than 130 meters, which, I judge, was due to an excess length of antenna. At any lower degree, in this particular case, the radiation would go to about one-tenth of an ampere, so in most cases my idea was to adjust the set as near 126 meters with a fair radiation at three-tenths of an ampere.

X Q. 48. How much of a departure from 126 meters did you permit as a maximum?

A. I would never calibrate a set to more than 130 meters; if the set would not calibrate at that wave length or shorter, I would generally take off a few feet of the antenna, where possible; in most cases these antennas were made up of a six inch cage type about fifty feet long, so it was impossible to shorten the antenna without practically reconstructing same.

Last question by the Notary: Do you know of any other matter relative to this claim?

A. I do not at the present time.

Deposition Closed

Deposition of Fred Hutton Kroger, for Claimant, taken at New York, N. Y., on the 26th day of October, A. D., 1926

Direct examination.

By Mr. Vaill:

Q. 9. Are you the same Fred H. Kroger who testified heretofore in this case on June 4th, 1926?

A. I am.

Q. 10. With what organization were you connected in the years 1917 and 1918?

A. With the International Radio Telegraph Company, located at 67 35th Street, Brooklyn, New York.

[fol. 1150] Q. 11. What was your position with the International Radio Telegraph Company during the years mentioned?

— Chief Engineer.

Q. 12. As Chief Engineer what did your work with the International Radio Telegraph Company include?

A. Design of spark transmitting equipment.

Q. 13. Did you design the spark transmitting equipment for any particular organization or customers of the company?

A. The Navy Department and the Army constituted the major customers to whom we supplied spark transmitting equipment during the years mentioned.

Q. 14. Can you give the particular designations by which transmitting sets made for the Navy and the Army of the United States were known at that time?

A. The major part of the spark transmitting equipment delivered to the United States Government during the time mentioned was known by the type numbers S.E.1300 and S.E.1310 for the Navy and S.C.R. 73 for the Army.

Q. 15. Please state whether or not actual orders were received by the International Radio Telegraph Company from the United States Navy and Army for these sets?

A. There were.

Q. 16. Can you give the approximate number of these sets ordered by both the Navy and the Army?

A. The Army placed an order for about 5,000 of the S.C.R.73 and the Navy an order for about 250 of the S.E.1300 and some 500 of the S.E.1310.

Q. 17. To what extent were these orders filled and delivered to the Government?

A. About 3,000 were delivered to the Army and about 200 to the Navy.

Q. 18. What was the reason that more of them were not delivered?

A. The undelivered portion was cancelled, due to the Armistice, terminating the World War.

Q. 19. What was the general nature of the spark-producing portion of these transmitting sets you have mentioned?

A. It consisted essentially of the high-tension transformer supplied by alternating current; this transformer charging a condenser which was discharged synchronously by a rotary spark-gap through an inductance set at a value to give the required wave length. The oscillating energy in this circuit is transferred to a tuned antenna connected conductively to the inductance referred to. In the application of this apparatus to air-craft the ground connection was the frame of the airplane and the antenna usually of the trailing wire type.

Q. 20. What proportion of the 5,000 S.C.R.73 sets ordered by the Army and the 750 sets ordered by the Navy of the S.E.1300 and the S.E.1310 types was intended for use on aircraft?

A. All of them.

Q. 21. Referring further to the structural characteristics of the spark transmitting sets manufactured for the U. S. Army and Navy, will you please state how the power was supplied for rotating the rotatable parts of the sets?

A. The power was obtained by means of a propeller driven by the force of the wind and which was connected directly to one end of the alternating current generator shaft which, in turn, was supplied with the rotary spark-gap on the other end.

Q. 22. Where was this propeller, the alternating current generator and the rotary spark-gap located with reference to the fuselage or body of the aircraft?

A. In the case of the Navy, it was located underneath the forward edge of one of the wings, this was also a loca- {fol. 1151} tion used by the Army, but in the case of the Army more often located on the struts of the landing gear.

Q. 23. What was the general shape and nature of the container in which the parts were carried as referred to in your last answer?

A. The assembly was so arranged as to permit the outline of the shell covering this assembly to be of streamline contour.

Q. 24. In answer to Q. 19 you mentioned a tuned antenna. Will you please state how the tuned antenna was adjusted to wave length and also the other parts of the circuit associated therewith?

A. The primary or spark circuit was set at the wave length assigned by a switch which could be adjusted to connect to that tap on the primary circuit inductance which

would give the desired wave length and then the inductance provided as an additional unit to the equipment was varied to give resonance with the primary circuit, as indicated by a maximum reading of the antenna ammeter.

Q. 25. What was the nature of the inductance provided as an additional unit in the equipment referred to?

A. It consisted of a helix of wire wound on a form having associated with it mechanism for varying the number of turns, consequently the inductance, used.

Q. 26. Where was this portion of the apparatus located with reference to the other parts you have mentioned?

A. This inductance was located near the operator accessible for conveniently adjusting the resonance.

Q. 27. With what person in the Navy Department did you have most to do concerning these transmitting sets of aircraft types S.E.1300 and S.E.1310, before mentioned by you?

A. With Mr. T. Johnson, Jr., Radio Aide.

Q. 28. In what way did you come in contact with him?

A. Mr. Johnson was assigned by the Navy Department as the party with whom all technical matters were taken up with reference to Naval aircraft transmitters and, therefore, all discussion of specifications and tests were made in conjunction with Mr. Johnson.

Q. 29. Do you know whether or not any descriptions have been published of these aircraft radio transmitting sets manufactured for the U. S. Navy, and if so, please state what they are.

A. Yes, in the Navy Manual for 1919 and 1924, under the chapter entitled "Aircraft."

Q. 30. I hand you copies of these Manuals and ask you to point out or name the pages of these Manuals on which these descriptions occur.

A. Referring to the 1919 Edition of the Navy Manual, a description of the S. E. 1310 type is found on pages 220 to 223, inclusive. Referring to the 1924 Edition of the Navy Manual, a description of the S.E.1300 will be found on pages 545 to 547, inclusive.

Q. 31. Please state to what extent these descriptions you have referred to in the 1919 and 1924 Navy Manuals describe and illustrate the Navy type S.E. 1310 transmitting sets.

A. The description of the S. E. 1300 referred to, applies ostensibly to the S.E.1310, except that in the latter case the

power rating was 500 watts, while in the case of the S.E.1300 it was 200 watts.

Q. 32. To what extent, if any, do these Navy S.E.1310 and S.E. 1300 sets differ from those furnished the U. S. Army as S.C.R.73?

A. The S.C.R.73 and S.E.1300 sets are the Army and Navy type numbers for the same apparatus. No apparatus of the S.E.1310 type was furnished to the Army.

[fol. 1152] Mr. Vaill: Counsel for claimant offers in evidence a photostat copy of pages 215, 217, 220, 221, 222 and 223 of the Naval Manual for 1919, and requests that the same be marked "Claimant's Exhibit No. 208".

A photostat copy of pages 545, 546 and the illustration opposite page 546, designated as "Fig. 13", and requests that the same be marked "Claimant's Exhibit No. 209".

(The Notary marks said exhibits as requested.)

It is agreed between counsel that the publications referred to above as "Naval Manuals" are respectively entitled "Robison's Manual of Radio Telegraphy and Telephony for Use of Naval Electricians, 5th Edition, Annapolis, Md., United States Naval Institute 1919" and "Robison's Manual of Radio Telegraphy and Telephony for Use of Naval Radiomen, 6th Revised Edition, Annapolis, Md., The United States Naval Institute 1924".

Mr. Edwards: It is not to be implied that defendant's counsel admits that the publications were published by the Navy Department or other branch of the Government.

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Q. 33. To what extent did you see the aircraft transmitting sets designated as S.E.1300, S.E.1310 and S.C.R.73 in use upon aircraft operated, or to be operated, by the U. S. Army and Navy?

A. The only sets of the types referred to which I saw operated after installation were those which I personally tested in the Army and Navy airplanes.

Q. 34. Please state how many when and where, you personally tested and installed, of the sets inquired about on airplanes.

* * * * * * *

A. One set of the S.C.R.73 type I tested in an airplane at Langley Field, and another of the same type I tested in

conjunction with an Army Officer at Mitchel Field. One of the S.C.1319 sets was tested by me in one of the HS hydroplanes of the Navy at Hampton Roads.

Q. 35. Will you please state where the Langley and Mitchel Fields were located at that time?

A. Langley Field was located near Old Point Comfort, Virginia, and Mitchel Field near Mineola, Long Island.

Q. 36. Will you please state about when these sets were tested by you, as stated in your last answers?

A. During the Spring and Summer of 1918.

Q. 37. To what extent are the circuit diagrams, the illustrations and the descriptions in "Claimant's Exhibits Nos. 208 and 209" correct, as regards the S.E.1300 Navy sets described by you in your answers to previous questions?

* * * * * * *

A. The exhibits are correct.

Q. 38. I invite your attention to the following sentence taken from page 1137 of the Printed Record in this case, [fol. 1153] which comprises a portion of an answer to Q. 36 asked of defendant's witness E. H. Loftin, and will ask you to what extent, according to your knowledge, the statement made therein is correct, or incorrect:

"I have in recent years examined the records of purchases of radio apparatus of both the United States Army and the United States Navy since 1910, and while an extremely large number of sets were purchased since that date, particularly during the war, I do not recall a single instance of purchases of the open-gap type in the records which I have examined, and in fact, am familiar with the use of the open-gap type in but a few instances since 1910, these instances being in the case of the battleship division of the United States Fleet which joined the British Fleet in its North Sea operations."

A. The sentence quoted would appear to be incorrect, in view of the relatively large number of open-gap sets supplied by the International Radio Telegraph Company to the Navy and Army during the time the United States was involved in the World War.

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Mr. Edwards: No cross-examination.

Last Question by the Notary: Do you know of any other matter relative to this claim?

Answer: No.

Deposition closed.

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Deposition of T. Johnson, Jr., for Claimant, Taken at New York, N. Y., on the 27th day of October, A. D. 1926.

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First Interrogatory by the Notary: State your name, your occupation, your age and your place of residence; whether you have any, and if any, what interest direct or indirect, in the claim which is the subject of inquiry; and whether, and in what degree, you are related to the Claimant.

Answer: My name is Theophilus Johnson, Jr.; my age is 34; my residence is 22 Hampton Avenue, Schenectady, New York; occupation, Commercial Engineer with the General Electric Company, at Schenectady, New York; I have no interest, direct or indirect in this claim, and I am not related in any way to the Claimant herein.

Direct examination.

By Mr. Vaill:

Q. 1. About how long have you occupied your present position as Commercial Engineer with the General Electric Company?

A. Since 1920.

Q. 2. What was your occupation prior to that time?

[fol. 1154] A. Expert Radio Aide Bureau of Steam Engineering, Navy Department, Washington, D. C.

Q. 3. When did you commence your work in that capacity?

A. 1917.

Q. 4. What were your main main duties as Expert Radio Aide in the Navy Department?

A. Supervision of the design of radio apparatus, including that for aircraft.

Q. 5. What other duties, if any, did you have relative to the operation of radio apparatus for aircraft?

A. Supervision of tests.

Q. 6. Where was such work carried out by you?

A. Norfolk, Va., and Anacostia, D. C.

Q. 7. After the design of radio apparatus for the aircraft of the Navy Department, by whom was such apparatus manufactured?

A. The International Radio Telegraph Company, Western Electric Company, Marconi Wireless Telegraph Company, Cutting & Washington, General Radio Company, General Electric Company.

Q. 8. What kind of sets were manufactured by the International Radio Telegraph Company?

A. Spark transmitters, known as types S.E.1300 and S.E.1310.

Q. 9. Will you describe briefly the S.E.1300 and S.E.1310 spark transmitting sets manufactured by the International Radio Telegraph Company, particularly as to the kind of spark-producing devices used in these sets?

A. A single description will serve for both types, which differed only in the power of the alternator and resulting power output in the antenna, the S.E.1300 having a rated alternator output of 200 watts and the S.E.1310 a rated output of 500 watts. Each equipment consisted of an alternating current generator which charged a condenser, this condenser being discharged by a synchronous spark-gap giving 1,000 sparks per second, into a primary inductance. This circuit was conductively coupled to an output or antenna circuit. The alternator and spark-gap were mounted on the same shaft and were furnished with motive power from an air-driven propeller. The primary oscillating circuit was tuned by taps on the inductance; the secondary circuit was tuned by a variometer. All units, with the exception of the variometer, were mounted in a streamline case, which was in turn usually mounted on an aircraft wing. The variometer with an antenna ammeter, was mounted in the body of the aircraft. A trailing-wire-type of antenna was used.

Q. 10. You have stated that the alternator and spark-gap were mounted on the same shaft. Will you please explain a little more in detail how this spark-gap was operated by the shaft referred to?

A. The spark-gap mounted on the alternator shaft was of the rotary type and consisted of fixed electrodes and rotating electrodes, so arranged that the condenser referred

to would discharge synchronously into the primary inductance.

Q. 11. In your answer to Q. 9 you stated that a synchronous spark-gap giving 1,000 sparks per second discharged into a primary inductance. In speaking of the primary inductance, did you intend to refer to a transformer or to the antenna inductance?

A. The primary inductance formed part of an oscillation transformer, the secondary of which was in the antenna circuit.

Q. 12. How was the power transmitted from the generator to the spark-gap and condenser you have mentioned? [fol. 1155] A. The alternator was connected to the spark-gap and condenser through a transformer, the purpose of which was to step-up the voltage of the alternator.

Q. 13. Where was this transformer located as regards the position of the generator and other parts you have mentioned?

A. This transformer was located in the streamline case previously referred to.

Q. 14. Please state to what extent you personally saw the S. E. 1300 and S. E. 1310 types of transmitting sets as installed on Navy aircraft?

A. I personally witnessed the tests made of this apparatus before its purchase by the Navy Department and personally engaged in the operation of this apparatus on aircraft during these tests. Approximately 250 type S. E. 1300 and 500 type S. E. 1310 sets were ordered by the Navy and I personally saw these in the process of manufacture at the factory of the International Radio Telegraph Company, and also personally saw them being installed on Navy aircraft for regular operating service.

Q. 15. With whom did you come in contact in connection with your visits and relations with the work of the International Radio Telegraph Company?

A. With Mr. F. H. Kroger, then Chief Engineer of that Company.

Q. 16. At what place were these transmitting sets S. E. 1300 and S. E. 1310 mainly installed on aircraft?

A. At the various Naval Air Stations in the United States,—at Chatham, Mass.; Cape May, N. J.; Norfolk, Va.; Anacostia, D. C. I personally saw these sets installed at these Air Stations; there was also several other Stations at which they were installed.

Q. 17. I invite your attention to a book entitled "Robinson's Manual of Radio Telegraphy and Telephony, 1919", of which certain pages, beginning with page 215, have been introduced in evidence in the form of photostat copies, as "Claimant's Exhibit No. 208", and also a book entitled "Robinson's Manual of Radio Telegraphy and Telephony, 1924", of which certain pages, beginning with page 545, have been introduced in evidence as "Claimant's Exhibit No. 209", and ask you what you recognize these pages to be.

A. I recognize pages 215 to 223, inclusive, of "Claimant's Exhibit No. 208" as describing the type S. E. 1300 and type S. E. 1310 sets referred to. I recognize pages 545, 546 and opposite Fig. 13 of "Claimant's Exhibit No. 209" as describing these sets.

Q. 18. From your knowledge of the S. E. 1300 and S. E. 1310 sets, will you please state whether or not the circuit diagrams shown in "Claimant's Exhibits Nos. 208 and 209" are correct representations of the electrical circuits used in these sets?

A. The diagrams shown in these exhibits are correct representations of the circuits used.

Q. 19. I invite your attention to Volume 8 of the Proceedings of the Institute of Radio Engineers for the Year 1920, particularly to pages 3 and 87 and the pages subsequent thereto, and ask you what you recognize these pages to be?

A. The article referred to is a paper presented by me before the Institute of Radio Engineers and entitled "Naval Aircraft Radio". On pages 32 to 38 is included a description of the types S. E. 1300 and S. E. 1310 sets.

Q. 20. In your last answer you have stated that the pages shown you constitute a paper presented by you; will you please state who composed or wrote this paper?

A. I personally wrote this paper which, before presentation was approved by the Navy Department.

[fol. 1156] Q. 21. Referring to page 33 of the Proceedings of the Institute of Radio Engineers mentioned in my previous question, will you please state whether or not Fig. 40 is a correct diagrammatical representation of the circuits in the types S. E. 1300 and 1310?

A. Fig. 40 referred to is a correct representation of the circuits used.

Q. 22. Can you state on what kinds of aircraft these two types of apparatus were installed?

A. On seaplanes known as types N-9 and R-6, and on flying boats known as types HS-1, HS-2, F-5-L and NC-4.

Q. 23. Which one of these flying boats you have mentioned is particularly noteworthy as to satisfactory performance of distance?

A. The NC-4, which made the Trans-Atlantic flight in 1919, from Rockaway, Long Island, to Lisbon, via the Azores, and Newfoundland. On this flight the set type S. E. 1310 on the NC-4, maintained perfect communication with the Cape Race Station up to a distance of 650 nautical miles. The signals from this S. E. 1310 were copied perfectly by the Naval Radio Station, Bar Harbor, Me., when the NC-4 was 1,400 miles distant.

Q. 24. Where was the Cape Race Station located with reference to the NC-4?

A. It was located approximately Northwest of the NC-4, on Newfoundland.

Q. 25. Referring again to your article in the Proceedings of the Institute of Radio Engineers, will you please point out where this NC-4 flight is referred to?

A. On pages 127 and 128.

Q. 26. From what source was the information of this flight and performance of the transmitting set on the NC-4 obtained by you?

A. From official Navy reports, which should be on file in the Navy Department, Washington, D. C.

Q. 27. In answer to Q. 20 you stated that approximately 250 of the type S. E. 1300 sets and 500 of the type S. E. 1310 sets were ordered by the Navy Department. How many of these sets were delivered to the Navy, if you know?

A. A total of approximately 300, the remainder being cancelled, due to the Armistice terminating the war.

Mr. Vail: Counsel for Claimant offers in evidence a photostat copy of pages 3, 32, 33, 34, 35, 36, 37, 38, 127 and 128 of the Volume of the Proceedings of the Institute of Radio Engineers, referred to by the witness, and requests that the same be marked "Claimant's Exhibit No 210".

(The Notary marks said exhibit as requested.)

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Cross-examination.

By Mr. Edwards:

X Q. 28. What other types of radio transmitters for aircraft were designed by you or installed on aircraft under your supervision during the period you were with the Bureau of Steam Engineering?

A. Vacuum tube transmitters manufactured by the Marconi Wireless Telegraph Company, the General Electric Company and the General Radio Company, and a spark [fol. 1157] transmitter manufactured by Cutting & Washington.

X Q. 29. I note on page 32 of the Proceedings of the Institute of Radio Engineers, constituting a part of your paper entitled "Naval Aircraft Radio", the statement is made that:

"There are at the present time in use in the Naval aircraft service four types of standard spark radio transmitters."

Will you refer to that article and identify each of the four types referred to?

A. The four types referred to are the types S. E. 1300, S. E. 1310, both manufactured by the International Radio Telegraph Company, type S. E. 1320, manufactured by Cutting & Washington and a fourth type, ultimately little used, manufactured by E. J. Simon.

X Q. 30. Am I right in understanding that the circuit connections of the first two types, that is, the S. E. 1300 and S. E. 1310 are illustrated in Fig. 40, page 33 of the article, and that the circuit connections of the third type, the S. E. 1320, are illustrated in Fig. 44 of page 39 of the article?

A. Yes.

X Q. 31. What was the circuit arrangement of the fourth type?

A. This was a quenched-gap transmitter with inductively coupled oscillation transformer.

X Q. 32. Was the S. E. 1310 a plain gap, or a quenched-gap transmitter?

A. It was the synchronous rotary-gap transmitter.

X Q. 33. I note that in your paper to which we have been referring, the statement is made with respect to the type S. E. 1320, commencing on page 38,

"The transmitter is of the impact excitation type and is designed for transmission on a wave length of 375 meters only."

Does that accord with your recollection?

A. The type S. E. 1320 utilized a gap of the quenched type.

X Q. 34. How many types of vacuum tube transmitters were designed or installed under your supervision during this period?

A. Six.

X Q. 35. Did all of them employ approximately the same circuit as is illustrated in Fig. 56 on page 51 of your paper that we have been discussing?

A. No. Fig. 56 refers particularly to the types manufactured by the General Electric Company.

X Q. 36. None of the vacuum tube transmitters employed spark-gaps of any kind, did they?

A. No.

X Q. 37. How did the number of transmitters of the various vacuum tube types compare with the number of spark-gap transmitters designed or installed under your supervision?

A. The number of spark transmitters actually installed on aircraft was of the same general order of quantity as the number of vacuum tube transmitters thus installed.

X Q. 38. What proportion of the spark transmitters installed were rotary-gap and what proportion quenched-gap?

A. Very approximately the same number of each type.

X Q. 39. I notice in Robison's Manual for 1919, on page 215, the statement is made:

"The earlier types of aircraft radio transmitters were mostly of the damped wave or spark type, having wind-driven generators as a source of primary current. The more modern transmitters are the valve type, using a generator directly connected to the aircraft engine, with a [fol. 1158] small capacity storage battery floating as an emergency source of power."

Does that accord with your recollection?

A. Yes, emphasizing that that statement refers only to the earlier types and the most modern types, and does not refer to the many intermediate types, of which the synchronous rotary-gap transmitter is one.

X Q. 40. On page 218 of the same publication, I note the statement:

"Figure 119 shows the fundamental airplane spark transmitter circuit. Either the quenched, rotary or impact type gap is used, preferably the latter."

Do you understand that this statement refers to the Figure 119 on page 217 of the publication, which latter page has been offered in evidence by claimant?

A. Yes.

X Q. 41. And is the statement is accord with your recollection?

A. Yes, except that I take exception to the statement "preferably the latter".

X Q. 42. Do you understand that the phrase "rotary or impact type gap" refers to one type or two types?

A. Two types.

X Q. 43. Will you state briefly the difference between the types?

A. Generally there is little essential difference between what is referred to as the "impact type gap" and the quenched type gap, as used with this general line of apparatus.

X Q. 44. What proportion of the spark transmitters installed during the period referred to were rotary-gap, quenched-gap and impact-gap respectively?

A. Approximately fifty per cent. rotary-gap, thirty per cent. impact type gap and twenty per cent. quenched-gap.

X Q. 45. I note that on page 218 of Robison's Manual, to which we have been referring, the statement is made:

"Fig. 119A shows the fundamental airplane valve transmitter circuit. The valve is the usual vacuum tube, with four terminals for the filament, plus and minus, the plate and the grid. The battery shown is for the purpose of keeping the filament hot."

Do you understand that that statement refers to Figure 119 A on page 217 of this publication, and if so, is the statement in accord with your recollection?

A. Yes.

X Q. 46. Are we to understand that it is your testimony that during the period from 1917 to 1920, while you were connected with the Bureau of Steam Engineering, that about half of the spark transmitters installed on Navy aircraft were rotary-gap transmitters?

A. Yes, as regards those installed and placed in operation.

X Q. 47. Are you acquainted with Mr. George H. Clark?

A. Yes.

X Q. 48. Was he connected with the Bureau of Steam Engineering during the period concerning which you have testified?

A. Yes, although leaving the Service of the Navy Department prior to the time that I did.

X Q. 49. Was he in the same Department or Unit that you were in?

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[fol. 1159] A. In the same Department, but his detailed duties differed from mine.

X Q. 50. Did you both report to the same authority?

• • • • • • •

A. Yes.

X Q. 51. To whom?

• • • • • • •

A. Commander S. C. Hooper.

X Q. 52. If Mr. Clark says that he was with the Department until June, 1919, would that be in accord with your recollection?

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A. Yes.

X Q. 53. Was he in position to have knowledge of radio set installed on Naval aircraft?

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A. Yes, although, after January 1st, 1918, my duties were specifically connected with aircraft installations and his were not.

X Q. 54. If Mr. Clark says that the quenched-gap sets formed the bulk of spark transmitters in the Navy between March, 1912, and ending in 1919, would that tend to change

your estimate as to the relative proportion of rotary and quenched-gap transmitters employed on aircraft during the period between 1917 and 1920?

A. No.

X Q. 55. Do you know of any reason why rotary-gaps were employed in the transmitters to which you have referred?

A. The manufacturers submitted the design and I do not know what particular reason they assigned to the use of the rotary-gap other than that they deemed it very suitable for the purpose.

Redirect examination.

By Mr. Vaill:

R. D. Q. 56. On cross-examination, X. Q. 42, you were asked concerning the rotary or impact type gap, and in answering X Q. 43, you referred to the "impact type gap, and the quenched-type gap". I will ask you to examine these questions and answers and to state what you understand to be the differences between the impact type gap and the rotary-type gap, as distinguished from the quenched-type gap?

A. The rotary-type gap consists of fixed and rotating electrodes, the arrangement of which and the speed of the rotating members determining the number of sparks per second. The quenched type gap and the gap used on the impact type transmitter, referred to in Robison's Manual, have fixed electrodes.

R. D. Q. 57. Did you mean to be understood by your answer to X Q. 43, that there is little essential difference between the rotary and the impact type gap?

A. I meant to indicate that in the mechanical arrangement and operation of the gap alone, the rotary type differed from the other two referred to.

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[fol. 1160] Last Question by the Notary: Do you know of any other matter relative to this claim?

A. No.

Deposition Closed.

Deposition of GEORGE H. CLARK, for Claimant, taken at New York, N. Y., on the 15th day of November, A. D. 1926.

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First Question by the Notary: State your name, your occupation, your age and your place of residence; whether you have any, and if any, what interest, direct or indirect, in the claim which is the subject of inquiry; and whether, and in what degree, you are related to the claimant.

Answer. My name is George H. Clark; my age is 45; my residence is 278 Madison Street, Passaic, New Jersey; occupation, Radio Engineer with the Radio Corporation of America; I have no interest direct or indirect in this claim, and I am not related in any way to the claimant herein.

Direct examination. 7

By Mr. Vaill:

Q. 1. Are you the same George H. Clark who has previously testified on behalf of the complainant during its *prima facie* proofs in this case?

A. Yes.

Q. 2. On page 1034 of the printed testimony, defendant's witness Loftin, in referring to open-gap spark transmitters, states as follows:

"As to cooling of the electrodes, I have pointed out that heat is necessary for generating the metallic vapors which are beneficial for maintaining the gap active for a long time. In the use of these open gaps, the art has not resorted to cooling means, except where very large power is used, resulting in too rapid a consumption of the gap electrodes."

What is your knowledge concerning the use of cooling means, so far as it concerns your experience with Navy transmitters?

A. In the early days of the use of radio in the Navy, open gaps with artificial cooling means were very generally used. During the period from 1904 to about 1910, I saw many examples of these cooled gaps in use. The most conspicuous example was the gap used in the Slaby-Arco sets, many of which I saw in use in the Navy.

Q. 3. What was the size of these Slaby-Arco sets you have referred to, as concerns their capacity or power?

A. They were about 1 k. w. in power, or less.

Q. 4. What was the cooling means used in these sets?

A. The sets consisted of a cylinder in which condensed jars were placed and around which the inductance coil was wound. Above this cylinder was a smaller one containing the spark gap. Beneath the larger cylinder was placed a fan which drove air through several holes into the condenser chamber, and through holes in the top of this into the spark gap container, the air finally escaping through an orifice at the top of the spark gap holder.

[fol. 1161] Q. 5. I hand you "Defendant's Exhibit J-2" and will ask you if you find in this exhibit any illustration or other matter relating to the transmitting sets you have referred to in your previous answer.

A. I find on page 9 of this exhibit a drawing which is numbered "Fig. 13". This shows a cross-section of the Slaby-Arco transmitter I have described. I see here the fan, openings into the condenser or Leyden jar case, openings into the spark gap case, the spark gap itself, and an exhaust opening from the top of the spark gap case into the open air.

Q. 6. Can you name any other types of Navy transmitting sets that had their spark gaps cooled by artificial means?

A. Yes, several. One type which I saw in several Navy transmitting sets was known as the Sweet gap, developed by then Lieut. G. C. Sweet, U. S. N. This consisted of two hollow electrodes, facing each other, and with a rotatable plate between the opposing faces. This plate had various projections on it, on both sides, and of different thicknesses, so that the width of the two effective spark gaps on either side of it could be changed. The hollow electrodes were pierced with various holes, and air from a compressed air tank blew out through both sets of holes. This action cooled the gap, due to the expansion of the air from the small holes, and also tended to blow out the gap.

Q. 7. Do you recollect whether there are in the files of the Navy Department drawings of this Sweet air-cooled gap to which you have referred?

A. I know that such drawings were in the file of the New York Yard around 1910, but I have not seen them since.

Q. 8. Have you ever seen this Sweet transmitting gap in actual use, and if so, where?

A. I have seen it in use in several Naval vessels, of which I now recall the U. S. Steamship Prairie and the U. S. Steamship Mississippi. I also saw it in a Naval Shore Station in the South of the United States, which I think was St. Augustine.

Q. 9. What was the size or capacity of these transmitters using this gap?

A. About one or two k. w.

Q. 10. What other types of Navy transmitting apparatus had spark gaps cooled by artificial means within your experience in the Navy?

A. I saw and used other transmitters which had the Hogg spark gap, invented by Commander Hogg, U. S. N. This gap consisted, in the form that I saw, of a hollow tube opposing a solid plate, the axis of the tube being at right angles to the plane of the plate. The tube was one spark gap electrode and the plate the other. Air was blown into the lower end of the tube, and on emerging from the upper end, tended to blow out the spark and also cooled the gap. This type of gap was used in sets of from one to two k.w., and I recall that at least two Naval Shore Stations in the Southern part of the United States were using this gap in 1911.

Q. 11. Can you recall any other air-cooled spark gaps that were used during your connection with the U. S. Navy?

A. I remember that some early sets submitted by the DeForest Company had spark gaps cooled by an external blower, and I also recall operating sets installed by the Stone Telegraph and Tele*graph* Company on the U. S. Steamship Georgia and the U. S. Steamship Minnesota. I saw these latter sets in 1911. In the Georgia installation, the two spark gaps consisted of rings bearing half spheres around their opposing faces, and with air coming up through the hollow support of one ring, to cool the gap. In the second installation, the gap was a point-to-plate type, [fol. 1162] and air was blown from a nozzle at right angles to the line of the spark, thus cooling the gap.

Q. 12. During Defendant's answering proofs, Mr. Loftin has made several statements regarding quenched spark transmitters used in the Navy. Will you please state what experience you have had in operating and tuning Navy quenched gap transmitters?

A. I have tuned and operated many hundreds of sets of

this type, ranging in power from portable and submarine sets of a fraction of a kilo-watt, to sets of 10 k.w. capacity.

Q. 13. Will you please describe briefly the method you used in tuning such quenched spark transmitters?

A. In my answer, I will assume that the transmitter in question is of the inductively-coupled type, of which type almost all quenched gap sets consisted. The procedure in tuning up such a transmitter would be as follows:

(a) I placed the secondary coupling coil some distance away from the primary coil, at such a separation as experience had taught me would be much greater than the final coupling distance.

(b) I then adjusted the primary circuit to the wave length to which I desired to tune the transmitter, using for this purpose a wave meter very loosely coupled with the primary inductance.

(c) Next I adjusted the secondary or antenna circuit to resonance with the primary. The indication of resonance was the obtaining of maximum current in the antenna ammeter.

(d) I then increased the coupling by moving the secondary coupling coil closer to the primary coil, continuing this until I obtained the maximum antenna radiation that could be had, consistent with a small decrement of the emitted wave. During this operation the alternating current supply source was adjusted so that the voltage on the quenched spark gap was that giving a clear note.

(e) I next measured the wave length sent out by the transmitter, using for this purpose a wave meter very loosely coupled with the antenna circuit alone.

(f) If this wave length did not agree with the wave length to which I was tuning the set, the above procedure was carried out all over again, the primary wave length being changed to a new value which experience led me to believe would result in the desired wave length being sent out by the transmitter. This was done, if necessary, several times, until finally the wave length measured in the antenna circuit was that desired.

Q. 14. Can you refer to any printed publication containing instructions for use of Naval Radiomen as to tuning

quenched spark transmitters which corresponds to the method you have described?

A. Yes. I have here a copy of "Robison's Manual of Radio Telegraphy and Telephony for use of Naval Radiomen", 6th Revised Edition, 1924. On page 538, under the heading "Wave-length tuning", the following paragraphs are instructions corresponding in general to the method of tuning which I have just described:

"(a), (e), (g), (i), (j), (k), (l), (m)," and on page 539, paragraphs "(o) and (p)." On page 539, under the heading "Full-power adjustments and tuning" the following paragraphs likewise are instructions as above:

"(a), (b), (c), (d), (e)", and under "(f)" the first paragraphs, and the last paragraph on the page, continuing for the first five words on page 540.

[fol. 1163] Q. 15. Who are given as the authors of this Manual you have mentioned in your last answer?

A. The title page states that the book was written by "Commander (Now Admiral) S. S. Robison, U. S. Navy, Revised by Commander S. C. Hooper, U. S. Navy."

Q. 16. Will you please state to what extent, according to your knowledge and experience, this Navy Manual and earlier editions of the Navy Manuals, were used by, and served as instruction books to, Radio operators and Radiomen generally in the United States Navy?

A. The editions preceding the volume which I have referred to in my answer to Q. 14, I have seen in practically every Naval Ship and Shore Radio Station that I have tested or visited. It was considered the standard Manual for instruction, and I often used it myself in giving instructions to the personnel of various Stations. The last edition, referred to in my answer to Q. 14, was issued after I left the Naval service, but since it is a continuing edition of preceding issues, I believe that it is likewise used as an authority for the instruction of Naval Radiomen.

Q. 17. Please state to what extent, according to your knowledge, these Naval Manuals relating to Radio Telegraphy and Telephony are regarded as standard reference books, and to what extent they are open to public inspection and purchase, if desired?

A. These Navy Manuals are considered by Radio Engineers generally as standard and authoritative reference books as to the state of the Radio art in the United States Navy. These Manuals have always been open to public

purchase and hence could be inspected by any purchaser or any other person viewing said book. These Manuals are on file in practically every Public Library.

Q. 18. On pages 1097 and 1098 of the Printed Record defendant's witness Loftin testified as follows:

"I will point out in connection with my discussion of the operation of the Seibt and Wireless Apparatus Co. type that there is no such thing as 'resonance' between the primary and secondary circuits of the quenched gap type."

In view of your experience with Navy quenched spark transmitters, will you please state the facts as you have found them, regarding resonance between the primary and secondary circuits of such transmitters?

A. I have always found that when such transmitters are in an operative condition, there is resonance between the primary and secondary circuits.

Q. 19. Will you please state what you may have in mind as embracing the term "resonance" used in your last answer?

A. I mean that if the wave length in the primary circuit and in the secondary circuit of an operative quenched gap transmitter be measured by a wave meter respectively coupled to each of these circuits alone, these measured wave lengths would be the same or substantially the same. By "operative condition" I mean that the transmitter shall have been correctly adjusted as to wave length and coupling.

Q. 20. How are the effects of tuning a quenched spark transmitter, as regards resonance and coupling and other characteristics of such circuits illustrated?

A. By means of resonance curves.

Q. 21. Can you produce any publication intended for use by Naval Radiomen that is in accordance with your testi- [fol. 1164] mony concerning resonance between the primary and secondary circuits of a quenched spark transmitter?

A. In my answer to Q. 14 I referred to a book which I will henceforth designate as "Robison's Manual". In the 1911 issue of this Manual, I find on page 156 a set of curves showing the resonance curves in both the primary and secondary circuits of a quenched gap transmitter. That it is the latter type of transmitter is shown by the schematic diagram on the same page, where the spark gap in the primary circuit is marked "Quenched Gap". The wave length

at the resonant position in the primary circuit is 977 meters, and the wave length at the resonant position in the secondary circuit is 973 meters, which two values are substantially in agreement. I find the same curves and schematic diagram on page 179 of the 1913 edition of Robison's Manual (Reproduced Opposite), on page 180 of the 1915 edition and on page 203 of the 1918 edition.

Mr. Vaill: Counsel for claimant offers in evidence a photostat copy of page 179 of Robison's Navy Manual of Wireless Telegraphy, 1913 Edition, and requests that the same be marked "Claimant's Exhibit No. 211".

(Said exhibit marked as requested.)

Q. 22. According to your experience with quenched spark transmitters, what has been the effect upon the apparatus when the primary and secondary circuits were not in resonance?

A. The antenna curren. radiated would be much less than when the two circuits were in resonance. The emitted wave would have two pronounced maxima or "humps". The gap note would be very poor, and the quenched gap itself would tend to "bead" or form metallic short circuits between the plate, and would also become very hot.

Q. 23. Can you refer to any publication for use of Naval Radiomen containing statements in accordance with your testimony as given in your last answer?

A. Yes. In Robison's Manual, 1924 Edition, the following appears on page 528:

"The momentary current flowing in the primary circuit is very heavy and, if the antenna circuit is not coupled and in tune with it, there is a serious danger that the spark gap will be burned".

Also, on page 539 of the same Manual, at the bottom of the page, occurs the following:

"In no case should the antenna circuit be detuned (thrown out of resonance with the primary), because (a) there will be a reaction between the two circuits and two waves will be radiated which can be found on a wave meter coupled to the antenna circuit; (b) the gap will not quench properly, thereby heating, and power will be retransferred from the antenna to the primary, and back again to the antenna, and

the decrement will be increased due to this retransfer of power."

Q. 24. Please consider the following testimony of defendant's witness Loftin, beginning near the top of page 1105 of the Printed Record, and state any facts in accordance with your knowledge and experience that may have a bearing on the same, to-wit:

"In such a calibration, the operator will first carefully adjust the primary circuit to a definite frequency, using a wave meter which is an instrument for measuring fre- [fol. 1165] quency, being certain that the secondary or antenna circuit is open so as not to influence his measurement. He will then open the primary and adjust the secondary to the same frequency. Having so adjusted the two circuits, he then starts his set in operation, and listening to the note given off by the transmitter, will gradually throw the two circuits out of tune until a nice clear note is had. * * *."

A. I have never used the above-quoted method of adjusting a set to resonance. The method which I always employed, and which was the general method used by Radio Engineers and operators during the period that I was in the Naval employ, was as outlined in my answer to Q. 13.

Referring to the adjustments as outlined in the above text, the two circuits having been adjusted as described, and having further been coupled to the optimum coupling position (which is omitted from the text), the operator then proceeds to obtain a clear note. This is not done by gradually throwing the two circuits out of tune; on the other hand, the two circuits are left at the tuning position obtained when optimum coupling was determined. What the operator does do to obtain a clear note is to adjust the generator voltage for the number of gaps in use at the moment. If the voltage is too high, the note is hissing and not musical; if the voltage is too low, the note "breaks" and is ragged; at the correct voltage the note is a clear musical one, with the characteristic 500-cycle sound.

All other adjustments of the transmitter having been made, it is impossible to obtain a clear note except by generator voltage adjustment.

Q. 25. Can you refer to any publication intended for use of Radiomen that is in accordance with your experience as

to the adjustment of the alternating current generator voltage to get the desired clear sound or note suitable for transmission in a quenched spark transmitter?

A. Yes. In Robison's Manual, 1924 Edition, I find on page 539, under the heading "Full-power adjustments and tuning", instructions practically identical with the practice given by me in my preceding answer. On this page I refer to sub-paragraphs "(a), (b), (d), (e)," and under "(f)" the sentence "Adjustment to proper voltage for clear note is best made while sending letters".

Q. 26. Testimony has been given in this case on behalf of defendant by Mr. Loftin, found on page 1137 of the Printed Record, to the effect that the open-type spark gap transmitter in the Navy was replaced by the quenched gap type. Please state what your knowledge is on this matter.

A. About 1910, open-type spark gaps began to be replaced in the Navy by quenched gaps. By 1916 or thereabouts, almost all the sets were fitted with quenched gaps, with the exception of some Shore Stations and a number of vessels still using rotary synchronous gaps. Possibly there were twenty vessels using this latter type, most of these being torpedo boat destroyers.

Q. 27. Do you know whether these Navy ships on which the quenched gap transmitters had been placed, were provided with other types of gaps at the same time?

A. Yes. Practically every ship or Shore Station set having a quenched gap was fitted with an auxiliary gap of the non synchronous rotating type. This was required by Navy specifications for spark gap transmitters.

Q. 28. What documentary Naval papers can you refer to, if any, that tend to confirm the statement of your last an- [fol. 1166] swer as to the non-synchronous gaps used on Navy ships?

A. I recall that the Naval specifications calling for the use of non-synchronous gaps were numbered RE 13-A 111.

In the 5th Edition of these specifications, numbered "RE 13A 111E", dated April 20, 1918, and headed "Specifications for" 1-2-5 & 10 K.W. Radio Transmitters", paragraph U, headed "List of Parts Comprising a Set" has, on page 25, the requirement that one quenched gap and one rotary non-synchronous gap are to be supplied with two k.w. sets, whether for d.c. or a.c. supply or engine-driven, and whether Navy standard or Naval auxiliary types of sets. The same requirement is found on page 39,

for five k.w. sets of the different classes above given, and the same is true on page 43 for ten k.w. sets. It is to be noted that only in the case of the one k.w. sets, on page 31, is the rotary non-synchronous gap not required in addition to the quenched gap.

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Q. 29. According to your knowledge and understanding, will you please state whether or not the original or copies of the specifications numbered "RE 13-A 111E", dated April 20, 1918, is on file among the records of the Navy Department?

A. The original typed copy, and the Van Dyke thereof, are on file in the Bureau of Engineering, Navy Department, Washington.

Q. 30. Understanding that you have at hand available for examination, a copy of these specifications referred to in the last question, will you please indicate therein the portions which refer to the rotary non-synchronous spark gap mentioned in your answer to Q. 28?

A. Beginning on page 115, and continuing on pages 116, 117 and 117½, I find a paragraph which is numbered 38 and which is headed "Rotary, Non-synchronous, 500 Cycle, Spark Gap". A portion of these specifications, giving a general outline of the requirements for this gap is found in the following sub-paragraphs:

"(a) To be operated in place of the quenched spark gap in a radio transmitter which is supplied with power from a 500 cycle alternator.

"(b) The gap shall operate satisfactorily at any input between ¼ K. W. and 5 K. W.

"(c) Design must be such that a musical note, corresponding to 1,000 sparks, or 1,000 groups of sparks, per second, may be readily produced and maintained at any input between ¼ K. W. and 5 K. W. The dominant note of the spark shall correspond closely to that produced by an approved type of quenched spark gap transmitter. It shall also be possible to obtain and maintain a note corresponding to 125, 250, and 500 sparks, or groups of sparks, [fol. 1167] per second, with corresponding variation in power, by suitable variation in voltage or spark length, and while the spark is *on*."

"(h) The gap shall operate satisfactorily while sending continuously for five (5) hours. Satisfactory operation means that the proper spark note and the power input shall remain constant without necessity for adjustment during the test, which shall be made at any wave-length between 300 and 3,000 meters, inclusive."

There are many other sub-paragraphs in the paragraph giving specifications for this type of gap, which I will not quote here.

Q. 30. Will you please state, if you know, where the design of the rotary spark gap apparatus referred to in connection with these specifications, originated?

A. Designs prepared by commercial companies were accepted if approved by the Navy, but the majority of the rotary non-synchronous gaps used in Navy sets were built from Navy design. I think that in time the Navy design was finally made obligatory for all contractors.

Q. 31. Will you please state approximately, if you know, the date that the rotary, non-synchronous gaps designed by the Navy and such as referred to in the specifications, were designed?

A. I estimate that it was about 1914 or '15.

Q. 32. I will ask you to refer again to Navy specifications "RE 13 A 111E" and to refer to any matter therein which indicates that the previous specifications were changed in accordance with drawings furnished by the Navy.

A. I find on sheet 4, under the heading "Note 2. Specifications RE 13-A 111D differ from the preceding issue (RE 13-A 111C) in the following major changes:—" the following reference under paragraph 3, sub-paragraph g:

"Paragraph 28. Rotary Non-Synchronous Gap. Specifications changed. The Bureau will furnish drawings of a type of gap which will be acceptable".

However, the heading given above as immediately following "Note 2." is in error. The correct heading is that given on the following page numbered 5, which latter heading is a repetition of the heading which should have been placed on sheet 4. The matter on sheet 5 follows consecutively, as to paragraph and sub-paragraph numbers, to the matter on sheet 4. This correct heading which I have above stated, appears on sheet 5, and which should have appeared on sheet 4, is as follows:

"Specifications RE 13-A 111E differ from the preceding issue (RE 13-A 111D) in the following major changes".

Q. Please state, if you know, the source of the design of the particular rotary gap referred to in the specifications, as mentioned in your last answer.

A. The design was made at the Philadelphia Navy Yard. I saw some of the design being drawn up, and later saw gaps being manufactured at that yard in accordance with this design.

Q. 34. About what year was it that you saw these gaps?

A. About 1916.

Q. 35. What personal connection have you had, if any, with the specifications RE 13A- 111E, referred to by you in your previous answers?

A. I prepared these specifications.

Q. 36. Will you please state whether or not you had oc- [fol. 1168] casion to see any of these non-synchronous rotary gap transmitter sets in place for use on United States Navy vessels?

A. Yes. I tuned up a large number of transmitters in which this gap was furnished, along with the quenched gap, and personally used the rotary non-synchronous gap in such tuning. I have also observed these gaps in operation for the sending of messages.

The above operations, such as tuning up the sets and seeing them in actual service, took place on almost all the Battleships of the Atlantic Fleet, such as the Wyoming, Florida, Utah, and others. The same took place at a number of Naval Shore Stations on the Atlantic Coast, and on smaller vessels of the Service.

Q. 37. During what period was this tuning and observation, referred to in your last answer?

A. During the period of the first installation of the wave changer, in 1914, and continuing through 1916.

Q. 38. According to your observation and experience, what was the occasion for using the non-synchronous rotary spark gap during the instances you have mentioned?

A. This gap was used to replace the quenched spark gap when the latter might be broken down or might be under repair or cleaning. During such conditions, the regular radio work of the ship or Shore Station would be carried on by using the rotary non-synchronous gap.

Q. 39. Can you refer to a printed publication where the Navy rotary, non-synchronous gap is described?

A. Yes. In Robison's Manual, 1924 Edition, the above gap is described on page 534 (Reproduced Opposite), and in Fig. 7 on that page is shown a picture of this gap. The picture is of the standard Navy design.

Mr. Vaill: Counsel for claimant offers in evidence a photostat copy of page 534 of Robison's Manual of Radio Telegraph and Telephony, referred to by the witness, and requests that the same be marked "Claimant's Exhibit No. 212".

(Said exhibit marked as requested.)

Q. 40. Defendant's witness Loftin, in speaking of Navy wave changers, testified in answer to Q. 32, as recorded on page 1121 of the Printed Record, as follows:

"The mere fact that these wave changers included arrangements for adjusting the inductance of the two circuits in which the device was connected does not mean that the adjustment was for the purpose of securing resonance between the two circuits as contended by Mr. Waterman, for in the quenched gap type, resonance between the two circuits is not used, and the adjustments are for an entirely different purpose".

Will you please state, in accordance with your knowledge and experience, any facts that may have a bearing on this statement of Mr. Loftin regarding Navy quenched spark transmitters and wave changers?

A. The statement is incorrect. The adjustment or tuning of the two circuits in which the wave changer was connected was for the purpose of securing resonance between the two circuits, it being understood that I am referring to transmitters using the quenched gap. When the set is in operative condition, the two circuits must be in resonance, or substantially so. I have testified to this status in a previous reply and have shown recorded evidence thereof.

Q. 41. Will you kindly point out what you intend to in-[fol. 1169] clude in the term "recorded evidence" referred to in your last answer?

A. I refer to the resonance curves on page 156 of Robison's Manual, 1911 issue, as referred to in my answer to Q. 21.

These resonance curves form "Claimant's Exhibit No. 211."

Q. 42. Upon what personal experience is your knowledge of the Navy wave changers and quenched spark transmitters based?

A. I have superintended the installation of, and have tuned and operated, hundreds of quenched gap transmitters in which the wave changer was a part of the mechanism. In co-operation with another radio engineer then in the service of the Navy Department, I invented the wave changer and by permission of the Navy Department, obtained a patent on the same from the U. S. Patent Office. I was assigned from Washington to the New York Yard to work with the radio engineer above-mentioned in designing and manufacturing the first Navy wave changer, and assisted in the design of succeeding types.

Q. 43. At the end of page 1124 and the beginning of page 1125 of the Printed Record, defendant's witness Loftin, in answer to Q. 34, testified as follows:

"Answer. The 'wave changers' referred to by plaintiff's witness Clark, were developed and designed for practical use after the quenched-gap type of transmitter was adopted by the Navy as a preferred form, and therefore included in the design particular consideration for the conditions to be met in quenched-gap operation, particularly in the matter of obtaining tight coupling".

From your knowledge and experience with these wave changers, will you please state the facts as regard the degree of coupling used therein?

A. The design of the Navy wave changer was such that loose coupling could be obtained as well as tight coupling.

Q. 44. On page 1125 of the Printed Record, Mr. Loftin also testified for defendant as follows:

"It was not possible, however, to use these wave changers with the open-gap type of transmitter, though I have never known one to be so used."

Will you please state the facts, in accordance with your experience, regarding this statement of Mr. Loftin?

A. It was possible to use the wave changers with the open gap type of transmitter. Practically every installation of the wave changer that I tuned and adjusted included

both a quenched gap and a non-synchronous rotary gap, and my adjustments were made first with the one gap, and then with the other. The non-synchronous rotary gap is an open type gap.

Navy specifications RE 13-A 111E, referred to first in my answer to Q. 28, contain on pages 35, 36, 37, 38, 39, 40, 41, 42, 43 and 44, the list of parts required for radio transmitters of 2 K.W., 5 K.W. and 10 K.W. capacity. In each case, there is required a quenched gap, a rotary non-synchronous gap, and a wave changer and inductive coupling. For instance, on pages 35 and 36, these items are respectively numbered 36, 37 and 43, this covering the 2 K.W. set. These required items show that the wave changer could be operated with an open-type gap, and my personal experience with Naval installations confirms this.

Q. 45. In what respects, if any, did the tuning and operation of the wave changers when used with the quenched gap, [fol. 1170] differ from the tuning and operation of the wave changers when used with a non-synchronous rotary gap?

A. As to adjustment of the closed and open circuit, there was no difference caused by which type of gap was used. The two circuits were substantially in resonance when correctly tuned for the rotary gap, just as they were when correctly tuned for the quenched gap. The coupling in the case of open gap operation was not critical, as it was with the quenched gap, and in general the operating coupling was looser in the case of the rotary than with the quenched gap.

Q. 46. How did the wave lengths of the primary or generating circuit compare with the wave lengths in the secondary or antenna circuit, when the quenched gap and the rotary gap portions were used respectively?

A. In either case the wave length of the primary circuit was the same as the wave length in the antenna circuit, or substantially so, when the set was correctly tuned for operation.

Q. 47. Referring again to the answer to Q. 34 of defendant's witness Loftin, as found on page 1125 of the Printed Record, will you please state whether the following testimony given by Mr. Loftin is correct or accurate, in view of your experience with wave changing devices, to-wit:

"The dials are marked with these predetermined wave lengths, and in setting up the apparatus for use when it is a quenched-gap type it is compulsory that the antenna or

open circuit be adjusted to the dial marking irrespective of any other adjustments of the apparatus."

A. I consider that this statement is very inaccurate and misleading. It is not compulsory that the antenna circuit be adjusted to the wave length of the dial marking irrespective of any other adjustments of the apparatus. It is just as compulsory that the closed circuit be adjusted to this same wave length. If both closed and open circuits are not substantially in tune with each other and with the wave length of the dial marking, the set is not in operative condition to transmit at that wave length.

When the wave changer handle is moved so that a definite wave length is indicated by the dial markings, this means (if the set is in operative condition), that the primary condenser is of the correct value for the wave length in question, that the primary inductance value is such that the primary circuit is in tune with the wave length in question, that the antenna series condenser is, or is not, in circuit with the antenna as determined by the requirements of the chosen wave length, and that the secondary inductance value is such that the secondary circuit is in tune with the wave length indicated on the dial markings. All these are compulsory if the set is adjusted for operative conditions

Q. 48. Please state in what manner the dial markings were used on the Navy type of quenched spark transmitter employing the wave changing device?

A. The dial markings were placed opposite the contacts of the primary circuit, on the front of the wave changer, where also was located the handle for moving simultaneously the various arms of the device. Thus the operator in moving the handle would have, within easy vision, the markings which indicated the wave length he sought. In some cases, the wave length or dial marking was repeated on the rear panel of the wave changer, opposite the secondary contacts. I do not recall any Navy wave changer design where the markings were on the secondary only.

[fol. 1171] Q. 49. Can you refer to any printed publication that is in accordance with your last answer as regards the position of the wave length markers on the wave changers?

A. I find this on page 529 of Robison's Manual 1924 Edition (Reproduced Opposite). On this page is a halftone of a photograph, marked "Fig. 2. 5-Kw, 500-Cycle,

Quenched-spark Transmitter. Front View". I identify herein the wave changer, which is a Navy design, and of which the front panel, with the wave length handle and the primary contact-arm is seen. Opposite the eleven primary contacts may be seen markers or tabs, and this is in accordance with my recollection of how the wave length markings were placed on the Navy wave changers which I used. These markers were engraved with the respective wave lengths in the range of the set.

Q. 50. According to your experience or observation outside of matters concerning the Navy Department, do you know whether or not these so-called wave changers have been used for commercial or other purposes, and if so, please refer to any publication which may describe or illustrate such wave changers?

A. The wave changers have been used for commercial purposes by commercial radio companies, particularly the Marconi Company of America. I find a description of a transmitter embodying this wave changer, and manufactured by the Marconi Wireless Telegraph Company of America, in an article written by Roy A. Weagant and published in Volume I, Part 4 of the Proceedings of the Institute of Radio Engineers, dated December, 1913. On page 47 of this article, I find the following:

"The transmitter here shown is designed so that eight definite and predetermined wave lengths * * * may be instantly obtained by the setting of a single rotary switch E, which makes connections in both open and closed circuits."

On page 49 of the same article (Reproduced Opposite) I find the following:

"The calibration of the primary circuit is accomplished at the factory. The fixed wave lengths used in these sets are 625, 750, 875, 1,000, 1,300, 1,575, 1,800, and 2,000 meters".

On page 50 of the same article, is found a front, side, and rear view of the transmitter. The front view shows the wave changer handle, and a pointer connected to it and passing over wave length stampings on a semi-circular dial. None of the wave changer contacts are seen in this front view. The rear view of the transmitter shows the antenna

contacts and I see no indication of wave length markings on this panel. The foregoing description agrees with my recollection of this transmitter which I saw at the Aldene Works of the company.

Mr. Vaill: Counsel for claimant offers in evidence a photostat copy of page 529 of Robison's Manual, referred to by the witness, and requests that the same be marked "Claimant's Exhibit No. 213".

(Said exhibit marked as requested.)

Mr. Vail: Counsel for claimant also offers in evidence a photostat copy of page 49 of the Proceedings of the Institute of Radio Engineers, Volume 1, Part 4, and requests that the same be marked "Claimant's Exhibit No. 214".

(Said exhibit marked as requested.)

[fol. 1172] Q. 51. How were the wave lengths indicated on Navy quenched spark transmitters that were not equipped with the wave changing apparatus?

A. In some cases by wave length markings placed directly on the clips used for the pick-off points in both the closed and open circuits. In some Telefunken sets, for example, the clips were provided with sockets at their outer ends, into which a plug could be inserted. Around this socket was a circular disk and on this disk was marked the wave length corresponding to the location of the clip on the coil.

Q. 52. Will you please describe the type of coils used in the Telefunken sets referred to in your answer?

A. These were flat spiral coils.

Q. 53. Will you please examine the illustrations forming part of "Claimant's Exhiibt No. 206" and state what these illustrate, according to your knowledge of transmitting sets?

A. The first illustration is that of a Telefunken commercial type transmitter which is practically the same as the one to which I referred in my answer to Q. 51. The coils of the set are the same as the type I referred to in my answer to Q. 52. The second illustration is that of a Telefunken receiver, of the upright type, with primary and secondary tuning condensers.

Q. 54. Will you kindly also state what the other sheets of this "Exhibit No. 206" contain?

A. The first sheet refers to the leads to be run between the power source and the transmitter; this sheet is marked 167A. The second sheet is numbered 167 and contains schematic circuit diagram of the power board, the radio transmitter and the receiver. This sheet also contains instructions for tuning the set to a definite wave length, and for obtaining a clear spark. Both of these sets of instructions agree in general with the methods for tuning and for obtaining a good spark gap note, as described by me in my answers to preceding questions. The next sheet, number 162A, gives the wiring of the receiver, and also shows in schematic form diagrams illustrating how the receiver can be used with or without secondary tuning condensers. The next sheet, No. 152, shows the make-up of the primary inductance, and also shows the tuning positions for various wave lengths. These tuning positions are indicated on the drawing by small circles placed at various points on the spiral coil, these circles each bearing a number. In an attached calibration table the wave length which is obtained when the connecting plug is placed on the coil at any given numbered circle, can be read. The remaining two sheets are the illustrations to which I referred in my answer to Q. 53.

Q. 55. Continuing his answer to Q. 34, on page 1125 of the Printed Record, Mr. Loftin testified for defendant concerning the dial markings on the open gap type of transmitter as follows, the same coming immediately after the quotation forming a part of Q. 44 of your present deposition:

"If so used, the wave-length marking on the dial would determine the natural frequency of the primary circuit, as in the open-gap type the primary circuit has the duty of establishing the frequency of the entire system. That is, if the open-gap type, assigned predetermined frequencies [fol. 1173] marked on the dials of the wave changers, it would be compulsory to adjust the frequency of the primary circuit to correspond to the markings irrespective of other adjustments."

Please state with your experience with this type of set any facts that may have a bearing on the correctness of the testimony quoted.

A. I consider the above statement very incorrect and misleading. It is not compulsory to adjust the frequency

of the primary circuit, in a transmitter of the open gap type, to correspond to the wave length marking on the wave changer, irrespective of other adjustments. It is just as compulsory to adjust the frequency of the secondary circuit to this wave length marking. Unless both circuits are substantially tuned to the same wave length, such as the wave length of the dial marking, the set is not operative for use.

In an operative, correctly tuned, transmitter of the open gap type, using a wave changer, placing the handle of this wave changer to a position corresponding to a certain definite dial marking, means that the primary capacity has thereby been placed at the correct value for this wave length, the primary inductance system has been tapped off at the correct point so that the primary circuit is tuned to said wave length, the antenna series condenser is or is not in circuit as required by the wave length used, and the secondary inductance system has been tapped off at the correct point, so that the secondary circuit is tuned to the wave length of the dial marking. All these operations are compulsory if the set is to be in operative condition.

Q. 56. Referring to your last answer, where you mention the "antenna series condenser is or is not in circuit as required by the wave length used", will you please state how this antenna condenser was controlled in the wave changer?

A. It was usually inserted in series with the tap-off point of the secondary circuit for the wave length in question. That is, the lead from the secondary contact would pass through the antenna series condenser before going to the pick-off point on the secondary coil system. Thus, when the wave changer was moved to such a secondary contact the antenna series condenser would be automatically cut into circuit.

Q. 57. On what wave lengths did this antenna series condenser become necessary?

A. At short wave lengths, nearing the fundamental wave length of the antenna in use.

Q. 58. Testimony has been given in this suit by defendant's witness Loftin, recorded on page 1137 of the Printed Record, concerning the open gap transmitting sets on the U. S. Battleships connected with the British Grand Fleet in the North Sea during the World War. Will you please state what knowledge you may have of the use by the United States Navy of such sets under those conditions?

A. Early in 1918 I was detailed by the Bureau of Engineering, Navy Department, to proceed to Halifax, Nova Scotia, and observe the various component parts of the radio installation of a British Battleship. I went through the entire installation of H. M. S. Roxburgh, and noted the details of the transmitters and receivers, so that I would [fol. 1174] be able to do my part in arranging for the manufacture of similar or modified apparatus to be used in the United States vessels serving in Foreign Waters. Among other things I studied what the British called their "Type 9" or 126 meter set, which later was manufactured in this country practially in the same shape as the original installation I saw. It was called in our Navy, the "Inter-Fleet Set".

I also saw this set in operation, and noted its tuning, as Major Cheesman, British Liaison Officer to the U. S. Navy Department was present on H. M. S. Roxburgh and tuned the set up in my presence. This set was a two-circuit, condenser-coupled transmitter, with an open type spark gap, and with a blower to cool the gap. The tuning that I observed was very sharp.

On my return to Washington I had a little to do with the details of getting such a set in manufacture for our use, and later used the set after its installation on some of the U. S. Naval vessels.

Q. 59. What U. S. Naval vessels had such sets or similar sets installed on them, as mentioned in your last answer?

A. I recall an installation of this Inter-Fleet set on the U. S. S. Delaware, which set I adjusted in the Summer of 1918, and used for receiving experiments made on the U. S. S. Mississippi at that time. The latter ship also had a set of this type. From my knowledge of the engineering work done in the Bureau of Engineering, with which I was in constant touch, I know that these sets were installed on a large number of United States battleships.

Q. 60. What experience, if any, have you had on United States Naval vessels under sailing or cruising conditions, where the 126 meter transmitting sets were used?

A. I used this set during a cruise of the U. S. S. Idaho to Guantanamo in 1919, the ship sailing from New York.

Q. 61. Will you please examine "Claimant's Exhibit No. 207" and state what you understand this exhibit shows.

A. The two wiring diagrams shown in this exhibit are correct diagrams of the circuits of the Inter-Fleet or 126 meter transmitter, as I recall it.

Q. 62. Will you please state, if you know, why these loosely coupled open gap 126 meter transmitting sets were installed on U. S. battleships?

A. On account of the military necessity for communication between a given battleship and some other ship of the Fleet near by, simultaneous with communication between this battleship and some distant radio station. The latter communication was carried on from the main radio room of the battleship, using relatively long wave lengths. The former communication was carried on on short wave lengths from another radio room.

It was found in the first tests of this simultaneous operation, that if a quenched gap transmitter were used for the short wave, short range, transmission, it interfered with reception on the main antenna, even though this reception were at a very long wave length and with very selective apparatus. But when the loosely-coupled, open-type gap set, above described as the Inter-Fleet set, was used at the short wave length, it did not interfere with simultaneous reception on the main radio antenna. Thus this type of Inter-Fleet transmitter was adopted as standard.

[fol. 1175] Q. 63. Testimony has been given in this suit by defendant's witness Loftin and recorded on Printed Record pages 1116, 1119 and at other points, to the effect that the U. S. Government used certain types of Telefunken and Atlantic Communication Company receiving sets, of which the secondary circuits were untuned. Will you please state, if you know, what types of these sets were used by the U. S. Navy Department?

A. I am familiar with three types of receivers made by the Telefunken Company, which were used by the U. S. Navy. There was an upright type, which I think was Type E 5, which contained one variable condenser for use in tuning the antenna circuit. This was a two-circuit receiver, the secondary coil being tuned by means of moving a plug to any one of a number of tap-off points, the tuning being obtained by the inductance of the portion of the coil in use, and the distributed capacity of the coil. There was another upright type, which as I recall, was termed "Type GAHU", wherein there were two variable condensers, one used for tuning the primary as before, and the other for tuning the secondary when condenser tuning was used in this circuit. In this latter type, however, there was also a coil supplied for the secondary circuit, which

coil had a number of tap-off points, and when this coil was used, the secondary condenser was not in circuit. Under these conditions the receiver was the same in operation as Type E-5. There was a third type of Telefunken receiver, known as "Type E-4", this being a flat type of receiver. The tuning of the secondary of this receiver was likewise by picking off an inductance tap, and making use of the distributed capacity of the coil. I think that a switch was used for passing from one inductance pick-off to the other.

Q. 64. Do you know of any Navy receiving sets which were designed in the Navy that had secondary circuits tuned in a similar manner; if so, please give their designations?

A. I do not know of any sets which were designed in the Navy and which embodied this feature. However, a number of sets of this type were designed under Navy supervision: for example, the receivers of the portable sets made by the National Electrical Supply Company of Washington, D. C. I was detailed by the Bureau to assist and supervise the design of these sets, including the receivers. The receivers of the Battleship, Type B, Type C and Type D portable sets had their secondaries tuned by a change of secondary inductance, combined with the distributed capacity of the coil. I used these sets after their delivery to the Navy, both for experimental work and in actual communication.

Q. 65. Will you please state where you saw and used the Telefunken sets referred to in the previous answer before the last?

A. I have used all three Telefunken receivers of the type referred to on a great many Naval vessels and at Naval Shore Stations. I can recall some specific instances. I remember using, and making a drawing of, a flat E 4 type on the U. S. S. Maryland at the Isthmian Canal Zone in 1912. I recall using, and making a picture of, the two condensers GAHU set on the U. S. S. Arkansas, on Christmas week, 1913, while en route to the Canal Zone with President Taft. The upright E-5 type I recall using at the Portsmouth Navy Yard, about 1911, and also at the Norfolk Navy Yard.

[fol. 1176] Q. 66. Where was this Portsmouth Navy Yard you have mentioned located?

A. On the opposite side of the river from Portsmouth, New Hampshire.

Q. 67. To how many different wave lengths was the secondary circuit of the upright form of the Telefunken receiver sets capable of being tuned?

A. When this secondary coil was used without tuning condenser, it could be tuned to any wave length within the range of the coil, which was approximately 250 to 6,000 meters. At each tap position, the secondary coil system would respond to a band of wave lengths, and in passing from one tap position to another next to it, the wave length bands overlapped. There were six of such tap-off points on the coils of this nature that I recall.

Q. 68. Can you produce any physical apparatus which substantiates your testimony as to the six bands of wave lengths referred to in your last answer?

A. Yes. I have here a secondary coil of a Telefunken receiver, such as would be used with the Type E-5, or with type GAHU when no secondary tuning condenser was used. This coil is marked "Detector Coil", and is stamped with the serial number 1653, a further identifying number, 350, being painted on the coil. There are six plug positions around a portion of the rim, to each of which wires pass to tap-off points on the coil. In these sockets would be placed the plug used for picking off the number of turns best suited for the wave length to be received.

There are tabs or markers for each plug position. On these are engraved the Greek letter Lambda, meaning "wave length", followed by the sign of equality, and below these, two sets of figures separated by a dash and ending with the letter "m". The figures signify the upper and lower wave lengths of the band of wave lengths to which the coil system best responds when the plug is in the associated socket. The letter "m" stands for meters. The following table gives the stampings on the various markers:

Plug Position	*Wave Length in Meters*
1	200- 500 m.
2	500- 650 m.
3	650- 900 m.
4	900-1500 m.
5	1500-2500 m.
6	2500-6000 m.

Q. 69. Will you please state where you obtained this coil which you produced in answer to the last question?

A. This coil was loaned to me by Commander S. C. Hooper of the Bureau of Engineering, about the last of 1919, for use in measurement work. I wished this particular coil, which I had used in Naval work, because I knew its constants.

Q. 70. In whose possession has this coil been since you obtained it in 1919?

A. It has been continuously in my possession until I turned it over to the custody of Mr. E. W. Vaill some days ago.

Q. 71. Will you please state your preferences as to putting this coil you have produced, in evidence as an exhibit, and your reasons therefor?

A. I prefer not to introduce it as a physical exhibit, in that I have use for it from time to time, and I am under personal obligations to return it whenever called for.

[fol. 1177] Mr. Vaill: Counsel for claimant offers in evidence a photograph of this coil produced by the witness, with the understanding that the original coil may be produced at the hearing in this case, if desired, and the same is available to claimant's counsel, and it is requested that said photograph be marked as "Claimant's Exhibit No. 215".

(Said exhibit marked as requested.)

Q. 72. Will you kindly examine this "Exhibit No. 215" and state whether or not it correctly represents the coil you have produced?

A. It does.

Q. 73. Can you refer to a printed publication containing an illustration of the upright type of Telefunken set?

A. I find such an illustration on page 176 of Robison's Manual, 1918 Edition (Reproduced Opposite). The illustration is marked Fig. 100. It shows an upright form of Telefunken receiver in which there is only one tuning condenser, and the series-parallel switch for changing the position of this condenser to various portions of the antenna circuit is clearly seen. The secondary coil is shown with six taps and a plug inserted in one of them. This secondary is of the type wherein the tuning is done by the inductance of the coil and its distributed capacity.

Mr. Vaill: Counsel for claimant offers in evidence a photostat copy of page 176 of Robison's Manual, 1918 Edition, and requests that the same be marked "Claimant's Exhibit No. 216".

(Said exhibit marked as requested.)

Q. 74. Can you refer to a printed publication explaining the effects upon tuning produced by variations of inductance and distributed capacity?

A. I find such an explanation in an article by Mr. Frederick A. Kolster, then with the United States Bureau of Standards, the article being headed "The Effects of Distributed Capacity of Coils used in Radio Telegraphic Circuits". This was published in Volume I, part 2 of the Proceedings of the Institute of Radio Engineers, April, 1913. On page 24 of this article, I find the following:

"Distributed capacity effects in the coils of the so-called untuned or aperiodic detector circuits are in many cases very striking, the result being that the circuit is not at all aperiodic but responds much more violently at a particular frequency, depending upon the natural period of the coil."

Mr. Vaill: Counsel for claimant offers in evidence a photostat copy of page 24 of Volume I, Part 2, of the Pro- [fol. 1178] ceedings of the Institute of Radio Engineers for April, 1913, and requests that the same be marked "Claimant's Exhibit No. 217".

(The exhibit marked as requested.)

Mr. Vaill: Counsel for claimant also offers in evidence a photostat copy of pages 538 and 539 of Robison's Manual of Radio Telegraphy and Telephony, Edition of 1924, referred to by the present witness in answer to Q. 14, and requests that the same be marked "Claimant's Exhibit No. 218".

(The exhibit marked as requested.)

Q. 75. Please refer to your answer to R. D. Q. 37 of your previous testimony given in this case, as found on page 250 of the Printed Record, where you stated that you made tests of a Navy Bellini-Tosi direction finder and that you made comparative tests of two electrode Fleming valves and a carborundum crystal detector in 1910 or 1911. Please also refer to the testimony of defendant's witness

John M. Miller, page 820 of the Printed Record, during which he comments upon your prior testimony and make any comments that may seem advisable, in view of Mr. Miller's testimony.

A. Referring to my answer to R. D. Q. 37, I wish to state that the tests referred to were made in 1914, and not in 1910 or 1911.

Referring to Mr. Miller's testimony on page 820 of the Printed Record, where he draws deductions from the Official Report which I made to the Navy Department on the above tests, I find that Mr. Miller has misquoted my report, and has made errors in his deductions. About three-quarters of the way on page 820 Mr. Miller states:

"So that we find the standard Navy crystal detector to be three and one-half times superior to the Fleming valve instead of the Fleming valve being twice as sensitive".

According to the ordinary rules of grammar, I understand that the phrase which is understood in this sentence is "as the standard Navy crystal detector", making the entire statement read:

"So that we find the standard Navy crystal detector to be three and one-half times superior to the Fleming valve instead of the Fleming valve being twice as sensitive as the standard Navy crystal detector".

With this understanding, Mr. Miller's statement is incorrect, in that my report stated that the Fleming valve was twice as sensitive as the carborundum detector. The standard Navy crystal detector at that time was the Galena detector.

Mr. Miller is in error in stating that it is found from my report that the standard Navy crystal detector was three and one-half times superior to the Fleming valve. As given on this same page 820, I found that the audibility of a given signal was 400 with the Galena crystal and 160 with the Fleming valve. The ratio of 400 to 160 is two and one-half, and not three and one-half.

In my answer to R. D. Q. 38, I testified that the valve was more sensitive than the crystal, specifically stating "possibly it was twice as sensitive". As I recall the tests in question, and as the Official Report shows, the main object of the tests was to obtain and furnish data primarily on the apparatus submitted for such tests, namely, the Bellini-

[fol. 1179] Tosi direction finder outfit. The detectors which were furnished with this outfit were a carborundum crystal and the Fleming valve, and my main comparison of detector sensitiveness was between these two elements of the outfit under test. That is why I stated in my answer to R. D. Q. 38 that the valve was twice as sensitive as the crystal detector. An auxiliary test was made, comparing the Galena detector and the Fleming valve, in which the sensitivities were respectively 400 and 160.

Q. 76. How much of a choice did you have in the use of Fleming valves in making the tests you have referred to in your last answer?

A. I think there were five operative valves submitted with the set, but as far as I know, I used only one valve in the above comparison between crystal and valve detector.

Q. 77. Did you make any comparison between the relative sensitiveness of the various valves themselves?

A. I probably did, though I have no specific remembrance of doing so.

Q. 78. In answer to Q. 20, page 799 of the Printed Record, defendant's witness, Mr. Miller, mentions the omission of choke coils from three of the circuits of "Plaintiff's Exhibit No. 116", "vacuum tube transmitters for radio telephony". What have you to say concerning this comment of Mr. Miller?

A. In the above reference, Mr. Miller states that the schematic drawings termed "De Forest", "Western Electric", and "General Electric (No. 2)", are inoperative because "this type of circuit to be operative requires a radio frequency choke coil in series with the plate battery B^2 in the diagrams of "Plaintiff's Exhibit No. 116".

In the light of my previous testimony, with the data at hand which is referred to in that testimony, the above statement of Mr. Miller is incorrect.

In my previous testimony, I stated on page 237 that the schematic drawings which are referred to above, were extremely simplified, and that they showed only the essential elements used to create oscillations in the antenna. About half way down this page I stated:

"B^2 represents the supply source for the plate voltage and this may be a generator or a battery".

On page 238, I furnished a table in which were given the actual wiring diagrams from which the several sche-

matic diagrams were made. Reference to each of these wiring diagrams shows that a generator was used as the supply source for the plate voltage.

When a generator is so used, the inductance of the armature is sufficient choke to permit of the apparatus functioning. I have used this identical circuit, without radio-frequency choke coils, many times in oscillating valve circuits, thus showing that such a circuit is operative, even though radio-frequency chokes are not present. In the circuits referred to by Mr. Miller as inoperative, radio-frequency choke coils are actually used in the sets themselves, but they are in the nature of safety devices, and are not "essential elements necessary to create oscillations in the antenna".

Q. 79. Referring to the original circuits from which your simplified diagrams were made, will you please state what effect, if any, would be produced if the generators shown [fol. 1180] in the plate circuits were replaced by batteries, as suggested in your last answer?

A. The original circuit from which the simplified drawing referred to as "DF" was made is given as Figure 10 in the publication which is "Plaintiff's Exhibit No. 117"; the original circuit from which the simplified drawing referred to as "GE No. 2" was made is given in Fig. 26 of the publication which is "Plaintiff's Exhibit No. 118"; the original circuit from which the simplified drawing referred to as "WE" was made, is given as Fig. 9 of the publication which is "Plaintiff's Exhibit No. 118". In all of these circuits, the set would be operative if the generators shown in the plate circuits were replaced by batteries.

Q. 80. Defendant's witness Mr. Miller, in answer to Q. 20, above referred to, also mentions "Plaintiff's Exhibit No. 116" and the circuit marked "General Electric Co. 2", stating:

"Mr. Clark has also omitted the grid leak resistance across the grid condenser 'I'.

What have you to say in this connection?

A. The grid leak resistance was inadvertently omitted from the extremely simplified diagram referred to.

Cross-examination.

By Mr. Edwards:

X Q. 81. In your answer to Q. 75 you say that Dr. Miller has misquoted your report; are not the quotations made by him from your report and found on printed page 820 of his deposition correct quotations?

A. Mr. Miller states in part:

"I have looked up Mr. Clark's Official Report to the Navy Department on these tests. * * * I find that Mr. Clark compared * * * etc."

Following this, Mr. Miller gives other statements as to my report; I consider these statements as quoting from my report, and therefore I still consider that the report was misquoted in the particular sentence referred to in my answer to Q. 75.

X Q. 82. Do you deny that the quotations given by Dr. Miller from that report, and appearing in quotation marks on page 820 of the Record, are correct quotations?

A. Without having the report here to compare, I cannot definitely answer, but to the best of my knowledge, as I recall that report, the quotations appearing in quotation marks are correct.

X Q. 83. Do you deny that in that report you gave the audibility of the carborundum detector as 80, the audibility of the Fleming valve as 160 and the audibility of the Galena crystal at 400?

A. No.

X Q. 84. Do you deny that after the first few tests on the direction finder, the Galena detector was used for all tests?

A. No.

X Q. 85. Do you deny that in that Report you recommended that the carborundum detector and the Fleming valve be replaced by a more sensitive crystal detector, such as a Galena or silicon arsenic detector and a DeForest audion amplifier?

A. No.

X Q. 86. Is it not true that aside from the typographical error of indicating the audibility of the Galena crystal as three and one-half times superior to the Fleming valve, [fol. 1181] instead of two and one-half times, that the only criticism you have to make of Dr. Miller's testimony is that

he understood the Galena crystal to be the standard Navy detector, whereas, you contend that the standard Navy detector was the carborundum detector?

A. I have not made the statement that the standard Navy detector was the carborundum, but I have stated that the standard Navy crystal detector was the Galena at that time. Furthermore, in addition to the incorrect ratio of sensitiveness given by Mr. Miller, I have the further criticism that he states, by inference, if my understanding of the grammatical meaning of the sentence is correct, that he finds in my report that the Fleming valve was twice as sensitive as the standard Navy crystal detector.

X Q. 87. Do you deny that if the standard Navy detector was the Galena detector, that your report shows that the standard Navy detector was two and a half times as sensitive as that of the Fleming valve?

A. No.

X Q. 88. Then wherein did Dr. Miller misquote your report, except for the obvious error of indicating that 400 is three and a half times 160 instead of two and a half times?

A. In that I understand his statement

"So that we find the standard Navy crystal detector to be three and one half times superior to the Fleming valve instead of the Fleming valve being as twice as sensitive"

to mean that my report stated that the Fleming valve was twice as sensitive as the standard Navy crystal detector, and this statement is a misquotation of my report.

X Q. 89. I note that you do not complete the sentence of Dr. Miller's testimony from which you quoted. The Record shows that after the word "sensitive" there is a comma, and the sentence continues "as one would gather from Mr. Clark's testimony." Do you deny that in your first deposition in this case you testified to the effect that the Fleming valve, in this set which you tested, was possibly twice as sensitive as the crystal and that your own report introduced in this case now shows that the crystal was twice and a half times as sensitive as the Fleming valve?

A. Your statement is incorrect.

X Q. 90. Do you deny those facts?

A. In the form which you have presented them, I do.

X Q. 91. Will you point out wherein the statement is incorrect?

A. In that you refer in the 8th line of your X Q. 89 to "the crystal" being half as sensitive as the Fleming valve and in the 9th line to "the crystal" being twice and a half times as sensitive as the Fleming valve. By such use of the same words "the crystal" without further designation, I understand you to mean that the same crystal is meant by you in both cases, and with this understanding your statement is incorrect.

X Q. 92. Then I take it your position now is that when you testified previously in answer to R. D. Q. 38, page 250 of the Printed Record, you meant that the Fleming valve was possibly twice as sensitive as the carborundum detector; is that correct?

A. Yes, it is.

X Q. 93. At that time, why did you omit reference to the fact that the Galena detector was two and a half times as [fol. 1182] sensitive as the Fleming valve?

A. Because the main test which I made was a comparison of the apparatus furnished with the Bellini-Tosi outfit and my chief aim in the test was to obtain such data and comparison; the carborundum detector was a part of this outfit, the Galena was not. I gave the ratio which I found in my main test.

X Q. 94. At the time of giving this testimony you knew, did you not, that the Galena crystal was the standard crystal of the Navy at the time the tests were made?

A. Yes.

X Q. 95. At the time of giving this testimony you knew, did you not, that when making the test, you had compared the Fleming valve with the Galena crystal, as well as the carborundum crystal?

A. I may have recalled it, but I do not definitely know.

X Q. 96. And you knew at the time of giving that testimony that the obvious purpose of the question which you were answering was to enlighten the Court upon the comparative performance of the Fleming valve and crystal detectors?

A. I did not consider that phase of the matter, but answered the specific question asked me as to certain tests made with the Bellini-Tosi direction finder.

X Q. 97. Was there anything in the question asked you which indicated that the answer was to be confined to carborundum crystals only, so far as you recollect?

A. Yes.

X Q. 98. What is your recollection?

A. To the best of my present knowledge, I was asked to give testimony as to tests made with the Bellini-Tosi direction finder, and I confined my answer to the tests which I made with this direction finder; the Galena detector was not a part of the Bellini-Tosi outfit. I understood that I was being asked as to the tests made with this outfit, and, as I recall, the question was so worded.

X Q. 99. I will ask you to look at page 250 of the Printed Record and note that Q. 37 asked you if you had had occasion to compare the sensitiveness of the two-element vacuum tube detector and "the crystal detector"; that you replied that you had made "a number of such tests" "in connection with" a Bellini-Tosi direction finder, and that then Q. 38 asked "What was the result of the comparison?" In view of that record, I will ask you if you do not think that your answer would have been more enlightening to the Court, and at the same time fairer, if you had pointed out that your answer only applied to the carborundum detector and that at the same time you had also compared the Fleming valve with the standard crystal detector of the Navy, the Galena detector, and found the Galena detector to be twice and a half times as sensitive as the Fleming valve?

A. I could have made my answer contain much more information than it did, by pointing out a number of other tests besides the main one which I used as the basis of my reply. Undoubtedly it would have been more enlightening had I added the comparison of the Galena and valve, and I might also possibly have given the Court more information by stating that in comparing the valve with one type of crystal detector, I found the former twice as sensitive, and with another type of crystal detector, less than half as sensitive, so that, in general, the valve and the crystal detectors used in the tests were of the same general order of sensitiveness. I do not admit the correctness of [fol. 1183] your word "fairer" in your question. My answer was given with strict adherence to fact, and in all fairness.

X Q. 100. I will ask you now if you think Dr. Miller was unfair, or unjustified, in assuming that your previous testimony was to the effect that the Fleming valve was twice as sensitive as "crystal" detectors, without limitation to whether the crystal was carborundum or Galena?

A. I do not know that he did so assume. I find no reference to such an assumption in his testimony.

X Q. 101. Is it not a fact that the only basis you have for charging that Dr. Miller misquoted your report and made errors in his deductions, is that the text of his answer reads "three and one-half" instead of "two and one-half" as the figures obviously indicate, and that when he said that your report showed the standard Navy crystal detector to be superior to the Fleming valve "instead of the Fleming valve being twice as sensitive, as one would gather from Mr. Clark's testimony", he was not a mind reader, and did not know that your testimony contained a hidden qualification to the effect that the crystal you referred to was a carborundum crystal, although you knew at the time that the standard Navy crystal was two and a half times as sensitive as the Fleming valve?

A. It is not a fact that my only basis for stating that Mr. Miller misquoted my report is the numerical error above referred to. I also consider that, based on the actual wording of his statement, a second error was made by him. The sentence on line 24 of page 820 of the Printed Record, beginning "So that we find the standard Navy crystal detector * * * " is an incomplete sentence, in that he starts a comparison by the phrase "the Fleming valve being twice as sensitive" without completing the sentence, and stating what it was that the Fleming valve was twice the sensitiveness of. From ordinary grammar, the understood phrase thus left out must refer to the matter in the rest of the sentence, namely, the standard Navy crystal detector. Thus if he gathers from my testimony that I said the Fleming valve was twice as sensitive as the standard Navy crystal detector, he misquoted my testimony.

I do not know whether Mr. Miller is a mind reader or not, but I think it fair to assume that he has the normal memory of a human being; therefore, when he made his statement regarding the standard Navy crystal detector, and its relation to the Fleming valve he cannot have forgotten that four lines above he himself stated that the

Galena crystal was the standard Navy detector. Therefore, he was not in any way in the dark as to what he was talking about.

X Q. 102. But I remind you again that you do not quote the complete sentence of Dr. Miller and omit that part referring to "twice as sensitive, as one would gather from Mr. Clark's testimony." Do you think there was anything in your former testimony that gave any indication that the crystal was not a standard Navy crystal, but was a carborundum crystal?

A. My former testimony did not state the type of crystal, but in the sentence in which I consider Mr. Miller misquoted me, he had my complete Report at hand and gave the actual figures and types of detector just a few lines before this sentence. He cannot be going entirely from my testi- [fol. 1184] mony, since in my former testimony, I did not state that the standard Navy crystal detector was three and a half times superior to the Fleming valve, and yet the phrase "as one would gather from Mr. Clark's testimony" reads as clearly on that statement as it does on the statement that the Fleming valve was "twice as sensitive."

X Q. 103. You understand, do you not, that Dr. Miller was comparing your Report on the one hand, with your testimony on the other?

A. Yes.

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X Q. 104. In your direct examination you referred to certain sets, such as the Slaby-Arco transmitters, which employed artificial cooling means in connection with open gaps. Is it not a fact that the artificial cooling means, such as air blowers, tends toward making the gap act like a quenched gap?

A. I have observed no phenomena in using sets with open gaps thus artificially cooled, which would lead me to consider them as acting like quenched gap sets.

[fol. 1185] X Q. 105. Would you consider that the cooling means, such as blowers, tends to interfere with, or prevent, maintaining the gap active for a long time?

A. That is a matter which I never actually observed or made measurements of.

X Q. 106. Can you express any opinion on the subject?

A. I prefer not to, as I wish to continue my testimony as a fact witness, dealing with observed facts and measurements.

X Q. 107. Can you express any opinion on the subject?

A. I have never made any measurements or observations on this matter, and therefore cannot express any opinion based on my own knowledge.

X Q. 108. Have you theoretical knowledge sufficient to enable you to express an opinion on the subject?

* * * * * * *

A. As in all previous cases where I have testified on radio matters, both for the United States Government and for private companies, I then confined my testimony and wish to confine my present testimony, to actual observations, measurements, and other physical operations which I have personally done or witnessed. This is what I mean by stating that I wish to give "fact testimony". I understand X Q. 106 to call for an opinion, and again I answer it by stating that I cannot give an opinion based on actual observations.

X Q. 109. Can you not answer X Q. 108 with a simple affirmative or negative?

A. I do not consider that I have sufficient theoretical knowledge to express the opinion referred to.

X Q. 110. It is a fact, is it not, that the cooled gaps to which you referred in your direct testimony, had a very considerably limited use, and have now substantially, if not entirely, disappeared?

A. In the early days of radio, say around 1909, or thereabouts, open gap transmitters formed the great majority of transmitting sets, and to my best present knowledge, about one-half of these transmitters had the spark gap cooled by artificial means. Therefore, I should not say that such sets "had a very considerably limited use." It is a fact that this type of set has now substantially disappeared.

X Q. 111. In your answer to Q. 13, you described the method used by you, in tuning quenched gap transmitters. [fol. 1186] And in step (c) you say that next you adjusted the secondary or antenna circuit "to resonance" with the primary. In doing this did you employ a wave-meter to measure the frequency in the secondary circuit?

A. Not in the act of adjusting the secondary circuit to resonance with the primary, to which you refer.

X Q. 112. The only circuit which you measured with a wave-meter was the primary circuit, was it not?

A. No, I also measured the wave length of the secondary circuit, but not in the act of adjusting this circuit to resonance with the primary, to which action your previous question referred.

X Q. 113. When did you use the wave-meter in measuring the frequency of the secondary circuit?

A. After all adjustments had been made putting the set into operative condition.

X Q. 114. You did not first tune the primary circuit to the desired wave length, measure it with a wave-meter, then tune the secondary circuit uncoupled, to the desired wave length, and then couple the circuits together and leave the circuits in their original adjustment, did you?

A. No.

X Q. 115. I take it from your answer to Q. 13, that when you followed out the procedure set forth in your answer you did not at all times, if ever, find that the antenna wave length was of the same frequency as the primary wave length; is that correct?

A. That does not agree with my recollection of my answer. I did frequently find that the antenna wave length, after the set was properly coupled, differed somewhat from the original wave length to which I had first adjusted the primary circuit, but I also found that this primary circuit, when the set was coupled, did not have the same wave length as it had when tuned alone. By re-adjusting both circuits I was always able to get the right or desired wave length in the antenna, and after this re-adjustment, both the primary and the secondary were substantially of the same wave length.

X Q. 116. I note that you qualify your last answer by saying "substantially" and also that in your direct examination for example, in your answers to Qs. 19, 40, 46, 47 and 55, and doubtless elsewhere also, you refer to the wave lengths or resonance being "the same or substantially the same". Do you draw any distinction between whether the frequencies are the same, or substantially the same?

A. No, I do not, because I could not find any difference in the ability of the transmitter to function properly, whether the primary and secondary final wave lengths were exactly the same, as they sometimes were, or whether they differed from each other by a few meters.

X Q. 117. Would you still subscribe to your testimony in this case if the words "or substantially the same" be

stricken out at the places indicated, and elsewhere throughout your deposition?

A. Where my testimony referred to measurements that I made, I would not subscribe to this testimony when the words "or substantially the same" were stricken out, because that would not be in accordance with the facts as I found them. However, I have stated in my answer to the previous question that at times I found the final wave lengths in both circuits to be the same, and in these cases I would subscribe to my testimony with the words referred to stricken out.

[fol. 1187] X Q. 118. If, for example, each circuit has a frequency of 900-meter wave length, I take it that you would then say that both circuits are in resonance; am I right?

A. Yes.

X Q. 119. Suppose one circuit is tuned to a wave length of 900 meters and the other circuit tuned to a wave length of 895 meters, have they the same frequency, and are they still in resonance?

A. From the viewpoint of adjusting a transmitter, my experience is that I would find such sets substantially in resonance from an operating viewpoint. Of course, they are obviously not in exact resonance.

X Q. 120. If one of the circuits is tuned to 900 meters and the other circuit to 850 meters, are they still in resonance?

A. I would not have adjusted a transmitter for use with such difference in wave length, for my best remembrance is that it would not operate satisfactorily. I would consider this difference in wave length to be beyond that tolerance allowable for the word "resonance" in operation.

X Q. 121. If one of the circuits is tuned to 650 meters, for example, and the other circuit is tuned to 550 meters, for example, would these circuits be in resonance?

A. I would not consider such a transmitter to be in operative resonance.

X Q. 122. If one circuit is tuned to 200 meters and the other to say 250 meters, would the circuits be in resonance?

A. I would say not.

X Q. 123. Can you give any indication as to how much of a departure from exact resonance can exist before it would cease to be substantially in resonance, according to your definition?

A. That would be entirely a matter of the conditions under which the set might be installed. My criterion in every case was to obtain an operative set, that is, emitting the right wave length, sharply tuned, with the radiation which my experience told me was satisfactory for the power used, and with the note good. Many of these conditions would vary in different locations, and what allowable difference in wave length could exist between primary and secondary would entirely depend on local conditions. In my answers to all the above questions, I tried as best I could to recall actual measurements with wave lengths about the same as those you refer to, but I could not give any numerical value as to a hard-and-fast allowable difference in wave length between primary and secondary which would not noticeably affect the operation of the set.

X Q. 124. I take it, then, from your last answer, that your criterion in determining whether or not two circuits have the same wave length, or are in resonance, depends not upon whether or not the product of the inductance and the capacity of each circuit is the same, but rather upon whether or not you were getting the wave length and radiation which your experience told you was satisfactory for the power used and the particular location; am I correct?

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[fol. 1188] A. I do not consider your statement correct. My criterion, in tuning a transmitter of resonance was the indication of some circuit capable of showing resonance by a maximum reading of some current-indicating device. For example, I measured the primary circuit by adjusting it until it gave a maximum deflection of an ammeter in a wave-meter circuit, the wave length of which wave-meter circuit was known to me from tables. I did not adjust the primary circuit to its wave length by measuring the inductance and capacity and multiplying them together. I adjusted the secondary circuit for maximum current in it, and thus again obtained resonance. After coupling the circuits, if the antenna wave length still remained the same as before, as it sometimes did, my criterion as to whether or not the circuits were "substantially in resonance" then became one of operative efficiency. I knew from previous experience that if there was material difference between the two wave lengths, the antenna would not be sharply

tuned and would not radiate the energy that should be sent out. Thus the amount that the primary circuit might differ from the secondary was entirely based on whether or not said difference was sufficient to affect the over-all operation of the set.

X Q. 125. In making the adjustments of quenched gap sets, as referred to in your answer to Q. 13, from what part of the primary coil did you take the measurement with the wave-meter?

A. In the first measurement of primary wave length, with the antenna circuit very loosely coupled and out of tune, the wave-meter was coupled with the operating portion of the primary coil itself. In re-measuring the primary wave length, after the antenna was tuned and coupled, this could not be done, because the wave-meter coil, under such conditions, would also be coupled with the antenna coupling coil. It then became necessary to couple the wave-meter to some part of the primary circuit where the wave-meter coil would pick up energy from the primary circuit only. Just where this would be would depend on each particular installation.

X Q. 126. At what part of the antenna circuit would you couple the wave-meter?

A. To the ground lead at a location where the primary circuit did not affect the wave-meter.

X Q. 127. What part of the circuit do you refer to as a "location in the ground lead where the primary circuit does not affect the wave-meter"?

A. That, of course, would depend on the particular installation under test. It was always possible to locate the wave-meter close to some portion of the ground lead, in such a position or location that the primary circuit did not affect it.

X Q. 128. Can you give us a specific example of such a location?

A. Not in feet and inches along a strip of copper unless a specific installation were mentioned.

X Q. 129. I mean relative position such as between cer- [fol. 1189] tain parts of apparatus located in the circuit.

A. The ground lead usually consisted of a copper strip running from a terminal on the wave changer to either the metal bulkhead of a ship, or to the grounding system of a Shore Station. Coupling the wave-meter coil to such

a strip, preferably as far away as possible from the set, and furthermore, adjusting the position or orientation of the wave-meter coil so that it would not take up any energy from the primary circuit, it was always easily possible to have the wave-meter affected only by the secondary circuit.

X Q. 130. Referring to your answer to Q. 21 and to the resonance curves shown on page 156 of Robison's Manual for 1911, it is a fact, is it not, that the diagram and text show that the resonance curve for the aerial, which curve is marked I, was taken at the place marked "Aerial Inductance"?

A. The curve so states.

X Q. 131. And both of these curves were taken after all adjustments were made, including the coupling, were they not?

A. The curves indicate that to me.

X Q. 132. And the curve showing the wave length II was taken by a wave-meter coupled to the "Primary Variometer" also in the antenna circuit, was it not?

A. The curve indicates that the wave length II was taken in the manner you describe. The primary variometer is in both the antenna and primary circuits.

X Q. 133. And it is a fact, is it not, that on page 157 of this publication, the following explanatory matter appears:

"Fig. 102 shows much steeper curves taken from a direct connected quenched gap, 500 cycle set.

"The position of the two small humps in curve I, fig. 102, taken at the primary variometer indicating a coupling of

$$\frac{1070 - 860}{975} = 22\%.$$

This is by no means very loose coupling, but the curve shows that the aerial radiates most of its energy while oscillating in its natural period (in this case 975 meters) and that when so oscillating it is persistent enough to permit very sharp tuning.

"Curve II in fig. 102 taken at the aerial inductance shows but one maximum which practically coincides in wave length with the maximum of curve I. (Curve II is drawn to a different scale, so that the coincidence in maximum

readings is only apparent. They are in reality smaller for the open than the closed circuit.)"?

A. Yes.

X Q. 134. Referring to your answers to Qs. 67 and 68, do you consider that if the antenna circuit is adjusted to a frequency of 250 meters, for example, and the plug position is 1, for example, that under these circumstances the secondary circuit is in resonance with the antenna?

A. Yes.

X Q. 135. Do you consider this to be resonance, or substantial resonance?

A. I prefer to call it broad tuning resonance. By "substantial resonance", I mean the condition between two sharply tuned circuits where the peak wave length of one differs only slightly from the peak wave length of the other.

[fols. 1190-1191] X Q. 136. Do you consider that the wave length of the secondary circuit which, as I understand your testimony, is tuned to a band of wave lengths, is in resonance with any particular frequency within the limits of the band; is that correct?

A. In broad resonance with it, yes.

X Q. 137. Is it not a fact that a circuit which is tuned to a band of wave lengths, or, as you call it, "broad resonance", of say 200 meters to 500 meters, is not, in fact, tuned to any particular frequency within those limits?

A. No, it is broadly tuned to all of them.

X Q. 138. But it is not "sharply tuned" to any particular frequency, is it?

A. No.

X Q. 139. And is it not a fact that according to your own definition, two circuits to be in resonance should be sharply tuned to each other, or substantially so?

A. I request that you quote my definition to this effect. If I made such definition, it was for a specific instance.

X Q. 140. Well, is it or is it not your understanding that in order for two circuits to be in resonance, they should be sharply tuned to each other, or substantially so?

A. My experience has been that a circuit can be in resonance with another, whether the tuning of this circuit be sharp or broad.

X Q. 141. Can you answer X Q. 141 with a simple affirmative or negative?

A. Such an answer would not give the best information that I can give.

X Q. 142. Can you answer X Q. 140 with a simple affirmative or negative?

A. It cannot be so answered by me.

Last Question by the Notary: Do you know of any other matter relative to this claim?

Answer: No.

Deposition closed.

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[fol. 1192] *Deposition of Roy A. Weagant, for Claimant, taken at New York, N. Y., on the 28th day of December, A. D., 1926.*

* * * * * * *

First Interrogatory by the Notary. State your name, your occupation, your age and your place of residence; whether you have any, and if any, what interest, direct or indirect, in the claim which is the subject of inquiry; and whether, and in what degree, you are related to the claimant.

Answer. My name is Roy A. Weagant; age, 45 years; occupation, Consulting Engineer; residence, Douglaston, Long Island. I have no interest, direct or indirect, in this claim and am not related in any way to the claimant.

Direct examination.

By Mr. Vaill:

Q. 1. Are you the Roy A. Weagant who has heretofore testified in this case and in the case in the Southern District of New York entitled Marconi Wireless Telegraph Company of America against DeForest Radio Telephone & Telegraph Company as a witness for the plaintiff in the main case and for defendant on the supplemental proceedings?

A. I am.

Q. 2. What has been your experience in the art of radio [fol. 1193] engineering since your previous testimony in this case?

A. At the time of giving my previous testimony I was Chief Engineer of the Marconi Wireless Telegraph Com-

pany of America. When that company was merged into the Radio Corporation of America, I became Consulting Engineer engaged in special research and investigation work. In addition to this I represented the Radio Corporation in various conferences in Europe and visited all of the great radio stations of Europe and the various manufacturing plants of the large radio companies. I also represented the Radio Corporation at the Pan-American Radio Conference in Mexico, during which matters pertaining to governmental regulation of radio were discussed.

Since testifying previously, I have received from the Institute of Radio Engineers the Morris Liebman Memorial Prize for my work in the reduction of static interference. I was also, for a period of something over a year, Vice-President and Chief Engineer of the DeForest Radio Telephone & Telegraph Company, which manufactures a variety of radio appliances, including the three-element vacuum tube.

Q. 3. Please state what you have been requested to do in this case with reference to two-element high vacuum oscillation valves or tubes as concerns demonstration of radio frequency oscillations and reception of signals?

A. I have been requested to demonstrate a two-electrode vacuum tube receiving broadcast signals and oscillating; also to demonstrate that the oscillations produced by this two-electrode tube could be picked up by a receiving instrument and thereby illustrate the use of this tube as a radio transmitter.

I have also been asked to demonstrate the two-electrode tube in one or more stages as an amplifier of radio signals.

Q. 4. Will you now demonstrate to those present the capability of the hard or high vacuum two-element tube to oscillate and receive broadcast signals, and in doing so please produce a diagram showing the circuit connections and giving the electrical characteristics thereof; also explain how the oscillations are produced so as to heterodyne with incoming radio frequency waves?

A. I now proceed to demonstrate with the apparatus before us a two-electrode tube as an oscillator, and produce a diagram (Reproduced Opposite) which illustrates the circuit connections (producing a paper). In this diagram n represents the antenna, R represents a variable condenser of conventional type, m an inductance, o the earth connection, all of the above constituting the antenna circuit.

Coupled to coil m is coil k, which is connected through lead j to the plate c of the two-electrode tube and through the other lead j through a battery p, telephone l to the filament b of the two-electrode tube. The filament is heated from a battery h, which is controlled by a resistance R_1. In the arrangement which I have set up here the two-electrode tube is placed close to the condenser R where it is under the influence of the electrostatic field which exists on condenser R.

I now light the filament of the two-electrode tube, and by an adjustment of condenser R the words and music from a broadcasting station may be heard.

Mr. Vaill: Opportunity is now given to counsel for defendant to listen to the broadcasting through the headphones and observe the effects described by the witness.

(Mr. Edwards listens with the headphones.)

[fol. 1194] Mr. Edwards: Counsel notes that he hears dots and dashes and nothing else.

(Mr. Edwards again puts on the earphones.)

Mr. Edwards: A few musical notes were heard and then more dots and dashes.

A. (continued) I will next, by a slight change of the coupling between the coils m and k make the tube oscillate, and this will be made evident by the whistle, which is the common way of showing that oscillations exist in a receiving tube.

Mr. Vaill: Opportunity is given opposing counsel to listen to the heterodyning effect of the whistles described by the witness.

(Mr. Loftin listens with the headphones.)

A. (continued) It will be noted that the oscillations take place over a wide range of coupling.

(Mr. Edwards listens with the headphones.)

Mr. Edwards: I hear squeals.

A. (continued) I will next show that the oscillations produced by the tube and apparatus just demonstrated can act as a transmitter and be picked up by an oscillating receiver in the neighborhood. I will show that a note is pro-

duced by the apparatus just demonstrated in the receiver which will be used to detect the oscillations. I will then vary these oscillations and demonstrate that these variations are heard in the usual receiver.

(Some adjustments are then made by the witness.)

A. (continued) A variable musical note can now be heard in the receiver, the variations in this note corresponding to the touching of a part of the first apparatus and it now can be heard by those present.

Mr. Vaill: Opportunity is now given to defendant's counsel and Mr. Loftin to listen to this demonstration.

(Mr. Loftin, Mr. Edwards and Mr. F. N. Waterman, in turn listen by means of the headphones.)

Mr. Vaill: It is noted that defendant's counsel and Mr. Loftin have listened through the headphones.

Q. 5. Will you please now explain the relation of the oscillating two-element tube in the circuit before us on the table, indicating how the oscillations are produced as indicated by the heterodyning action?

A. One side of condenser R, namely, the side which is connected to inductance m, is close to the glass of the two-electrode tube at a point midway between the two electrodes. This physical association of the apparatus results in the electric field which exists on condenser R affecting the electron stream which passes between the hot electrode a and the cold plate c, giving thereby an electro-static control of the electron flow. As the result of this control, this arrangement is able to oscillate, since small electro-motive forces on this condenser can release relatively greater amounts of energy flowing between the plate c and the filament a.

* * * * * * *

Q. 6. Will you now demonstrate the capability of the hard or high vacuum two-element tube to amplify broadcast signals by one or more stages of amplification; also please produce a diagram and explain the connections of the circuits?

A. I will now do so with the apparatus before us: I now [fol. 1195] produce a diagram showing an arrangement of four two-electrode tubes, one of which at the right of

the diagram is used as a detector, the other three being amplifiers. In the arrangement illustrated in this sketch I am able, by throwing a switch marked s, to throw the antenna connection so that it is connected to the oscillating circuits of the two-electrode tube, or so that it is connected to the input circuit of the first amplifier and thereby puts the amplifier into action. An additional switch s' is opened when the amplifier is not working, because when closed it slightly reduces the intensity of the signal received by the two-electrode tube.

I will now show you a signal as received by the two-electrode detector without the amplifier from the local broadcasting station WEAF. It is now ready for anybody who wants to listen.

Mr. Vaill: Opportunity is given at this point to opposing counsel and Mr. Loftin to listen to the effects described by the witness.

(Mr. Loftin puts on the headphones.)

A. (continued) The signal which you hear now is that receiver by the detector alone.

(Mr. Edwards puts on the headphones.)

A. (continued) Now I will throw to the amplifier if you will put the phones on.

(Mr. Loftin, Mr. Edwards and Mr. Waterman, in turn, put the headphones on.)

A. (continued) The intensity of the responses as received with the amplifier in circuit, that is to say, with the three two-electrode tubes arranged for the purpose of amplifying, is very much greater than that received by the detector alone, I should say at least one-hundred times as loud.

The diagram which I have produced represents everything which is in the physical apparatus which I have just demonstrated, and can be checked detail by detail.

* * * * * * *

Q. 7. Will you please state the degree of vacuum as far as possible in the various tubes which you have been using in the sets which you have been demonstrating?

A. These tubes were made to have the same order of vacuum as that produced by modern processes for the three-

electrode tube. In other words, the vacuum is extremely high, of such an order that the residual gas plays no part in the action, and, for practical purposes, may be considered a perfect vacuum.

Q. 8. Will you now kindly state whether or not the apparatus shown in the diagram, "Claimant's Exhibit No. 225", first produced by you corresponds with the apparatus on the other table in which the set was used for producing oscillations, reception and transmitting?

A. This diagram does so correspond.

Q. 9. Will you kindly describe these high vacuum two-element tubes which you have mentioned, giving the structural features so that the court may understand from the record how they are constructed?

A. These high vacuum two-element valves consist of a cylindrical tube approximately one inch in diameter by about four inches long. The filament is in a roughly circular form supported by wires attached to the glass stem coming in from one end. The plate is a circular disc of metal slightly smaller in diameter than the inside of the glass [fol. 1196] tube. The spacing between the electrodes is approximately a half inch for the oscillator and the amplifier tubes, and approximately a quarter of an inch for the detector tube. There is a film having a somewhat mirror-like appearance on the inside of the tubes between the plate and the end of the tube, which is due to the flashing which is incident to the process of exhausting the tubes, and is the same thing as is seen in the modern commercial type of three-electrode vacuum tube.

Q. 10. Will you kindly now describe the relations between the various amplifying tubes and the transformers used in connection therewith?

A. In the arrangement of the amplifier tubes in the apparatus which I have just demonstrated the two-element vacuum tube is arranged so that the glass of the tube is close to one end of the winding of the input circuit. This is illustrated in the diagram which I have produced, where it will be noted that one end of coils L_3, L_5 and L_7 are close to the two-electrode tube. This end of the coil is what is commonly referred to as the high potential end, and it is the electric field from this coil which influences the electron stream in the tube, with the result that the two-electrode tube functions as an amplifier.

Q. 11. Does your description of the amount of vacuum in the tubes which you have been using apply to the tube used in the oscillating demonstration first made by you?

A. It does.

Q. 12. Can you produce a diagram of the receiving set used in connection with the oscillations produced in the first demonstration you made of the transmitting capability of the two-element vacuum tube?

A. I produce a rough pencil sketch showing a conventional three-electrode regenerative circuit.

Mr. Vaill: The diagram produced by the witness in response to the last question is offered in evidence as "Claimant's Exhibit No. 223."

The apparatus first used by the witness in demonstrating the reception of broadcast signals and the oscillating effect and the transmitting effect is offered in evidence as "Claimant's Exhibit No. 224".

The diagram produced by the witness showing the connections of Exhibit No. 224 is offered in evidence as "Claimant's Exhibit No. 225".

The detector and three stages of radio frequency amplification demonstrated by the witness is offered in evidence as "Claimant's Exhibit No. 226".

And the diagram produced by the witness in connection with said receiving set of Exhibit 226 is offered in evidence as "Claimant's Exhibit No. 227".

(The Exhibits were respectively so marked by the Notary.)

* * * * * * *

[fol. 1197] Q. 13. Referring to the apparatus constituting Claimant's Exhibit No. 224, which you yesterday caused to oscillate and produce transmitting waves which were received on the receiving apparatus on the adjacent table, will you please state what distance you have actually received signals out doors by such an apparatus?

* * * * * * *

A. I have made a test in which I received signals from a two-electrode vacuum tube oscillating from the same circuit which I demonstrated yesterday, a distance of approximately one-half mile away.

* * * * * * *

Cross-examination.

By Mr. Edwards:

X Q. 14. Was the tube which you used in the instance just referred to by you the same tube as one of those employed in these experiments performed by you in our presence yesterday?

A. I believe it was.

X Q. 15. Which one?

A. That I am not able to say, but I believe it was either one of the three tubes used as amplifiers or the tube used as an oscillator in the demonstration yesterday.

X Q. 16. That is, you would identify this tube as being No. 663, 642 or 644, the tubes present in this apparatus?

A. Yes, it includes these tubes of Claimant's Exhibit No. 226 and tube No. 665 of Claimant's Exhibit No. 224; that is, I believe the tube used in the test to which I referred was one of these four tubes.

X Q. 17. That is, either 665, 663, 642 or 644?

A. Yes.

X Q. 18. But you are unable to identify which one of these it was?

A. No, I am not able to.

X Q. 19. How long were you connected with the Marconi Wireless Telegraph Company?

A. From 1912 until the formation of the Radio Corporation in 1920.

X Q. 20. Did you continue in the employ of the Radio Corporation from the time it was organized?

A. Yes, I did.

X Q. 21. How long did you remain with the Radio Corporation?

A. Until the fall of 1924.

X Q. 22. What was the occasion of your leaving the Radio Corporation?

A. I resigned.

X Q. 23. Was there any especial reason for that?

A. No, I guess not, except that I thought I wanted to do something else for a while.

X Q. 24. At that time what was your position with the Radio Corporation?

A. Consulting Engineer.

X Q. 25. And what was your position witth the Marconi Company?

A. Chief Engineer.

X Q. 26. How long after you left the Radio Corporation did you engage in other employment?

A. About a year.

X Q. 27. And what employment was that?

[fol. 1198] A. I was Vice-President and Chief Engineer of the DeForest Radio Telephone & Telegraph Company.

X Q. 28. And how long did you continue in that position?

A. Actively about a year.

X Q. 29. Are you still connected with the DeForest Company?

A. No, I am not.

X Q. 30. Are you at present in the employ of or retained by the Radio Corporation?

A. I am retained by them as Consulting Engineer, that is to say, I have an office of my own and I am doing some work for the Radio Corporation, but I am not directly in their employ.

X Q. 31. You have frequently given testimony for the Marconi Company and Radio Corporation, have you not?

A. Yes, I have.

X Q. 32. In giving this testimony, was the nature of it in general the making of demonstrations such, for example, as you made here yesterday, except, of course, designed to illustrate other operations?

A. I have in the course of previous testifying, conducted a number of demonstrations.

X Q. 33. These demonstrations have been in practically all cases on behalf of the Marconi Company or the Radio Corporation or allied interests, have they not?

A. Usually, yes, although I believe I testified once for the DeForest Company.

X Q. 34. In what case did you testify for the DeForest Company?

A. It was a case having to do with the Armstrong Patent.

X Q. 35. You testified for the Marconi Company in the case of the Marconi Company against the DeForest Company on the Fleming patent, did you not?

A. Yes, I did.

X Q. 36. In the main trial you made demonstrations purporting to show that the early DeForest patents employing

heat other than an incandescent filament were uncommercial or useless, did you not?

A. I have a dim recollection of having made some tests, with a flame detector, but I have forgotten the details and general significance of these tests.

X Q. 37. You also demonstrated or assisted Mr. Waterman in demonstrating in the same case the action of a two-electrode audion for the purpose of showing that it would oscillate, did you not?

A. I believe I made some tests and demonstrations showing that a two-electrode vacuum valve would generate oscillations.

X Q. 38. In that demonstration, the circuits employed were those shown in the sketches entitled "Plaintiff's Exhibit No. 2" and "Plaintiff's Exhibit No. 3" appearing on pages 87 and 88 of the Record in this case, were they not (showing the sketches to the witness)?

• • • • • • •

A. The diagrams referred to appear familiar, and, as near as I can recollect, were the ones which I used in the demonstrations referred to.

X Q. 39. You recall, do you not, that the two-electrode tube was used in the transmitter as shown in the drawing on page 87 of Claimant's Exhibit No. 171 in this case, and that in the receiver employed in the tests a three-electrode tube was used as indicated in the drawing on page 88 of Claimant's Exhibit 171?

• • • • • • •

[fol. 1199] A. I recollect that the combination referred to was used in some demonstration.

X Q. 40. Did you attempt to use any of the two-electrode tubes forming part of your demonstrations here in the transmitter circuit shown on page 87 to which we have just been referring?

• • • • • • •

A. I was requested to demonstrate a high vacuum tube oscillating, and I did not use any others in this test.

X Q. 41. Any other what, circuits or tubes?

A. Any other tubes.

X Q. 42. (X Q. 40 was repeated to the witness by request of Mr. Edwards).

A. I did not.

X Q. 43. Do you understand that any of the tubes in your present demonstration would operate in the circuit shown on page 87 of Claimant's Exhibit 171 in the Record in this case to produce the same results as were attained in the demonstration before Judge Mayer or to produce the same results which you claim to have produced here?

A. I have not attempted to use the tubes which I demonstrated yesterday in the circuit shown on page 87 of the exhibit mentioned.

X Q. 44. Is it your understanding that if the tubes or any of them used in your tests here were inserted in a circuit like that shown on page 87 of Claimant's Exhibit 171 in this case, you would obtain the same results as you have demonstrated here with the apparatus which you have demonstrated here?

A. There is only one possible way in which I could answer that question; that is by trying it, which, as I have already said, I have not done.

X Q. 45. Have you ever experimented with hard tubes in a circuit like that shown on page 87 of Claimant's Exhibit No. 171?

A. Not so far as I recollect, if by "hard tubes" you mean tubes having the order of vacuum of the modern three-electrode tube.

X Q. 46. Do you undertake to say that if any of the tubes which you have produced here are employed in a circuit like that shown on page 87 of Claimant's Exhibit No. 171, you can make the tube amplify or oscillate?

A. I can hardly make such an assertion, due to the fact, as previously stated, that I have not tried it.

X Q. 47. Can you offer any explanation as to why you employed the circuit shown on page 87 of Claimant's Exhibit 171 in making the demonstration before Judge Mayer and not employing the circuits which you have employed here as shown in Claimant's Exhibits 225 and 227 using the tubes which you have here?

A. Certainly; I used the circuit shown on page 87 of the Record because I had found by experiment that that circuit, with the tubes which I happened to have at the time I was requested to make that demonstration, would work, and I used the circuit which I demonstrated yesterday because that happened to be a circuit which I knew would work with a hard tube as the result of experimental work which I did years ago.

X Q. 48. Having demonstrated as you believe, before Judge Mayer that a two-electrode tube would oscillate in the circuit shown on page 87 of Claimant's Exhibit 171, [fol. 1200] did it not occur to you that it would be natural to employ the tubes which you have produced here to-day in the same circuit?

A. Not necessarily at all. As one goes on with engineering work of this sort, new information is obtained, and an experimenter seldom feels bound by anything which he has done previously, but when requested to make a demonstration uses those methods and apparatus which will produce the results asked for.

X Q. 49. What person or persons associated with the claimant asked you to make these tests?

A. The firm of Sheffield & Betts.

X Q. 50. With whom did you consult in the matter?

A. Mr. Cosgrove, Mr. Vaill principally, I believe.

X Q. 51. Did you consult with Mr. Waterman before making the tests?

A. Well, I believe I told Mr. Waterman that I had made some such test. I do not recollect the nature of the conversation.

X Q. 52. Did Mr. Waterman offer any suggestions to you as to the nature or character of the test?

A. Not that I recollect.

X Q. 53. Did any of these gentlemen inform you of the purpose of making the tests?

A. I was informed that the purpose of the tests was to show that the two-electrode so-called high vacuum or hard tube could oscillate.

X Q. 54. And it never occurred to you to employ a two-electrode hard vacuum tube in the circuit shown on page 87 of Claimant's Exhibit No. 171, did it?

A. I am not able to say whether or not it occurred to me, but I chose the particular circuit which I demonstrated yesterday.

X Q. 55. Did not any of the gentlemen associated with the claimant with whom you consulted prior to making your tests advise you that the defendant had challenged the validity of the alleged demonstration before Judge Mayer?

A. I have no recollection of being informed that the validity of these tests was challenged.

X Q. 56. Did they not inform you that the defendant had asserted that the two-electrode tube is inherently incapable of amplification or oscillation?

A. I believe I was informed that the defendant had asserted that the two-electrode hard vacuum tube was incapable of oscillation or amplification.

X Q. 57. Was not the matter of the alleged demonstration before Judge Mayer referred to in any of these conferences or consultations prior to making your tests here?

A. Yes, I believe reference was made to it.

X Q. 58. Did not any of these gentlemen ask you if you could make a two-electrode hard vacuum tube amplify or oscillate in a circuit like that shown on page 87 of Claimant's Exhibit No. 171?

A. If they did I do not recollect it. Certainly it left no impression on my mind.

X Q. 59. The tube or tubes which you demonstrated before Judge Mayer were not hard vacuum tubes, were they?

A. They were tubes, as I recollect it, of varying vacua. I do not think any of them were of the highest obtainable vacuum.

X Q. 60. Do you know of about what order of vacuum they were?

A. No, I do not.

X Q. 61. So far as you know, were any special pains taken to secure any special degree of vacuum with the tubes employed before Judge Mayer?

A. Yes, I know that they were intended to be as high a [fol. 1201] vacuum as we were able to get at the particular time the tubes were made.

X Q. 62. At that time the degree of vacuum attainable was quite different from that in the modern hard vacuum tube, was it not?

. . . . . .

A. I hardly think that is quite right. The order of vacuum obtainable today was obtainable many years ago, but the process of obtaining it had not been reduced to convenient commercial forms.

X Q. 63. Well, what order of vacuum is present in the tubes which you tested here yesterday?

A. That I am not able to tell you from any measurements, except that I can state, as I did in my direct examination, that they were made under instructions to produce

a present-day commercial high vacuum, that is to say, to produce a tube which would be, in the language of the art, a hard tube.

X Q. 64. Well, what order of vacuum would that be?

A. Well, that calls for figures which ordinarily I do not carry in my head. My recollection is something like ten to the minus five or six millimeters, but I am speaking there from recollection, not having recently had occasion to refer to the figures.

X Q. 65. Compared with that what was the order of vacuum of the tubes employed before Judge Mayer?

A. That I am unable to say, as no measurements were made on those tubes that I have any recollection of.

X Q. 66. What was the order of vacuum of the commercial tubes of that day?

A. That was a rather variable quantity. Commercial tubes were not numerous at that time. I recollect some which would be called soft tubes in the language of today; there were others to my knowledge which had very high vacua, I should say quite equal to anything that is used today.

X Q. 67. Can you undertake to give any figures as to the approximate degree of vacuum in the tubes demonstrated before Judge Mayer?

A. At the present moment I am not able to undertake to give any such figures.

X Q. 68. They were, however, tubes in which there was some residual gas present were they not?

A. That, of course, is true of any tube, even the highest vacuum obtainable today.

X Q. 69. Well, they had more residual gas in them than the tubes which you have demonstrated here, did they not?

A. I would suppose that they did have, although I made no measurements of the vacuum.

X Q. 70. Referring to your apparatus Exhibit No. 224, what is the voltage of the battery indicated in your sketch Exhibit No. 225?

A. Approximately 180 volts.

X Q. 71. What is the voltage of the battery h?

A. Approximately six volts.

X Q. 72. And how much current passed through the filament b?

A. That I don't really know. It could be determined by inserting an instrument and measuring it.

X Q. 73. What is the capacity of the storage battery h?

A. I should guess that it was about 80 ampere hours.

X Q. 74. Will you measure by measuring instruments if [fol. 1202] you can the voltage and amperage of the filament current employed by you in your demonstration of this Exhibit 224?

(Some instruments are produced.)

A. (Applying the instruments to the exhibit in question.) The voltage of battery p is shown by the Weston voltmeter to be 181 volts. The current in the filament b is shown by the Weston ammeter to be 1.25 amperes. The voltage across the filament is shown to be 4.1.

X Q. 75. What is the distance between the plate c and the filament a in the tube No. 665 employed in this Exhibit 225?

A. Approximately three-quarters of an inch.

X Q. 76. What is the distance between the filament and the plate in each of the tubes 624, 663, 642 and 644 employed in the Exhibit 227?

A. The space between electrodes in tubes 663, 642 and 644 is approximately one-half inch; in tube 624 approximately one-quarter inch.

X Q. 77. Were these tubes made under your supervision?

A. Not directly, no; I specified the distance between the elements and the order of vacuum. That was all.

X Q. 78. Who made the tubes?

A. I am informed that the Westinghouse Lamp Company made them.

X Q. Who gave them to you?

A. Messrs. Sheffield & Betts.

X Q. 80. With whom did you place the order for the tubes?

A. Well, I did not place the order; I simply told Sheffield & Betts the sort of tubes to get.

X Q. 81. Did you give them this information orally or in writing?

A. Orally.

X Q. 82. Did you give them any written specifications as to the character of the tubes?

A. None whatever.

X Q. 83. What information or specification did you give them as to the order of vacuum?

A. That the tubes should be exhausted in just the same way, same process, and the same order of vacuum as is used in the modern hard three-electrode tube.

X Q. 84. And what specifications did you give them as to the distance of separation between the plate and filament?

A. I specified those distances which I have already mentioned as being found in the tubes in the demonstration.

X Q. 85. This was done orally, was it?

A. Yes.

X Q. 86. How many tubes did you ask for?

A. I do not recollect; in fact, I am not sure that I specified the number.

X Q. 87. How many did you get?

A. That I do not recollect, except that I think I had something like a dozen or a half dozen,—a half dozen I guess, and some of them were found not to be hard.

X Q. 88. Have you any others left over?

A. I don't know; I haven't any. I haven't paid any particular attention to those I was not using.

X Q. 89. Are they around this laboratory here, if you know?

A. Well, I don't know, no. I have not seen them for some time.

X Q. 90. Is this place where these tests are being made your laboratory?

A. No, it is not.

X Q. 91. Whose is it, do you know?

A. I believe it is Mr. John V. L. Hogan's.

X Q. 92. And he furnished you with the apparatus which you have employed?

[fol. 1203] A. I believe part of it was furnished by this laboratory and part of it by the R. C. A. Laboratory.

X Q. 93. What is the R. C. A. Laboratory?

A. That is a laboratory of the Radio Corporation at Van Cortlandt Park.

X Q. 94. Will you inquire and see if there are any more of these tubes such as you have used in this demonstration available?

A. I will do so.

X Q. 95. How long will it take you to find out?

A. That I do not know. I will inquire as soon as we are through with the cross-examination.

X Q. 96. Can you make the inquiry now?

(Witness goes into the next room.)

• • • • • • • •

A. I have made the inquiry, and there are six tubes which I produce in addition to those used in the demonstration (placing the tubes before counsel).

X Q. 97. These were produced from the drawer of a desk about fifteen feet away, were they not?

A. Even closer than that.

X Q. 98. Were any of these tubes which you have just produced employed by you in these circuits Exhibits 224 and 226?

A. I believe they were all tested.

• • • • • • • •

X Q. 99. And from the tests of all of the tubes you selected the ones best available for your purposes, did you not?

A. I selected five tubes, as some of those tested were defective.

X Q. 100. I note that these tubes which you have just produced here are numbered 622, 623, 645, 668, 6213 and 6414. That is correct, is it not (showing the tubes to the witness)?

A. Yes.

X Q. 101. What do these numbers signify?

A. As far as I know merely identification marks.

X Q. 102. Who placed the numbers on the tubes?

A. I do not know

X Q. 103. Are these tubes all supposed to have the same degree of separation between the plate and the filament?

• • • • • • • •

A. Obviously they have not; as can be seen by an inspection, the separation is different in the different tubes.

X Q. 104. When you gave your specifications to Messrs. Sheffield & Betts, did you give them any special degree of separation or did you ask them to give you a variety of different spacings?

A. I asked for three different spacings, as I recollect it, one-quarter inch, one-half inch and three-quarter inch.

X Q. 105. Why did you require different degrees of spacing between the plate and the filament?

A. I knew from previous experience that there were differences in the results obtainable with different spacings, and so I had several spacings in order to select those suit- [fol. 1204] able for the purpose. It has been some years since I had previously worked with these tubes, and my recollection of just what was the best spacing was somewhat uncertain.

X Q. 106. Will you explain in as great detail as possible why you expected different results to be attained by reason of different degrees of spacing between the plate and filament, what the different results are and all of the considerations affected by the degree of spacing?

A. The answer to that is rather simple: I simply had found from previous experience that a spacing made a difference in the way in which a tube worked. I therefore simply followed my experience in having the present tubes made.

X Q. 107. What difference does it make whether the spacing between the plate and filament in these tubes is large or small?

A. Well, if it is too small it is difficult to control the electron stream with an exterior electrostatic field. If it is too great the internal resistance of the tubes becomes very high and it is difficult to get any energy out of the tube. In general, these are characteristic effects which are found in the construction of valves of either two of three-electrode type, and in the case of the three-electrode type or tube many years of work have been consumed in determining the best spacing of the electrodes, their size, etc.

Mr. Edwards: Defendant's counsel asks to have the six tubes produced by the witness marked for identification "Defendant's Exhibit U-6".

(The six tubes were so marked.)

X Q. 108. What difference does it make whether or not the tube is located close to the condenser R in Exhibit 225 or close to the coils L_1, L_3, L_5 and L_7 in Exhibit 227?

A. As I explained in my direct examination yesterday, the location of the two-electrode vacuum tube in the vicinity of either the condenser R or coils L_1, etc., permits the electrostatic field which exists on these elements to affect the electron stream which flows between the cold electrode and the hot electrode in the two-electrode vacuum valve.

X Q. 109. Which has the greatest effect upon the electron stream, locating the tube close to the condenser as in Exhibit 225, or locating the tube close to the induction coils as in Exhibit 227?

A. So far as I know, there is no difference.

X Q. 110. In both cases the electrostatic field operates upon the electron stream between the plate and the filament in the same way?

A. As I understand it, yes.

X Q. 111. Why is the degree of separation greatest in the tube employed in Exhibit 225?

A. I believe that that is merely a matter of chance, as I recollect it.

X Q. 112. I believe you said the space between the plate and filament in the detector tube No. 624 in Exhibit 226 was about a quarter of an inch, did you not?

A. Yes, that is right.

X Q. 113. And the other tubes about half an inch?

A. Yes.

X Q. 114. What is the reason for using the smaller separation in the detector tube and the larger separation in the amplifier tube?

A. The smaller separation is a little better as a detector. The larger separation in the amplifier tube is considerably better than the smaller separation.

[fol. 1205] X Q. 115. In what way is the smaller separation better in the detector tube and the larger separation better in the amplifier tubes?

A. The detection with the smaller separation is a little better, that is to say, the tube is a little more sensitive. The amplification with the larger spacing is better than with the smaller spacing.

X Q. 116. Why or in what way is it better?

A. Well, the real reason why it is better I expect would require a rather elaborate research to determine. I merely know that it is better from my experimental experience.

X Q. 117. Can you not explain in what way it is better?

A. Not in a way that would be satisfactory to me. That happens to be the sort of thing that I require rather exhaustive investigation for before I am satisfied as to the exact mechanism by which it works. In a general way, I can say that the electrostatic field affects the electron stream, and that when the spacing is of the order of that

used in the amplifier and in the oscillator it appears to be unable to so affect the electron stream as to produce amplification and oscillation.

X Q. 118. In your demonstration of Exhibit 226, did you use approximately the same voltage between the plate and filament as in your demonstration of Exhibit 224?

A. Yes, I did.

X Q. 119. That is to say, about 180 volts?

A. Correct.

X Q. 120. In this case, however, I note from the drawing that the filament battery is marked 12 volts. Was that larger voltage used in the set Exhibit 226?

A. That was simply because the rheostats we happened to use and shown in the drawing Exhibit No. 227 as R_1, R_2, R_3 and R_4 were of rather high resistance.

X Q. 121. Then I take it that the voltage and amperage of the filament current used in the demonstration of set, Exhibit No. 226, was the same as that in the demonstration of set, Exhibit 224?

A. That is correct.

X Q. 122. How long have you known that a two-electrode tube could be made to oscillate?

A. I do not remember the exact date when I first made a two-electrode tube oscillate, but it is something more than twelve years ago.

X Q. 123. And since that time have you given considerable attention to studying the phenomena of oscillation by two-electrode tubes?

A. I have done considerable work with two-electrode tubes since that time, including the phenomena of oscillation.

X Q. 124. And you have taken out a number of patents, have you not, designed to make two-electrode tubes amplify or oscillate?

A. I have taken out a number of patents on a tube which had two internal electrodes and one external electrode.

X Q. 125. Do you regard that kind of a tube as a two-electrode tube or a three-electrode tube?

A. Well, that is largely a matter of language, nomenclature, but if such a tube had an exterior electrode made to go around it as was the case of the tubes illustrated in my patents referred to, I personally would consider it a three-electrode tube.

X Q. 126. Are you the Roy A. Weagant who applied for and obtained United States Letters Patent No. 1,252,520, granted January 8, 1918; No. 1,278,535, granted September 10, 1918; No. 1,289,981, granted December 31, 1918; No. 1,306,208, granted June 10, 1919; No. 1,342,399, granted June 1, 1920, and No. 1,380,206 granted May 31, 1921?

[fol. 1206] A. Yes.

X Q. 127. Do you regard the tubes shown in these patents, particularly 1,252,520, 1,278,535, 1,289,981, 1,342,399 and 1,380,206 as operating in those patents as a two-electrode or three-electrode tube?

A. The answer to that depends largely on the significance and meaning given to the word "electrode". The patents to which you have referred, with the exception of No. 1,342,399, show three separate conducting elements, two of which are inside of the tube and one of which is outside. As the word is ordinarily used, "electrode" would apply only to the two elements inside of the tube. In the case of No. 1,342,399 there are two outside separate conducting elements, so that this particular arrangement has four elements, two of which are internal, and, under the usual significance of the word, would be known as the electrodes. The outside elements I have been in the habit of calling "shield", although that word is not particularly appropriate.

X Q. 128. Do you consider that the tubes in Patents Nos. 1,252,520, 1,278,535 and 1,289,981, for example, are operating as two-electrode tubes or three-electrode tubes?

A. Giving to the word "electrode" the significance that I have just mentioned, namely, that of the essential separate conducting elements within the tube, I would call them two electrode tubes.

X Q. 129. But you would add, would you not, that in order to attain the operation set forth in the patent you must employ a third element, namely, the element k, outside the tube?

A. For the operation of the tube as illustrated in these patents, the exterior element illustrated therein is necessary.

X Q. 130. Is it necessary that that element k shall extend entirely around the outside of the tube?

A. Not necessary but preferable.

X Q. 131. Do you consider that you could have attained amplification or oscillation or both in either your apparatus

Exhibit 224 or Exhibit 226 without locating either the condenser R in Exhibit 225 or the inductance in Exhibit 227 adjacent to the tubes?

A. As I stated in my direct, it is necessary to locate the tube adjacent to either the coil or the condenser.

X Q. 132. And it is a fact, is it not, that the coil or the condenser performs a function analogous to the function of a grid in an ordinary three-electrode vacuum tube?

A. I think I would put that the other way around by saying that the grid performs in a way which is analogous to the performance of the two-electrode tube which I have demonstrated, but it does it in a more complete and more perfect manner due to the location of the grid within the tube and directly in the path of the electron stream. Both devices function as the result of the control by an electrostatic field of the electron stream flowing within the tube. In the demonstration of the two-electrode tube which I showed, the means of getting the electric field where it could control the electron stream was the arrangement of the apparatus; that is to say, I simply put the tube near a suitable electric field and *is* operated. Now, in the case of the grid which is used in the three-electrode tube this electric field is on the grid itself and the grid is right in the midst of the electron stream. Consequently, it is so located as to [fol. 1207] produce the greatest possible effect. In one case the result is accomplished by the use of an additional electrode in the tube itself; in the other case merely by a suitable association of the ordinary parts constituting the radio receiver.

X Q. 133. Then it is a fact, is it not, that in your demonstrations, by reason of the location of the condenser or inductance adjacent to the tube you created an electrostatic field which operated upon the electron stream between the plate and filament of the tube in substantially the same way, although perhaps not in degree, as the grid of an ordinary three-electrode tube operates upon the electron stream between the plate and filament of that tube?

A. I intended in my last answer to make clear the fact that in both cases the electric field was the controlling element which acted upon the electron stream; that in the case of the three-electrode tube this field was brought right inside of the tube itself, while in the case of the two-electrode tube which I demonstrated the field was adjacent to the tube but outside of it.

X Q. 134. What would have been the effect or the result if in your demonstration you had employed tubes in which the plate element comprised a continuous cylinder surrounding the filament?

A. That seems to me to be somewhat of a speculation. I do not think I would care to answer what would happen under those circumstances, unless I tried it. Long experience in this particular art has taught me that the way to find out what will happen under a given set of circumstances is to make experiments.

X Q. 135. Based upon your long experience, have you no opinion upon this subject?

* * * * * * *

A. As a matter of opinion and purely as a matter of speculation, I believe that I could construct a tube with a cylindrical plate surrounding a filament which would operate in the manner of the tubes demonstrated in the test.

X Q. 136. To do that I take it you would have to increase the strength of the electrostatic field, would you not?

* * * * * * *

A. But that question as it stands is not answerable, because I do not know what electric field you refer to.

X Q. 137. I am referring to the electrostatic field which you created by the condenser in the one case and the inductance in the other case for the purpose of controlling the electron stream between plate and filament.

A. In my answer to the question before the last one, where I expressed my opinion as to what might be done, I meant that it was my opinion that a tube could be constructed in the way specified which would operate under the same conditions, circumstances, circuits, etc., as those of the tests and demonstrations which I made.

X Q. 138. You would expect that if the plate element consisted of a cylinder entirely surrounding the filament it would at least tend to shield the electron stream from the effect of the electrostatic field which you used to control the electron stream, would you not?

A. Not if you put the electrostatic field in the right place. [fol. 1208] X Q. 139. Meaning where?

A. I think I would have to illustrate that by a sketch.

X Q. 140. Please do.

A. If I may have a piece of paper. (A sheet of paper is handed to the witness, who draws thereon.) I have drawn

a very crude sketch in which, in top view, Fig. 1, a circle a represents the glass tube and circle b represents the cylindrical plate. The part of a circle c represents the filament. These same things are shown roughly in elevation in Fig. 2 by corresponding letters. A tube of the construction so shown with the electrostatic field in the vicinity of the top, in my opinion would function the same as those demonstrated the other day.

Mr. Edwards: Defendant's counsel offers this sketch in evidence, and asks that the same be marked "Defendant's Exhibit Q-6".

(The sketch was so marked.)

* * * * * * *

X Q. 141. In the case I have just referred to, by locating the electrostatic field above the tube you would, in effect, not be shielding the electron space from the electrostatic field by the plate element, would you?

A. That is correct; by locating the electrostatic field near the top of the tube the plate does not shield it.

* * * * * * *

Last Question by the Notary: Do you know of any other matter relative to this claim?

Answer: No.

Deposition Closed

* * * * * * *

[fol. 1209] Deposition of Roy A. Weagant, for Claimant, taken at New York, N. Y., on the 17th day of January, A. D. 1927.

Direct examination.

By Mr. Vaill:

Q. 142. Are you the same Roy A. Weagant who has heretofore testified as a fact witness during Claimant's *prima facie* proofs and as a fact witness relative to demonstrations for the two-element high vacuum valve as an oscillator?

A. I am.

Q. 143. Can you produce photographs of the apparatus which you used in demonstrating the capability of oscil-

lating and amplifying in the two-element high vacuum tube on Tuesday, December 28th, 1926, at the laboratory of Mr. John V. L. Hogan, 140 Nassau Street, New York City?

A. I can and do.

Q. 144. How did you obtain these photographs?

A. These photographs were made by a professional photographer accustomed to this sort of work, under my direction, on the day after the demonstration you have referred to.

Mr. Vaill: Claimant's counsel offers in evidence the two photographs produced by the witness, and requests that the same be marked respectively "Claimant's Exhibits Nos. 228 and 229".

(Said exhibits marked as requested.)

At the request of counsel for Claimant counsel for Defendant admits that the Bill of Complaint in the suit in the United States District Court for the Eastern District of New York, entitled Marconi Wireless Telegraph Company of America, Complainant, *versus* National Electric Signaling Company, Defendant, Case D. E. 23, for the [fol. 1210] infringement of Re-issue Patent No. 11,913 to Marconi, and Patent No. 609,154 to Lodge, was filed on May 10th, 1912.

Mr. Vaill: Counsel for Claimant offers in evidence a copy of an article by E. H. Armstrong, entitled "Operating Features of the Audion", published in the Electrical World (New York) in the issue of December 12, 1914, pages 1149-1152, which article was referred to and adopted as a part of his Opinion by Judge Julius M. Mayer in the suit of Marconi Wireless Telegraph Company of America, Plaintiff, *versus* DeForest Radio Telephone and Telegraph Company, *et al.*, Defendants, in the United States District Court for the Southern District of New York on the Fleming Patent No. 803,684, which Opinion is reported in Volume 236 of the Federal Reporter, page 942, and requests that the same be marked "Claimant's Exhibit No. 230".

(Said exhibit marked as requested.)

It is Stipulated and Agreed by and between counsel for the respective parties hereto, that should C. D. Mitchell

be called as a witness on behalf of Claimant in this case, he would testify as follows:

That he is of mature age and is employed by the Westinghouse Lamp Company at Bloomfield, New Jersey; that during the month of November, 1926, he was instructed by the Director of the Research Laboratory of the Westinghouse Lamp Company to prepare certain two-element high vacuum radio tubes for use in the suit of Marconi Wireless Telegraph Company of America *vs.* The United States; that in accordance with certain instructions he prepared such tubes; that such tubes were manufactured at the plant of the Westinghouse Lamp Company and given to him for the purpose of producing the required vacuum in such tubes before they were sealed off; that his instructions in this respect were to produce such a degree of vacuum as is now used in the modern high vacuum or "hard" three-element vacuum tubes and by the modern and usual methods now employed in exhausting such tubes; that he proceeded to exhaust said tubes so that the degree of vacuum produced in all of said tubes is the same as in present-day commercial three-electrode hard vacuum tubes known as the UX 201 A and in general said tubes have a vacuum of about ten to the minus five millimeters (10^{-5} m.m. or 1 100,000 m.m.) of mercury in terms of barometric pressure; that the tube No. 665, forming a part of "Claimant's Exhibit No. 224", was so exhausted by him; that tubes Nos. 624, 642, 644 and 663, forming a part of "Claimants Exhibit No. 226", were also exhausted by said method; that tubes Nos. 622, 623, 645, 668, 6213 and 6414, marked for identification as "Defendant's Exhibit P-6" at the request of Defendant's counsel, were also exhausted by the same process.

It is Also Stipulated and Agreed by and between counsel for the respective parties hereto, subject to correction should error appear, that the following letter which appears in the printed text on pages 177 and 178 of a book entitled "A Handbook of Wireless Telegraphy", by James Erskine-[fol. 1211] Murray, published by Crosby, Lockwood & Son, London, in 1907 is a substantially correct copy of a letter transmitted by J. M. Hudgins, Lieutenant U. S. Navy, on or about August 6th, 1905, from the U. S. S. Kearsarge, Bar Harbor, Maine, to the Chief of the Bureau of Equipment at Washington, D. C., through the Division Com-

mander, Second Division, and Commander-in-Chief of the North Atlantic Fleet, and that said letter was received in due course of transmission by the Chief of the Bureau of Equipment, Navy Department, Washington, D. C., to-wit:

"U. S. S. Kearsarge, 1st Rate,
Bar Harbor, Maine, *6th August 1905.*

SIR:

1. I have the honour to make the following report on the test of the Fessenden Wireless Telegraphic apparatus between the U.S.S. 'Alabama' and U.S.S. 'Illinois' on the afternoon and night of the 2nd inst., and forenoon of the 3rd.

2. The apparatus was handled, both in preparation for, and during the test by the regular ship's operators. In obedience to orders from the Commander-in-Chief, I reported on board the 'Illinois,' and observed the working of the apparatus on that ship. The test took place at sea, over clear water between the latitudes of 38° and 44° north, and longitudes of 68° and 70° 48′ west, and lasted from 1 P. M. of the 2nd inst. until 3:30 P. M. on the 3rd.

3. The 'Illinois' separated from the Fleet at Nantucket Shoals Lightship at 12:30 P. M., 2nd August, and steamed on a course south-west by south at a speed of twelve knots. The 'Alabama' continued with the Fleet, and steamed generally on a course north-east by north, at a speed of from ten to twelve knots. In accordance with the pre-arranged schedule, the 'Alabama' sent her position in latitude and longitude on the hour and thirty minutes, and the 'Illinois' sent hers on the fifteen and forty-five minutes.

4. Sending with a normal strength of from thirty to thirty-five amperes, fifty to sixty volts on transformer, and with a spark-gap on each side of the cooling plate of from 3/16 inch to 1/4 inch, the ships continued in easy communication with each other up to 11 P. M., at a distance of 230 miles, when the 'Alabama' asked the 'Illinois' to send stronger, increased spark-gap on 'Illinois' to 5 16 inch each side of cooling plate, and sending current to forty amperes. The 'Alabama' continued to receive up to midnight, a distance of 251 miles, after which she failed to make out any message from the 'Illinois', or even satisfactory parts of messages, until the following morning at 9:45, when she got part of the 'Illinois' position message, but was

interrupted by the Maryland and Boston Navy Yard. The distance between the two ships at that time was 267 miles. The reception on the 'Illinois' continued good, and the position of the 'Alabama' was correctly received for mid. and [fol. 1212] 12:30 P. M. The position for 12:30 was sent up to 12:45, and the distance between the two ships at 12:45 was 268 miles.—Very respectfully,

J. M. HUDGINS,
Lieutenant, U. S. Navy.

THE CHIEF OF BUREAU OF EQUIPMENT,
Through the Division Commander, 2nd Division, and the Commander-in-Chief, North Atlantic Fleet."

RICHARD A. FORD,
EDWARD W. VAILL,
Counsel for Claimant.
C. V. EDWARDS,
Special Assistant to the Attorney-General.

Approved:
HERMAN J. GALLOWAY,
Assistant Attorney-General.

Q. 145. Please state your theoretical and practical experience and training in the radio art, which would tend to qualify you as an expert in such art.

A. I am an Electrical Engineer and was educated at McGill University, Montreal, Quebec, Canada, where I completed the course in Electrical Engineering in the year 1905, and I hold from this institution the Degree of Bachelor of Science. After leaving College I engaged in the usual preparatory work of a young engineer, serving in shops, drawing offices and engineering offices, and in 1908 I took up wireless telegraph work with the National Electric Signaling Company, serving under Professor Reginald A. Fessenden. I remained in the employ of this Company from 1908 until 1912, during which time I engaged in the design, development and research work of wireless telegraph apparatus. In 1912 I became an engineer in the employ of the Marconi Wireless Telegraph Company of America, and in 1915 was made Chief Engineer in charge of all of the Company's technical activities. I remained Chief Engineer of the Marconi Wireless Telegraph Company of America until the formation of the Radio Corpo-

ration of America. During this period from 1912 until 1920, I had to do with every phase of wireless telegraph work, including research, design of apparatus, manufacture of apparatus, installation and operation of apparatus. There were made under my direction during this time many thousands of radio outfits, both transmitting and receiving.

From 1920 until October, 1924, I was in the employ of the Radio Corporation of America as Consulting Engineer, and was occupied during this time with various special investigations. I am a Fellow and Charter Member of the Institute of Radio Engineers and have received from them the Morris Liebman Memorial Prize for my work in the reduction of static interference. I am also a Member of the American Institute of Electrical Engineers and the New York Electrical Society. I have published several papers in the Proceedings of the Institute of Radio Engineers. In addition to the practical work which I have done during my nineteen years' connection with radio, I have devoted a great deal of time to the theoretical study of this subject, including its mathematical and physical aspects.

Q. 146. Have you read the depositions taken by Claimant [fol. 1213] in its prima facie testimony in this case, and have you examined the exhibits referred to therein?

A. Yes, I have.

Q. 147. Have you read the depositions taken on behalf of defendant in its answering testimony herein, and have you examined the exhibits referred to in such depositions?

A. Yes, I have.

Q. 148. Have you read the fact depositions taken in Rebuttal on behalf of the Claimant herein, and have you examined the exhibits referred to in such depositions?

A. Yes, I have.

. . . . . .

[fol. 1214] In Tesla patents Nos. 645,576 and 649,621, "Defendant's Exhibits X-2 and L-6", we find, however, that Tesla has reduced his ideas to definite form. In patent No. 645,576, he refers to the work of William Crookes in the matter of gas conductivity, and he states, lines 10, *et seq.*:

"It has been well known heretofore that by rarefying the air inclosed in a vessel its insulating properties are impaired to such an extent that it becomes what may be con-

sidered as a true conductor, although one of admittedly very high resistance. The practical information in this regard has been derived from observations necessarily limited in their scope by the character of the apparatus or means heretofore known and the quality of the electrical effects producible thereby. Thus it has been shown by William Crookes in his classical researches, which have so far served as the chief source of knowledge of the subject, that all gases behave as excellent insulators until rarefied to a point corresponding to a barometric pressure of about seventy-five millimeters, and even at this very low pressure the discharge of a high-tension induction-coil passes through only a part of the attenuated gas in the form of a luminous thread or arc, a still further and considerable diminution of the pressure being required to render the entire mass of the gas inclosed in the vessel conducting. While this is true in every particular so long as electromotive or current impulses such as are obtainable with ordinary forms of apparatus are employed, I have found that neither the general behavior of the gases nor the known relations between electrical conductivity and barometric pressure are in conformity with these observations when impulses are used such as are producible by methods and apparatus devised by me and which have peculiar and hitherto unobserved properties and of effective electromotive forces, measuring many hundred thousands or millions of volts."

Tesla is quite evidently interested in the conductivity of gases and he brings out the fact that gases ordinarily are [fol. 1215] of very high resistance and that with usual electrical apparatus it is very difficult to get electrical currents to flow through them, but he points out in the concluding paragraph of my quotation that he has devised apparatus which, because of its ability to produce enormous electrical pressures, is able to overcome this difficulty.

Having first referred to the conductivity of gases and the fact that he has discovered means of sending electrical currents through them, he next proceeds to point out the reason why he is interested in gas conductivity, particularly gases at low pressure. This reason is that he wants to send electrical currents through the upper air strata, where its pressure, that is, the atmospheric pressure, is very low, so that the air is in the rarefied condition, under

which condition it is, as pointed out by Crookes, a conductor.

On page 2 of patent 645,576, Tesla states various facts relative to the conductivity of the atmosphere and then sums up the whole matter in lines 114 to 121, in the following statement:

"Expressed briefly, my present invention, based upon these discoveries, consists then in producing at one point an electrical pressure of such character and magnitude as to cause thereby a current to traverse elevated strata of the air between the point of generation and a distant point at which the energy is to be received and utilized."

This paragraph brings out quite clearly that Tesla's theory of operation was based on the conductivity of the upper strata of the atmosphere and that he proposed to utilize these properties to conduct electricity from one point to another. It is of interest to note in this connection the height to which Tesla expected to carry his conductive wires in order to realize the requirements of his theory of operation, and we find the following statement, line 129, page 4, of patent 645,576, to line 11, page 5, of the same patent:

"From my experiments and observations I conclude that with electromotive impulses not greatly exceeding fifteen or twenty million volts the energy of many thousands of horse-power may be transmitted over vast distances, measured by many hundreds and even thousands of miles, with terminals not more than thirty to thirty-five thousand feet above the level of the sea, and even this comparatively small elevation will be required chiefly for reasons of economy, and, if desired, it may be considerably reduced, since by such means as have been described practically any potential that is desired may be obtained, the currents through the air strata may be rendered very small, whereby the loss in the transmission may be reduced."

In order, therefore, to carry out the requirements of Tesla's theory of operation, it would be necessary to sustain a conductor some thirty to thirty-five thousand feet in the air. From my knowledge of engineering matters in general and my experience with radio, I know that no

one has as yet ever succeeded in maintaining a wire of any such length in the air, and I am quite unable to see how it could be done. It occurred to me, however, in examining the Tesla patents, that perhaps Tesla would cite some actual practical arrangement which he had used, but I [fol. 1216] find that instead of an aerial conductor thirty-five thousand feet in the air, that in his statement explaining his practical use of his invention, he refers, lines 8 to 18, page 4, to the outer end of the secondary or high tension coil A as being connected to the ground, while the free end was led to a terminal placed in the rarefied air strata through which the energy was to be transmitted, which was contained in an insulating tube of a length of fifty feet or more, within which a barometric pressure varying from about 120 to 150 millimeters was maintained by means of a mechanical suction pump. And in lines 23 to 27, that the receiving apparatus was connected to the other end of the fifty-foot tube. It therefore appears that in such practical use as Tesla himself states that he made of his apparatus, instead of conducting large currents through the upper atmosphere to distances of hundreds or thousands of miles, he merely sends his electrical energy from one end to the other of a fifty-foot tube. So far as I am aware, no one else has succeeded in effecting the transfer of electrical energy to any appreciable distance following the theory and method of Tesla. The actual results obtained under Tesla's theory and Marconi's theories form a most interesting contrast and supply the best possible means of determining their relative correctness. In the case of Tesla, conduction through a rarefied gas to a distance of a few feet; whereas, under the theories of Marconi Hertzian waves carrying intelligence through thousands of miles of space and forming today one of the great communication systems of the world.

Not only has Tesla, in his direct statements in the patents to which I have referred, set forth a theory of operation totally distinct from that of the Marconi Reissue patent No. 11,913 but, in lines 73 to 82, page 2 of patent 649,621, he has specifically denied the usefulness of Hertzian waves for his purpose in the following words:

"It is to be noted that the phenomenon here involved in the transmission of electrical energy is one of true conduction and is not to be confounded with the phenomena

of electrical radiation which have heretofore been observed and which from the very nature and mode of propagation would render practically impossible the transmission of any appreciable amount of energy to such distances as are of practical importance."

The phenomena of radiation referred to here is, of course, the Hertzian wave phenomena employed by Marconi, and Tesla's statement shows that he failed completely to recognize its usefulness.

In the light of the foregoing facts it is my opinion that Marconi and Tesla proceeded on two totally distinct and different theories of operation; that Marconi's theory of operation depended upon Hertzian waves radiated out from the transmitting station and received by a receiver at a distant point, while Tesla's theory of operation depended upon the conductivity of the upper strata of the earth's atmosphere and the actual conduction of electricity from one point to another through this conducting atmosphere. One theory, that of Marconi, proven by enormous and ever increasing practical use, the other theory, that of Tesla, never reduced to practice even by its originator.

Q. 155. Do you find shown or described in the Tesla book of Martin, "Defendant's Exhibit B-4", any apparatus as [fol. 1217] shown in Loftin's sketch A (Defendant's Exhibit R-4), referred to by Mr. Mauborgne in answer to Q. 7 of his deposition, on Printed Record page 1210. Please give reasons for your answer.

A. I fail to find any such association of apparatus as is shown in Loftin Sketch A opposite page 957 of the Printed Record. I fail not only to find the association of elements shown in Loftin sketch A considered in the Martin book, but, on the contrary, I find statements which show with great distinctness that no such association was contemplated.

On page 348 of the Martin book of Tesla, "Defendant's Exhibit B-4", Fig. 185, is shown the arrangement which I have already discussed in answer to the previous question, and the comment relative to it on page 349, which I have quoted in my last answer, shows very clearly that Tesla did not recognize any possibilities of associating any apparatus with which he was familiar with the scheme which he outlines on page 348. Mr. Loftin in his answer to Q. 2 in the middle of Printed Record page 957, states:

"It is reasonable to associate the system in Figure 185 (of the Martin book) with any one of the numerous systems illustrated in Figu-e 165 for producing high-frequency currents."

The reasonableness or otherwise of this association seems to me to be determined by what Tesla himself did and in the Martin book, "Defendant's Exhibit B-4", as previously pointed out, there is not only no such association as shown in Loftin sketch A but the very definite statement previously referred to on page 349, that Tesla lacked at that time any knowledge or ideas which would lead him to make the association.

In drawing the sketch Mr. Loftin has taken one element of Fig. 165, viz., that next to the bottom of page 363 of "Defendant's Exhibit B-4" and one of the generators G. The elevated conductor system he has taken from Fig. 185, apparently, and inserted therein an inductance coil S-1 (Loftin Sketch A), which inductance is not to be found in Fig. 165.

Mr. Loftin, in his answer to Q. 2, states, page 958 of the Printed Record, middle paragraph:

"While Tesla did not specifically illustrate a switch generally known as an operator's key, for making dots and dashes in the Morse code, I consider that the insertion of such a key in a system was decidedly obvious to those skilled in the art at that time."

As an inventor of many years' experience, I have had a great deal to do with the question of whether or not a thing which has actually been done and accomplished is obvious, and in practically all of such instances I have concluded that if a thing were obvious, it would have been done. In the consideration, therefore, of the present question, I have no hesitation in saying that if it were reasonable to associate anything disclosed in "Defendant's Exhibit B-4" in the manner of Loftin's sketch A, that Tesla would have made such an association. That he did not do [fol. 1218] so is evident from a mere inspection of this exhibit. If it were obvious to insert a transmitting key in the place shown as S in Loftin's sketch A, and if Tesla had any purpose in so inserting this key he would have done so, but he did not. I am therefore unable to agree

with Mr. Loftin that the arrangement of Loftin sketch A is disclosed anywhere in "Defendant's Exhibit B-4."

. . . . . .

[fol. 1219] Q. 166. What part did you take in the case of Marconi Wireless Telegraph Company of America versus National Electrical Signaling Co., in the United States District Court for the Eastern District of New York, on Mar-[fol. 1220] coni Re-issue patent No. 11,913, and Lodge patent No. 609,154?

A. I served as a fact witness in that case and I assisted Mr. Waterman in the making of numerous experiments with the apparatus of these patents. I also spent considerable time in Court during the taking of the testimony.

Q. 167. Will you please state in what other suits in the United States Courts involving wireless or radio patents you have testified on technical matters as a Radio Engineer?

A. I have testified as a Radio Engineer in the following cases:

1. Marconi *vs.* Atlantic Communication Company, on Marconi patent No. 763,772, and on Lodge patent No. 609,154 in the Eastern District of New York.

2. Marconi *vs.* Atlantic Communication Company, Southern District of New York, on Fleming patent No. 803,684.

3. Marconi *vs.* DeForest Radio Telephone and Telegraph Company, Southern District of New York, on Fleming patent No. 803,684.

4. Marconi *vs.* Kilbourne & Clark Manufacturing Company, United States District Court, Western District of Washington, Northern Division, Ninth Circuit, on Lodge patent No. 609,154 and Marconi patent No. 763,772.

5. Marconi *vs.* National Electric Signaling Company; Second Circuit, Marconi patent No. 763,772, Marconi Reissue patent No. 11,913, on Lodge patent No. 609,154 and Marconi patent No. 627,650, U. S. District Court, New York, Eastern Division.

6. Marconi *vs.* United States, Court of Claims, in the present suit, No. 33,642.

. . . . . .

[fol. 1221] Q. 182. Have you read, and do you understand, the invention described in Marconi patent No. 763,772 in

suit, and particularly, as claimed in claims 1, 2, 3, 6, 8, 10, 11, 12, 13, 14, 16, 17, 18, 19 and 20?

A. I have read the patent and believe that I understand the disclosures thereof, and the claims specified.

Q. 83. Please give your understanding of the disclosures of the invention of Marconi patent No. 763,772 as to the claims mentioned in the last question, and state the position and value of the invention in the art at the date of the application, and subsequently thereto, down to the present time. Please give your reasons therefor in contradistinction to reasons advanced by Mr. Loftin, tending to indicate a lack of valuable advance over the prior art.

A. Marconi patent No. 763,772 discloses for the first time in a radio-communication system a transmitter having two tuned circuits, one of which constitutes a reservoir for the [fol. 1222] storage of energy, while the other constitutes a good radiator of this energy, and both circuits are in tune one with the other, that is to say, have the same natural time-period. It also discloses a receiving system consisting of an open antenna circuit, which is a good absorber of energy and a closed circuit, which is a good conserver of energy, and the tuning together of these two circuits to have the same natural time-period. Not only are the two circuits at the transmitter and the two circuits at the receiver tuned together, but all four circuits are tuned together; that is to say, have the same natural time-period.

Marconi's patent not only sets forth the above great essentials in the matter of tuning, but gives complete and minute details for the construction of the apparatus necessary to bring about the result desired.

In the antenna circuits of both the transmitter and the receiver there is shown a variable inductance, which provides the simple and effective means of tuning the antenna circuit.

In the closed reservoir circuit of the transmitter, consisting of the condenser c and inductance d, and a spark-gap C, the condenser c is made variable, as will be seen by reference to lines 88 to 94, page 1 of the patent, and this variable construction is a simple and effective means for bringing the closed reservoir circuit into tune with the open radiating circuit.

In the receiving circuit of Fig. 2 the closed circuit, consisting of inductance g^2, inductance j^2, condenser j' and inductance g^2 and condenser h' is provided with simple and

effective means for tuning the closed circuit to the open circuit in the form of the inductances g^2.

The arrow shown in the diagram Fig. 2 resting on these coils is the conventional indication of variability, and it will be noted that in the specification, page 2, lines 104 and 105, that the coils g^2 are referred to as variable inductances.

Marconi in this patent has not only set forth a great fundamental principle, accompanied by complete necessary wiring diagrams and electrical specifications, but he has also given minute details of the actual construction of the parts involved as, for instance, page 3, line 25, and continuing on through the following page. The completeness of the disclosure of this Marconi patent is very impressive, as it is a record of work actually done, rather than an exposition of a mere speculation or hope.

That the data disclosed by this patent is of such a nature as to enable one skilled in the art to actually duplicate the results of Marconi, is a fact which I know as the result of having constructed and tested, some ten or twelve years ago, the actual arrangements of this patent, which were found to work as described.

In order to make clear the significance of Marconi's patent No. 763,772, I will briefly point out the three great steps in the art of radio-communication which made possible all of the development which has since taken place. The first step was, of course, that disclosed in the Re-issue patent No. 11,913, with which patent radio began. As is always the case in a new art, the initial step which brings it into being is crude and full of imperfections, and so we find that in Marconi's first step his performance was limited in two important respects. He disclosed tuning between the antenna systems, but, due to the inclusion therein [fol. 1223] of the spark-gap at the transmitter and the coherer at the receiver, and the lack of adjustable tuning means, the degree of tuning or selectivity possible was, in the light of present-day standards, poor. Only a small amount of power could be used, since increasing power meant increasing spark-length and, therefore, antenna voltage, and the permissible limit in this respect is reached before any considerable power is used.

Lodge with his variably-acting inductance coil, provided the next vital improvement and furnished a means which prolonged the oscillations at the transmitter, increased

the selectivity in the receiving circuit and provided a simple and effective means of making tuning practicable.

Both the original Marconi arrangements and the Lodge improvement were still greatly limited in two respects, due to the inclusion in the transmitting circuit of the spark-gap which, by reason of its high resistance, introduced electrical losses in the circuit with a resulting detrimental effect upon the selectivity. The amount of power which could be used in either of these arrangements was limited, due to the fact that increasing the power meant increasing the length of the spark-gap, resulting in a high voltage on the antenna and an increased resistance, due to this spark-gap. Practically these limitations operated to prevent the use of any considerable amount of power.

The next great step, therefore, was to get the spark-gap at the transmitter and the detector at the receiver out of the antenna circuit and into an associated circuit of the right sort. It is this problem which Marconi solved in his patent No. 763,772. He puts the spark-gap in an associated circuit, that is, one coupled to the antenna, and which contains a condenser, whose capacity may be, and usually is, very large compared to that of the antenna, and thus provides a reservoir circuit into which may be stored any desired amount of electrical energy. This, however, is only the first step in his solution, since having stored the energy, he must transfer it to the antenna circuit, and to do this he first provides in his closed circuit, an inductance d in Fig. 1, which is electrically associated with a second inductance d^1 and he then proceeds to tune the closed circuit; this tuning, plus the association of the coils, giving the complete solution of the problem of transferring the energy from the closed circuit to the open radiating circuit.

This step was one of tremendous consequence, and is the thing which distinguishes the Marconi patent No. 763,772 from everything which preceded it. In Marconi's solution of the problem at the receiving station of getting the detector effectively and efficiently out of the antenna circuit, Marconi employs the same idea, and puts it in a closed tuned local circuit, and then he proceeds to make the complete receiving system, viz., antenna circuit and detector circuit in tune with the complete transmitting circuit, viz., the antenna circuit and the closed circuit.

This great step of Marconi's was of such fundamental importance that it has been an inherent part of nearly every radio communication system up to the present time. Due to the employment of the closed tuned reservoir circuit it has been possible to employ great powers, resulting in radio communication over thousands of miles, and due to the removal of the spark-gap from the antenna system at [fol. 1224] the transmitter and the detector from the antenna system at the receiver, and the tuning between all four circuits, a tremendous improvement in selectivity was brought about, which latter improvement made possible the working of a great number of radio stations without interference with each other.

It is of interest to note also, at this point, that so vital and fundamental was this step of Marconi's that although endless efforts have been made, to my own knowledge, for many years, to find substitutes for it, none of these methods have met with success.

Q. 184. Will you please refer to the deposition of Mr. Loftin, beginning with the last paragraph on page 1023 of the Printed Record, and state whether his explanation of the action during the transfer of alternating current energy from one circuit to another, as generally understood in the electrical art, accords with your knowledge and experience in that matter?

A. Mr. Loftin's statement is quite incorrect. If two or more circuits are associated together and are acted upon by an alternating current, except for an instant after the closing of the switch, there is only a single frequency existing in these circuits. Mr. Loftin's statements apply only to the case of circuits in which a spark-gap or other means exists, which causes them to oscillate and give rise to what are known as "free oscillations".

Q. 185. What comment have you to make on Mr. Loftin's statement in the paragraph beginning on page 1024 of the Printed Record, that in the Marconi 4-circuit tuning apparatus of patent No. 763,772 the control of the development of the coupling frequencies is "entirely through the degree of interlinkage"?

A. I disagree with Mr. Loftin's statement, for the simple reason that he has omitted to consider an electrical element, which is vital and controlling equally with the coupling in the matter of the production of two frequencies and that is, the quantity known as "resistance". If the re-

sistance of the circuits is sufficiently high, relatively close coupling may be applied, without giving rise to the usual indications of two or more frequencies.

Q. 186. Will you please consider the testimony of Mr. Loftin on the lower portion of page 1027 of the Printed Record, regarding what he considers to be the amount of coupling indicated in Marconi patent No. 763,772 and state whether or not you agree with him in his statements; if not, please give your reasons.

A. It seems to me that Mr. Loftin's statement is predicated on a lot of inference and not on any substantial basis. Mr. Marconi, in his patent 763,772, has given very complete details relative to his circuits, and while, in his specification, he nowhere says anything about coupling, these details are sufficient to enable one skilled in the art to find out, either by calculation, or by construction and measurement, just what order of coupling he did have in mind.

Mr. Waterman, in Volume I, page 152, in the Kilbourne & Clark case, has testified that the couplings between the circuits in Marconi patent No. 763,772 varied from five to nineteen and one-half per cent., according to his calculations. It so happens that I assisted Mr. Waterman in the making of these calculations and also in the making of some actual measurements, and my recollection is very clear that Marconi's actual arrangements disclosed a wide variety of couplings. To my mind, what Mr. Marconi actually dis- [fol. 1225] closed in the actual work which he did is the only real evidence of what his ideas were in this matter of coupling, and this evidence is that he proposed to use and did use, a wide variety of couplings.

From the engineering standpoint, it is inconceivable that he should have done otherwise, because the degree of coupling, that is to say, the amount of the association between his circuits, is a thing which can only be found by trial, and varies widely with different circumstances.

It is my opinion, therefore, that Mr. Loftin's conclusion that the Marconi patent 763,772 either discloses or implies any particular degree of coupling, is entirely at variance with the facts disclosed by the patient itself, since the actual values vary from some five per cent., which is a loose coupling, to nineteen and one-half per cent., which is about

as close a coupling as is ever employed in any radio transmitter or receiver.

I note that Mr. Loftin has referred to the particular way in which coil *d* is drawn with the loop away from coil *d'*, as indicating a loose association or coupling between these circuits and I wish to point out that this Fig. 1 is purely a wiring diagram and indicates nothing whatsoever as to the matter of coupling. Furthermore, he has stated that because only a single turn was employed in the closed circuit, as illustrated in the diagram Fig. 1, and also in constructional details as *d* Fig. 4 that this was an indication of loose coupling. In his statement he has neglected to point out that this single turn is the entire inductance of the closed circuit, also as shown in Fig. 4, that it was physically arranged very close to coil *d'*, from which it follows that the coupling between the two circuits may be very close. Under these circumstances the closeness or looseness of the coupling will depend upon the amount of the coil *a'* which is included in the antenna circuit. If the antenna *f* is of such a size that for the given wave length only a few turns of *g* are included, the coupling will be close; or, if many turns are included, it may be loose; consequently, inferences from the diagram are without significance, without other practical information.

Q. 188. Please refer to the last paragraph beginning on page 1028 of the Printed Record and continuing on page 1029, including the first seven lines thereof, and state whether or not you consider Mr. Loftin's consideration of the questions of conductivity and resistance are in accordance with the facts relating to such matters.

A. I do not agree with Mr. Loftin's statements relative to the action of the spark-gap in the Marconi patent 763,772 and I note furthermore that he has used the word "low" in conductivity where he evidently meant "high" and the word "closed" where evidently he meant "opened". Unless these words are altered in the way indicated above, his statements at the bottom of Printed Record page 1028 and the top of page 1029 are meaningless.

Assuming that these changes are made in the wording, I then disagree with Mr. Loftin's statements as to the way in which the spark-gap of the said Marconi patent should function. This is the means which Marconi describes for instance, claim 1, as the means which automatically causes oscillations of the desired frequency. In order that it may

do this, it must have, first of all, at high and practically infinite resistance until it breaks down and it must also have the property of automatically restoring its resistance [fol. 1226] after it has broken down, and after the oscillations have ceased to exist in the closed circuit and have been transferred to the secondary circuit, that is, the antenna circuit. Just how long the gap shall remain conducting is no where specified in the Marconi patent, and Mr. Marconi certainly does not state that the gap must "remain high in conductivity for a long time and not open too soon to stop the flow of oscillations", as Mr. Loftin states. He does, however, show constructions of such nature that widely varying couplings exist and the length of time which the spark-gap remains active depends upon the coupling; that is, if the coupling is close to the energy is rapidly transferred and the spark gap should stop working. If the coupling is loose, the oscillations last for a longer time in the closed circuit, and the spark-gap would remain active until, as before, all the energy is transferred to the antenna circuit.

Mr. Marconi, in his patent No. 763,772, does not say anything about maintaining the oscillations for a long time in the closed circuit, but merely refers to this circuit as a persistent oscillator in contradistinction to the open antenna circuit, which is a good radiator. What he really did mean in the matter of the persistency of the oscillations, is shown by the construction which he adopts, and that is that he really didn't care how many oscillations there were in the closed circuit, so long as there were enough to get the energy out of this circuit into the antenna circuit. The very fact that Mr. Marconi has not specified in his patent any particular number of oscillations, or any particular degree of coupling is, to my mind, one of the best illustrations to be found in his work, of Mr. Marconi's great practical knowledge and experience. He recognized that these quantities were variable depending on all sorts of circumstances incident to the design of the apparatus and its use, and he knew that these were best determined by actual experiment and use, and he did not handicap the user and designer by arbitrarily specifying these quantities, but rather laid down the fundamental principles, viz., the tuned reservoir circuit and the tuned radiating circuit, and, in addition, gave practical examples of the carrying out of these principles.

Q. 189. Considering further the subject-matter involved in your last answer and the quotation by Mr. Loftin on page 1033 of the Printed Record from lines 18 to 20, page 2 of the specification of the Marconi patent in suit, which is as follows:

"electrical oscillations are set up in the circuit which persist or are maintained for a long time—in the primary circuit * * *."

will you please state what is your understanding of what Mr. Marconi meant by the use of the term "persistent oscillator"?

A. My understanding of the meaning of the term "persistent oscillator" is very different from that of Mr. Loftin, and it is particularly different in so far as its use by Mr. Marconi in the explanation of his invention is concerned.

Patent No. 763,772, lines 12 to 24, inclusive, page 2, states:

"By experiments have demonstrated that the best results are obtained at the transmitting-station when I use a persistent oscillator—an electrical circuit of such a character that if electromotive force is suddenly applied to it and the current then cut off, electrical oscillations are set up in the circuit which persist or are maintained for a long [fol. 1227] time in the primary circuit and use a good radiator—*i. e.*, an electrical circuit which very quickly imparts the energy of electrical oscillations to the surrounding ether in the form of waves—in the secondary circuit."

This statement is a perfectly clear specification as to the type, form or nature of the circuit which he has in mind for his closed circuit, and an equally clear description of the open or radiating circuit. This description of the closed circuit refers to its characteristics when taken by itself, but it says nothing about what takes place in such a circuit when it is coupled to some associated circuit, such as the antenna circuit, which extracts energy from it. There is no inference in this statement such as Mr. Loftin has drawn, that when coupled to another circuit, the oscillations therein must persist or be maintained for a long time and, furthermore, no such requirement is anywhere stated in the Marconi patent 763,772, or is found in practice. As a matter of fact, due to the coupling existing in certain of Mr. Mar-

coni's structures only a very few oscillations could possibly exist in the closed circuit.

Mr. Loftin has extended his inferences drawn from the statement quoted from the patent to the point of determining the nature of the spark-gap, an inference which is totally unsupported by any statement that I can find in the patent and which, furthermore, is entirely contrary to all my practical experience.

Mr. Marconi himself says only a little about the spark-gap C' of Fig. 1 of patent 763,772, lines 83 to 85, page 1:

"the spherical terminals or other contacts of a spark-producer or other electric-wave or oscillation producer."

This indicates that he proposed to allow a very wide latitude in the construction of the spark-gap and from the minute exactness with which Mr. Marconi has described the essential features of his invention, it is evident to me that had he desired a spark-gap which would keep active as long as possible, he would most certainly have said so, and told how to build it. The little he does say, however, is of exactly the opposite nature, for he refers to the spark-gap C', Fig. 1, as having "spherical terminals" which, as is well known, have considerable heat-radiating capabilities. Had he desired the use of a gap which would not cool quickly, he would have specified "pointed electrodes".

It is of interest to note in this connection that the art at this time was already familiar with types of spark-gaps which had marked cooling capabilities. For instance, there is shown in the Marconi Re-issue patent No. 11,913 a spark-gap, Fig. 2a, which consists of four spherical electrodes resulting in two spark-gaps in series, and is a construction which tends to cool the spark and cause it to go out. There is also shown in the British patent to Tesla, No. 20,981, of 1896 (Defendant's Exhibit Y-2"), Fig. 12, a type of spark-gap in which one element indicated by *i*, *i'* and *i''*, rotates and the spark takes place between this rotating member and two other members, which are stationary, and are indicated by *l*.

This form of spark-gap has very marked cooling capabilities and is highly efficient, and has been found in practice up until quite recent years.

[fol. 1228] As a matter of practical fact, I may add to the above, that ever since radio has existed and a spark-gap

been used, the cooling of this gap and the extinguishing of the spark as quickly as possible has been recognized as a matter of great practical importance.

There is a point in connection with the language used to describe the closed circuit, which seems to me is of consequence in understanding Marconi's use of the words "persistent oscillator" and "good radiator"; expressions very often get into an art when it is new, which appear less apt than could be desired from the standpoint of later knowledge. When radio was young, the wave-lengths were very short; in some cases, as illustrated in Marconi Re-issue patent No. 11,913, a matter of inches or a few feet. When this was the case, an open radiating circuit was very non-persistent, any oscillations existing therein traveling off into space and extracting the energy so rapidly that the oscillations ceased to exist after a very few swings. The contrast between this type of circuit and the closed circuit either with or without a spark-gap, was very great, and led to the use of the language above quoted in distinguishing the two circuits, one from the other.

As radio developed, the wave-lengths used became longer and longer, until today we have them in use which are some 60,000 or 70,000 feet in length, and the result of this slow change and progress in the art has been that the open radiating circuit has become more and more persistent, due to the fact that the rate at which energy goes out into space from it diminishes very rapidly with the increase of wave-length, and the result of this fact is that the distinguishing language of the early art, when taken literally, in the matter of the number of oscillations existing in the two types of circuits, is not as apt as it formerly was, although the types of circuits and their functioning remains identical with that described by Marconi in his patent No. 763,772.

Q. 190. Referring further to the quotation which you have made in your last answer from the Marconi patent No. 763,772, will you please state your understanding of what Mr. Marconi had in mind in the use of the term "a good radiator" and its technical bearing upon the use of the term "persistent oscillator"?

A. The significance of the expression "a good radiator" in the Marconi patent is very clear. By this expression Mr. Marconi means a circuit of the sort which he has shown in Fig. 1 at the transmitter, for instance, comprising an

elevated conductor *f* A, inductance coils *g d'* and an earth connection E.

This is what is known in the language of the art as an "open circuit", one end of it being in the earth and the other end somewhere up in the air, and it has the electrical characteristic of being able to radiate out into space electrical energy in the form of electromagnetic waves. As shown by Mr. Marconi in his patent, it is associated with a closed reservoir circuit, in which the electrical energy exists, and from which the open radiating circuit must extract it, in order to make it useful in the production of electromagnetic waves. So long as the energy is in the closed circuit, it is of no particular use, and it must therefore be transferred to the open radiating circuit as rapidly as possible, in order to be useful, and that is why Mr. Marconi tunes these two circuits together. As a result of this combination of the two kinds of circuits of different characteristics, coupled and tuned together, Mr. Marconi is able to store up a large quantity of electrical energy and to rapidly and effec- [fol. 1229] tively send it out into space from the open radiating circuit in the form of electromagnetic waves.

Q. 191. In the next to the last paragraph on page 1034 of the Printed Record, Mr. Loftin refers to the use of cooling means in spark-gaps, and states that the art has not resorted to such means except where very large power is used. Will you please comment upon this paragraph in accordance with your experience and knowledge of the facts?

A. I disagree entirely with Mr. Loftin's statements in the matter of the cooling of the electrodes used for spark-gaps. It has been the practice of the art, within my own personal knowledge since 1908, to employ means for cooling the spark-gaps and great efforts have been directed in devising simple and effective means for accomplishing this purpose. I know, also, from my early recollection, that spark-gaps were cooled in the practice of radio prior to my entrance into this field, and I have already pointed out that both Marconi and Tesla, prior to the date of patent to Marconi No. 763,772, used spark-dischargers which involved cooling means. Practical men recognized as a result of actual experience that the cooler they could make the spark-gaps, the more efficiently the radio transmitter would work, and the testimony of Messrs. Reinhard, Lehr and

Clark in this case is illustrative of the practical employment of devices for the purpose of cooling the spark-gap.

It is impossible for me to conceive of a statement more contrary to the known facts of practical operation than that of Mr. Loftin on page 1034 of the Printed Record, were an engineer to follow out the principle outlined therein, viz., do all that was possible to keep the gap hot and maintain it for as long a time as possible, the spark-gap would not only work inefficiently, but would cease to operate at all. As previously mentioned, the spark-gap is a means which automatically causes oscillations of the desired frequency, and this it cannot do unless it cools rapidly, for the simple reason that if it becomes hot beyond a certain point the voltage of the secondary of the transformer which is connected to the spark-gap, will be short-circuited through the spark-gap and will not charge the condenser, with the result than no oscillations will be produced.

It follows, therefore, both from theoretical considerations and as a matter of practical experience that the spark-gap to work at all, must be cooled, and the more effectively it is cooled the more efficiently it will work. Had Mr. Marconi constructed a spark gap to comply with the ideas expressed by Mr. Loftin, he would have constructed an inoperative arrangement, and this he certainly did not do.

Q. 192. Referring to Mr. Loftin's deposition, as found on pages 1035 to 1042 of the Printed Record, will you please comment upon the correctness and accuracy of the diagrams used by him and the statements made in connection with such diagrams?

A. Mr. Loftin, pages 1035 to 1042 of the Printed Record, has made a number of sketches purporting to illustrate what takes place in the circuits of a radio transmitter when one of these circuits is an open radiating circuit, and the other is a closed reservoir circuit.

Opposite page 1039, Sketch Fig. 1a shows a couple of trains of oscillations taking place at each half cycle of the alternator in the spark-gap circuit, but these appear to be incorrectly drawn as they are apparently of logarithmic [fol. 1230] form, which is the form that such such an oscillation would take if in a circuit without a spark-gap, but when the circuit contains a spark-gap, due to the fact that the resistance increases as the oscillation gets smaller and smaller, the oscillations have a linear decrement and not a

logarithmic. Figs. 2 and 2a seem to be intended to illustrate what happens when two oscillating circuits are coupled together, and gives the impression that the motion of the electricity in these circuits is simultaneously of two different sorts. This, of course, is a totally incorrect impression. The correct impression would result from leaving out of Fig. 2 or Fig. 2a either the red or the green lines, and leaving in the others. The correct method of representing this action is shown on page 25 of "Claimant's Exhibit No. 219", being a pamphlet entitled "Elementary Principles of Radio Telegraphy and Telephony", published by the Signal Corps of the U. S. Army. Fig. 20 illustrates the usual sort of thing that happens when electrical circuits, such as those used for radio transmitters, are coupled closely together with an insufficiently cooled spark-gap. This is a sort of waxing and waning of the amplitude of the motion of the electricity in the two circuits.

* * * * * * *

I note that Mr. Loftin at the bottom of page 1041 states:

"I have quoted the statement of objects of the Marconi invention from the specification of the patent in suit as being obtaining efficiency and localizing communication. From my discussion above as to the effects of tight coupling it is quite apparent that the Marconi system did not include tight coupling—that tight coupling actually prevents obtaining the stated object."

Mr. Loftin is here referring to his discussion on the same page of Fig. 2 and Fig. 2a, opposite page 1039 of the [fol. 1231] Printed Record, which I have also just referred to. Starting with this particular and incorrect hypothesis as to the objects of the Marconi invention, he argues that a tight coupling, giving rise to the sort of wave-train which is correctly illustrated in "Claimant's Exhibit No. 219", is not intended to be used in the Marconi patent. This inference, as I have already pointed out, is entirely unjustified by any disclosures of the patent and, furthermore, as has already been pointed out, the sort of wave-train shown in "Claimant's Exhibit No. 219" is not a necessary result of close coupling, since if the resistance of the antenna be high enough, very close coupling may be used without the production of the above described type of wave form.

I might also point out that while in general it is undesirable to so arrange matters in the transmitter of the Marconi system that a wave train of the form above described is produced, there is certainly nothing which prevents such use in case the operator desires to so use it, and there are occasional circumstances under which there may be some reason for such an adjustment. If a ship, for instance, happens to be working under such circumstances that it is important to get the greatest possible distance while at the same time there is no disturbance to other communications resulting therefrom, the operator may, and in practice occasionally has, closed up the coupling to the point where oscillations of two different frequencies were emitted by the antenna and, at the same time, the total power radiated was somewhat increased. Reception of such a radiation by a receiver, also closely coupled, may be efficient when considered simply from the standpoint of the distance covered, and when, for the time being, the matter of selectivity is not of consequence.

This illustration is intended merely to bring out the fact that operation of the Marconi system with close coupling and a complex form of radiation, is possible and occasionally used, but no inference should be drawn from it to the effect that such operation is either desirable or customary.

Q. 193. Referring to Mr. Loftin's sketch "H" opposite page 1042 of the Printed Record and the description applying thereto on pages 1042-1044, will you please state whether the figures of this sketch, particularly Fig. 4a, represent correctly the waves of the antenna circuit under conditions of unequal L and C in the two circuits of an open gap loosely coupled transmitter? Please give the reasons for your answer.

A. In Fig. 4a opposite page 1043 of the Printed Record, Mr. Loftin shows a curve which purports to illustrate what happens in a Marconi system with an open gap when loosely coupled. As in Figs. 2 and 2a, opposite page 1039, Mr. Loftin gives an incorrect picture of what is taking place. This incorrectness arises from the fact that the curve Fig. 4a would lead one to think that the electricity in the open radiating circuit was moving in two different ways at once, viz., in the manner shown by the blue curve of Fig. 4a, and at the same time in the manner shown by the red curve of Fig. 4a, and such an impression is quite in-

correct. If we assume that the blue curve and the red curve are correctly drawn as illustrating the individual components of the wave-train for some particular set of conditions, then the true picture of the motion of the electricity in this circuit would be obtained by adding together the vertical ordinates of these two curves.

[fol. 1232] In so far as any practical use of a Marconi transmitter is concerned, this diagram is entirely without significance, since it shows or rather, purports to show, something taking place when the antenna circuit and the closed circuit are not in tune, and this is not an adjustment prescribed by the Marconi patent No. 763,772, or employed in practice.

In Figs. 5 and 5a of page 1042 of the Printed Record are shown two curves, the former purporting to represent the motion of the electricity in the closed circuit and Fig. 5a, the motion of the electricity in the open circuit of a Marconi transmitter with a loose coupling and plain gap.

I note that Fig. 5 shows a curve which appears to decrease in accordance with the logarithmic law and, as I have previously pointed out, the decay of the oscillations in a circuit containing a spark-gap is, due to the resistance of the spark-gap, linear.

I fail to find anywhere in Mr. Loftin's testimony any technical data disclosing the usual necessary facts required, in order to plot curves of this sort, and I am therefore forced to state that they do not disclose any real facts relative to the operation of a Marconi transmitter with a loose coupling and a plain gap.

I have, at several points, referred to the decrement in a circuit containing a spark-gap as being linear, and not logarithmic, and will now refer to some work published by Dr. J. Zenneck. On page 13 of a translation of Dr. Zenneck's book entitled "Wireless Telegraphy" by A. E. Seelig, First Edition, 1915, there is a paragraph, 9, headed "Condenser Circuit with Spark Gap. Damping due to Spark".—This paragraph describes some experiments on the circuits containing a spark-gap and contains the following statement:

"* * * The amplitude curve is now no longer an exponential curve but approaches a straight line more and more as the energy absorbed by the spark exceeds the energy lost as heat."

The "exponential curve" referred to here is the logarithmic curve, the two words being alternatives and the "straight line" signifies the linear decrement which I have referred to as characteristic of circuits containing a spark-gap.

It will be seen from the statements on pages 13 and 14 (Claimant's Ex. 241) of this publication that the greater the energy loss in the circuit due to the spark-gap, the more nearly the law of decay approaches a straight line.

Mr. Vaill: Counsel for claimant offers in evidence photostat copies of pages 13 and 14 of the book just referred to by the witness "Wireless Telegraphy" by Dr. J. Zenneck, First Edition, 1915, and requests that same be marked "Claimant's Exhibit No 241".

(Said exhibit marked as requested.)

Q. 194. At the top of page 1045 of the Printed Record, and in answer to Q. 22 of Mr. Loftin's deposition, beginning on page 1052, Mr. Loftin states that in the apparatus of the Marconi patent the desired result is obtained in one way by

"causing the oscillations in the lateral circuit to persist or be maintained for a long time—that is, having provided for [fol. 1233] conserving its energy not to cease slowly feeding energy to the antenna circuit unnecessarily early."

Please state to what extent you agree or disagree with him, and give your reasons for your answer.

A. I do not, of course, agree with Mr. Loftin's statements to which you have referred.

His statement at the top of page 1045 is simply another statement by him of his particular and incorrect picture of the requirements, operation, and general functioning of the apparatus and system of Marconi patent No. 763,772. Mr. Loftin's statement is divided into five parts, and he says that Marconi's result is obtained first "by creating oscillations in a lateral circuit". Mr. Loftin uses the word "lateral" in place of the more usual word "local", as describing the closed reservoir circuit of the transmitter, and he is correct in stating that the production of oscillations in this circuit is one of the necessities of the Marconi system.

Secondly, he states that the lateral circuit should be a good conserver of energy, which statement he qualifies by the expression "not unreasonably wasteful". This qualification expresses a condition which is, of course, highly desirable, but not specified in the patent—it also is not a condition which is necessary for the carrying out of the objects of the Marconi patent.

Thirdly, he states that the oscillations in the lateral circuit should persist as long as possible and shall feed their energy slowly into the antenna without stopping unnecessarily early.

It is at this point that Mr. Loftin's conception of the Marconi system becomes entirely incorrect. There is no single word in the patent which supports his statements and there is a great mass of information which is diametrically opposed to it. This information is contained in the constructions which Marconi so minutely details and which, as I have previously pointed out and explained, indicate a wide variety of couplings and, therefore, a wide variation in the rates at which energy is transferred to the antenna circuit. These constructions show, or rather some of them, that the energy was transferred slowly, and in some others, the energy was transferred relatively rapidly, and in all cases they disclose the work of a practical man who knew how to make the transmitter work and was not interested in any fine-spun theories. Mr. Loftin's point relative to slowly feeding the energy into the antenna through a coupling sufficiently loose so as not to disturb the frequency of the oscillations in the lateral circuit rests purely on his own misconception of the requirements of the patent and is, for the reasons pointed out in connection with his third point, quite unsupported by anything disclosed in the patent.

His fifth point is a direct misstatement of the wording of the patent. He says:

"and, fifth, to adjust the antenna or good radiating circuit to have a natural period the same as the frequency period of the oscillations in the lateral circuit—that is, to get the resonant transfer of energy described by Lodge."

Reference to the patent shows that Marconi has nowhere instructed the adjustment of the antenna circuit in any way whatsoever relative to the frequency of the oscillations

[fol. 1234] in the closed circuit; what he does state, however, is found for instance, page 2, line 118 to line 129:

"The capacity and self-induction of the four circuits—*i. e.*, the primary and secondary circuits of the transmitting-station and the primary and secondary circuits at any one of the receiving-stations in a communicating system—are each and all to be so independently adjusted as to make the product of the self-induction multiplied by the capacity the same in each case or multiples of each day—that is to say, the electrical time periods of the four circuits are to be the same or octaves of each other."

This is a complete clean cut instruction to any electrical man as to how to relate the electrical constants of the circuits. Marconi has found out that when he does this he gets the best results, and, like the good practical man that he is, he sets down the facts and leaves the theorizing to others. Not only are his instructions in this respect perfectly clear and concise, but they are also of such a fundamental nature that no alternative has ever been found.

In answer to Q. 22, on page 1052 of the Printed Record, Mr. Loftin comments on Mr. Waterman's answer, commencing at page 145 of his deposition relative to the persistency of the oscillations in the closed circuit. He quotes Mr. Waterman as follows:

"Hence the amount of energy, and consequently the distance that could be reached with a given wave length by the original Marconi arrangement having the spark gap in the antenna, was limited by the small capacity of the antenna and the low charging pressure that could be applied to it on account of the presence of the spark gap."

Mr. Loftin argues from this quotation that a very slow transfer of energy is required, a statement which is entirely contrary to the facts, since, as is well known, two or three oscillations in the primary circuit, lasting an exceedingly short time, are quite sufficient to transfer relatively large quantities of energy to the antenna system without the production of excessive potentials.

Mr. Loftin next refers to the quotation:

"the approximately closed circuit of the primary being a good conserver."

and states that:

"This requirement has no meaning unless the energy remains long enough in the primary or lateral circuit for conservation."

In these quoted statements of Mr. Loftin, he appears to be arguing facts relative to the operation of a radio transmitter from an expression which is merely descriptive of a type of circuit.

While Mr. Marconi has used the expression "good conserver" to describe the characteristics of the closed oscillating circuit, he does not anywhere state that this circuit, when in operation, and coupled to another circuit, shall hold the energy as long as possible. He does not so state for the very simple reason that he does not want it to do anything of the kind but, on the contrary, wishes to get it [fol. 1235] into the antenna circuit where it will be useful. In some of the structures which he has described he allows the energy to remain in the closed circuit a relatively long time; that is, when he uses five per cent coupling; while in other cases the energy remains a relatively short time as, for instance, when he uses a nineteen and one-half per cent coupling.

The fact that the closed circuit is a good conserver of energy, therefore, does not mean that it is being used in a radio transmitter for the purpose of holding the energy as long as possible, but that it is used for the purpose of holding the energy as long as may be necessary for the purpose of transferring it to the antenna circuit. How rapidly it may be transferred depends upon conditions as, for instance, the resistance of the antenna circuit, or the cooling of the spark-gap. Since the energy in the closed circuit is of no use while it is there, it is perfectly obvious that it is desirable to get it into the antenna circuit as quickly as possible. This is a fact which has been recognized by every practical worker in the radio art but, while highly desirable, though the quick transfer of energy is, it was not possible at first to realize all of the possibilities in this direction. Mr. Loftin has pointed out, and I have briefly discussed, the complex and undesirable wave-train illustrated in "Claimant's Exhibit No. 219" resulting from too close an association between the open and closed circuits. This results from the fact that the

spark-gap used did not cool sufficiently, so that, after the energy had been transferred to the antenna circuit, the spark-gap did not go out, and so the energy was re-transferred back to the primary circuit. This action was recognized very early in the radio art and continued efforts were directed toward the improvement in the spark-gap for the purpose of making it cool more quickly, and as time went on, closer and closer couplings, that is to say, more and more rapid transfer of energy from the closed to the open circuit, became possible.

Mr. Loftin refers to the third requirement of the quotation to the effect that the local circuit shall be a "persistent oscillator" and he reiterates again that this means long sustained oscillation, but since this argument is, I believe, completely met by my statement above, it appears unnecessary to indulge in further comment.

Mr. Loftin's fourth statement, in which he says:

"electrical oscillations are set up in the circuit which persist or are maintained for a long time—in the primary circuit."

again uses language which is descriptive of a type of circuit and not of facts of operation to infer and argue conclusions relative to operation which are totally contrary to the intent of the Marconi patent 763,772, the disclosures thereof, and many years of practical experience in the use of Marconi's arrangement.

* * * In my opinion, the language which describes the particular sort of circuit used by Marconi for his closed circuit implies nothing whatsoever relative to the functioning of that circuit when used in combination with the radiating circuit and I know as a matter of practical experience of a very extensive sort, that the Marconi arrangement does not require that the electrical oscillations which are set up in the closed circuit shall persist for a long time, when the transmitter is in actual operation. [fol. 1236] Q. 195. At the bottom of page 1045 of the Printed Record, and on page 1046, Mr. Loftin refers to certain pages of Zenneck's book ("Defendant's Exhibit H-6"); will you please consider the pages referred to by Mr. Loftin and state in what way the matter referred to by him and other matter contained in said book are pertinent on the question of coupling?

A. Mr. Loftin has used the quotation from Zenneck to illustrate what happens when the two circuits of an oscillator are coupled together in a manner which he calls "extremely loose", this extreme looseness being indicated by the fact that there is no appreciable reaction between the closed and open circuits. This is the sort of coupling which Mr. Loftin, as I understand his deposition, believes to be the sort of coupling which the Marconi patent infers.

As I have already pointed out several times in my answers, I consider this inference as entirely without support from the disclosures of Marconi patent 763,772, and quite contrary to the practice of the art.

There is a difference between a loose coupling and an "extremely loose" coupling, which is of great practical importance. When the coupling is so loose that there is no appreciable reaction between two associated circuits and if we neglect entirely the cutting-off action of the spark-gap, then the theoretical requirements for a single frequency in the secondary circuit exist. This, however, is an ideal of theory which is impossible of realization and which, if realized, would be quite useless for the simple reason that if the coupling between circuits is so loose that there is no reaction, there will then be no transfer of energy and, consequently, no usefulness in the combination. In order to transfer energy we must, of necessity, close the coupling up to some point which will be satisfactory from the practical requirements of operation. These practical requirements are, first, the transference of energy; secondly, a reasonably pure wave in the secondary circuit and these two things are of such a nature that they call for exactly the opposite condition in the matter of coupling; that is to say, the closer the coupling up to a certain point, the more energy we can transfer. On the other hand, the looser the coupling the purer the wave in the secondary circuit. From which it obviously follows that the practical adjustment must be a compromise and a coupling chosen which transfers the energy reasonably and gives a reasonably pure wave form, the criterion of reasonableness being, of course, the knowledge derived from practical experience.

Due to the action of the spark-gap in cooling rapidly, and thereby restoring its initial high resistance, the degree of coupling which may be employed without seriously distorting the wave form is much closer than that indicated by

the theoretical treatment of Bjerknes, referred to on page 85 of "Wireless Telegraphy" by Zenneck and translated by Seelig, dated 1915, and which forms the basis for the explanation which Dr. Zenneck sets forth.

This theoretical treatment, while it takes account of the resistance in the coupled circuit, takes no account whatever of the cutting-off action of the spark-gap, which action exists in all practical forms of radio transmitters employing a spark-gap and tuned coupled circuits and is the controlling factor in determining the degree of coupling permissible without distortion of the wave form. While this [fol. 1237] theoretical treatment of coupled circuits is important and useful to students of the fundamental actions in electrical circuits, it is of very little significance or help in understanding the action of circuits containing a spark-gap and for this reason I am unable to find any support in this publication for Mr. Loftin's position in the matter of the operation of the wireless telegraph system described in Marconi patent No. 763,772.

Paragraph c, page 85 of the book referred to, contains a statement distinguishing a loose coupling, involving an appreciable reaction, from the extremely loose coupling, in which no appreciable reaction exists, and the paragraph also explains that the result of this association is to increase the apparent resistance of the driving circuit. This is equivalent to putting a load on the driving circuit and relates to a condition more nearly approximating that of practical operation than the extremely loose coupling outlined in paragrap'- 56, page 85, referred to by Mr. Loftin.

It does not, however, bring out the dominant fact controlling the degree of coupling, viz., the cutting-off action of the spark-gap.

Q. 196. Referring to Mr. Loftin's consideration of the claims of the Marconi patent in suit, No. 763,772, beginning at the middle of page 1046 of the Printed Record, will you please state wherein you may differ with him in his conclusions as to the meaning of the technical terms of said claims?

A. Mr. Loftin, in his treatment of claim 1 of Marconi patent 763,772, at the bottom of page 1046, argues that the statement in the claims which reads:

"discharging through a means which automatically causes oscillations of the desired frequency."

requires that the open circuit and the closed circuit shall be loosely coupled, for he states, at the top of page 1047 of the Printed Record:

"It is therefore clear that the 'means' referred to in claim 1 requires that the lateral circuit and the elevated conductor or open circuit shall be loosely coupled."

This is a most astonishing conclusion, with no basis whatever, which I am able to find, except Mr. Loftin's consistent attempt throughout his deposition to read "loose coupling" into the Marconi patent 763,772. If we examine the language of claim 1, we find, lines 30, 31 and 32, the statement:

"a condenser discharging through a means which automatically causes oscillations of the desired frequency;".

From the diagram of the closed circuit in Fig. 1 and from well known electrical principles, it is evident that the condenser *c* can only discharge through the circuit *c*, *d*, C. This discharge cannot take place in any way through the associated antenna circuit; consequently there can be no basis for including this antenna circuit in explaining the meaning of the expression contained in the claim.

The significance of the expression is still more closely defined by consideration of claim 6, lines 29 to 32, which state:

"and whose primary is connected to a condenser-circuit [fol. 1238] discharging through a means which automatically causes oscillations of the desired frequency."

The only possible condenser circuit for the discharge to take place is shown in Fig. 1, and consists of the condenser itself *c*, the inductance *d* and the spark-gap C, together with the necessary connecting wires, and the only element of this combination which has an automatic action of any kind in the production of electrical oscillations, is the spark-gap C. This automatic action is as follows:

The induction coil shown in the diagram charges the condenser *c* until the spark-gap breaks down, becomes conducting and permits of the oscillatory discharge of the condenser. After the oscillations have ceased, this spark-gap must automatically, that is, by its own action, recover its high resistance again since, if it does not, the voltage produced by the induction coil will flow through the spark-

gap and will be prevented from charging the condenser. It follows, therefore, that this spark-gap is the thing referred to by the expression in claim 1 under the designation of "means which automatically causes oscillations of the desired frequency".

There is no justification, therefore, in my opinion, for extending the meaning of this expression to cover the coupling between the circuits, either in the light of any understanding of this term by those skilled in the art, or in the disclosures of the patent itself.

On page 1049 of the Printed Record, Mr. Loftin has summarized the transmitting claims, and he states:

"Summarizing the group of transmitting claims above listed, it is to be noted that in no one of the claims does Marconi claim the two circuits actually in resonance."

Resonance being an electrical phenomenon, is outside of the possibilities of any patent claim, as I understand patent law and, therefore, seems to require no further comment.

Mr. Loftin states further:

"The claims include 'means' for adjusting the time periods of the circuit, in some cases naming the specific devices; that is, Marconi only included in his claim the instrumentality for accomplishing the result".

Marconi patent No. 763,772 is an "apparatus" patent, and not a "method" patent, for which reason, very naturally, the claims are confined to apparatus.

Mr. Loftin next states:

"Adjusting the time period of circuits was old at the time of the Marconi application, and these claims clearly show that Marconi fully appreciated this and made no claim to two circuits having time periods in accord with each other. He merely included in his claims an enumeration of instrumentalities adapted to conveniently adjust the circuits to secure this relation."

This statement gives a totally incorrect impression of the claims of the patent, since they are directed to means which resulted in a great epoch-making advance in the art of Wireless Telegraphy, while Mr. Loftin states that it was old to adjust the time-period of electrical circuits, [fol. 1239] he does not state that it was old to adjust time-

periods of the two circuits at a transmitting station and two circuits at a receiving station in resonance with each other, which is the all-important disclosure of this patent.

The statement that Mr. Marconi "made no claim to two circuits having time periods in accord with each other" creates a quite erroneous impression, since while the language of the claims is necessarily restricted to means for bringing the circuits into accord with each other, the result of the employment of these means is that the two circuits are brought into tune and the great improvement in the art of radio telegraphy is secured.

On page 1051 of the Printed Record, Mr. Loftin states:

"Summarizing this group of receiver claims, I do not find any requirement by Marconi that the two circuits at the receiving station shall be adjusted to accord in time periods or adjusted to resonance. This clearly shows that Marconi fully appreciated that the art prior to him had disclosed this feature and Marconi made no claim thereto. His claims are for the means or instrumentalities for adjustment in combination with other specific elements."

As in the transmitter claims, the receiver claims are, of necessity, since this is an apparatus patent, drawn to means necessary for accomplishing the objects of the patent. When the means so claimed are employed as directed in the specification of the patent, the two circuits at the receiving station are adjusted to resonance, or to accord in the time-periods; this result which is secured by the apparatus of Marconi patent 763,772, is in direct contradiction to Mr. Loftin's statement quoted above, to the effect that there is no requirement by Marconi that these circuits at the receiving station should be in tune. As a matter of fact, the employment of the means claimed in these claims not only produces this result, but the specification recognizes it and requires it in quite unmistakable language on page 2, lines 118 to 129, where it states:

"The capacity and self-induction of the four circuits—*i. e.*, the primary and secondary circuits at the transmitting-station and the primary and secondary circuits at any one of the receiving-stations in a communicating system—are each and all to be so independently adjusted as to make the product of the self-induction multiplied by the capacity the same in each case or multiples of each

other—that is to say, the electrical time periods of the four circuits are to be the same or octaves of each other."

On page 1052 of the Printed Record, Mr. Loftin summarizes his opinion of the three groups of claims in language similar to that already quoted in so far as the receiver claims and transmitter claims, taken separately, are concerned.

In so far as those claims involve four circuits, Mr. Loftin states that he has claimed resonance for the four circuits, in spite of the showing in the prior art of radio systems having two tuned circuits at the transmitter and two tuned circuits at the receiver. With respect to this statement, I will merely make the comment that I have been quite unable to find anywhere in the prior art any [fol. 1240] showing of two coupled tuned circuits at the transmitter, or of two coupled tuned circuits at the receiver, or of any complete radio system involving a combination of the transmitter and receiver above specified.

As I have stated in the preliminary part of my deposition, I have taken part in most of the litigation involving Marconi patent No. 763,772 which has taken place in the United States, and am generally familiar with the prior art relied upon by the defense in these various cases and interpreted by various Experts, and my opinion, above stated, is based on this experience and the knowledge obtained therefrom.

Q. 197. Will you please describe briefly the various kinds of spark-gaps capable of use with the tuned transmitting circuits of the Marconi patent in suit, No. 763,772, giving a brief outline of their development, and state in what respects their operation and effect in said circuits are similar? In answering this question please refer to X Q. 196 and the answer thereto of Mr. Loftin's deposition (page 1164 of the Printed Record), and state to what extent you agree with his answer to that question.

A. A great variety of spark-gaps has been used in radio and much labor and ingenuity been expended in efforts to prove the effectiveness of this device. It was recognized by the workers in this art almost, if not quite, from the very start of radio that cooling was an essential feature and that the more effective the cooling, the more effective was the operation of the gap. The reason for this effectiveness is simple and has already been pointed out in

some of my previous answers, and is the fact that the cooler the gap is, the greater is its power of automatically restoring its initial condition of high resistance. When a circuit containing a spark-gap, such as that shown in the Marconi patent No. 763,772, Fig. 1, is coupled to an antenna circuit, the effect of the coupling and the extraction of energy by the antenna circuit is to decrease the number of oscillations which would otherwise take place in the closed circuit, and the closer the coupling the more rapid is this decrease.

When, due to this action, the oscillations in the primary or spark-gap circuit have been reduced down to a very small value, if the gap is effectively cooled it will automatically restore itself to its original condition of high resistance, and the oscillations which are taking place in the antenna circuit will not be transferred back again into the spark-gap circuit, thereby causing a complex and undesirable wave form and useless waste of energy.

All of the types of spark-gaps used in practice have this capability to a greater or less extent. At first, as is shown [fol. 1241] in the Marconi patent No. 763,772, a type of gap was sometimes employed which consisted of two metallic spheres on the ends of metal rods. This type of gap had some cooling capabilities, particularly when used with small powers.

Reference has already been made in a previous answer to the type of gap illustrated in the Marconi Re-issue patent No. 11,913 and in the British Tesla patent No. 20,981, of 1896 ("Defendant's Exhibit Y-2"), which have greater cooling powers than the single pair of spheres.

In the "Manual of Wireless Telegraphy for the Use of Naval Electricians", 1911 Edition, by Commander S. S. Robison, U. S. Navy, there is shown on page 105, "Plaintiff's Exhibit 100", a number of spark-gaps of different construction which represent the development of this device and the methods adopted to secure satisfactory cooling.

Fig. 54 shows a simple form, consisting of two metal rods with rounded ends, on which is directed an air blast. Fig. 55 shows a spark-gap consisting of two metallic strips having a considerable surface for radiating heat. Fig. 60 shows a spark-gap in which the electrodes are hollow and compressed air, for the purpose of cooling, forced through them. Fig. 61 shows two metallic rods with rounded ends

and a metallic plate of large surface interposed between them and dividing the spark-gap into two sections. Fig. 58 shows a number of sets of spherical ball spark-gaps, in series with each other, which result in the sparks being broken up into a number of small parts.

All of the spark-gaps above described belong to the class known as "fixed gaps" and are good illustrations of the expedients adopted to increase the cooling of these devices.

The next step in the development of the spark-gap is illustrated in Fig. 53 as a non-synchronous rotating spark-gap. "Claimant's Exhibit No. 212" shows a form of this gap adopted by the United States Navy and referred to by Mr. George H. Clark, on page 1496 of his testimony. In this device one set of electrodes is fixed, while the other terminal consists of a number of studs attached to a rapidly-rotating disk. This type of gap operates in two ways to put out or quench the spark, viz., a marked cooling effect, due to the rapid rotation, and the fact that on the rotating element each stud handles only a portion of the total number of sparks. In addition to this, the rapid rotation of the gap draws the rotating electrodes away from the fixed electrodes, thereby mechanically increasing the length of the spark-gap and its resistance, and therefore its tendency to go out.

The word "non-synchronous" used in connection with this type of spark-gap signifies that the rate of rotation of the spark-gap is not definitely related to the rate of rotation of the generator which supplies the alternating current power.

In "Plaintiff's Exhibit 112", there is shown a spark-gap of this type connected in the circuit of a Navy transmitter, and Mr. Clark, on page 231, testifies to the effect that practically every quenched spark-gap set purchased by the Navy had as an auxiliary a spark-gap of this type. This statement of Mr. Clark's is relative to the time down to the date of his leaving the Navy in 1919. It happens also that I know from my own personal experience that large numbers of spark-gaps of this type were employed [fol. 1242] by the Navy Department as auxiliaries to quenched sparks and used in the identical circuits in which the quenched spark-gap was used.

Many of these sets were manufactured by the Marconi Wireless Telegraph Company under my supervision, and I saw others in the Navy Yard, manufactured by various

competing companies. I saw most of these spark-gaps during the period when the United States was in the World War.

In Fig. 52 of the "Manual of Wireless Telegraphy" is shown a synchronous rotating spark-gap, whose general action is similar to that of the non-synchronous spark-gap, except that it is usually attached to the shaft of the generator and I find on page 425 of the "Proceedings of the Institute of Radio Engineers" dated October, 1916, an illustration of a gap of this type used by the Government at its Arlington station. This particular spark-gap was one of the largest of its kind that was ever constructed and I happen to have been one of those who did the work of designing and testing this device while I was with the National Electric Signaling Company. ("Plaintiff's Exhibit No. 81," pages 424 and 425.)

As will be seen from the statement under this illustration, this spark-gap handled a very large power, viz., 100 kilo-watts and gave very satisfactory practical operation.

The rotary spark-gap represents the second stage in the development of effective cooling means for spark discharges, while in Fig. 57, page 105, of "Plaintiff's Exhibit No. 100," there is shown the third and last practical development of spark-gaps with effective cooling, which is called the "quenched" spark-gap. This spark-gap consists of a number of circular plates, separated by insulating materials and the separation between the sparking surfaces is very small. The number of such plates are usually varied from five or six up to fourteen or fifteen. The surfaces between which the sparks actually took place were highly polished, circular in form and about two and a half inches in diameter, and were attached to cooling flanges in order to quickly radiate away the heat.

Due to the large number of very small gaps in series, the large sparking surface and the large cooling flanges, this type of gap has greater capabilities in the matter of extinguishing the spark than any of the types previously mentioned. This property of rapidly cooling and extinguishing the spark is one common to all of the types of spark gap above described, and the differences between the various types are merely differences in degree, since the action in all of them is identical.

With this action of the spark-gap in mind, it will, perhaps, be of interest to note that in the actual operation

of a radio transmitter this action has been a controlling one in the matter of the degree of coupling which could be employed. In all cases it has been the universal practice to adjust the coupling between the closed circuit and the open circuit as close as was possible, without the production of a complex wave form.

With the first type of simple fixed spark-gap a particular order of coupling would be found in practice which would meet this condition, but when a spark-gap of the rotary type was substituted, it would be found that a [col. 1243] closer coupling was possible, without spoiling the wave form and a greater efficiency in the transfer of the oscillations to the open circuit realized.

When the quenched spark-gap was developed, it was found that a still closer degree of coupling could be employed and a still greater efficiency could be secured. In all cases the coupling employed was of such a nature that, with the particular spark gap used the oscillations in the primary circuit stopped, due to the quenching action of the gap at the time when their amplitude was reduced nearly to zero. The more perfect the quenching action, the closer the coupling which could be employed (without the energy from the secondary circuit transferring back to the primary circuit), and the smaller the number of oscillations taking place in the primary circuit during the transfer.

In addition to the similarity in the matter of quenching between all types of gaps to which I have just referred, is the fact that all of them are most effectively employed in the tuned coupled circuits of Marconi patent No. 763,772; regardless of which type of gap is used, the spark-gap circuit must be tuned to the open antenna circuit in order to transfer the energy effectively and I have personally on numerous occasions, made the experiment of using all three types of gap one after the other in the same circuit arrangement, and found that the tuning adjustments for all three were the same, but that the coupling adjustments was loosest with the plain gap, closer with the rotary gap and greater still with the quenched gap.

I note that Mr. Loftin, on page 1164 of the Printed Record, in answer to X Q. 106, states that the Marconi patent 763,772 is not limited to any particular kind of gap and

with this statement I agree. His further statement, however,

"I have contended that the Marconi patent, and its transmitter claims, is limited to a system in which oscillations of but one and the desired frequency are created in the primary circuit of a transmitter and are transferred at this one and desired frequency into the secondary circuit, or radiating circuit, without change in frequency."

is not at all in accordance with the disclosures of the Marconi patent and I am in complete disagreement with it.

The patent says nothing whatever about the mechanism of the transfer of energy from one circuit to the other, other than to specify the apparatus necessary for the purpose and the further fact that the circuits shall be in tune, and these requirements of the patent constitute the complete and necessary disclosures for the purpose of making a wireless telegraph transmitter with coupled tuned circuits.

Mr. Loftin's concluding statement in this answer is:

"I have contended, however, that for the 'best results' in the matter of getting a persistent long drawn out train of oscillations in the primary circuit the open-gap form is the preferred form."

This contention appears to me to be directed toward something which is neither of interest nor consequence in the operation of a wireless telegraph transmitter, and which is not one of the objects set forth in the Marconi patent. On the contrary, it appears to me, for reasons [fol. 1244] previously set forth at some length, to be a totally undesirable result and one which the art has made every effort to get away from.

Here again, it seems to me that Mr. Loftin is extending the language used by Mr. Marconi to describe a type of circuit to the point of describing an action after that circuit is coupled to an open radiating circuit, and this extension, in my opinion, is without justification, either in the facts of operation, or the patent itself.

Q. 198. Please refer to Mr. Loftin's answer to Q. 24 on page 1058 of the Printed Record, in which he discusses the effect of different degrees of coupling and criticizes Mr.

Waterman's Sketch No. 2, and state wherein you agree or disagree with Mr. Loftin's statement.

A. I have read Mr. Loftin's reply to Q. 24, page 1058, and I do not agree with his remarks relative to Mr. Waterman's statements on page 151 of the record, wherein he explains certain facts relating to the transfer of energy from a primary circuit to a secondary circuit.

As I understand Mr. Waterman's explanation, he has illustrated in *a* of Waterman Sketch No. 2, oscillations taking place in the closed reservoir circuit of the Marconi transmitter and brings out the fact, to which I have just referred in my last answer, that when the oscillations of the primary circuit reach a certain minimum value they will if the coupling adjustment is right, cease entirely, due to the opening of the spark-gap, while the secondary circuit will go on oscillating without disturbance from the primary circuit until it dies out.

Mr. Loftin interprets Mr. Waterman's statement, which he quotes in the middle of Printed Record, page 1059, and which is:

"It is important, therefore, in order that the efficient radiation to which the patent refers may be secured that the association between the two circuits should not be so close as to permit the secondary circuit to break down the spark gap by reaction upon it."

to be a direction to employ a loose coupling in accordance with Marconi patent 763,772.

Such an understanding is, to my mind, quite unjustified by Mr. Waterman's statement but, on the contrary, I find that it is an entirely correct technical statement of the adjustment requirements of a Marconi transmitter, viz., that the coupling should not be too close for the type of spark-gap employed.

Mr. Loftin further contends, as he has consistently throughout his deposition, that the Marconi patent specifies "loose coupling", and that for this reason Mr. Waterman, in his Sketch No. 2, has illustrated a type of action of which the Marconi transmitter is incapable.

This statement is, of course, totally contrary to the facts, since, as I have previously pointed out, the degree of rapidity with which energy can be transferred from one circuit to another in the Marconi tuned coupled transmitter is merely a matter of the type of gap employed.

Mr. Loftin states:

"As a matter of fact, the cessation of oscillations in the primary circuit is not determined by the association of the two circuits, but upon spark gap conditions opposed to [fol. 1245] those which are necessary to secure the long drawn out persistent oscillations in the primary circuit of the Marconi invention."

This statement is entirely misleading, both in so far as it infers the necessity for persistent oscillations in the primary circuit of the Marconi invention, and in its reference to spark-gap conditions, which are in opposition to the requirements of the Marconi patent.

As I have pointed out many times in my deposition thus far, the Marconi patent does not specify, and does not require, long drawn out oscillations in the primary circuit, when that circuit is coupled to an antenna and in my last answer I have shown that the action of spark-gaps of all types is similar and that they differ only in the degree of cooling and, therefore, spark-extinguishing capabilities.

Mr. Loftin's criticism to the effect that no open or plain gap will function to cut off energy in the manner shown in *a* of Waterman Sketch No. 2 is quite without justification, since Mr. Waterman in his explanation of this figure, has made no reference to any particular type of spark gap.

Mr. Loftin further states that there is no foundation of Fig. 2 in the Marconi specification and then proceeds to state that the figure is a counterpart of that shown in most text-books as typical of the action of the quenched gap type of radio transmitter, which type of transmitter is, as a matter of fact, the arrangement of the Marconi patent No. 763,772.

Referring to this type of transmitter, Mr. Loftin states that it was an invention made some ten years subsequent to the Marconi invention, which statement I consider entirely incorrect since, from my own experience I know that the invention referred to could only be the particular type of gap.

* * * * * * *

Q. 199. Will you please illustrate by a diagram or curves, the relative forms of wave trains in the primary and secondary circuits of an open-gap loosely coupled transmitter, as compared with the forms of wave trains in the

quenched spark closely coupled transmitter, and explain how they are arrived at; also please state in your explanation whether or not the circuits of the quenched gap transmitter are in resonance, giving your reasons for your conclusions.

A. On page 94 of Seelig's translation of the work entitled "Wireless Telegraphy" by Zenneck ("Defendant's Exhibit H-6") are found two sets of curves, one illustrative of the action taking place in a quenched spark-gap transmitter with close coupling, and the other showing what takes place with an open gap, and the same close [fol. 1246] coupling and these curves illustrate, in a simple way, the cutting-off action of a spark-gap having a high degree of cooling; such, for instance, as the quenched spark-gap and the sort of wave train which results from a close coupling when the cutting-off capabilities of the spark-gap are insufficient.

The two upper curves of Fig. 130 show that the oscillation in the primary circuit starts at a high value and is very rapidly, after about three oscillations, reduced down to zero, while the secondary oscillation rapidly builds up during this time.

Reference to the lower curves, Fig. 131, illustrative of the quenched spark-gap, shows that during this same period the action taking place in the circuit containing the quenched spark gap is identical, and this is the period during which energy is transferred from the primary circuit to the secondary circuit, due to the coupling between them and the fact that they are in tune.

Referring now to the upper two curves, it will be noted that when the primary current is at zero, the secondary current is at maximum, and that, for the next few oscillations the secondary current decreases, while the primary current rapidly builds up to maximum. This action continues and is repeated several times, resulting in a sort of waxing and waning of the wave train.

This is the complex wave form to which I have several times referred in my previous statements and it is mathematically analyzable into two principal frequencies, often referred to as the "coupling frequencies".

It will be noted in the lower two diagrams that when the primary oscillation falls to zero it ceases altogether, due to the fact that the great quenching power of the quenched gap has caused it to open. It will also be noted that the

secondary oscillation decreases slowly for a long period of time, and this is illustrative of the fact that, due to the opening of the gap, no energy from the secondary circuit is fed back into the primary circuit, with the resultant distortion of the wave form.

The state of affairs which is represented in the two upper curves is, from the standpoint of practical operation and use of the open gap, undesirable and is the result of an improper adjustment of the coupling; that is to say, a coupling which is too close for the quenching capabilities of the open gap.

In the sketch which I produce (Claimant's Ex. 243), I have shown the oscillations in a circuit with an open gap, in which the coupling is correctly adjusted, and it will be noted that the wave forms of both the primary and secondary circuits are similar to those of the quenched spark-gap shown on page 94 of the Zenneck book.

In the sketch which I have produced, there are more oscillations in the primary circuit than are shown in Fig. 130 for the quenched gap which I have just described, because the coupling is, of necessity, looser and the energy, therefore, is transferred to the secondary circuit more slowly. It will be noted also, however, that when this oscillation reached the zero point it ceases, exactly as in the case of the quenched spark-gap.

It will be seen also that the secondary oscillation builds up in the same manner as the secondary oscillation of the [fol. 1247] quenched spark-gap, but more slowly, due to the looseness of the coupling, but that it dies out in the same slow fashion as does the oscillation of the quenched spark-gap arrangement.

The curves which I have produced are illustrated of the action of tuned coupled circuits containing an open gap when the coupling between these circuits is correctly adjusted; that means, is as close as it can be, without the energy from the secondary circuit being transferred back into the primary circuit, due to the failure of the spark-gap to go out.

It will be seen from this description that the action of Marconi tuned coupled circuits containing either an open spark-gap or a quenched spark-gap is identical in principle; that in both cases the proper adjustment of the coupling is that adjustment which transfers the maximum energy, without distortion of the wave form; that is to say, in

both cases the coupling should not be so tight that the spark-gap is unable to open after the primary oscillation has been reduced to some small value, and that the oscillation in the secondary circuit is that due to the antenna oscillating in its own natural way, without interference from the primary circuit.

In the transfer of energy from the circuit contaning the spark-gap, that is, the closed reservoir circuit, to the antenna circuit or open radiating circuit, there is a relation between the electrical constants of these circuits which is vital. This is, that the condition of resonance shall exist, that the circuits shall be in tune, or, as stated in the Marconi patent 763,772 specifically the product of inductance and capacity in one circuit shall equal the product of inductance and capacity in the other circuit. This is a fundamental law, and tuned coupled circuits obey it, regardless of the type of the spark-gap employed. While it is true that some technical writers, in treating of the action of such circuits with a quenched spark-gap in them, have occasionally referred to a slight mis-tuning between the circuits, I know that these references are the result of insufficient experiment or improper handling of the apparatus.

It so happens that in the course of my long experience in radio I have supervised the design, construction and operation of thousands of tuned coupled circuit transmitters employing the quenched spark-gap, and I have tested, in the most thorough and complete manner possible, many times, and with many different transmitters, the question of resonance between the closed and open circuits and from this experience I am able to make the positive statement that quenched spark transmitters must be tuned in exactly the same way, and for exactly the same reasons, as the same circuits used with the open type of spark-gap.

While there are occasional brief references in the literature of the art to slight mis-tuning between the circuits of the quenched spark-gap transmitter, there are numerous other references which indicate clearly a recognition by the authors of the existence of the fact that these circuits are tuned.

On page 408 and 409 * * * (Claimant's Ex. 244) of the work entitled "Robison's Manual of Radio Telegraphy and Telephony for Use of Naval Radiomen" by Commander (now Admiral) S. S. Robin, U. S. Navy, published by the

[fol. 1248] United States Naval Institute 1924, there is a description of the action of coupled circuits containing the quenched spark-gap.

At the bottom of page 408 is a paragraph referring to Figs. 272 and 273, which figures are curves similar in nature to those of Fig. 131 of the Zenneck book, which I have just described.

This paragraph states:

"Such would be the ideal way, but the actual equipment used permits a series of surges through the gap as indicated in figure 272. The resulting induced antenna current is shown in Figure 273. If the time periods or frequencies of the two circuits are not the same under these conditions, a very small energy transfer takes place. It, therefore, becomes of first importance that the primary oscillatory and the antenna circuits be adjusted to identical time periods. For this it is necessary that the $L_1 C_1$ value of one circuit equal the $L_2 C_2$ value of the other. This does not mean that L_1 must equal L_2 and C_1 equal C_2, but it does mean that the product of L_1 and C_1 expressed in henries and farads, or convenient subdivisions, must equal the product of L_2 and C_2 expressed in the same units."

This quotation shows very clearly that the authors of the Navy Manual in issuing instructions on the subject of Radio to Naval electricians, recognized and taught that the circuits of the quenched spark-gap transmitter were tuned.

I find also, on page 1096 of the Printed Record, that Mr. Loftin, in referring to the Wireless Specialty Apparatus Company transmitters, and others of similar type, has stated that these were the kind of wireless transmitters described in patent No. 1,216,615 to G. Seibt, and as I understand his statement at the bottom of this page, this Seibt patent discloses fully and completely that sort of transmitter which is today known in the art as the "quenched spark-gap transmitter."

It seems fair to assume that the inventor of this system would disclose his ideas and the results of his experience in the use of his system, and in this disclosure indicate whether or not the circuits are to be tuned.

I find in the File Wrapper of this Seibt patent a number of statements which very clearly show that Seibt considered

that the tuning of the associated circuits; that is, the closed circuit containing the quenched spark-gap and the antenna circuit, was of vital importance.

In Paper No. 8, Amendment B, and Affidavits received October 4, 1911, pages 4 and 5, is the following statement:

"* * * The invention does not consist of a spark-gap; nor does it consist of a short spark-gap. It does, however, consist, among other things, as set forth in the claims, of a *combination* comprising, for instance, two inter-related oscillating systems, including a primary oscillating system and a secondary oscillating system, these two systems being in resonance with each other and being coupled together in such manner that by reason of the particular kind of spark-gap employed and of the other elements employed and fully described in the specification, the spark snaps off and the primary circuit is opened at the end of the first beat in the primary circuit and the coupled waves [fol. 1249] practically disappear, with the new result that powerful and useful slowly damped, free oscillations are produced in the secondary oscillating system, causing a beautifully clear, high, musical note, * * *"

* * * * * * *

It will be noted that this statement prescribes resonance between the two coupled circuits, that is, the closed reservoir circuit and the open radiating circuit, and that it describes the action in the matter of the cutting off of the spark in language similar to that which I have used in explaining the action of spark-gaps generally.

I next quote from Paper No. 15, Amendment C, received July 1st, 1912, page 4:

"* * * In describing the commercial form of apparatus made in accordance with applicant's invention and shown in the photograph annexed to applicant's affidavit, the means and method of adjusting the coupling of the primary and secondary circuits 'thereby enabling the operator to make the coupling of the two circuits sufficiently strong to secure the snapping off of the spark at the spark-gap at the end of the first beat' are pointed out; and the affiants say that by listening at the receiving apparatus they could determine whether the note was clear or not and that if the note was not clear, they adjusted the coupling in the manner described and also brought the two circuits in

better tune with each other in the manner described, and furthermore, they regulated the potential of the current in the primary circuit of the transformer B, thus making the note clear."

This quotation describes a practical method of adjusting the apparatus and states that in order to make the note clear the circuits, that is, the closed reservoir circuit and the open antenna circuit were brought into better tune with each other.

I next quote from Paper No. 22, Amendment E, received July 18, 1913, page 20:

"* * * Wien did not disclose what applicant discloses —namely, means for producing powerful slowly damped free oscillations in the secondary circuit. In order to accomplish this result, which turned applicant's invention from a laboratory experiment into a practical, useful and commercial device, applicant brought the two oscillating circuits in tune with each other, coupled them in the manner described, employed a very short spark-gap having electrodes of high thermal conductivity and used a source of electrical current having a potential capable of quickly effecting a disruptive discharge across the spark-gap. [fol. 1250] This statement expresses the inventor's belief that his invention lies in the use of the Wien spark-gap in a closed reservoir circuit tuned to the open radiating circuit, and his belief that, as the result of tuning these circuits he has converted the Wien device from a laboratory experiment into a commercially useful radio transmitter.

It would be difficult to find language more expressive of the importance of the tuning of the quenched spark-gap circuits than that quoted above.

I again quote from page 22 of Paper No. 22, Amendment E, received July 18, 1913, as follows:

"In further explanation of applicant's invention the following remarks may be made. Two circuits are in tune when an indicating instrument in the secondary circuit gives the maximum deflection. Applicant puts the two circuits in tune and then determines the best coupling, looking at the needle of an indicating instrument. The tuning depends on the capacity and self-induction and not on the coupling. In coupling applicant adjusts the circuits to get the maximum deflection of the needle of the indicating instrument. In applicant's combination of elements

described, when the coupling is correct, that is, when it is sufficiently strong the spark will snap off at the spark-gap at the end of the first beat of the oscillations in the primary circuit. Hence the importance of the proper coupling of applicant's elements, as stated in the specification and heretofore pointed out."

This statement constitutes the practical method of detering when the circuits of a quenched spark-gap transmitter are in tune and is the method which has been employed in practice for many years.

It also states that the coupling has nothing to do with tuning, which latter is governed solely by the capacity and self-induction. This statement is in strict accordance with the facts relative to the Marconi patent 763,772 which I have frequently brought out in my deposition. Marconi very carefully specifies the inductive and capacity of his tuned circuits, but says nothing in the matter of the coupling, leaving that to be determined by the circumstances of actual operation.

Mr. Loftin, in his answer to Q. 21, page 1017 of the Printed Record, describes the nature and operation of the Marconi patent and deals with the question of loose coupling and close coupling between the open circuits and the closed circuits.

In the course of this discussion Mr. Loftin deals with the complex wave form resulting from a too close coupling of two tuned coupled circuits and argues from his explanation that the Marconi patent discloses, or at least, infers loose coupling. He again, in his answer to Q. 29, page 1096 of the Printed Record, wherein he testifies relative to the action of the quenched spark-gap apparatus of "Plaintiff's Exhibit No. 87," takes up the question of resonance between the circuits and the manner in which energy is transferred from one circuit to the other.

In the course of his discussion he identifies the apparatus of "Plaintiff's Exhibit No. 87" with the Seibt patent No. 1,216,615, and attempts to interpret a statement in the patent, page 1, lines 62 to 70, which reads as follows:

"In the arrangement shown in Figure 1 two separate [fol. 1251] oscillations are produced, as is well known, even though the natural periods of the two circuits, I and II, are the same. In the case where these two circuits are in resonance with respect to their natural periods, the two

wave lengths of the system are given by the following formulæ, neglecting resistance—"

In the light of the quotations given in this answer from the Seibt patent, it is perfectly evident that there is only one possible interpretation of the inventor's use of the words resonance and tuning, and that is that he meant exactly what M. Marconi meant in his patent No. 763,772, viz., that the two circuits should have the same L C product, that they should be in tune.

In his answer to Q. 29, Mr. Loftin undertakes to explain that the purpose of the approximate tuning which he admits between the circuits of a quenched spark-gap transmitter is the production of beats, and that since an oscillation which takes the form of the waxing and waning, to which I have previously referred, sometimes called "beats" is analyzable into two principal frequencies, both of which are different from the periods to which the closed and open circuits are tuned, that this tuning plays no part in the transfer of energy.

This argument is totally contrary to, and unsupported by, the physical facts involved in the operation of a quenched spark-gap transmitter and is based on a totally incorrect picture of the mechanism by means of which energy is extracted from the closed circuit by the open circuit and an incorrect inference in the matter of the significance of the word "frequency." He has used this word in such a way as to indicate that, in order for the energy to be transferred from the closed circuit to the open circuit the frequency of the oscillations in the two circuits must be the same and this statement is totally incorrect, for the following reasons:

The word "frequeacy" has two different meanings, one of which is the ordinary meaning, non-technical, and is represented by the motion of various things. As an illustration, suppose an ordinary clock pendulum is pulled a little to one side and allowed to swing back-and-forth until it stops. Each successive swing of this pendulum is of smaller amplitude, but the time taken to execute each swing is the same; as, for instance, one second; and, in the ordinary or lay significance of the word "frequency," this pendulum then has a frequency of one cycle per second.

In the technical sense the word "frequency" is quite different and is confined to a motion which is known as a simple harmonic motion. It is customary to illustrate

graphically motions of both sorts by means of curves and the motion of the pendulum which I have described could be illustrated by the same curve as is used in Fig. 272, page 408, "Manual of Radio Telegraphy and Telephony by Robison and Hooper," 1924 Edition, which illustrates the motion of electricity in a closed oscillating circuit and which shows that the swings are of constantly decreasing amplitude, but occupy the same time, this latter fact being indicated by the fact that the distance along the central horizontal line of the drawing is the same for each half cycle; that is, for each part of the curve above the line, and for each part below.

Referring now to "Weagant Sketch No. 2" (Claimant's Ex. 246), I have shown in the curve A a curve which is [fol. 1252] known as sine wave, which is a correct representation of a simple harmonic motion, that is to say, is the representation of that sort of motion which mathematically and technically is known as a "single frequency." The method of drawing this curve is illustrated in the little figure at the top of the sheet "Weagant Sketch No. 2." It will be noted that the successive amplitudes of this curve are equal; that the curve has a particular shape and that the time of each swing is the same. Now it so happens that this simple harmonic motion illustrated by the sine wave of my sketch No. 2 is a fundamental thing in nature and that when a motion of any other kind exists it is at once analyzable into several sine waves of the sort which I have described.

Regardless of the form of a curve which illustrates a motion, by combining the right number of sine curves having some particular frequency (usually many different frequencies), and the right amplitude, the particular curve under consideration can be secured.

For instance, the curve of Fig. 272, page 408 of the Navy Manual to which I have just referred, while representing a single frequency in the ordinary lay sense, represents very many frequencies in the technical sense. In general, it may be stated that if a curve is drawn representative of some sort of motion in which successive amplitudes are not equal, and in which the form is not that of the sine curve, that that wave form is a complex one and involves more than a single frequency, although the time between the successive zero points may be identical with the time between the successive zero points of a sine curve. Such,

for instance, is the curve shown in Fig. 274 or the curve shown in Fig. 275, which represent the motion of electricity in two circuits coupled too closely together for the particular spark-gap used.

In Weagant Sketch No. 2, in addition to curve A, I have drawn a second curve B, differing slightly in frequency, and I curve C, I have added the vertical ordinates of the two curves together, and it will be seen that I have obtained a resultant curve which is practically a duplicate of that shown in Fig. 274, page 409 of the Navy Manual. As will be noted, this curve represents the waxing and waning action which is sometimes referred to as "beats," and it is because of the fact that a complex curve of this sort can be analyzed into two or more components of simple harmonic form that a wave form of this kind is said to consist of two frequencies.

In the use of this particular instrument of mathematical analysis it is very important not to draw wrong conclusions therefrom relative to the physical phenomena involved and it is not possible, from this method of reasoning, to determine the nature of the physical phenomena which have given rise to the particular wave form. To illustrate this point, I may state that if curves A and B represent two high frequency alternating currents which are put into a detector of radio signals, they will combine to form a resultant electrical motion illustrated by curve C, and which, when rectified, will give a musical note of audible frequency, this frequency corresponding to the rate of occurrence of the zero points of curve C and this method constituting what is known as the heterodyne method of detection. When we examine the physical phenomena underlying the curves of Figs. 274 and 275, page 409 of the Navy Manual, we find a totally different thing.

Here we have oscillations existing in a closed primary [fol. 1253] circuit and which are the result of the electricity swinging back-and-forth in that circuit at a rate which is determined by its natural time-period. Due to the losses in the circuit, this motion would, if the circuit were alone, slowly die out, but due to the fact that the coupled circuit is rapidly extracting the energy from it, the motion dies out very rapidly, and quickly comes to zero. Since the energy now exists in the secondary circuit and since the spark-gap has not sufficient restorative powers, the secondary circuit now becomes the driving circuit and starts trans-

ferring the energy back to the primary circuit again. This results in a type of motion exactly like that of curve C of Weagant Sketch No. 2, but the physical phenomena involved are totally different.

The next point of vital consequence is the fact that the oscillations in the primary circuit of Fig. 274, while rapidly decreasing in amplitude, consume the same time, and are, therefore, in the ordinary sense of the word, of one frequency. Now it happens that in the transfer of energy from one circuit to another that the requirement is that the resultant motion of the electricity in these circuits should correspond with the natural time-period of the circuits, because in this transfer of energy an electrical circuit recognizes not "frequency" as defined by the mathematician, but "frequency" as understood in the ordinary lay sense. It is very easy to see this if we examine coincidently the two curves Figs. 274 and 275 and note that the first half of the curve of Fig. 274 occupies the same length of time as the first half of Fig. 275.

Now Fig. 274 represents the driving circuit and during the time of this first half oscillation, the driving force is in one direction, represented by the distance above the curve. As the point where this curve crosses the zero line in Fig. 274, the curve of Fig. 275 also crosses the zero line, so that when the driving force reverses in the driving circuit, the electricity in the driven circuit is ready to, and does move, in the same direction, and this continues throughout the action.

If these circuits were not in tune, however, this action would not result, because the motion of the electricity in the driven circuit would not correspond to the driving force, since this motion is determined by the natural period of the circuit, and the result would be that when the first half oscillation of the driving circuit arrived at zero, the first half oscillation of the driven circuit would be either a little ahead, or a little behind, and after several half oscillations the motion in one circuit would oppose that in the other, with a resultant neutralization, and the transfer of very little energy.

In other words, electricity in a circuit will move back-and-forth at a rate which is determined by the natural time-period of the circuit, and if driven by another circuit, in which the electrical motion has the same time-period, it will be helped in its motion by the associated circuit, but

if the time-periods of the two circuits are not the same, then the motion of electricity in one cannot support the motion of electricity in the other.

It is important in understanding this action, to have clearly in mind that this effective transfer of energy takes place when there is a coincidence in the time rates of the motion of the electricity in the two circuits and the natural period of the circuits, but that the shape of the wave form and, therefore, the presence of more than one frequency in the mathematical sense, is of no consequence.

[fol. 1254] When two circuits are coupled together and their time-periods are adjusted to be the same, then the motion of electricity in these two circuits is isochronous and the energy is most effectively transferred from one circuit to another.

* * * * * * *

On page 94 of Zenneck's book on "Wireless Telegraphy" translated by Seelig, 1915 Edition, there are shown two separate curves, Fig. 130, representative of the action of a close coupling between coupled circuits, having a gap of insufficient quenching powers and Fig. 131 representative of a quenched gap circuit, both circuits having the same degree of coupling.

It will be noted that during the time when the energy is being transferred from the closed circuit to the open circuit, that is, the time when the primary oscillation is decreasing from a maximum to zero, that the form of the curve is identical for both types of gap and this is a recognition by Zenneck of the fact that the action of transferring energy from one circuit to another has nothing whatever to do with the type of gap employed and the action here illustrated is strictly in accord with the explanations which I have just given.

Mr. Loftin, throughout his entire explanation of the action of the quenched gap, has referred to the adjustment of the quenched gap as being for the purpose of producing "beats" and one might infer from this statement that these so-called "beats" were the output of the radio transmitter. As a matter of fact, when the quenched gap is used and it opens at the end of the first wave train, it is quite incorrect to call the action illustrated by this curve a beat, since this can only exist when the wave form waxes and wanes a number of times.

Again, even though it were correct to so designate this action, it would still be incorrect to describe it as the object of the adjustment; since, as a matter of fact, it is merely an incident to the adjustment, which primarily is made for the purpose of getting the energy out of the closed circuit, and which results in the oscillations in the closed circuit being rapidly reduced to zero.

Mr. Vaill: Counsel for claimant offers in evidence a photostat copy of page 94 of the work entitled "Wireless Telegraphy" by Zenneck, and requests that the same be marked "Claimant's Exhibit No. 242."

(Said exhibit marked as requested.)

Mr. Vaill: Also the sketch produced by Mr. Weagant as "Weagant Sketch No. 1" to be marked "Claimant's Exhibit No. 243."

Also photostat copies of pages 408 and 409 of "Robinson's Manual of Radio Telegraphy and Telephony," 1924 Edition, to be marked as "Claimant's Exhibit No. 244."

Also photostat copies of the first page of a certified copy of the File Contents of the application on which was issued patent No. 1,216,615, February 20, 1917, to George Seibt, together with photostat copies of five pages referred to by Mr. Weagant in answer to Q. 199, to be marked as one exhibit, "Claimant's Exhibit No. 245."

Also a copy of the drawing produced by Mr. Weagant as "Weagant Sketch No. 2," to be marked as "Claimant's Exhibit No. 246."

(Said exhibits marked as requested.)

[fol. 1255] Q. 200. Will you please consider the deposition of Major Joseph O. Mauborgne on behalf of defendant relative to his statements concerning the action of quenched gap transmitters, as found in answer to Qs. 10, 11 and 12, beginning on page 1215 of the Printed Record, and to Qs. 20 and 21, beginning on page 1252 of the Printed Record, and state to what extent your answer to the last question just made, applies to said testimony of Major Mauborgne. Please consider particularly the last part of Major Mauborgne's answer to Q. 12.

A. Major Mauborgne, in his answer to Q. 10, has testified in a manner similar to that of Mr. Loftin, relative to the use of loose coupling and close coupling in circuits

containing different types of gaps, but his statements in this regard have, I think, been completely answered by my answers to previous questions.

In answer to Qs. 11 and 12 he describes the manner in which what he calls the "Marconi transmitter" and the "quenched spark transmitter" are adjusted and calibrated for practical operation, and he states, (P. R., p. 1219), in connection with the quenched gap transmitter:

"What the operator really needs to know in this case is the adjustment he must make in order that when real quenching takes place in the gap a wave of a certain definite frequency in length, say 600 meters, will be emitted from the set."

Since it happens that I have personally tested and operated large numbers of radio transmitters which involved both the quenched spark-gap and the open type of spark-gap, I can say without any hesitation, that the procedure is identical in both cases.

I may also comment at this point on the fact that Major Mauborgne attempts to differentiate between the quenched spark-gap transmitter and the Marconi transmitter, although they are one and the same thing, and I have been obliged to assume in this answer that he was merely referring to two types of the Marconi transmitter, one involving the quenched spark-gap and the other involving the open spark-gap.

I will state further relative to the quotation just given, that I have never known an operator to adjust a set for the purpose of securing quenching. On the contrary, he adjusts the quenched spark-gap transmitter for the purpose of securing maximum antenna current and a clear note. Good quenching may be an incidental accomplishment of this adjustment, but it is not the main purpose.

Further, in discussing quenched spark-gap adjustment on Printed Record, page 1219, he states that the primary and secondary are more or less in tune, indicating to my mind that he recognizes that tuning is an essential in the operation of the quenched gap set.

After describing the adjustment of the primary and secondary circuits, he states that the coupling adjustment should be made, and then says, page 1219 of the Printed Record:

"This last adjustment may cause the primary and the secondary to be slightly out of tune with each other, as can be demonstrated by a measurement of the primary if the antenna and ground be disconnected."

In other words, in order to show even a slight mistuning, he removes the ground connection and the slight capacity [fol. 1256] effect due to it, which are actually there when the set is being operated, and constitute a real part of the primary capacity. I am personally more or less familiar with this effect and, instead of indicating that the circuits of the quenched spark-gap are out of tune, it proves rather the opposite; viz., that they are so exactly tuned that even a slight change of the capacities inherent in the structure and method of connection is sufficient to be noticed.

The same statement is made again by Major Manborgne in his answer to Q. 12, and so is answered by the remarks above.

In answer to Q. 20:

"Is there a resonant transfer of energy from the primary or lateral circuit to the secondary or antenna circuit in the quenched-gap type of transmitter, as, for example, the Wireless Specialty Apparatus type, Plaintiff's Exhibit No. 87?"

Major Manborgne states that there is no resonant transfer of energy from the local circuit to the open circuit, but that this transfer takes place by brute force, and not at resonant frequencies, since it is transferred from the local circuit to the open circuit by means of two frequencies.

Major Manborgne's statement is utterly untrue, so far as the transfer by brute force is concerned, since, were this the case, this transfer would be accompanied by great losses and would be highly inefficient; whereas, the actual use of the quenched spark-gap transmitter shows that the efficiency of transfer is very high, and his statement relative to the transfer by means of two frequencies, is based on a failure to understand the nature of the physical phenomena involved, and the fact that in the transference of energy from one circuit to another if the time-periods of two circuits are identical the oscillations in the two circuits execute their motions in the same time. The fact that the wave form is complex and may be analyzed into two or more

frequencies of the mathematical sort has no bearing on the question whatever, as I have already pointed out in my explanation in my previous answer.

Major Mauborgne also makes the statement that it is not necessary to adjust the product L and C in each circuit to be the same and this statement is directly contrary to the observations of practice and to the statements contained in the File Wrapper of the Seibt patent and the "Manual of Radio Telegraphy and Telephony" by Robison and Hooper, 1924 Edition.

He farther states (P. R., p. 1232):

"* * * that beats between the two frequencies set up will assist in the operation of quenching out or preventing the further supply of energy from the local circuit to the antenna at the end of the first beat so that the energy may be radiated from the antenna at the predetermined frequency which is not the frequency of either of the two high-frequency oscillations by means of which the energy is transferred from the lateral circuit to the antenna."

He here refers to the two frequencies as though they were the cause of an effect, viz., the reduction to zero of the oscillations in the primary circuit; whereas, as a matter of fact, they are not the cause of anything in particular but merely mathematical components into which a particular type of wave motion may be analyzed, and they are, therefore, the result of its action, and not its cause.

[fol. 1257] His statement in this quotation relative to the transfer of the energy from one circuit to the other by means of these two frequencies is also incorrect in its inference, since it indicates a transfer resulting from motions of electricity which are not timed to correspond with the natural time-periods of the circuits. As a matter of fact, the actual oscillation, that is, the real physical thing, the actual motion of the electricity in the circuit, is timed to correspond with the natural time-periods of the circuits, and if it were not, the transfer of energy would be inefficient and ineffective.

In his answer to Q. 21 he states that the circuits of the Marconi patent 763,772 must be tuned and that the coupling must be the least possible; and third, that the spark gap must be of such a nature that the oscillations will be long drawn out.

In so far as his statement relative to tuning is concerned, Major Mauborgne is correct and is supported by the state-

ments of the Marconi patent 763,772, but his statements relative to the coupling are nowhere to be found in the Marconi patent, nor is there any limitation placed upon the type of spark-gap which shall be used therewith, of the sort which he makes in this answer.

I have already covered, in my answers to previous questions, the last two points of Major Mauborgne's answer and further explanation seems unnecessary.

Major Mauborgne further states (Printed Record, page 1233):

"If resonance between these two circuits did not exist, in other words, if the energy was transferred at two different frequencies, it would never be radiated at but a single frequency from the antenna."

and this quotation seems to me to be directly contrary to his statements on page 1232 relative to the quenched spark gap, where he says:

"for in this case the energy is transferred from the lateral circuit to the antenna circuit at two frequencies, neither of which corresponds to the wave length emitted by the transmitter."

Q. 201. Will you please refer to the statements of Government officials or to statements in any Government publications, referring to the necessity and advantage of bringing the coupled circuit into tune, resonance or syntony?

A. I have ready, in answer to a previous question, referred to the "Manual of Radio Telegraphy and Telephony by Robison and Hooper" ("Claimant's Exhibit No. 244"), and to the statements on pages 408 and 409. There is also in the "Manual of Wireless Telegraphy (Radio) for the Use of Naval Electricians" of 1913, pages 162, 163 ("Plaintiff's Exhibit No. 78"), and 1915 Edition, pages 163 and 164, the following statements:

"The closed sending circuit should be in resonance with the open circuit and the coupling and decrement of the open circuit such as to afford the necessary selectivity to the receiving circuits with the best efficiency of radiation.

"Receiving circuits to receive from such a sender should be in resonance with each other and with the sending circuits and should have the same coupling as the sending circuits. The telephone diaphragm should be in resonance

with the wave train (alternator) frequency and with the operator's ear.

[fol. 1258] "As was previously stated, instead of designing telephone diaphragms for resonance with alternators, we designed the alternator for resonance with the telephone diaphragm or with the human ear.

"Resonance is thus seen to be a vital quality in wireless telegraph circuits. (1) Resonance of alternator frequency with primary sending circuit. (2) Resonance of primary circuit with secondary sending circuit. (3) Resonance of closed oscillating circuit with open radiating circuit. (4) Resonance of coupled receiving circuits with each other and with coupled sending circuits. (5) Resonance of telephone diaphragm with primary frequency. (6) Resonance of human ear with telephone diaphragm.

"Of these (1), (2) and (5) are elements of design and are not changeable at the will of the operator. (1) and (2) can be varied to a certain extent by reactance regulators which in some sets are provided for both circuits; but it is preferable to cover this feature in the original design of the transformers. (3) and (4) are entirely under the operator's control and on them the efficiency of the set depends."

In "Radio Telegraphy, U. S. Signal Corps," 1914, the Government Printing Office, 1914, pages 66 and 67 ("Plaintiff's Exhibit No. 90"), is found the following statement:

"When the adjustments of a quenched spark transmitter have been correctly made—that is, the circuits are in resonance, the coupling is right, etc.—a simple experiment will show that the primary current is a *minimum;* that is, the spark has been quenched and the primary current has been stopped quickly, as at the point Q of figure 53, and that at the same time the secondary current is a *maximum;* that is, it persists for a long time, as shown in figure 53. The experiment consists in making simultaneous readings of the currents in the primary and secondary oscillating circuits and plotting the readings for the different separations or couplings of the primary and secondary coils. This is shown in figure 57, where the scale at left is in amperes and that at the bottom is the separation of the two coils, the upper curve being for the primary and the lower for the secondary. At the point of correct coupling the primary

current was a minimum and the secondary or antenna current a maximum."

. . . . . .

That the use of a quenched spark-gap does not avoid the desirability or necessity of adjusting the gap circuit into tune or resonant relation with the open circuit is further [fol. 1259] shown at page 105, at the bottom of the same exhibit, under the subject "Tuning of Sending Set":

"The tuning of the closed and open circuits to resonance, and the determination of the correct coupling between them are the two most important adjustments in a quenched spark transmitter."

Similarly in the 1915 edition of the Signal Corps book on Radio Telegraphy, at the bottom of page 107, and in the 1916 edition of the same work, at the middle of page 110, and particularly at the bottom of the page, "Plaintiff's Exhibit No. 92," are found the same statements.

In the Navy Manual, 1924 Edition, pages 529 and 540, is found the following statement:

"In no case should the antenna circuit be detuned—the utility and efficiency of the quenched spark system will be entirely lost."

In the Proceedings of the Institute of Radio Engineers, Volume I, Part III, is an article by Seelig and Van Derwoude on "The Sayville Station of the Atlantic Communication Company." Mr. Van Derwoude was the Engineer of the Telefunken Company, the German Company which built the apparatus installed in Sayville, and Mr. Seelig was the Manager of The Atlantic Communication Company.

On page 30, in speaking of the 30 K.W. transmitter and its two circuits, the article states:

"These two circuits, primary and secondary, must of course be in resonance or nearly so."

This particular station contained the largest quenched gap transmitter, I believe, which was ever built, and carried on communication with the German station at Nauen, which was also equipped with a similar transmitter. I personally inspected and examined this transmitter and observed it in operation and saw adjustments made in its

circuits, which indicated to me that they were in tune. I also saw the similar set in Nauen in operation.

Q. 202. In view of the references to tuning and syntony in your last answer, will you please consider Mr. Loftin's statements regarding the use of the term "perfect tuning" in the Marconi patent in suit No. 763,772, as found near the bottom of page 1018 and the top of page 1019 of the Printed Record, and in the same connection Mr. Loftin's statements on page 1060 of the Printed Record, where he discusses Mr. Waterman's testimony regarding the preciseness or degree of tuning disclosed in the said Marconi patent and please state to what extent you may agree or disagree with Mr. Loftin regarding this matter. In answering this question, will you please indicate the conditions which determine the degree or exactness of tuning in the use of practical radio circuits?

A. The quotation by Mr. Loftin near the bottom of page 1018 of the Printed Record from the Marconi patent 763,772, in the matter of "perfect tuning," seems to be the basis for Mr. Loftin's criticism of Mr. Waterman's statement made near the bottom of page 153 of the Printed Record, and quoted by Mr. Loftin on Printed Record, page 1060, to the effect that no mathematically exact or precise equality of the circuits is realizable in practice.

The particular accuracy of tuning adjustment in the [fol. 1260] practical use of radio circuits is largely a matter of the electrical conditions obtaining in those circuits and Mr. Loftin is incorrect when he states that this adjustment is, of necessity, a very precise one.

Mr. Waterman, on the other hand, is entirely correct when he states, in the quotation referred to, that it is important to the efficient transfer of energy that this equality and (the product of the inductance and capacity of the two circuits) should be approximately or substantially obtained.

When two radio circuits are tuned and coupled together, the tuning condition may be that which is termed "sharp tuning" or it may be that which is termed "broad tuning," depending upon the amount of resistance in the circuit. "Perfect tuning" in the exact mathematical sense, is unattainable in practice, and the use of this term in the patent is, in my opinion, intended to mean the best tuning practically obtainable. Marconi is an extremely practical man,

and it is inconceivable that he should use an expression of this kind in any theoretical or mathematical sense. The exactness with which a circuit can be tuned is dependent upon two things; first, the total amount of resistance in the circuit and, secondly, the wave form of the applied electromotive force. If the circuit resistance is zero and the applied electromotive force is of the simple harmonic form, which I have previously described; that is to say, if it is one frequency in the strict mathematical and technical sense, then the tuning of the circuit will be perfect.

Under these circumstances the ratio of the current flow in the circuit, when tuned to the current flow when detuned the slightest imaginable amount, would be infinite. This, however, is a condition of affairs quite unrealizable in practice, since all electrical circuits have resistance and often quite a large amount of resistance.

If an electrical circuit has a relatively small amount of resistance, it is said to tune "sharply", and this fact is indicated by a large change in the current flow when it is slightly mistuned. If such a circuit contains a relatively large amount of resistance, then it is said to be "broadly" tuned, and this means that the inductance or capacity of the circuit may be changed an appreciable amount from the exact values indicated by theory, with a resulting slight or negligible change in the current flow in the circuits.

Both types of circuits are encountered in practice, consequently the preciseness of tuning required between the tuned coupled circuits of a radio transmitter or receiver is a variable quantity and one which can be stated with definiteness only as the result either of actual tests or calculations based on exact knowledge of all the conditions.

Examples of "sharply tuned" circuits and "broadly tuned" circuits used in practical radio apparatus are found in both the transmitting sets and the receiving sets. If a transmitter is coupled to the antenna of a ship which has the very good earth connection provided by the salt water, the antenna resistance in general will be relatively low, and the circuit tuning fairly "sharp." On the other hand, if the transmitter be coupled to some shore station antennae, relatively high resistance will be encountered, and the tuning will be relatively "broad." Similarly in receiving sets, if a detector is used which inserts a negligible resistance into the circuit and the coils and condenser of

the secondary circuit are well made and have small re- [fol. 1261] sistance, this secondary circuit will be sharply tuned, and this is the case of a modern receiving set with a three-electrode vacuum valve for detector.

If, in such a receiving set, the detector is one which introduces a large resistance into the tuning circuit, the tuning will be relatively "broad" and a considerable departure in adjustment from the exact tuning point is permissible without appreciable loss in effectiveness. Such a detector is the crystal detector, and it is very common to provide the circuits of a receiver or, rather, the secondary circuit of a receiver used with the crystal detector, with relatively rough adjustments, due to the facts just outlined.

Referring now to the statement of Mr. Waterman at the bottom of page 153 of the Printed Record, which statement is quoted by Mr. Loftin on page 1060 of said record, and to Mr. Loftin's criticism of this statement, I will again express the opinion, based on the facts outlined above, and a long experience with them in practice, that Mr. Waterman correctly presents the matter of precision of adjustment of tuned circuits, while Mr. Loftin incorrectly represents it.

Q. 203. In answer to Q. 26 of Defendant's testimony, Mr. Loftin criticises Mr. Waterman's Sketch No. 3 inserted opposite page 155 of the Printed Record. Will you please consider Mr. Loftin's answer on page 1062 of the Printed Record and state in what respects you agree or disagree with him?

A. I disagree with Mr. Loftin's statement relative to Mr. Waterman's Sketch No. 3, opposite page 155. The function of the condenser j^3 in Fig. 2 is to provide a means of connecting the associated battery circuits to the secondary of the receiver circuit in such a way that no interruption is caused to the flow of electrical oscillations around through the circuit g^2, j^2, g^2, h', while at the same time the battery current can flow through g^2, j^2, g^2, coherer T, back to the battery B and the indicating mechanism R. The insertion of the condenser j^3 at the point shown in Fig. 2 permits of this action without the short-circuiting of the battery, while at the same time offering a negligible impedance; this is to say, opposition, to the flow of the oscillating current.

If the value of j^3 is large, then so far as the tuning of the circuit is concerned, it is without effect, and may be considered as the equivalent of a short-circuit. If the

value is small, then it would have some effect on the tuning, but merely the effect of requiring a different value of h' for a particular wave length, a difference of which the operator using the set would not be conscious.

When inserted in the position shown in Waterman Sketch No. 3, condenser j^3 functions in a way similar to that in which it functions in the location shown in Fig. 2 of the Marconi patent 763,772, viz., it permits the introduction of the battery circuit and indicator circuit into the receiver circuit in such a way that the direct current can pass through the detector T and the indicating mechanism R receive the direct-current impulses; that is to say, the rectified oscillations.

As will be noted from diagram, Waterman Sketch No. 3, the battery current starts at battery B, flows through coil C'', detector T, inductance g^2, inductance j^2, inductance g^3, coil C^3, indicator R, arriving back at the battery again. This battery is not short-circuited, due to the insertion of the condenser j^3, so that in this respect it operates in the identical manner in which it operates in Fig. 2.

[fol. 1262] In the location shown in Waterman Sketch No. 3 it is outside of the oscillating circuit g^2, j^2, g^3, h' and, therefore, does not interfere with the flow of the oscillations in this circuit. It cannot, in the position shown in Waterman Sketch No. 3, appreciably affect the tuning; whereas, in the location shown in Fig. 2 of the Marconi patent No. 763,772, it can affect the tuning, but it does not matter the slightest if it does, since the result is one of which only the designer of the arrangement and not the user would be conscious.

The two locations of condenser j^3 are the complete equivalents or alternatives, and it does not matter the slightest, practically, which one is actually used, except that from the standpoint of construction, that of Waterman Sketch No. 3 is more convenient.

Q. 204. Mr. Loftin, in answer to Q. 27, * * * refers to the following United States Patents:

Hutin and LeBlanc, No. 838,545, dated December 18, 1906 (Filed May 9, 1894).

Pupin, No. 519,347, dated May 8, 1894.

Pupin, No. 640,516, dated May 28, 1895.

Stone, No. 638,152, dated November 28, 1899 (Filed December 15, 1896).

Will you please consider these patents, point out what they disclose, and what bearing, if any, they have upon the Marconi four-circuit tuning patent No. 763,772, so far as relates to the combination of elements referred to in the claims in issue, and their mode of operation and results, giving your reasons for any opinion you may express?

A. The patent to Hutin & LeBlanc discloses, as its title indicates, a patent for a system of multiple telegraphy and telephony and has nothing whatever to do with a radio telegraph system.

Fig. 6 of this patent indicates schematically the general idea the inventor had in mind, which was that of affecting a number of different telegraph stations, all connected to the same line, by the employment of different frequencies for the purpose of transmitting and some circuits having inductance and capacity so adjusted as to pick out one of the frequencies from the line. The patent contains some theoretical statements relative to the relation between frequency, current flow and circuit constants, which indicate that the inventor was familiar with the underlying principles of alternating current phenomena which, of course, were well known prior to the date of the application for this patent.

I fail to find any disclosure in this patent which has any bearing on a radio communication system, or any information which would be useful to one working in the radio art, except the scientific principles referred to, a statement of which could be found in any text-book dealing with the subject of alternating currents.

Patents Nos. 519,347 and 640,516, issued to Pupin, are similar in their disclosures to the Hutin & LeBlanc patent, just described, and deal with apparatus for the transmission of electrical variations over line wires.

In patent No. 519,347, Pupin shows how the inductance of a transformer may be neutralized by the use of capacities and telephonic or telegraphic communication may be improved.

In patent No. 640,516 there is disclosed a system involving [fol. 1263] a plurality of transmitters of different frequency and a plurality of receivers connected in circuits, so adjusted as to be in resonance with the line circuit. I fail to find any disclosure in this patent which has any bearing on a radio communication system, or which is in any way related to the Marconi patent 763,772.

The statements contained in the patent relative to resonance are merely the statements of the well-known principle governing the action of alternating currents in circuits having inductance and capacity therein.

Patent No. 638,152, issued to J. S. Stone, is another system of wire communication whose purpose is to permit the simultaneous transmission over a wire line of several signals simultaneously. Resonant circuits are employed at the transmitter and at the receiver for this purpose.

I do not find that there is any disclosure in this wire system or anything which is of consequence in its bearing upon Marconi patent 763,772, nor anything particularly useful to a worker in radio, but merely the employment of some resonant circuits in a wire communication scheme.

Q. 205. Will you please consider Mr. Loftin's statement regarding the Marconi Re-issue patent No. 11,913 and the Marconi patent No. 763,772 and state briefly the differences between the means for tuning shown and described in the Marconi Re-issue patent and that shown in Marconi patent No. 763,772, giving an explanation of the differences in results obtained in each instance.

A. Marconi, in the Re-issue patent, discloses as his only means of tuning one station to the other, the adjustment of the length of the antenna. No independent adjustable units, such as inductance or capacity, are described or illustrated in this patent.

In Marconi patent No. 763,772 means for completely and conveniently tuning both the transmitter and the receiver are described.

Referring to Fig. 1, in the antenna circuit there is a variable inductance g, and in the closed circuit there is a variable condenser c. By the use of these variable elements the open radiating circuit and the closed reservoir circuit are readily brought into accord.

In Fig. 2, the open antenna circuit is provided with a convenient adjustable tuning means, indicated as the variable inductance g', and an additional variable tuning means in the condenser h. In the secondary circuit, the inductance coils g^2 are variable, and enable an operator to readily adjust the time-period of this circuit to accord with the time-period of the antenna circuit. The variable condenser

h' is an additional means in this same circuit and, in general is preferred in practice over the variable inductances g^2 as the means of tuning this circuit.

It appears, therefore, that Marconi patent No. 763,772 discloses the necessary means for readily adjusting each and all of the four circuits to the same time-period.

Mr. Loftin discusses Mr. Waterman's statement and states that Mr. Waterman's views as expressed therein, correspond to his own, to the effect the Marconi patent now under discussion was in no way responsible for the principles of resonance. The statement of Mr. Waterman referred to by Mr. Loftin is as follows:

[fol. 1264] "Thus this idea of resonance between local circuits in the Marconi second or tuning patent is an entirely different thing from the interstation tuning, referred to in the first Marconi patent and the Lodge patent, but it is a means which, while increasing the energy and the distance of signaling, possible with antennae of given dimensions, also improves and facilitates interstation tuning.

"In the first Marconi patent and in the Lodge patent there is one circuit at the transmitting station and one circuit at the receiving station tuned to agree with the transmitter. In the arrangement of the second Marconi patent there are two circuits tuned to resonance with one another at the transmitting station and two circuits tuned to one another at the receiving station, these circuits being also tuned to the wave length emitted by the transmitting station."

I consider the statement made by Mr. Waterman to be a very fair and correct statement of the difference between the Marconi tuning patent, that is, No. 763,772, and the first Marconi patent, that is, the Re-issue patent No. 11,913.

Mr. Loftin's conclusion that the tuning patent was in no way responsible for the principles of resonance seems to me to be entirely inapplicable and without any significance which I am able to understand. A patent could hardly be responsible for the principles of resonance, since these were established by nature. Their discovery and exposition has resulted from the work of scientific men, and these principles are not matters usually disclosed in a patent, or which can be covered by Letters Patent.

He further states, at the top of page 1068 of the Printed Record:

"There appears to be no contention that Mr. Marconi put resonance in radio, but I understand Mr. Waterman's summary to mean that it is merely contended that Mr. Marconi added to existing resonance systems a couple of steps that would work better under resonant conditions."

This is a conclusion which appears to be entirely unjustified by anything which Mr. Waterman has stated and which is most certainly contrary to the facts.

Marconi Re-issue patent No. 11,913 disclosed to the world the first practical radio-communication system, and resonance or tuning is part of this disclosure. Lodge improved on this original disclosure of Marconi by the inclusion of his variably acting inductance coil, and Marconi very greatly improved radio-communication systems by his disclosures of his tuning patent No. 763,772 and made an extended use of the principle of resonance when he tuned four circuits to the same time period.

Mr. Loftin further states that Mr. Waterman has neglected to include in his statement any reference to the matter of coupling, and goes on to say that there can be no resonance unless coupling conditions are specified. This is a statement with which I am in complete disagreement. Resonance between two circuits exists when the time-constant, that is, the product of the inductance and capacity in the two circuits is the same, regardless of what coupling may exist.

Mr. Marconi directs that his circuits should be in reso- [fol. 1265] nance, but he says nothing *in words* about coupling, disclosing, however, in his structures, that coupling may be a widely variable quantity.

In my discussion of the quenched-gap circuit I have referred to a number of references in the File Wrapper relative to the matter of resonance between the circuits of this type of transmitter. In one of these, contained in Paper No. 22, Amendment E, received July 18, 1913, page 22, "Claimant's Exhibit No. 245," is the following statement:

'Applicant puts the two circuits in tune and then determines the best coupling, looking at the needle of an indicating instrument. The tuning depends on the capacity and self-induction and not on the coupling."

This statement, which is in accord with the remarks I have just made, expresses the facts relative to resonance between electrical circuits in the manner which I have always understood them, and which I believe to be the understanding of men in general skilled in this particular art. In fact, I am unable to recollect ever having read or heard the statement that coupling was involved in the matter of resonance between two circuits, prior to reading Mr. Loftin's deposition.

Mr. Loftin states that his view in this respect is in accord with the art, and in particular with Mr. Marconi's own view, as expressed by him in an address before the New York Electrical Society, and from which Mr. Loftin quotes the following:

"These two circuits are tuned so as to have approximately the same natural period of electrical oscillation. They then—like tuning forks—have been adjusted in syntony. It is well known that when using an ordinary spark discharge in the primary circuit, unless weak coupling is employed, the oscillations set up in one circuit create oscillations of two frequencies in both circuits. This has the disadvantage that the radiated energy becomes divided between two waves of different length, and if the receiver is tuned to only one of these wave lengths, it will utilize or absorb only part of the energy reaching the receiver—the energy of the other wave being lost."

* * * * * * *

This quotation does not appear to have any bearing whatsoever on the matter referred to by Mr. Loftin. While it indicates a recognition on the part of Mr. Marconi of the well-known fact that if two circuits are coupled together too closely, a complex wave form will result which is analyzable into two frequencies, it nowhere states that the two circuits depend on any particular value of coupling, in order that they may be in tune.

[fol. 1266] I therefore fail to find in this quotation any support whatever for Mr. Loftin's contention that resonance depends upon coupling.

Mr. Vaill: Counsel for claimant offers in evidence "Proceedings of the Institute of Radio Engineers," pages 23 and 30, referred to by the witness in answer to Q. 201, and

requests that the same be marked "Claimant's Exhibit No. 247."

(Said exhibit marked as requested.)

Q. 206. Please consider "Loftin Sketch M" opposite page 1071 of the Printed Record, and state whether you agree with Mr. Loftin's consideration of the action of the circuits illustrated therein, as concerns Marconi Patent 627,650 ("Defendant's Exhibit B-6").

A. Mr. Loftin's statements relative to "Loftin Sketch M" are quite incorrect and at variance with the disclosures of the Marconi patent No. 627,650.

The coil j' of "Loftin Sketch M" is not shown variable in the Marconi patent, but is shown as a fixed coil. Mr. Loftin further states that the following quotation from page 1072 of the Printed Record:

"The capacity of the condenser on the connection between the imperfect contact and the secondary of the coil should be varied (in order to obtain best effects) if the length of wave is varied."

is a definite instruction to vary the time-period of the secondary circuit of the receiver. Inspection of the diagram shows that condenser K is in series with inductance j^2 and detector T and, due to the perfectly well-known fact that the resistance of detector T is relatively high, a condenser connected in the position shown at K is totally incapable of tuning the receiving circuit and it seems to me incredible that Mr. Loftin should not be aware of this fact.

In order for condenser K to tune with inductance j^2, that terminal of the condenser K which goes to the detector T, should go to one terminal of inductance j^2 through a connecting path which does not contain a high resistance. Totally aside from the question of theory involved, I may say that I have actually set up the circuits shown in "Loftin Sketch M" and can state positively, as the result of practical observations, that condenser K does not tune.

The action referred to in the patent and quoted by Mr. Loftin, is merely the ordinary action of what is known as the "stopping condenser." The purpose of condenser K is to stop the flow of the battery current from Battery B, through the inductance j^2, which would short-circuit the battery and prevent potential being applied to detector T. Oscillating current does not flow through condenser K, but the recti-

fied half cycles of the oscillating current, which are all in one direction.

As the wave length becomes longer, the time consumed by each pulse becomes longer, its rate-of-change slower and, consequently an increase in the value of the condenser K allows these pulses to flow more readily. This change, however, is a slow one; in practical operation is totally unlike that of the adjustment of the tuning condenser and, in fact, for all practical purposes may be omitted entirely, condenser K being fixed in value, since the advantage obtained as the result of any adjustment is so small as to be inconsequential.

I have no hesitation, therefore, in stating positively that [fol. 1267] Marconi patent No. 627,650 does not disclose tuning in the secondary circuit, and does not disclose any means for tuning the secondary circuit.

The statement of the patent itself (Page 1, lines 31 to 37):

"It is desirable that the induction-coil should be in tune or syntony with the electrical oscillation transmitted, the most appropriate number of turns and most appropriate thickness of wire varying with the length of wave the oscillation transmitted."

is perfectly clear in this respect, and indicates that, in accordance with the knowledge of the art at that time the antenna system should be in tune with the incoming waves. Had Marconi had the slightest thought at this time of tuning the secondary circuit, he would unquestionably, in my opinion, have stated in his usual explicit manner, that such was his intent and, furthermore, in accordance with his practice of giving detailed instructions in the matter of actual structure, would have specified the necessary coil and condenser arrangement for the carrying out of his purpose.

There is, however, no information of this nature to be found anywhere in this patent, and I recollect that in some of Mr. Marconi's testimony he has positively stated that the idea of tuning had not yet occurred to him. On Printed Record, pages 557 and 558, where the testimony of Mr. Marconi was stipulated into this case, occurs the following:

"Q. In your patent 627,650, you say, at page 1, line 32:

"'It is desirable that the induction-coil should be in tune or syntony with the electrical oscillation transmitted.'

Notice the words 'the induction-coil in tune or syntony.' What does that mean, except that the two members of the induction have the same time period?

"A. It does not mean that there, at least I do not think it does, because I didn't know it at the time that this specification was filed.

"Q. What is that date?

"A. That date was the 5th of January, 1899.

"Q. In 1899 you didn't know it?

"A. I didn't know that it was necessary to tune the two circuits of the receiver or transmitter in order to attain those effects."

Q. 207. Will you please refer to Marconi patent No. 647,007 ("Defendant's Exhibit C-6"), Marconi Patent No. 647,008 ("Defendant's Exhibit D-6"); Marconi Patent No. 647,009 ("Defendant's Exhibit E-6") and Marconi Patent No. 668,315 ("Defendant's Exhibit F-6"), briefly stating what they refer to in the radio art and also whether they disclose, either in the specifications, or drawings, the requirement that open and closed circuits of a transmitter or receiver are intended to be tuned so as to be in resonance with each other, giving your reasons for your opinion?

A. Marconi patents referred to in your question all refer to particular kinds of coil construction usable in the circuits of the prior Marconi patents.

Patent No. 647,007 refers, lines 15 to 25, page 1, to the fact that the coils of the previous patent, 627,650, consisted of single layers, while those of the patent under discussion consist of a plurality of layers and sections wound in a particular way.

[fol. 1268] A diagram of connections for employing these coils is shown in Fig. 1.

Patent No. 647,008 is also directed to a coil of multiple layer construction and the connection of the end of the secondary coil which is farthest away from the nucleus or axial line of the coil, direct to the sensitive tube and not through a condenser.

Patent No. 647,009 is also directed to a particular type of coil construction and a direct connection to the sensitive device.

Patent No. 668,315 discloses a method of connection of the battery and indicating mechanism to the secondary coils and detector, which involves splitting the secondary

coil in the centre, inserting a condenser therein and attaching the battery circuit to the two sides of the condenser; this is the method of connections employed in Fig. 2 of the tuning patent 763,772.

All of the patents above mentioned are merely for coil constructions and details of connection, and they do not, in any way, disclose anything in the matter of tuning between the closed circuits and the open circuits.

Q. 208. Please consider the Lodge patent No. 609,154 and state what, if any, bearing it has upon the invention of the Marconi four-circuit tuning patent No. 763,772, particularly as concerns Figs. 4 and 13 of the drawings and Mr. Loftin's "Sketch L" (opposite page 1069 of the Printed Record), pointing out to what extent you may agree or disagree with Mr. Loftin in his statements regarding the disclosure of said Lodge patent with reference to the claims of Marconi patent No. 763,772, giving your reasons for your answers.

A. Mr. Loftin, in his "Sketch L," in drawing the circuits for Fig. 4 of the transmitter, has omitted the spark-gap in the antenna circuit shown in Fig. 4. He described the action of this Fig. 4 of the Lodge patent in language taken from the patent itself, and which is descriptive of Lodge's idea of charging the antenna circuit by what he terms "impulsive rush."

This idea of Lodge's was a very beautiful conception but, unfortunately, the apparatus disclosed in Fig. 4 is incapable of functioning in this manner, a fact which is readily evident to one skilled in the art from a simple inspection of the circuits and spark-gaps employed. In order to carry out this thought in any manner whatsoever, the spark-gaps h^6 and h^7 of the patent would have to cool so rapidly that they would be extinguished after the first half oscillation of the condenser circuit. No spark-gaps have ever been constructed and used commercially which are capable of cooling with this degree of rapidity. If, in Fig. 4, the coil k is constructed in accordance with any information to be found either in the specification or the drawing, Fig. 4 is totally inoperative, for the reason that the coil k short-circuits the condensers, so that any oscillations taking place in the circuit containing the condensers are unable to get into the antenna.

If the coil k is omitted the figure will operate, but in a way which is anything but the manner described by Lodge. In the first place, it is inefficient and less effective than

the original Re-issue Marconi patent No. 11,913, and in the second place, instead of omitting a single pure wave train, it gives rise to a complex wave train analyzable into two rather widely-separated frequencies. In the light of these facts I consider that Fig. 4 of the Lodge patent has not disclosed anything in the way of a transmitter capable [fol. 1269] of rapidly transferring energy from a closed circuit to an open circuit, and allowing the open circuit to oscillate in its own free way.

I find no basis whatever, for instance, for Mr. Loftin's contention that this figure discloses the principle of the quenched gap system.

In Mr. Loftin's "Sketch L, Lodge Receiver" taken from Fig. 13 of the patent, he shows a condenser *w* in parallel with the telephone and contends that this is a means for tuning and that its inclusion by Lodge is a direction to tune this circuit. Nothing that I can think of could be further from the facts disclosed by the Lodge patent. In the first place, this condenser is so connected in the circuit that it is in series with the detector and the inductance and, as was the case in "Loftin Sketch M" of Marconi patent 627,650, a condenser when so located is incapable of tuning the circuit.

In commenting upon this condenser, Mr. Loftin quotes, lines 62 to 68, page 4 of the patent as follows:

"In all cases it is permissible and sometimes desirable to shunt the coils of the telegraphic instrument by means of a resistance or a capacity, as shown at *w* in Figure 12, in order to connect the coherer more effectively and closely to the capacity areas or receiving arrangement whereby it is to be stimulated."

and it is to be noted that the quotation states that either a resistance or a capacity may be used for the purpose of shunting the telegraphic instrument.

Now, it is a matter of elementary knowledge that electrical circuits may be tuned by an inductance or a capacity; whereas resistance not only is incapable of effecting any tuning action, but is actually detrimental in circuits which are tuned, and is excluded in practice as much as possible. It is therefore inconceivable to me that so able a scientist as Lodge could have been thinking of tuning, and in the same breath specify capacity or resistance as alternative means for accomplishing the purpose.

It is further perfectly obvious from the specification of the Lodge patent and the invention disclosed therein of the variable inductance, that if Lodge had had any thought of tuning his secondary circuit he would have described carefully and in detail the way to do it, and the purpose for doing it, which he did not.

Q. 209. Has the transmitter illustrated in Fig. 4 of the Lodge patent No. 609,154 and described in the specification thereof, ever been practically used by the claimant herein or, as far as your knowledge and experience goes, by the British Marconi Company, or anyone else? If not, please state, according to your understanding and knowledge of the matter, the reasons why the Lodge transmitter of Fig. 4 has not been used practically. In answering this question you may refer to any tests that have come within your knowledge as indicating the action of transmitters similar to those of the Lodge patent.

A. No practical use of the Lodge Fig. 4 of sufficient consequence to come within my notice has ever been made, and there are perfectly good technical reasons which have been brought out in tests of the Lodge Fig. 4 with which I am personally familiar, why it has not.

During the Kilbourne & Clark case the apparatus of Fig. [fol. 1270] 4 of the Lodge patent was set up and operated by the Expert for the defense, Mr. Pickard, and practically all of the facts of operation were brought to light. I personally witnessed a large number of tests on this apparatus, some of which were made at my suggestion. As set up by Mr. Pickard, the coil *k* was constructed with an iron core, a construction nowhere disclosed in the patent and quite contrary to the usual practice when coils are used for the purpose of carrying high-frequency currents. On substituting for this coil one made as nearly as possible like the disclosure of the patent, the device was found to be entirely inoperative. Following this, various other coils *k* were constructed, having different values of inductance, and their effect on the operation of the set observed. It was found, on making measurements of the current in the antenna that the wave length radiated was not, as should have been the case, if the device were operating in accordance with Lodge's "impulsive rush" idea, a pure wave but, on the contrary, the wave form was found to be a complex one and indicated two wave lengths in the antenna

circuit, which wave lengths varied with the construction used in the coil k.

These observations were of fundamental importance and significance, since if the circuit were operating as described by Lodge, in the "impulsive rush" fashion, not only would there be a single frequency in the antenna, but the coil k or any other electrical element in the charging circuit could not have any effect on the wave length, since, under Lodge's idea of things, the charging circuit would be cut off, while the antenna was oscillating in its own natural way. The fact that it did not do so, that the wave form was complicated and that the change of coil k changed this wave form, is conclusive proof, technically, that the device was not operating on the basis of "impulsive rush" charging, and no more conclusive technical proof of this fact could possibly be obtained.

A most interesting point in connection with the tests on this apparatus was the fact brought out in the first test demonstrated by Mr. Pickard, in which wave lengths of 324 meters and 1,010 meters were radiated. I remember being curious at the time as to just where these widely-separated wave lengths were coming from, and I noted that the 324-meter wave length was much the stronger. In a subsequent test I found that the coils h^4, h^4 of the patent which, under the Lodge theory of operation, should be controlling in the wave length produced could be disconnected entirely from the circuit and a wave length of 324 meters, viz., the principal one when two are being radiated, was still being radiated, showing that it was the wave length of the antenna circuit down through condensers j and the coil k to ground; a most astonishing discovery relative to the operation of a device supposed to be radiating in accordance with the natural mode of vibration of the antenna system when taken alone.

Additional interesting facts were noted relative to the operation of the spark-gaps h^6 and h^7. If there is anything whatsoever in the Lodge idea of "impulsive rush" charging, it is that spark-gaps h^6 and h^7, after throwing the energy into the antenna system, immediately open up and allow the antenna to oscillate in its own free way. This is what Lodge believed that they were doing, and this is the action which he ascribes to them in his patent, but in the tests above referred to on the actual apparatus [fol. 1271] shown and described in Fig. 4 of the Lodge

patent, the spark-gaps h^6 and h^7 could be closed up; that is to say, so adjusted that no spark-gap existed any longer but a metal-to-metal contact, without any appreciable change in the action of the system.

There is no more conclusive test possible than this test as to whether or not the spark gaps h^6, h^7 are serving any useful purpose; that is, are enabling energy to be transferred in an impulsive rush to the antenna system, and the results of the tests show, beyond a shadow of doubt, that the apparatus of Lodge Fig. 4, as arranged by Mr. Pickard, and with some alternative modification, did not function in the way which Lodge thought it did; that is, on the basis of transferring energy with an impulsive rush to the antenna system.

Still further light was thrown on the action of these circuits by a comparison with the simple arrangement of the Re-issue patent No. 11,913 to Marconi, using the same induction coil to supply the power, and the comparison shows that the original Marconi arrangement was materially more efficient. This, again, is most pertinent to the question of "impulse charging" since, were the latter actually taking place in the Lodge Fig. 4, the efficiency of the arrangement should be materially greater than that of the simple Marconi arrangement. Actually, however, it was less; when, in a modern quenched spark-gap transmitter we actually succeed in transferring energy relatively rapidly from the closed circuit to the open circuit, this increase in efficiency is one of the important results, although this method is still a long way from the "impalsive rush" idea, but not accomplishment, of Lodge.

Summing up my knowledge and experience gained from actual tests of apparatus arranged as in Lodge Fig. 4, together with my study of the theory of operation involved, I may state that this arrangement is entirely useless, is about one-half as efficient as the original re-issue arrangement of Marconi, and does not operate on the basis of "impulsive rush."

* * * * * * *

As I have already pointed out in my discussion of the question of "impulsive rush" charging or, as it is sometimes termed, "impulse charging," no system embodying this idea has ever been developed which has been appreciably successful in finding extensive commercial use.

Laboratory experiments, however, have been conducted in order to determine the nature of the actions involved when true impulse excitation was secured.

A report of an experimental investigation of this subject is found in the "Proceedings of the Institute of Radio [fol. 1272] Engineers," Volume 8, 1920, page 75. A paper by John H. Morecroft, Associate Professor of Electrical Engineering at Columbia University, gives, in Fig. 1, an arrangement of electrical circuits adapted for the production of an electrical impulse and an oscillating circuit excited by the impulse. As is stated in the paper, an oscillograph is connected to that part of the circuit which produces the impulse, and another one to that part of the circuit in which the resulting oscillation takes place. The oscillograph is a device which is capable of giving a picture in the form of curves of the actual motion of electricity in a circuit.

In Fig. 1 is a battery B, switch S, a resistance R, and a second resistance not lettered, but shown between two wires *a*, *b*. When the switch S is closed, current flows through the circuit mentioned and an electromotive force is produced across the terminals of the two resistances. The electromotive force induced at the point *a*, *b* operates the oscillograph, while the electromotive force produced across resistance R, charges the condenser C which, when it discharges through the circuit C, R, L, R', gives rise to an oscillatory current, due to the presence in this circuit of the inductance L.

Across the terminals of resistance R' is connected a second oscillograph to the wires *c*, *d*, which gives a picture of the electrical motion in this circuit. The switch S is so contructed mechanically as to be able to make a contact lasting between two one-thousandths of a second and any longer time desired.

Various oscillograms are shown in the paper, which illustrate in a very clear and fundamental way, what takes place under conditions of "impulse charging." In Fig. 2 • • • (part of Claimant's Ex. 248) will be seen two curves, the upper one representing the "pulse" which, as will be noted, rises almost perpendicularly, has a slight curve at the top, and falls in the same practically instantaneous manner.

The lower curve represents the oscillations taking place in the oscillating circuit and shows an oscillation which starts with a maximum amplitude and decreases to zero.

As will be seen, there is a marked contrast between this curve and the curves representative of the action in quenched spark-gaps such, for instance, as shown in the "Manual of Radio Telegraphy and Telephony" by Robison and Hooper, 1924, page 408, Figs. 272 and 273 ("Claimant's Exhibit No. 244").

In Fig. 272, representative of the action in the exciting circuit, it will be noted that there are a number of complete oscillations, a number which, as a matter of fact, is considerably less than usually exists in practice. This is in contrast to the single pulse of the upper curve of Fig. 2 of Morecroft's paper.

In Fig. 273, "Claimant's Exhibit No. 244," the secondary oscillations are seen to increase in value up to the point where the primary oscillations cease entirely, while in Fig. 2 of the Morecroft paper the oscillation rises to maximum value at the start, and falls off thereafter.

In Fig. 3 of the Morecroft paper a pulse is shown in the upper figure, which occupies a longer time than that of Fig. 2, and this is indicated by the fact that the distance between the two vertical sides of the pulse is longer.

Under these circumstances the second oscillation is slightly greater than the first, and Mr. Morecroft has, in [fol. 1273] Figs. 3 and 4 (part of Claimant's Ex. 248), page 77, plotted two curves, one of which shows the variation of the first swing in the oscillating circuit with the duration of the pulse, while the other curve shows the variation of the second swing with the duration of the pulse. These curves bring out the fact that the amplitude of the first swing or alternation does not change after the pulse has a length equal to one-quarter of a cycle, while the amplitude of the second one is a maximum when the pulse length is equal to one-half the natural period of the oscillating circuit, after which time it decreases in amplitude.

The effect of the variation in the length of the pulse is due to the following: If we examine the curve illustrative of the pulse in any of these figures, we find that the rise and fall are very nearly vertical, while the top is either slightly curved, as in the short ones, or nearly flat in the longer ones. The effect produced by the pulse on the oscillating circuit takes place during this rapid rise and rapid fall, while *while* nothing at all happens during the period represented by the flat part of the curve.

When the rise takes place in the curve illustrative of the pulse the action in the oscillating circuit starts; that it to say, the oscillating circuit is given a "kick" which can be represented by the mechanical analogue of striking a pendulum bob with a hammer. When the pulse falls again, it gives another "kick", which will either assist or retard the current flowing in the oscillatory circuit, depending on whether or not it occurs when the electricity in the circuit is moving in the same direction as the "kick".

Fig. 3 of the Morecroft paper illustrates the case when the impulse, due to the falling of the pulse, occurs at the right time to help the oscillations in the oscillating circuit, thereby making the second alternation greater in amplitude than the first.

In Fig. 5 (part of Claimant's Ex. 248) a case is shown in which the impulse occurs at the wrong time, catches the second alternation before it is complete, turns it around, and makes it start all over again, thus destroying, instead of assisting, the motion.

Each "pulse" in these figures is in reality two pulses, one represented by the rise and the other represented by the fall. The reason that this particular situation exists lies in the fact that it is extremely difficult, if not impossible experimentally, to produce a single pulse which would be represented by a single vertical line in the oscillogram.

It can be deduced, however, with absolute certainty from the experiments recorded in this paper of Morecroft's that if a single ideal pulse could be produced, the resultant train of oscillations in the oscillating circuit would always start at a maximum and slowly fall off.

No action such as is shown and described in this Morecroft paper is obtainable with the Lodge Fig. 4 arrangement and no apparatus is disclosed which is capable of being used in any way to produce such results as these. Furthermore, as is very evident from a mere inspection of the curve such as those of "Claimant's Exhibit No. 244", the quenched spark gap arrangement does not function on the basis of impulse excitation, but requires the transfer of energy from the closed circuit to the open circuit during a period which is very long compared to that of impulse excitation, involves several oscillations in the primary circuit and a resonant relation between the circuits.

[fol. 1274] The Lodge Fig. 4 circuit not only does not employ the impulse method of excitation, but also does not

employ the tuned coupled-circuit method of energy transfer. It was intended for the purpose of impulse excitation, but possessing none of the requirements of this method, it falls into the category of unsuccessful and misconceived experiment, unless for any purpose other than an instruction as to what not to do in a radio transmitter.

Mr. Vaill: Counsel for claimant offers in evidence a printed copy of the article entitled "An Experiment on Impulse Excitation" by John H. Morecroft from the "Proceedings of the Institute of Radio Engineers", Volume 8, 1920, Issue No. 1 (February), pages 75 to 84, inclusive, and requests that the same be marked "Claimant's Exhibit No. 248".

(Said exhibit marked as requested.)

Q. 210. Referring further to your answer to Q. 208, in which you considered Figs. 12 and 13 of Lodge patent No. 609,154 and "Loftin Sketch L", will you please refer to any additional information you may have indicating what Lodge may have had in mind in referring to the resistance "*w*" of Fig. 12?

A. In a work entitled "Signaling Through Space without Wires" by Oliver Lodge, 3rd Edition, Mr. Lodge described some of the arrangements of his patent No. 609,154, and on page 52 (Claimant's Ex. 249), Fig. 25, he illustrates Fig. 13 of his British patent (Fig. 12 of the United States patent). Beneath the drawing of Fig. 13 is the following statement:

"* * * Diagram of connections for Syntonic Receiver; *r* being coherer and *w* a non-inductive conducting or capacity shunt, to eliminate the self-induction of the receiving instrument."

It will be noted that he specifies that the element *w* is "a non-inductive or capacity shunt" for the purpose of eliminating the self-inductance of the receiving instrument. This is a perfectly clear statement of the purpose of the condenser *w* which Mr. Loftin has chosen to consider in his sketch "Loftin Sketch L" as a tuning element, and a perfectly clear showing of the fact that Lodge had no intention of using it for tuning.

The statement of the purpose of this element is further supported by the diagram, wherein Lodge illustrates the element *w* as a resistance. Resistance is an electrical

quantity which makes it entirely suitable for the purpose illustrated in the drawing and described in the explanation underneath it, viz., the purpose of eliminating the self-inductance of the indicating instrument by providing an alternative path.

While resistance is capable of functioning for the purpose described, it is totally incapable of performing a tuning action; that is to say, you cannot tune an electrical circuit by means of resistance.

Since Lodge, in describing this figure of his patent, has clearly stated that the use of the element *w* was for the purpose of providing a shunt, and since in illustrating his descriptive language by means of a drawing of circuits, he has given to this element *w* a form, viz., that of "resistance", which is totally incapable of acting as a tuning agent, there seems to be only one logical conclusion which can be [fol. 1275] arrived at in the matter of Lodge's thought at this time, and that is, that he had no idea whatsoever of tuning the indicating circuit of Figs. 12 or 13 of his patent 609,154.

Q. 211. Referring to Mr. Loftin's testimony, beginning on page 1073 of the Printed Record, will you please discuss the so-called "Tesla transmitter and receiver" of the Tesla patents Nos. 645,576 and 649,621 ("Defendant's Exhibits X 2 and L-6" respectively), pointing out what bearing they may have, if any, on the claims at issue of Marconi patent No. 763,772, giving your reasons for any differences of opinion you may have over Mr. Loftin's statements?

A. I have read Mr. Loftin's statements relative to the Tesla patents referred to in your question and I am unable to find in either of them either a disclosure of a wireless system, or of an arrangement capable of functioning in this manner. While Mr. Loftin, in the middle of Printed Record page 1074, states that the fact that Tesla's theory was different from Marconi's is not of consequence, since authorities in this are still groping and guessing as to the real manner of transfer, I am of the opinion that the expression of a theory by an inventor, in this case Tesla, is of the utmost importance in indicating the results sought after and the purpose of the invention.

I also take exception to Mr. Loftin's statement that the art is still "guessing" as to the manner of the transfer,

for I am satisfied that this is an action which takes place through the medium of Hertzian waves. This is the "means" which has been accepted by practically the entire radio art up to the present day and is the means described by all writers on the subject of radio-communication.

Tesla was not unaware of this phenomena; on the contrary, on page 2, lines 73 to 82, he specifically takes note of its existence and specifically disclaims it in the following words:

"It is to be noted that the phenomenon here involved in the transmission of electrical energy is one of true conduction and is not to be confounded with the phenomena of electrical radiation which have heretofore been observed and which from the very nature and mode of propagation would render practically impossible the transmission of any appreciable amount of energy to such distances as are of practical importance."

The significance of this expression, to my mind, is that Tesla, having the conduction theory of operation in mind, and not the radiation theory, proceeds quite naturally to construct apparatus which, as he believes, will work along the lines of his theoretical speculation. *Conduction*, and not *radiation* is Tesla's guide, and he proceeds to follow it, in spite of the absurdities into which it leads him. He knows that gases will conduct when sufficiently rarefied, and he knows that the upper atmosphere is conducting; therefore he proposes to stick up in the air conductors 35,000 or more feet long and the fact that there is no known way of supporting such a conductor, does not worry him in the slightest. Practically, however, it means that the Tesla apparatus never functioned in the manner and for the purpose described by the inventor, and the nearest he comes to a reduction to practice, that is, actual operation, is to conect his arrangements to either end of a vacuum tube some fifty feet long,—interesting as a laboratory experiment,—but without any practical usefulness that I am aware of.

[fol. 1276] Mr. Loftin, of course, contends that the Tesla apparatus, regardless of what Tesla himself was trying to do with it, could be used for purposes of radio-communication, but a little detailed consideration of just what the apparatus is, rather quickly dispels any illusions as to its usefulness for a radio-communication system.

In both patent Nos. 645,576 and 649,621 are shown a transmitter and a receiver for the Tesla system. The figure at the left represents the transmitter and consists of an elevater conducting systtem D, B, a transformer A, C', of which A is the secondary and C' the primary, and an earth connection. The primary C' is connected to G, which is a source of electrical oscillations.

In order that a wireless transmitter can function it must have first, a source of electrical oscillations secondly, an antenna system which will permit of the flow of these oscillations and, thirdly, some method of breaking up the electrical oscillations into a code since, without this, the mere radiation of electrical energy into space would accomplish nothing in the matter of transferring intelligence. This latter arrangement is, in the usual wireless system, the operator's key, and while vital to the operation of a radio transmitter, is nowhere disclosed or indicated in either of the two Tesla patents referred to.

The next point to consider in the Tesla patents is the question of whether or not Tesla describes a mechanism of such a nature as to produce high-frequency oscillations and an antenna system of such a nature that these oscillations of the desired frequency can be effectively developed therein.

The patent specifications indicate that the Tesla transmitter has means for generating high-frequency oscillations, which, existing in coil C', act inductively on the secondary A, and produce at the terminals of the coil a very high voltage. This was the primary object of this arrangement of Tesla's, as indicated by lines 85 to 87, page 3, of patent 645,576:

"As the main requirement for carrying out my invention is to produce currents of an excessively high potential",

and in order to accomplish this purpose Tesla gives instructions to make the coil in a particular way, which is contained in the following quotation (lines 58 to 73, inclusive, of page 3):

"The length of the thin-wire coil in each transformer should be approximately one-quarter of the wave length of the electric disturbance in the circuit, this estimate being based on the velocity of propagation of the disturbance through the coil itself and the circuit with which it is

designed to be used. By the way of illustration, if the rate at which the current traverses the circuit, including the coil, be one hundred and eighty-five thousand miles per second then a frequency of nine hundred and twenty-five per second would maintain nine hundred and twenty-five stationary waves in a circuit one hundred and eighty-five thousand miles long and each wave would be two hundred miles in length."

Having constructed the coil in this particular fashion, he next describes the purpose of this construction (lines 78 to 85, inclusive, page 3 of patent 645,576), in the following words:

[fol. 1277] "By such an adjustment or proportioning of the length of wire in the secondary coil or coils the points of highest potential are made to coincide with the elevated terminals D D', and it should be understood that whatever length be given to the wires this condition should be complied with in order to attain the best results."

As will be seen from this description, Tesla proposes to make the secondary of his transformer equal in length to one quarter of the wave length of the oscillations impressed upon it, and to attach to one terminal of the coil an elevated conductor, the coil to be the same, regardless of the length of the antenna. It is at this point that the Telsa transmitter fails completely.

As has been shown by Marconi and confirmed by many years of practical use in order to develop oscillations of a desired frequency in an antenna system, it is necessary that the electrical period of the antenna system, as a whole, should be in tune or have a natural period corresponding to the natural period of the local circuit.

Tesla, however, adjusts the natural period of his secondary coil alone and then directs the attachment to the high potential point of an antenna of any length. When he does this he at once completely upsets the resonant condition of his secondary coil, since the attachment on the antenna adds to the coil a capacity which, in the case of a 35,000-fot wire, would be relatively great and which, even in the case of a wire a few hundred feet long, would be sufficient to absolutely throw the secondary coil out of tune. As a result of this action a high potential would no longer be developed at one terminal of the coil and the resulting flow

of current in the antenna would be negligible, even though very great power were used.

Another way of stating this is to say that Tesla did not choose his secondary coil of such size and his antenna of such size that the prod-uct of the inductance and capacity would be the same as in the closed circuit. It seems to me to be rather easy to understand why Tesla missed this all-essential point. He had been using his arrangement with a 50 foot vacuum tube in the laboratory and the attachment of this tube to his secondary coil would produce no disturbance to the electrical conditions therein, since the capacity of the attachment would be negligible. He did not actually test his arrangement with an antenna of the kind described in this patent, because he couldn't build it. Consequently, he had had no practical experience of the sort which would have made evident to him the fact that the attachment of the antenna at once changed the electrical conditions of his secondary.

A transmitter constructed in the manner shown and described by Tesla would, for the reasons just given, be totally worthless as a radio transmitter; or, for that matter, for any other purpose.

In both of the patents under discussion a receiving system is shown, which is totally inoperative for the purposes of a radio receiving system, and which does not involve the mechanism necessary for such a system. In the first place, instead of the sensitive detector and indicating devices which are always necessary in a radio receiver, there are shown some lamps and motors which were expected to receive power through the air from a distant transmitter to operate them. These, of course, are incapable of acting as indicators of the presence of Hertzian [fol. 1278] waves, or of converting Hertzian waves into anything affecting the senses in a manner useful for a communication system.

Tesla again, in the receiver, employs a coil construction of the sort which he employs at the transmitter and which is a quarter wave length long, and to which he attaches the antenna, without regard to the length of the antenna and the effect which its attachment to the coil would have upon its electrical condition.

Actually, however, the attachment to this antenna would entirely change the electrical condition of the coil and would result in an antenna system which, as a whole, would be very

widely out of tune with the incoming oscillations, assuming there were such, and would be entirely useless in a practical radio system.

The receiving arrangement shown in the Tesla patents, for the reasons above outlined, does not disclose the necessary mechanism for a radio receiver and the arrangement is incapable of functioning in any useful manner in a radio system.

Since the Tesla patents fail to disclose either a transmitter or a radio receiver, it follows as a matter of course that they do not disclose a complete radio system.

Mr. Loftin, in attempting to make use of the Tesla patents, as a reference against the Marconi tuning patent, makes certain comments which are easily answered on the basis of the facts just brought out. He quotes as one of the objects of the patent:

"to transmit intelligible messages to great distances." (P. R., p. 1073.)

as indicating that Tesla contemplated a communication system, as well as a system for the transmission of electrical energy.

In view of Tesla's disclaimer of the only possible fundamental basis upon which such a system could operate, viz., Hertzian waves, and his complete failure to disclose an operative arrangement either on his own, or any other basis, it does not appear to me that he is entitled to any credit for having accomplished or taught anything useful as the result of this short quotation.

Mr. Loftin further discusses the question of the height of the antenna systems and introduces the following quotation from Tesla patent 645,576 beginning at the bottom of Printed Record page 1073:

"In some cases when small amounts of energy are required the high elevation of the terminals, and more particularly of the receiving-terminal D', may not be necessary, since, especially when the frequency of the currents is very high, a sufficient amount of energy may be collected at that terminal by electrostatic induction from the upper air strata, which are rendered conducting by the active terminal of the transmitter or through which the currents from the same are conveyed."

This statement is entirely vague and completely fails to indicate what Tesla meant in so far as any definite height of conductor is concerned. Since the whole idea of his arrangement depends upon getting his conductors up into the upper atmosphere, where, due to reduction of pressure, the air is conducting, it is impossible to interpret this quotation to mean, so far as the transmitter at least, is [fol. 1279] concerned, that the elevated wire should be any shorter than is necessary to reach this upper strata.

I might also point out that even if the elevater conductors were very much shorter than required by this condition, their attachment to the coils of the Tesla arrangement would result in an antenna system hopelessly out of tune.

Mr. Loftin further quotes, page 4, commencing line 27 of patent to Tesla, 645,576 (P. R., p. 1075):

"The primary and secondary circuits in the transmitting apparatus being carefully synchronized, an electromotive force from two to four million volts and more was obtainable at the terminals of the secondary coil A."

and states that this is an instruction to tune the primary and secondary circuits together. He omits to point out, however, that this quotation is part of Tesla's description of the only actual use he ever made of his arrangement, viz., to connect it up to a 50-foot vacuum tube and that there is, therefore, no antenna attached to it.

When Tesla did connect an antenna to it, not actually, of course, but in the drawings of his patents, he did not know or appreciate the fact that the resulting arrangement would be completely de-tuned.

* * * * * * *

In connection with my statements above relative to the action of a Tesla coil when attached to an antenna, I am reminded of some actual tests illustrative of what I have just said, which I witnessed some years ago.

During the course of the trial of the suit against the Kilbourne & Clark Manufacturing Company at Seattle, Washington, Mr. G. W. Pickard, defendant's Expert in that case, conducted a demonstation of what purported to be an arrangement of the Tesla patent 645,576, in so far as the transformer A, C of this patent was concerned. The secondary coil was supposed to be constructed in accordance with the directions on page 4, lines 3 to 7 of said patent, and to have a total length of wire of some 300 meters, the length

of wire being determined by Tesla's instruction found on page 3, lines 58 to 64 of said patent:

"The length of the thin-wire coil in each transformer should be approximately one-quarter of the wave length of the electric disturbance in the circuit, this estimate being based on the velocity of propagation of the disturbance through the coil itself and the circuit with which it is designed to be used."

the disturbance in the closed circuit in this case being 1200 meters.

[fol. 1280] As demonstrated, while the coil had fifty turns, the total length of wire was only 200 meters, so that the coil was short 100 meters of the amount specified by Telsa.

When demonstrated by Mr. Pickard, only five and a quarter turns of this coil were actually employed, the other forty-four and three-quarters not being used at all. The antenna employed was a small antenna of about the dimensions of a ship's antenna.

Tesla's instructions contained in the patent, and already quoted, are very specific to the effect that the elevated conductor should be connected to one terminal of the coil and the earth to the other terminal; an instruction which, if carried out in actual practice, results in a completely inoperative system.

The fact that in the tests just referred to only five and one-quarter turns could be employed, while the remaining turns were left idle, shows how very far out of tune any aerial system would be if constructed in accordance with Tesla's instructions.

In the ordinary operation of a radio transmitter one or two turns of the inductance coil, usually employed, is sufficient to seriously detune the aerial system. Consequently since in the case of the test referred to the aerial system was in tune when five and one-quarter turns were included in the circuit, it follows that if the entire secondary coil had been included, the antenna system would have been so far out of tune as to be utterly useless.

Mr. Loftin's statement on Printed Record page 1076:

"Adjusting the length of wire to one-quarter of a wave length, as set forth in the first part of the quotation, is a very common rough or thumb rule used among practical radio workers for obtaining approximate resonance in wire conductors. When the result mentioned in the last part of

the quotation is obtained; that is, when the highest potential exists at the elevated terminal resonance is actually obtained, and Tesla points out that this is the final test irrespective of the thumb rule as to length of wire, and points out that 'best results' are obtained when this adjustment is attained; that is, that there is resonance between the elevated conductor circuit and the primary oscillating circuit feeding energy into the elevated conductor circuit."

is correct in so far as resonance between the primary circuit and the secondary coil is concerned; that is to say, Tesla directed the construction of a coil whose own natural period corresponded to that of the closed circuit. This is a possible construction due to the fact that a coil of wire has not only inductance, but a capacity; consequently it can have a particular natural period.

Mr. Loftin's statement in the concluding part of the quotation, that there is resonance between the closed circuit and the open *circuit* is entirely incorrect for reasons which have been discussed at length in this answer.

It may be of interest in connection with Tesla's work, to point out certain facts in his experience and their bearing on his attempt to construct a system for the transmission of electrical energy through the upper atmosphere. Tesla was primarily a power engineer and his work in the development of the polyphase electric motor was of very [fol. 1281] great importance, but in the carrying out of this type of work his mind naturally fell into a particular channel, dominated by this experience.

When he undertook the work in connection with high-frequency oscillations it is evident that he was inspired by the idea of carrying power to a distance without wires, but this inspiration led him into a field in which he was no longer master of the technique involved. This sort of thing is a matter of common observation to engineers of long experience, and it is a well-known fact that no matter how thoroughly trained and experienced an engineer may be in some particular field, when he steps into a new field it requires a long period of time to become familiar with the technique involved.

It has been my custom in the past, when employing radio engineers who were experienced in other branches of electrical work, to expect that a period of at least five years

in radio work would be required before they would be really good radio engineers.

Tesla's work, which was of real consequence, is referred to and described in the Martin book, of which "Defendant's Exhibit B-4" is an extract. The first half of this book is devoted to this phase of Tesla's accomplishments in polyphase power apparatus. The second half describes a little of his work when he took up high-frequency phenomena, and which, while it evidently inspired Tesla to dream great things, never led to anything of real usefulness, but merely to some arrangements capable of producing interesting and spectacular effects in the laboratory, and in the diagrams shown in the Martin book, the dominance of the power-transmission idea is evident.

Q. 212. Will you please consider the British patents to Braun Nos. 1,862 of 1899, and 12,240 of 1899 ("Defendant's Exhibits Nos. Z-2 and A-3"), as referred to by Mr. Loftin on page 1076 of the Printed Record and state what bearing, if any, they have upon claims in issue of Marconi patent No. 763,772?

A. I note that Mr. Loftin, page 1076, has made a brief reference to these two patents and states that patent No. 1,862 discloses a transmitting arrangement, while patent No. 12,420 discloses a receiving circuit. Transmitter patent No. 1,862, while it discloses a circuit containing a condenser coupled to a second circuit, makes no suggestion of tuning.

Examination of the patent discloses that Braun had a very hazy idea of what he was trying to do and his principal interest seemed to lie in getting a somewhat longer wave length than had previously been used.

In my opinion, the disclosures of this patent 1,862 to Braun have no particular bearing on the Marconi tuning patent 763,772.

Braun's receiver patent No. 12,420 deals with a receiving arrangement which is little more than a technical curiosity, and I am unable to discover therein any disclosure of significance, or any disclosure having a bearing on the Marconi four-circuit tuning patent.

Mr. Loftin's statement, Printed Record, page 1076, to the effect that these two patents disclosed a four-circuit system, does not involve any contention that they are tuned, nor any contention that either patent shows a combination employing both transmitter and receiver.

It is my opinion, therefore, that the Braun patents fail to disclose anything relative to the invention of the Marconi patent 763,772.

[fol. 1282] Mr. Vaill: Counsel for claimant offers in evidence a photostat copy of page 52 of the Lodge book entitled "Signalling Through Space Without Wires" (3rd Edition), and requests that the same be marked "Claimant's Exhibit No. 249".

(Said exhibit marked as requested.)

Q. 213. Please consider Mr. Loftin's statements concerning what is disclosed in the letters passing between Mr. Joseph D. Baker and Mr. John S. Stone, purporting to be dated June 30, 1899, July 18, 1899, and July 22, 1899 ("Defendant's Exhibit F-3"); also Mr. Stone's original application for his patent No. 714,756 ("Defendant's Exhibit R-3") and also the so-called Stone transmitter and receiver, purporting to be illustrated in the Pickard chart ("Defendant's Exhibit O-5"), and referred to in his testimony, as stipulated on pages 1197-1198 of the Printed Record, and state whether you agree with Mr. Loftin's opinion that said letters or the original Stone application, or his patent as issued, disclose the Marconi transmitting and receiving apparatus of patent No. 763,772 in suit, giving your reasons for any opinion you may express.

A. While Mr. Loftin's statements relative to the Stone-Baker letters and the Stone patent No. 714,756 are very lengthy, the facts disclosed in these documents are simple, readily understood and are quite different from Mr. Loftin's exposition. Stone does not disclose four-circuit tuning and, furthermore, it is perfectly obvious from both the letters and the patent, that he did not want to tune his antenna circuit but, on the contrary, proposed to generate oscillations in a closed circuit of whatever frequency he wished and to force these oscillations upon his antenna at the transmitting end, and to extract them from the atmosphere at the receiving end by means of an antenna system which was not tuned, but which had associated with it a closed circuit which was tuned.

The words "forced oscillations" or "forced vibrations" used continually by Stone throughout the letters and his patent, have but one significance in this art, viz., vibrations or oscillations differing in frequency from that of the circuit

on which they are impressed. Stone was a man possessed of unusual theoretical knowledge relative to the behavior of circuits, understanding fully the means necessary to tune an electrical circuit and capable of employing language exactly descriptive of his purpose and of drawing circuits illustrative of his purpose when he desired to tune a circuit. Nowhere in the Stone-Baker letters, or in the subsequent patent, in which he reduced his ideas to practice, is there a disclosure of a variable inductance or other variable tuning element in the antenna circuit.

While Stone illustrates in detail the principles of operation and the necessary apparatus for the tuning of the circuits associated with his antenna system, he neither shows in the sketches, nor describes in words, any method of tuning the antenna system.

In the light of Stone's mastery of electrical technique, it is inconceivable that this omission is the result of anything other than the fact, very completely brought out in both the letters and the patent, that he did not want the antenna to be tuned; but, on the contrary, expressly desired that the antenna period should not correspond to the period of the oscillations forced upon it. His whole theory of [fol. 1283] operation requires such a condition and is expressed at one point in the Stone-Baker letters as follows:

"* * * In my arrangement the vibratory current developed in the vertical wire is not due to the oscillatory discharge of the wire but is due to a simple harmonic electromotive force impressed upon it which electromotive force *produces* forced current vibrations in the wire which forced vibrations as is well known depend for their period and form only upon the period and form of the impressed forces and not upon the electromagnetic constants of the circuits in which they are developed as in the case with *free* or *natural* vibrations of a system."

This quotation expresses in technical language the fact that the electrical oscillations impressed upon the antenna system were to be of a nature quite independent of the effect of the electrical constants of the antenna circuit, a condition which is directly contrary to tuning; that Stone in his use of the words "forced oscillations" intended to sharply differentiate this method of operation from that

of the Marconi circuits is evident from his own statements contained in his patent No. 767,975, page 2, lines 70 to 113:

"A sharp line of demarcation is to be drawn between the system herein described and such systems as that described, for example, in British Patent No. 7,777, series of 1900. In the system herein described the frequency of the radiated waves is determined solely by the capacity and inductance of the sonorous circuit, which, determining the frequency of the electrical oscillations developed in said circuit and by it forced in the elevated conductor, necessarily determine the frequency of the waves radiated by said elevated conductor, the length or other geometric constants of said elevated conductor or its fundamental or its natural periods having no effect in determining the frequency of the radiated waves. In the system described in said British patent and elsewhere, as, for example, in the *Journal of the Society of Arts*, Vol. LI, page 722, in connection with Fig. 14, the frequency of the radiated electromagnetic waves is determined not solely by the capacity and inductance of the sonorous circuit associated with the elevated conductor independently of the capacity and inductance of the latter, but by the capacity and inductance of the elevated conductor taken in conjunction with the capacity and inductance of the associated sonorous circuit and the mutual inductance and capacity of the two circuits. In these systems, which are systems of at least two degrees of freedom, as explained in my prior Letters Patent, any change in the length or other geometric constants of the elevated conductor whereby the capacity and inductance of said conductor is altered will produce a change in the frequency of the radiated waves, and therefore it cannot be said that electrical oscillations in the elevated conductor are forced oscillations of a frequency determined by the electromagnetic constants of the sonorous circuit and irrespective of the constants of the elevated conductor."

The above quotation so completely and unmistakably expresses Stone's thought in the matter of the difference [fol. 1284] between a system employing forced oscillations such as that described in the patent from which the quotation was taken and the Marconi system disclosed in Marconi British patent No. 7,777 ("Plaintiff's Exhibit No. 34"), that is, the tuned system, that further comment on this point

would be superfluous, and I will merely add in explanation that the Stone patent No. 767,975 discloses a system employing forced oscillations, in which respect it is identical with those disclosed in the Stone-Baker letters, and the Stone patent under discussion, No. 714,756.

In the Stone-Baker letters are statements used and misinterpreted by Mr. Loftin, as follows (P. R., p. 1077):

"Instead of utilizing the vertical wire itself at the transmitting station as the oscillator, I propose to impress upon the vertical wire, oscillations from an oscillator, which oscillations shall be of a frequency corresponding to the fundamental of the wire. Similarly at the receiving station, I shall draw from the vertical wire, only that component of the complex wave which is of lowest frequency."

* * * * * * *

"If now the fundamental of the wire at the receiving station be the same as that of wire at the transmitting station, then the receiving station may receive signals from the transmitting station, but if it be different from that of the transmitting station, it may not receive those signals."

These quotations are the only statements found in the Stone-Baker letters which make any reference to a definite natural period for the antenna system, and require a brief consideration.

In the first place this is not a statement to the effect that the *antenna circuit* shall be tuned, but simply that the natural period of the wire taken alone shall correspond to that of the closed circuit and, as is shown from Stone's sketches, he proposes to insert a coil between the base of this antenna and the earth, in order to drive it—a method of procedure entirely in accordance with the idea of forced oscillations.

It is of interest at this point to note that whereas Tesla suggested tuning the coil itself and then attaching an antenna, overlooking entirely the fact that his *antenna circuit* would then be completely detuned, Stone goes on the other side of the fence as it were, and suggests an antenna which, when taken by itself, might be tuned, and then inserts an inductance between the base of the antenna and earth, which results in a complete detuning of the antenna circuit. Stone was on one side of the correct principle, Tesla on the other side, while Marconi stood in between with a

recognition of the true principle, viz., that the *antenna circuit* should be tuned.

There is an interesting exposition of Stone's valuation of this suggestion contained in the quotation from the Stone-Baker letters to be found in his patent No. 714,756, page 2, lines 15 to 35, which are as follows:

"• • • Thus the frequency impressed upon the elevated conductor may or may not be the same as the natural period or fundamental of such conductor; but, as will be hereinafter explained, an elevated conductor that is aperiodic may be employed and is best adapted for use when the apparatus is to be used successively for different fre- [fol. 1285] quencies, and such aperiodic elevated conductor is likewise the preferred form of elevated conductor when two or more frequencies are to be simultaneously impressed upon or received by a single elevated conductor; but forced simple harmonic electric vibrations of different periodicities may each be separately impressed upon a different elevated conductor, and the several energies of the resulting electromagnetic waves may be selectively conveyed each to a separate translating device."

The statements above contain one of the instructions in the Stone patent to tune the antenna wire, as distinguished from the antenna circuit and were inserted in the patent April 11, 1902, which date is subsequent to the disclosure by Marconi in his British patent No. 7,777 of 1900.

It is quite apparent from this fact that Stone did not consider the reference in his letters to Baker relative to tuning the antenna wire to be of any particular consequence when he applied for his patent February 8, 1900, and his insertion of this statement some two years later and subsequent to Marconi's disclosure, speaks for itself.

Stone's main thought in the employment of forced oscillations was first of all to secure a system which would produce a relatively pure wave and, secondly, as is indicated in his patent, to enable one antenna system to transmit and receive two or more messages simultaneously, which particular branch of his thought was along the same direction as some of his previous work in wire line transmission as, for example, that shown and described in his patent No. 638,152 ("Defendant's Exhibit U-3").

Stone's principle of forced oscillations, while interesting as a theoretical speculation, never resulted in a practical accomplishment, or, rather, in any practical system of radio-communication, due to the fact that tuning of the antenna circuit is an inescapable requirement, and any attempt to work without it, results in such an enormous waste of power that for practical purposes it is useless.

Mr. Loftin shows in his sketch "Loftin Sketch M" at the top of page 1078 of the Printed Record, an arrangement of transmitting and receiving circuits which purports to be the Stone disclosure, but is actually made up, as admitted by Mr. Loftin, of arrangements found partly in his patent and partly in the Stone-Baker letters.

It will be noted that the inductance coil in the antenna is not variable, but is fixed, which, in the light of the facts already brought out in my answer is, by itself, quite sufficient to show that Stone did not intend to tune his antenna system.

Mr. Loftin quotes, Record Page 1079, the last paragraph of the Stone Baker letter of June 30, 1899, as follows:

"The tuning of these circuits one to another and all to the same frequency will probably be best accomplished empirically, though the best general proportions may be determined mathematically."

and states that this quotation leaves no doubt that Stone intended to tune all four circuits. As a matter of fact, the only statement in either the letters or the patent which give any clue to what Stone meant by this quotation is the statement already quoted relative to tuning the antenna wire—not the antenna circuit, and which instruction was [fol. 1286] not inserted into the Stone patent until Marconi had disclosed tuning in his British patent.

Mr. Loftin further states in commenting on this quotation, that Stone clearly shows inductance coils and condensers in all of his circuits and that from the teachings of Lodge, he knew how to use a variable inductance to tune the antenna circuit.

As I have already pointed out, Mr. Stone was possessed of most unusual technical knowledge in the matter of electrical circuits and his omission of the variable tuning element in the antenna circuit was not the result of ignorance

relative to the action of such an inductance in an electrical circuit, but the result of his definitely indicated purpose of having an antenna circuit which was not tuned.

Mr. Loftin's interpretation of the following quotation from the Stone-Baker letter of July 18, 1899, found on Printed Record, page 1079, viz.:

"In my arrangement the vibratory current developed in the vertical wire is not due to the oscillatory discharge of the wire, but is due to a simple harmonic electromotive force impressed upon it which electromotive force produces forced current vibrations in the wire which forced vibrations as is well known depend for their period and form only upon the period and form of the impressed forces, and not upon the electromagnetic constants of the circuit in which they are developed as is the case with free or natural vibrations of a system."

is a use and interpretation of the expression "forced oscillations," which is quite contrary to the usage of the radio art, and it is not customary to speak of a circuit which is in tune as being "forced" to accept oscillations of its own period.

Mr. Loftin emphasizes, at the bottom of Printed Record, page 1080, and the top of page 1081, Stone's direction relative to the use of "swamping" inductance and the looseness of coupling which would result therefrom. While it is a fact that the inductance referred to by Mr. Loftin would result in loosening the coupling, it is also a fact that in order to make the Stone system operate at all with its forced oscillations and an aerial system greatly out of tune, it would be necessary to use a very close coupling.

Mr. Loftin next takes up the discussion of the Stone patent and attempts to make Stone tune the antenna circuit by referring to a statement in the Stone-Baker letters relative to empirical tuning. Stone was far too good a technician to have allowed his patent to issue without clearly indicating how to tune his antenna circuit, had this been his purpose. Not only was he familiar with electrical theory, but, in the closed circuits described in this patent, he gives definite instruction, and discloses the necessary means for carrying out his purpose, and I shall consider that this comment applies to all statements made by Mr. Loftin, to the effect that tuning in the antenna circuits of the Stone patent can be "inferred."

On Printed Record, page 1084, Mr. Loftin refers to Figures 5 and 6 of the Stone patent No. 714,756 and states that they are the same as Figs. 1 and 2 of the Marconi patent 763,772, and that they disclose a radio system in which the transmitter and receiver each embody two circuits tuned alike, and all four circuits tuned together. This statement, of [fol. 1287] course, rests entirely on the "inferred" tuning of the antenna circuits and, in fact, resemblance to the Marconi patent lies largely in the fact that the drawings look somewhat alike.

In so far as the disclosure of useful and valuable information is concerned, the two patents are totally unlike; that of Marconi being one of the outstanding contributions to the radio art, while that of Stone being an arrangement which, for all practical purposes is inoperative.

Marconi discloses a system in which all four circuits are tuned together, while Stone discloses a system primarily for the purpose of multiplex wireless telegraphy and involving antenna systems which are forced to oscillate in a manner determined by an electromotive force impressed upon them, and not in a manner determined by the electrical constants. Marconi drives his antenna circuits in the way in which they want to go, while Stone tries to make them go in some different manner, and the results obtained in the two cases are very similar to those obtained when these two methods of procedure are applied to human beings.

Mr. Loftin, on Printed Record, page 1085, comments on the fact that Mr. Stone understood how to so connect his detector in the oscillating circuit of a receiver that the resistance of the detector should not be included in the tuned circuits, a teaching which Mr. Loftin seems to have forgotten when he attempted to make the secondary circuit of Marconi patent 627,650 a tuned circuit.

On Printed Record, page 1085, Mr. Loftin sums up the matter of "novelty" or otherwise in the Marconi patent, and states:

> "There certainly can be no novelty in the Marconi patent in the matter of tuning, resonance, or syntony, because there was no lack of information in the art on this subject."

While I am aware of the fact that prior knowledge in an art has a certain bearing on the technical question of invention as disclosed in the patent, yet I have, as the result of

many years of experience with inventions, something in the nature of a contempt for statements of this sort when the invention is one of such outstanding importance as that of the Marconi patent 763,772 and when I consider the tremendous gap which exists between the existence of information and the employment by someone of that information for a useful purpose.

Were it only necessary, in order to produce an invention, to have available the information on which that invention is based, then most of the inventions which will be made in the next ten years or more would be made today.

In the case of the Marconi patent, of course, this condition in fact does not exist, since, while the scientific principles of resonance, etc., were understood, their application to a radio system prior to Marconi's patent, was not, and the fact that such skilled workers as Tesla and Stone completely missed, one on one side of the fence, as it were, and the other on the other side, illustrates far more convincingly than anything which I can say, the magnitude of Marconi's accomplishment in his correct solution of the problem.

. . . . . .

[fol. 1288] Mr. John Stone Stone, in testifying in the suit of Marconi Wireless Telegraph Company of America *vs.* Kilbourne & Clark Manufacturing Company, which testimony has been stipulated into the present case, a part of which is found on pages 924 and 925 of the Printed Record in this case, makes statements which are of considerable interest relative to both the original Marconi patent No. 11,913 and the four-circuits tuning Marconi patent No. 763,772. This testimony is as follows:

"194. Cross-question. Did you testify for the defendant in a suit of the National Electric Signaling Co. against the Telefunken Co. on a patent to Fessenden, No. 928,371, in September, 1911, as follows:

"Will you please give a concise statement of the principles involved in radiotelegraphy, as a practically applied art, including in your statement its genesis and evolution down to and including the date of Marconi's British patent No. 7,777 of April 26, 1900, as respects its development after that date. I will ask you subsequently concerning each step thereafter.

'A. Referring first to the work of Marconi, it is safe to say that his British patent No. 12,309 of June 2, 1906, was the first patent ever granted for an operative system of radiotelegraphy based upon a creation and detection of radiated 'Hertzian or electromagnetic waves.' "

"Answer. I believe I made that statement.

"195. Cross-question. Did you also testify in that same case as follows:

'Q. 28. Now, please state briefly the character of the apparatus constituting the next decided step in the art made by Marconi.

'A. The British patent No. 7,777 of 1900 discloses the really important advances made in the art at that date. Marconi therein discloses a variable inductance coil in series in the antennae, or aerial structure, conductor, and the tuning condenser in shunt with the primary of the transformer in a tuned secondary of which is connected the detector and tuning condensers and inductance coils. Both the condenser in the primary and secondary and tuning inductance coils in the secondary, are made variable for the purpose of tuning the circuits with which they are associated.'

"Answer. I believe I made that statement.

"196. Cross-question. And in the same case did you not also testify as follows:

'Q. 10. Speaking generally, how do the subsequent advances in the art of radiotelegraphy, down to the present [fol. 1289] time, compare in relative importance to what was summed up in Marconi's two British patents of 1906 and 1900, to which you have referred, and others substantially co-contemporaneous with the latter?

'A. Though it is undoubtedly true that the apparatus substantially as it is clearly shewn in the separate drawings of Marconi's British patent, is preserved in every efficient form of commercial apparatus, and of all systems used today, it is equally true that many of the elements in it were not of his invention.'

"Answer. I believe I made that statement.

"197. Cross-question. And did you not also testify in that same case as follows:

'The first very clear and complete exhibition of the use of a continuously variable tuning condenser in shunt to the

primary of a transformer in a wireless telegraph receiver, so far as I am aware, is contained in the specifications and drawings of the English patent to Marconi, No. 7,777, of 1900.'

* * * * * * *

"Answer. I believe that is a correct statement of what I said."

The British Patent No. 7,777, referred to in Mr. Stone's testimony, corresponds to the United States Patent No. 763,772, and Mr. Stone's statements, quoted above, unmistakably bring out the fact that Stone himself credits Marconi with being the first to use the tuning elements in the aerial circuit in conjunction with tuned and coupled local circuits, and seems to me to be conclusive to the effect that he himself had not used or described such an arrangement. This statement by Mr. Stone is quite in accord with my own remarks relative to the Stone-Baker letters and the Stone patent No. 714,756.

Mr. Stone's statements relative to the apparatus of Marconi's patent being substantially preserved in every efficient form of modern radio apparatus, is also in accord with the statements which I have made on the same subject.

The reference to Marconi's British Patent No. 12,309 of June 2, 1906, is evidently a misprint, so far as the patent number and date are concerned. Examination of the original Kilbourne and Clark record shows the same misprint, but the patent introduced as "Defendant's Exhibit No. 33. I-8" in that case is the Marconi patent No. 12,039 of June 2, 1896, which is the correct number and date for the original Marconi patent.

It is of interest to note that Mr. Stone refers to this patent as the first ever granted for an operative system of radio telegraphy.

I note a reference on page 6 of Stone Patent No. 714,756 to the construction of a vertical wire highly resonant to a particular frequency (lines 62 to 70), as follows:

"The vertical wire may with advantage be so constructed as to be highly resonant to a particular frequency, and the harmonic vibrations impressed thereon may with advantage be of that frequency. The construction of such a ver- [fol. 1290] tical wire is shown and described in other applications of mine now pending."

which statement was inserted into the patent application April 11, 1902, more than two years after the date of filing of the application, and much later than the date of publication of the British Marconi Patent No. 7,777.

Again, on page 9, line 130, to line 5, page 10 of Stone patent No. 714,756, is the following statement:

"* * * Both of the circuits I have spoken of are tuned circuits, and they may be conveniently distinguished with reference to their respective functions by denominating the circuit employed in the development of the vibrations as an 'Oscillating' or 'sonorous' circuit and by denominating the circuit employed in the reception or absorption of the vibrations as a 'resonant' circuit."

This statement seems to be intended to indicate some sort of tuning of the aerial system, a statement quite unsupported by the drawings of the patent, and it was inserted into the application June 19, 1902, which was after the publication of the British Marconi Patent No. 7,777.

These references are cited as showing that everything in the Stone patent 714,756 which might be interpreted to mean tuning of the antenna circuits was put into the patent after Marconi's work was known, and the importance of having all four circuits in tune, appreciated.

The original disclosures of the Stone patent 714,756 in the matter of the drawings did not disclose any means for tuning the antenna circuits, and these insertions at a much later date indicate the attempt by Stone to get into his patent as much as possible of Marconi's work.

Mr. Vaill: Counsel for claimant offers in evidence printed copy of patent No. 767,975 to J. S. Stone, dated August 16, 1904, referred to by the witness in his last answer, and requests that the same be marked "Claimant's Exhibit No. 250".

(Said exhibit marked as requested.)

Q. 214. Will you please refer to Mr. Loftin's answer to Q. 27 of his deposition, where he considers the claims of the patent in suit No. 763,772, in view of the prior art, on pages 1087 to 1091, inclusive, of the Printed Record, and state wherein, in view of your knowledge and experience, you may agree or disagree with Mr. Loftin's statements regarding said claims?

A. Referring now to claim 1, Mr. Loftin undertakes to read this on the prior art, bringing in Stone and Tesla. A necessary element in this claim is the variable inductance included in the open circuit, which is not disclosed in either Stone or Tesla.

The signaling instrument called for by this claim requires an operator's key of some sort, and no such device is to be found in Tesla.

Claim 3: This claim again requires a variable inductance and a signaling device. Neither Tesla nor Stone, cited by [fol. 1291] Mr. Loftin against claim 3, show a variable inductance, and Tesla does not indicate any transmitting key.

This claim covers means for adjusting the oscillation period of each of the two circuits, to bring them into accord with each other.

Mr. Loftin again cites Tesla and Stone in connection with this claim, but neither discloses the means necessary for tuning the two circuits.

Claim 8 is similar to claim 6, except that it refers to a variable inductance in the open circuit.

Loftin again cites Tesla and Stone, stating that Tesla has provided means for varying the number of turns. The patent does not disclose anything whatsoever which can be interpreted to mean varying the number of turns in a manner necessary to tune the antenna. As I have previously pointed out, he has merely directed the tuning of the oscillation transformer secondary alone and attaches his aerial thereto, regardless of the resulting consequences, which are fatal to the requirements of successful operation.

The reference to Stone in the matter of tuning the aerial wire "empirically", does not in any way meet the requirements of this claim, which requires a variable inductance, said variable inductance not being shown in Stone and all of the descriptive language in the patent which might be interpreted to indicate tuning having been inserted after the publication of the British Marconi Patent No. 7,777.

Claim 11: This is the same as claim 1, except that a signaling device; that is, the operator's key, is separately specified as one of the elements of the claim. Mr. Loftin refers to the switch S in his "Tesla Sketch A" as being something which one skilled in the art would naturally connect to the Tesla arrangement, but it was not connected there by Tesla himself and, therefore, I see no anticipa-

tion or meeting of the requirements of this claim by Tesla. Stone, however, does disclose the operator's key.

Mr. Loftin comments (No. 3, claim 11) on that part of the claim which reads as follows:

"* * * the secondary coil of the oscillation-transformer electrically connected, at one end to capacity and, at the other end, to an inductance, and an aerial conductor connected to the inductance, substantially as and for the purpose described."

Referring to Fig. 1 of patent 763,772, the oscillation-transformer referred to is indicated by d', the capacity by the earth E and the inductance by the coil g.

Neither Stone nor Tesla disclose an inductance coil similar to g', but only one coil, corresponding to the oscillation-transformer coil d', and Mr. Loftin's very curious statement under heading (3), is to the effect that the secondary of the oscillation-transformer is connected to itself, and since it is an inductance it is therefore connected to an inductance in the circuit.

As an illustration of the way in which the English language can be employed to convey incorrect impressions, the statement is very good, but it is quite evident from the drawing of Fig. 1 of the Marconi patent 763,772, that Mar- [fol. 1292] coni was talking about and claiming a coil additional to the secondary of the oscillation-transformer.

Claim 12: An extension of claim 11, requiring that the additional inductance be variable. Loftin again cites Tesla and Stone but, as already pointed out, neither discloses a variable inductance in the open circuit.

All of the claims so far covered refer to the transmitting station.

Loftin next takes up the receiving claims.

Claim 2: This claim requires the combination of a variable inductance in the antenna circuit and a wave-responsive device electrically connected with said inductance and in circuit with a condenser.

Mr. Loftin cites Lodge, Marconi's 1899 patent and Stone, as meeting the requirement. The wave-responsive device referred to by this claim, is shown as T in Fig. 2 of the patent and, as shown in Fig. 2, this device, which is a coherer, is in circuit with condenser j^3 and also with condenser h'. Condenser h' being for the purpose of tuning the secondary circuit. While the Lodge patent discloses

the use of a variable inductance in the antenna circuit, it does not disclose a tuned secondary circuit, nor the use of a detector connected in shunt with a condenser similar to the connection shown between T and *h'* in Fig. 2 of the patent to Marconi.

The Marconi 1899 patent does not show a variable inductance in the primary circuit, consequently does not meet the requirement of this claim. While Stone discloses a wave-responsive device in circuit with a condenser, it does not disclose a variable inductance in the primary circuit; consequently it fails to meet the combination required by the claim.

Claim 13: Loftin again cites Lodge, Stone and the Marconi 1899 patent. This claim requires a variable inductance in the antenna circuit, as shown by *g'* of Marconi patent 763,772 and a wave-responsive device connected with the secondary winding of the oscillation transformer.

Neither Lodge, Marconi nor Stone show a variable inductance in the antenna in addition to the secondary of the oscillation-transformer, and none of them disclose this combination.

I therefore find that none of the prior art cited against this claim by Mr. Loftin discloses the combination of elements called for therein.

Claim 14: This claim requires means in both the open and closed circuits for adjusting the time-periods of the open circuit and the closed circuit into electrical resonance with each other. Loftin cites Lodge and Marconi 1899 patents and contends that, in the case of the Lodge patent, one adjustment only is sufficient to bring the circuits into resonance. This, of course, cannot be the case, since the antenna circuit must be adjusted to correspond either with the frequency of the incoming signal, or the product of the inductance and capacity of the transmitter circuit, while the secondary circuit must then be capable of adjustment in a corresponding manner. Lodge discloses no means of tuning the secondary circuit, nor does he recognize anywhere in his patent, the advantage of so doing.

[fol. 1293] Mr. Loftin's statements relative to the 1899 patent have already been referred to in a previous answer, and are to the effect that Marconi provided for varying the number of turns of *j'* of the 1899 patent and the capacity of condenser K.

As stated in my previous remarks, condenser K is incapable of tuning the secondary circuit; consequently, there is no disclosure in this patent of two-circuit tuning.

It is evident, therefore, from the above remarks, that none of the disclosures of the prior art referred to by Mr. Loftin, provide the combination called for by claim 14.

I omitted to mention that Loftin also referred to Stone, but, as stated so many times already, Stone did not disclose any mean for tuning the antenna circuit and, therefore, no means for bringing the two circuits into tune with each other.

Claim 16: Mr. Loftin's only comment on this claim is that it is the same as claim 14, except that it claims the condenser *h* of Fig. 2, Marconi patent No. 763,772, which Mr. Loftin states:

"• • • is merely one of the 'impirical' methods employed by the art."

Perhaps the best answer to this comment is Mr. Stone's statement contained in the testimony which I quoted from my last answer, as follows:

"197. Cross-question. And did you not also testify in that same case as follows:

'The first very clear and complete exhibition of the use of a continuously variable tuning condenser in shunt to the primary of a transformer in a wireless telegraph receiver, so far as I am aware, is contained in the specifications and drawings of the English patent to Marconi, No. 7,777, of 1900.'

"Answer: I believe that is a correct statement of what I said."

Mr. Stone's statement and Mr. Loftin's failure to cite any prior art complying with the requirements of this claim, indicate that it was a new and novel combination.

Claim 17: Requires means included in each of the circuits for adjusting the circuits in resonance with each other. In Fig. 2 of the Marconi patent 763,772 the open circuit is provided with two means, viz, coil g' and condenser *h*, while the secondary circuit is provided with variable coils g^2 and a variable condenser h'.

Mr. Loftin, commenting on this claim, attempts to read Lodge into it, stating that varying condenser *w*, shown in

the "Loftin Sketch L," is for the purpose and capable of tuning the secondary circuit.

As I have already pointed out in connection with this condenser *w*, Lodge specifies a resistance as an alternative to the condenser, which specification precludes the possibility that Lodge was thinking of tuning, since resistance can never be used to tune the circuit, a fact well known to Lodge, or anyone else familiar with electrical circuits. Furthermore, in the position shown in Mr. Loftin's Sketch L, the condenser *w* is incapable of tuning, because the high [fol. 1294] resistance of the detector intervenes between the condenser and the inductance and is therefore in circuit with them and its high resistance prevents tuning.

The Marconi 1899 patent is cited by Mr. Loftin, but has been disposed of in previous answers.

I find no disclosure of the combination called for by claim 17 in the prior art.

Claim 18: This claim is the same as claim 17, except that it calls for the specific means,—viz., a variable inductance included in both circuits for the purpose of tuning.

Loftin attempts to find these elements in Lodge and Stone, but while Stone shows a means for tuning the closed circuit, and Lodge the means for tuning the open circuit, there is no disclosure in the patents or publications of either of the combination.

Claim 19: This is similar to claim 18, with the addition of a receiving instrument and battery. Loftin again cites Lodge, Stone and Marconi 1899 patents, but, as already pointed out, none of these disclose a variable inductance in both circuits.

The next claims dealt with cover both stations.

Claim 10: This claim requires an open circuit at the transmitter and receiver, and a closed circuit at each station, and all four circuits in resonance with each other. A transmitter and a receiver complying with this requirement are shown in Figs. 1 and 2 of the Marconi patent 763,772, and the specification, page 2, lines 117 to 129:

Loftin cites Tesla, Marconi 1899 patent, but these references have, I think, been completely disposed of in my previous answers. He also refers to his "Stone Sketch M" and the statement in the Stone letter June 30, 1899, as follows:

"The tuning of these circuits one to another and all to the same frequency will probably be best accomplished empirically, though the best general proportions may be determined mathematically."

as a disclosure of four-circuit tuning.

I have already pointed out that Stone was working on a totally different idea, disclosed nowhere either in his letters or patent the necessary means for securing four-circuit tuning and, in fact, in the patent itself, did not put any statements of the sort contained in this quotation until after Marconi's disclosure when, having learned the importance of the four-circuit tuning, he attempted to get some of it into his own patent. An attempt, however, which is unsupported by either the original disclosure in the specification or the drawings.

I do not find, therefore, that claim 10 of Marconi patent 763,772 is found in any of the prior art cited by Mr. Loftin.

Claim 20: Mr. Loftin's comment on this is to the effect that it is met by his references cited against claim 10, with which I disagree, for the reasons outlined in my remarks on claim 10.

Q. 215. In answer to Q. 28 of Mr. Loftin's deposition he reviews the File Wrapper and Contents of Marconi patent No. 763,772, and attempts to point out the significance of [fol. 1295] the citations by the Examiner of the Patent Office of certain patents in the prior art, particularly Tesla patent No. 645,576, Lodge patent No. 609,154 and Stone patent No. 714,756 (pages 1092-1095 of the Printed Record). Mr. Loftin comes to the conclusion that the Examiner probably allowed the Marconi application over the Stone patent because: "Stone probably intended tuning his vertical wire through varying its length, and Marconi having shown the Lodge variable acting coil as a tuning means for his vertical wire he was entitled to claim it." Will you please consider Mr. Loftin's statements as contained in the answer above referred to in connection with the File Contents of the Marconi patent No. 763,772 and state wherein your views may differ from those of Mr. Loftin?

A. I have examined the File Wrapper and Contents of Marconi patent No. 763,772 and also Mr. Loftin's statements relative thereto.

I note that he attaches considerable importance to the various statements and actions by the Examiner, but I think

that there are certain facts relative to the Examiner's knowledge which are of rather fundamental importance in considering the value of his point of view, and facts which have impressed me particularly in reading the File Wrapper and Contents.

At the time of application there was scarcely anyone, outside of Marconi himself, and a few other experimenters, who knew anything at all about radio, and the Examiner in passing upon the Marconi application, was confronted with a situation which occurs usually only at the birth of a new art and, as it happens in this case, one of the most complicated and difficult to understand, which man has yet produced.

Years of familiarity with this art constitute the only basis for qualifying a man to intelligently discuss it and determine whether or not a patent application involves new matter over the prior art. That the Examiner in the Marconi case was handicapped in this respect, and also by a lack of familiarity with some of the conditions of high-frequency circuits, is illustrated in various places in the File Contents, of which I will give examples.

* * * * * * *

In an office action dated August 12, 1901, the Examiner replies to amendments of July 3 and 8, 1901, as follows:

"In the first paragraph of page 4 of the specification the definitions of persistent oscillators and good radiators are not sufficient. In general, a circuit which is a persistent [fol. 1296] oscillator is a poor radiator of electro-magnetic waves, and inasmuch as applicant states that his aerial circuit is the same in period as the primary circuit in which the oscillations are generated, it appears that said aerial circuit would likewise be a persistent oscillator and therefore a poor radiator. Applicant is required to further explain this feature of his invention, and accordingly claims 2, 3, 7 and 8 are objected to."

This statement is based on a complete misunderstanding of the nature of the circuits described as a persistent oscillator and a good radiator.

In general the aerial system involving an elevated conductor and commonly referred to as an "open circuit" is a good radiator, while a circuit which is closed in form; that

is, involves a condenser consisting of two or more plates very close to one another, is practically without radiating powers.

If a circuit such as the open aerial circuit of a radio transmitter is a good radiator, this characteristic is in no way affected by an association with, or tuning to, some other circuit, but remains a good radiator, because the power of radiation is a characteristic of the circuit itself, and not of any association. While this is a fact with which all radio men are familiar today, it is not at all surprising that the Examiner, acting at a time when very little experience had been had by anyone in radio, should have had an incorrect picture of these circuit characteristics.

Another illustration of this sort is found in an action dated February 11, 1902, page 4, in which claim 1 is rejected, as follows:

"Claim 1 is rejected on the first set of references cited because in each of the systems therein set out 'the time period of *electrical oscillations* in all the circuits of the transformers' may be the same, or the oscillations of the secondaries may be harmonics of the primaries. This claim covers a very different structure from that called for by claim 3. The statement above quoted from claim 1 does not imply tuning of the circuits. By forced oscillations the time periods would be the same in any of the patents cited against the claim."

It is quite obvious, in the light of present-day knowledge, that the statement in the claim referred to the period of the oscillations which the circuits themselves would have if oscillating in their own period.

Not only did the Examiner fail to recognize this, but it is evident also that the attorneys prosecuting the application were as yet unfamiliar with the art and the language necessary to exactly describe the characteristics of radio circuits.

Mr. Loftin has made a good deal of the abandonment, so-called, of the application, but a careful consideration of the facts brought out in the File Wrapper and Contents, particularly the final petition to the Commissioner for renewal, which was granted,—show clearly that great efforts were made to prosecute the application diligently, and that the lapse occurred due to the fact that Mr. Marconi was pursuing with intense enthusiasm, his great invention, and was traveling almost continuously.

[fol. 1297] While it is true that the Commissioner at first rejected the petition for renewal, yet, when a complete affidavit was presented which included all the facts, it is evident from his action that he was entirely satisfied that there had been no lack of diligence on the part of the applicant and his attorneys.

It is also very significant that after the renewal of the application all of the claims were allowed, except 4, 5, 6 and 7.

I think it may be fairly assumed, since some time had elapsed since the previous actions, that the Examiner had had more time to become familiar with the art and to appreciate the fundamental difference between the disclosures of Marconi and the prior art.

It is of interest to note the statement of the Examiner in this action relative to the Stone arrangement, he says:

"Stone shows in Fig. 5 a transformer M whose secondary L_2 is connected to an open circuit including a radiating conductor V at one end and a capacity E at the other and whose primary L_1 is connected to a condenser circuit discharging through a spark gap, viz., the circuit C s L_1 L. These circuits are in 'electrical resonance with each other',—see lines 16-20, page 2. It is not stated how the elevated conductor is given a natural period equal to that of the oscillations impressed upon it, but it is well known by all skilled in this art that this may be accomplished by adjusting the length of the elevated conductor, thereby adjusting the distributed capacity and the distributed inductance of the same until the natural period of such conductor is equal to the natural period of the condenser circuit C s L_1 L. When this is done 'the frequency impressed upon the elevated conductor' is 'the same as the natural period or fundamental of such conductor', to quote from the Stone patent.

"Applicant discloses another means whereby the same result may be effected, viz., by including a 'variable inductance' in the elevated conductor. All claims which include this element are considered allowable over the Stone patent."

It is evident from this statement that all the Examiner was able to find in Stone, in so far as the antenna circuit was concerned, was the suggestion to make the antenna wire

itself of the same natural period as the closed circuit. This statement is quite in accord with the remarks that I have already made relative to Stone, and it is also interesting to note that the inclusion of a variable inductance in the elevated conductor was considered by the Examiner in the quotation above to be something not disclosed in Stone, which statement is also strictly in accord with my own statements in this respect, and at variance with the inferences drawn by Mr. Loftin in his many uses of the Stone patent as a prior reference.

A most striking fact disclosed by an examination of the Marconi File Wrapper and Contents is that, although the Stone application and the Marconi application were copending, no interference was declared between them, which fact shows conclusively that they were considered to be different inventions by the Examiner.

Mr. Loftin, on Printed Record, page 1094, comments on the action of the Examiner, above referred to, and states [fol. 1298] that in his opinion had the Stone-Baker letters been before the Examiner, he would not have taken the action or have considered Stone in the light indicated by his statements. He quotes the following passage from the Stone-Baker letters in support of his contention:

"The tuning of these circuits one to another and all to the same frequency will probably be best accomplished empirically, though the best general proportion may be determined mathematically."

The significance of this statement in the Stone-Baker letters has already been pointed out, viz., that in order to know what Stone meant by it, one must examine the complete letters and the drawings illustrative of the arrangements Stone had in mind. My examination of this data has shown conclusively that Stone provided no means for tuning his antenna circuit and, therefore, for bringing all circuits in tune, and that the only possible meaning which could be given to this expression is that he intended to make the wire constituting the elevated conductor of the right length to have a natural period corresponding with his closed circuits. This is a method of procedure strictly in accordance with Stone's thought of forced oscillations, but utterly opposed to Marconi's thought, and quite useless practically.

Mr. Loftin, on Printed Record, page 1095, in commenting

further on the Examiner's action, states that the only difference which he could find between Marconi and the prior art, was the placing of the Lodge variably-acting coil in the antenna circuit, and that in his (Loftin's) opinion, this difference was an extremely narrow one.

In point of fact, however, it was a difference of a most tremendous order of magnitude, in so far as the results to a radio system were concerned; it was that difference which made it possible to have all four circuits in tune which, in turn, made possible the tremendous development of radio subsequent to Marconi's invention.

Both Stone and Tesla missed it and, as a result, failed to produce practically useful arrangements. I find that Mr. Loftin, on page 1095 of the Printed Record, admits that all of the prior art, except the Stone-Baker letters which he referred to in his deposition, was considered by the Patent Office, and I may add that since, in my opinion, the Stone-Baker letters add nothing to the prior art in any way affecting the Marconi invention, I believe the Patent Office was correct in granting to Marconi his patent No. 763,772.

One or two further points in connection with the File Wrapper and Contents occur to me. Mr. Loftin, on page 1092 of the Printed Record, quotes a statement by the Examiner in the letter of June 3, 1902, relative to the Tesla system, as follows:

"Since it is impossible to exactly calculate the values of the electromagnetic constants of two circuits for the purpose of making their time period agree, it is fair to assume that the electrical oscillator of Tesla must necessarily be made with an adjustable inductance or condenser, or both."

This statement is quite at variance with the facts in the [fol. 1299] matter of the Tesla coil. In the first place, Tesla gives instructions in the matter of building the secondary coil which are definite, and do not involve any adjustable means. Furthermore, his instructions call for making the coil of a length suitably related to the frequency of oscillations impressed thereon and, as a matter of actual construction, this length could be determined by trial until the right number of turns was found to give the very high voltages everywhere referred to by Tesla. When once found then, following Tesla's instructions, an antenna

would be attached to it, and no change made in the coil, regardless of the size of the antenna.

Tesla's instructions, as a matter of fact, are exactly contrary to adjusting of any kind, he wants the coil to be of such length as to produce the very high voltages when taken alone, and he wants the user to employ the coil so constructed, no matter what antenna he uses with it. Nothing conceivably could be farther from the thought of adjustability or from any recognition of the usefulness of this adjustability.

Mr. Loftin's comment on page 1093 of the Printed Record relative to the Tesla oscillator, which was widely known at that time, merely emphasizes the facts outlined above. It is true that the Tesla oscillator was widely known as a means for producing very high voltages and consequent spectacular displays and it is this oscillator which Tesla attempts to hook up to an antenna system, using the same arrangement with a secondary coil constructed to produce very high voltages, but failing to appreciate that the attachment of the antenna totally changed the electrical conditions previously existing.

Marconi, on the other hand, recognized all of the essential conditions, employed the necessary apparatus and accomplished wonderful results.

Q. 216. In answer to Q. 29, beginning on page 1096 of the Printed Record, Mr. Loftin made certain statements concerning the function and mode of operation of the parts of the apparatus illustrated in "Plaintiff's Exhibit No. 87, Wireless Specialty Apparatus Type" as compared with the function and mode of operation of the apparatus of Marconi patent No. 763,772. Will you please state wherein you agree, or disagree, with Mr. Loftin's statements concerning this apparatus of "Plaintiff's Exhibit No. 87"?

A. Mr. Loftin, in his testimony, Printed Record, page 1096, relative to "Plaintiff's Exhibit No. 87", identifies this apparatus as a quenched-spark transmitter of the type described in U. S. patent No. 1,216,615 to G. Seibt, and which has a mode of operation entirely different from that of the Marconi patent 763,772.

In my answer to Q. 199, I have, I think, very clearly shown that the quenched-spark transmitter system is, in fact, the system of the Marconi patent 763,772, and that it embodies the same essential elements, viz., an open radiating cir-

cuit, a closed reservoir circuit and tuning between these two circuits. I have also shown that the Seibt system was considered by the patentee to involve resonance and tuning between the close and open circuits, and have cited refer- [fol. 1300] ences from the File Wrapper and Contents expressive of this fact.

Mr. Loftin further describes the apparatus of "Plaintiff's Exhibit No. 87" as being based upon the Lodge patent 609,154 in suit, particularly Fig. 4, with improvements in the matter of the spark-gap used, as the result of Seibt's work.

As I have already shown in anwer to Q. 209, Lodge patent 609,154 disclosed an arrangement in Fig. 4 which is not only inoperative as shown by actual tests, for the purpose of carrying out Lodge's thought of "impulsive rush", but was not usefully operative in any other sense, since less effective than the original Marconi patent 11,913.

Furthermore, I have shown in my answer to that question that the sort of energy-transfer from one circuit to another contemplated by Lodge has never actually been realized in a substantial commercial arrangement. In explaining the action of this sort of transfer, I have, in that answer, illustrated the results of some laboratory experiments and showed that the curves representative of the electrical motion in the circuits of the experiment were quite different from those of the quenched-spark transmitter. The actions taking place in a quenched-spark transmitter are wholly unlike those of the Lodge Fig. 4 and entirely different from Lodge's theory, unrealized by his actual apparatus. As I have shown in answer to Q. 199, in the quenched spark-gap transmitter there is a resonant transfer of energy from the closed circuit to the open circuit, and this resonance is demanded, both by the theory of operation, and by the facts of actual use.

This answer, viz., my answer to Q. 199, develops theories and facts which are in complete contradiction to Mr. Loftin's statement at the bottom of Printed Record page 1097 and the top of page 1098, that there is no such thing as resonance between the primary and secondary circuits of the quenched spark-gap transmitter, and his further statement at the top of page 1098, to the effect that the adjustment of the time periods of the circuits is for a purpose having nothing to do with a resonant transfer of energy between the circuits.

The facts shown by innumerable tests are conclusive relative to the tuning of the quenched spark gap transmitter and show that these circuits *must* be tuned for proper operation, while the simple theoretical analysis given in my answer to Q. 199, clearly brings out the reasons why they are tuned, viz., in order to transfer the energy.

Mr. Loftin, in commenting, at page 1097 of the Printed Record on the Lodge system, distinguishes it from the Marconi system on the basis that whereas, in the Marconi system the frequency of oscillations was determined by the closed circuit in the Lodge system, the primary circuit has nothing to do with the frequency and duration of the oscillations. This comment is based entirely on the statements in words of the patent, while the facts disclosed by the actual working of the arrangement in the patent are entirely at variance with the hopes expressed therein, and show that in so far as the principal wave length radiated by the Lodge system is concerned, the primary had a great [fol. 1301] deal to do with the frequency radiated, while the antenna coils h^4, h^4, of Fig. 4 of the patent, which should be the determining elements if this figure worked as Lodge thought it would, have nothing whatever to do with the principal wave length radiated.

I can only conclude from my knowledge of the operation of the Lodge system and of the quenched spark-gap systems derived from actual experimental use in the case of the Lodge system, and very long practical experience in the case of the quenched spark-gap transmitter, that the latter, an operative and efficient arrangement, is not based on the former, a practically useless arrangement and, in fact, is not in any way related to the Lodge system, except in the use of the Lodge variably-acting inductance coil.

Mr. Loftin, on page 1098, in referring to the quenched spark-gap transmitter of "Plaintiff's Exhibit No. 87", again takes up the matter of two oscillations of different frequencies, resulting from the tight coupling of two oscillatory circuits together, and attempts to conclude from this that the purpose of resonance in tuned coupled circuits in which a quenched spark-gap is employed, is the production of beats, rather than the transfer of energy, which conclusion to me is analogous to concluding that a pump handle is operated for the purpose of producing squeaks; whereas, it is actually operated for the purpose of getting water out

of the ground and the squeaks are merely an incidental result of that action.

So in the quenched spark-gap transmitter the circuits are tuned and coupled together for the purpose of getting the electrical energy out of the closed circuit and into the open circuit, where it will be effective and useful in radiating into space, and as an incident to this action the wave form illustrative of the motion of electricity in the closed circuit takes that form which is sometimes described as "beat".

The two frequencies resulting from the tight coupling are not the cause of anything, but are merely the result of a particular wave form. They have nothing whatever to do with the transfer of energy between the two circuits, since, as shown in my answer to Q. 199, the transfer of energy between resonant circuits requires merely that the resultant motion of electricity in the driving circuit shall occupy a time for each swing which corresponds with the resultant motion of electricity in the driven circuit, a condition which is realized when the two circuits are in tune, and only then.

While Mr. Loftin, on page 1099 of the Printed Record, refers to Seibt and his work as though it supported his contention that resonance did not exist between the closed circuit and the open circuit, the statements contained in the Seibt File Wrapper and Contents, already referred to, indicate that Seibt thought quite otherwise. He quotes the following from the Seibt patent:

"From the moment of this snapping off of the current at the spark gap, or the resulting opening of the primary circuit the secondary circuit takes up an independent oscillation, uninfluenced to any appreciable degree by the coupling there of to the primary circuit, the character of the oscilla- [fol. 1302] tions therein being changed so that the two coupled waves n_1 and n_2 disappear and the free oscillation n_0 alone, of the secondary circuit takes place, this free oscillation being of slowly damped form and depending on the natural period of the secondary circuit."

and comments on this quotation by stating that two arbitrary coupling frequencies exist and act to create a point of no energy or beat. He illustrates this action, Fig. 6, "Loftin Sketch O", opposite P. R., p. 1100, by showing two curves, one in green and one in red. Either of these

curves taken alone would illustrate correctly the electrical motion in a closed circuit of a quenched spark-gap, but the two together are not representative of the actual motion. His statement above referred to, that the two oscillations interact to produce a beat, is an inversion of the facts, a putting of the cart before the horse, because the two frequencies do not cause the beat, but are the result of the beat; that is, are the components of the particular wave form which results when the oscillations in a closed circuit are rapidly reduced to zero; and physically, there is only one sort of motion taking place in a closed circuit employed with the quenched spark-gap transmitter, and that is the sort of motion which could be correctly indicated by one or the other of the curves of Fig. 6 of "Loftin Sketch O", opposite page 1100 of the Printed Record.

While, as I have already pointed out, the term "beat" is used in connection with that type of wave form which waxes and wanes, it is incorrect to use it in connection with the sort of motion indicated by one of the curves of Fig. 6, for the reason that there is not true waxing and waning indicated here, but simply one period of waning.

Mr. Loftin, on page 1101 of the Printed Record, extends his explanation of the quenched-gap action and brings out the fact that the oscillations of the antenna circuit, after the spark-gap has quenched or gone out, continue in accordance with the natural period of the antenna itself, and concludes with the statement as follows:

"It is seen that this is a system entirely different from that described by Marconi, which Marconi system has been termed by the art the 'open gap system'."

With this conclusion I disagree most emphatically, for reasons extensively set forth based, I believe, on a sound foundation.

Mr. Loftin continues, page 1101 of the Printed Record, to differentiate between the Marconi system and the quenched-gap system. He states:

"In the open gap system, no beats are produced, first, because it is required that the primary circuit determines or sets the pace for the one frequency of the system and to produce beats there must be two frequencies."

My own experience with open gaps of various kinds has indicated conclusively that the production of the so-called

beat is not the property of the quenched-gap alone but, on [fol. 1303] the contrary, that all types of spark-gaps have this same characteristic and that the difference between them is only one of degree.

In all cases the best adjustment in practice is that adjustment of the coupling which is sufficiently close to extract the maximum energy without being too close and thereby allowing the open circuit, by its action on the closed circuit, to re-ignite the spark gap, and so produce the complex wave form. When this adjustment is effected the oscillations in the closed circuit will be reduced down to zero and then stop, in the manner shown in Fig. 6 of "Loftin Sketch O", either the red or green curve alone, but in the case of the open gap, more oscillations will take place in this circuit than when the quenched gap is used. This does not mean that the gap has anything to do with the number of oscillations which take place, because that is determined by the coupling, but the more effectively the gap cools, the more closely may the circuits be coupled, without re-igniting the gap.

Recognition of this action of the gap is shown in the work carried on continuously and referred to by witnesses in this case directed toward improving the means for cooling the gap and the quenched gap is merely the most satisfactory solution of this problem up to the present time. In this quotation Mr. Loftin again refers to the two frequencies as the cause of the beat, and not, as is actually the case, as the result.

He gives as his second reason for differentiation (P. R., p. 1101):

"* * * because the primary must be persistent and have its oscillations drawn out for a long time, and it cannot be persistent if it quickly transfers all of its energy to the secondary to produce the beat required in the quenched gap system, and the oscillations in the primary will not be long drawn out; * * *"

This statement is a repetition of Mr. Loftin's oft-repeated contention that the Marconi system must be persistent and have the oscillations drawn out for a long time.

As I have frequently stated, in the course of my testimony, there is nothing in the Marconi patent, which I can find, or which Mr. Loftin's testimony has called my atten-

tion to, which requires that the oscillations in the primary circuit should be persistent or long drawn out, but merely the use of the term "persistent oscillator" to describe a form of circuit when considered by itself; a form which is the same in the Marconi patent and in the quenched spark-gap transmitter. The persistence, or otherwise, of the oscillations in the closed circuit of the transformer, is determined by the degree of coupling with the secondary circuit; the closer the coupling, the fewer the oscillations, and *vice versa*.

Mr. Loftin gives a third basis for differentiation (P. R., p. 1101), as follows:

"* * * third, because in the open-gap system, the primary must act as a reservoir and slowly feed energy to the secondary to persistently make up for the energy expended by the secondary in radiating for useful communication, whereas in the quenched-gap system the energy is quickly [fol. 1304] dumped into the secondary during which period there is no useful radiation, and when the secondary is usefully radiating, the primary is entirely out of action and supplies no energy; * * *"

This statement starts by requiring the primary of the Marconi system to slowly feed the energy to the antenna, while it describes the action of the quenched-gap circuit as being a quick dumping of the energy into the secondary circuit.

These are distinctions and differences existing only in Mr. Loftin's language since, in fact, there is no requirement upon the closed circuit of the Marconi arrangement that it should slowly feed the energy to the secondary circuit, and the practical use of the Marconi arrangement has always involved a transfer use of the Marconi arrangement has always involved a transfer of this energy which is as rapid as the spark-gap wil permit. On the other hand, in the quenched spark-gap transmitter the energy is by no means quickly dumped into the antenna circuit, but requires, usually, quite a number of oscillations;—somewhere about ten, as I recollect my experience—while, if the energy were quickly dumped, as described by Mr. Loftin, there would exist in the primary circuit a "pulse" of the sort shown in "Claimant's Exhibit No. 248", Fig. 2, for instance, page 76, and the upper curve of this figure.

A fourth distinction given by Mr. Loftin (P. R., p. 1101), is as follows:

"* * * there must be a resonant transfer of energy between the primary and the secondary in the open-gap system, because the primary is always and continuously supplying energy at a particular desired frequency to the secondary, and the secondary must have the same natural period of oscillation as the frequency of the oscillation from which it is being fed to obtain an efficient transfer at the slow rate of feeding, whereas in the quenched gap system there is no resonant transfer, the energy merely quickly going over at two widely separated frequencies, neither one of which corresponds to the natural period of either the primary or secondary circuit."

In this statement Mr. Loftin again requires the Marconi arrangement to be "always and continuously supplying energy at a particular desired frequency to the secondary." The Marconi patent 763,772 says nothing about any necessity for acting in this particular way and experience with its use indicates that such is not the fact. The patent, furthermore, says nothing about the transfer of energy at a particular frequency, and the physical facts relative to the transfer of energy in this manner are, as already stated, that that thing which is technically and mathematically known as a frequency, has nothing to do with the efficient transfer between two circuits oscillating in their own natural manner.

There might perfectly well be a dozen frequencies; that is to say, a wave form of such shape that it was analyzable into a dozen frequencies; yet, so long as the time-period of the driven circuit corresponded with the time-period of the resultant motion of the electricity in the driving circuit, resonance between the circuits would be the controlling element of transfer of this energy.

[fol. 1305] This statement is an answer to Mr. Loftin's statement in the above quotation, relative to the secondary having the same natural period of oscillation as the frequency of the oscillation from which it is being fed. Mr. Loftin's concluding statement, of course, shows the reason for his attempt to confine the Marconi arrangement to a transfer of the energy at one frequency, because in this statement he differentiates the quenched-gap arrangement

by stating that the energy goes over quickly at two widely separated frequencies. This is a distinction based, first of all, on the use of the term "frequency" in a way which is quite misleading and, secondly, on a mode of operation of the Marconi arrangement which is incorrect in point of fact. Actually, and for the moment, using Mr. Loftin's own language, the coupling in a properly-operated open-gap set of the Marconi type is of such closeness that the primary oscillation dies down to zero, while the secondary oscillation continues for some time thereafter.

This is the transfer of the energy by means of two frequencies in Mr. Loftin's language, and it differs from the action of the quenched-gap transfer solely in the fact that the primary oscillation dies out more slowly, due to the less perfect cooling of the gap, and the "two frequencies" are not so different from each other as with the closer coupling and the quenched gap. This language, however, is technically incorrect as a means of describing the action taking place when energy is transferred between two circuits, since it is the resultant motion of the electricity, which may be analyzable into many frequencies, and its relation to the natural time-period of the two circuits which determines the transfer.

This, of course, goes somewhat into theories which are difficult to understand, and to my mind the whole story is best summed up in the statement that the coupled circuits of a spark transmitter, regardless of the type of spark, have to be tuned to get good results; when this is done, the requirement of the Marconi patent, viz., the product of the inductance and capacity in one circuit equals the product of the inductance and capacity in the other circuit.

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On Printed Record page 1107 Mr. Loftin summarizes his point of view relative to the transmitter of "Plaintiff's Exhibit No. 87", and states that it is entirely different from the transmitter of the Marconi patent No. 763,772, which he incorrectly designates as the open-gap type. His summary is divided into five parts, and in the first he states that the [fol. 1306] apparatus of "Plaintiff's Exhibit No. 87" is based upon the principle of Lodge, viz., quickly dumping the energy into the radiating circuit, and then disconnecting the closed circuit, while the Marconi transmitter requires that oscillations be maintained for a long time in the

primary circuit. As I have already pointed out, Lodge does not function in the manner hoped for by Lodge, and stated by Mr. Loftin, but in a non-descript and useless manner.

As I have also already pointed out, the quenched spark-gap neither operates on the basis of Lodge's principle, nor his apparatus but, on the contrary, functions in exactly the same way as a Marconi transmitter with an open spark-gap, the difference in the spark-gap not resulting in a different mode of action, but merely an improvement in the mode of action of the open gap.

His second point again contains the statement relative to the energy going over in two frequencies but, as I have already pointed out, this incorrect description in the method of transfer of the energy between the closed and open circuits, if used at all, applies equally well to the open gap as to the quenched gap.

His third point is his oft-repeated statement that the arrangements for the adjustments of the two circuits; that is, the tuning adjustments, are for entirely different purposes; that is, in the case of the Marconi transmitter, for the purpose of transferring the energy; while in the quenched-gap, it is for the purpose of producing a beat.

This statement is, of course, nonsensical and the purpose of tuning in both open-gap Marconi gap transmitters and quenched-gap transmitters is to get the energy over into the open circuit as efficiently as possible, which is the same thing as saying as quickly as possible; since, the longer it circulates in the closed circuit the more energy is there wasted in this circuit, and the less available for radiating purposes. The so-called "beat" is an incident in the operation of both types of gap and the difference between the two types is merely that the so-called "beat" is shorter with the quenched-spark than with the open spark.

His fourth point states that the quenched-spark system depends upon a tight coupling between the two circuits,—a statement which is entirely incorrect, because the quenched-spark system will operate with a wide variety of couplings functioning in exactly the same manner with all of them, but becoming more efficient as the coupling is closed up.

In general, the maximum coupling usable with the quenched-gap is about twenty per cent, while the maximum coupling which I recollect as being embodied in the Mar-

coni arrangement, that is to say, the actual constructions outlined in the patent, is about nineteen and a half per cent.

The action of a Marconi tuned coupled transmitter with the quenched-gap is the matter of different couplings, is identical with the action of the same transmitter with an open type of gap, and in both cases the coupling is made as close as possible, without re-ignition of the spark gap.

In this point Mr. Loftin again refers to the two frequencies as being an object of the adjustment; whereas, as a matter of fact, they are merely an incidental result.

[fol. 1307] His fifth point is that when the quenched-gap is employed as part of the tuned coupled transmitter and signals from it are received by a two-circuit receiver, that the resulting system is a three-circuit system, since the spark-gap circuit only acts for a small part of the time. This is a most peculiar reasoning, and its fallacy is so obvious that it hardly seems to need comment. Nevertheless, I will merely state that under the circumstances above specified, the complete radio system consists of four circuits, two at the transmitter, two at the receiver, and all four tuned to the same time-period. Of course, the Marconi patent says nothing about how long the closed circuit shall remain in action, but merely specifies its use. There is also the additional technical fact that the quenched-gap does not differ from any other type of gap in the matter of cutting off the oscillations in the primary circuit, except in degree. That is to say, it will stand a closer coupling without re-ignition and, therefore, fewer oscillations in the closed circuit.

On page 1109 of the Printed Record Mr. Loftin takes up the receiving system of "Plaintiff's Exhibit No. 87", but prefaces his remark by a repetition of his statement already answered, that the complete system is a three-circuit system. He introduces an additional statement to the effect that the Marconi open-gap system requires a precise adjustment, while the apparatus of "Plaintiff's Exhibit No. 87" requires only three adjustments.

This statement is entirely contradictory to the facts, since in both cases, as I have many times pointed out in my deposition, all four circuits are in tune; are found to be in tune by extensive practical experience, and the precision of adjustment required with either the open-gap or quenched-gap is the same.

I may say in this respect that I have used in the same arrangement; that is, the same transmitter, antenna, etc., first an open-gap and then a quenched-gap, adjusting both for best results, and found that the tuning adjustments necessary to bring the two circuits into tune were the same in both cases.

The quenched-spark apparatus, contrary to the statement of Mr. Loftin, and for reasons already given, bears no resemblance to the Lodge arrangement, either in theory or in action, except that it employs the Lodge variably-acting coil.

Mr. Loftin's further statement on this page, to the effect that Lodge implied tuning in the secondary of his receiver, has already been contradicted in my previous answers, and the same remarks apply to his statement at the bottom of this page, that the Marconi 1899 patent disclosed a tuned secondary circuit.

Q. 217. Will you please state whether or not you agree with Mr. Loftin's answer to Q. 30 of his deposition on page 1109 of the Printed Record, as to the matter of the relation of the Wireless Specialty type of apparatus to the language of the individual claims sued on in Marconi patent No. 763,772?

A. I do not agree with Mr. Loftin's statements but, on the contrary, consider that the Wireless Specialty type of apparatus completely meets the requirements of the claims referred to.

While Mr. Loftin, in his reply to Q. 30, sets forth in de- [fol. 1308] tail the reasons for his opinion, his statement includes no points which are new, and which I have not already answered in my detailed consideration of these claims and the mode of operation of the quenched spark-gap type of transmitter. I will therefore content myself with the general statement that, in my opinion, the reasons set forth in Mr. Loftin's answer to Q. 30 for his belief that the apparatus of "Plaintiff's Exhibit No. 87" is not covered by the claims of the Marconi patent 763,772 do not rest on a sound basis of either technical fact or the state of the prior art at the time of the Marconi application.

Q. 218. Referring to Mr. Loftin's answer to Q. 32 on page 1117 of the Printed Record, will you please state whether or not you agree with Mr. Loftin's statements concerning the "Atlantic Communication Company Type" and the

"Signal Corps Pack Set, 1915 Type"? Please give your reasons for your answer.

A. I do not agree with Mr. Loftin's statements on Printed Record page 1117 relative to the Atlantic Communication Company Type of receiver and the Signal Corps Pack Set receiver. Mr. Loftin quotes Mr. Waterman's statement relative to the capacity of the coil supplying the necessary capacity for tuning and states the same line of argument would lead to the conclusion that the Lodge secondary winding is a tunable circuit. No such conclusion is warranted or justified. The Telefunken type of receiver is made adjustable as to the number of turns, and this number of turns is so chosen that each tap is broadly tuned over a small range.

As I have previously pointed out in answer to Q. 202, a secondary circuit of the receiver containing a crystal detector, may be broadly tuned, and this is particularly true when the only capacity in this circuit is the inherent capacity of the coil, which is small.

With the method of connection of the detector to this circuit, such as that employed in the Telefunken receiver, the effect of the crystal detector is to add a large damping to the receiver circuit and make the tuning quite broad. In order, however, to take advantage of this situation, knowledge relative to the benefit of tuning this circuit, as was disclosed by the Marconi patent, is necessary. That Lodge was not aware of the benefits of such tuning, and did not employ it, has already been pointed out, and while it is true that the secondary coil of his receiver would have inherent capacity, this fact does not signify tuning. Had Lodge been aware of the benefits of tuning he could have adjusted the number of turns in his secondary coil and provided this with some variably-acting adjusting means, as in his transmitting coil; or, rather, as in the coil included in the antenna circuit, and so have secured tuning. It is no more correct to infer that he might have tuned his secondary circuit in this way than to infer that he might have tuned it with a condenser. Since he did neither of these things, I am unable to consider that Lodge has any bearing on the Telefunken receiver.

In so far as the Signal Corps Pack Set of "Plaintiff's Exhibit No. 91" is concerned, I am of the opinion that the short-wave arrangement shows two tuned circuits, one con-

sisting of the antenna, the two coils marked "Primary" and the ground, and the other—the secondary circuit—consisting of the two coils marked "Primary", the two con- [fol. 1309] densers marked "Fixed Coupling Condensers" and the coil marked "Secondary". The two coils marked "Primary" allow of the independent adjustment of the antenna circuit, since they are variable, while the variable coil marked "Secondary" permits the tuning of the secondary circuit.

In so far as the coupling is concerned, it will be seen that the two coils marked "Primary" are common both to the antenna circuit and the secondary circuit and therefore constitute a direct coupling, which Mr. Loftin has admitted is equivalent to the inductive coupling of the Marconi patent No. 763,772.

While there are two condensers marked "Fixed Coupling Condensers", I am unable to see how they are capable of functioning for this purpose, in the location shown, but appear to me merely to supply the necessary capacity in the secondary circuit to tune with the secondary inductance.

In so far as the figure marked "Long Wave Lengths" is concerned, I am unable to state from the available information, whether or not the secondary circuit is tunable.

Q. 219. On page 1118 of the Printed Record, Mr. Loftin criticizes the diagrammatic sketches constituting "Plaintiff's Exhibit No. 79" (Telefunken Apparatus); "Plaintiff's Exhibit No. 101" (Lowenstein Apparatus) and "Plaintiff's Exhibit No. 102" (Foote-Pierson Pack Set), as illustrating two windings, one in black and one in red. Please state whether or not you consider Mr. Loftin justified in so interpreting the diagrams of these exhibits, and if not, why not?

A. Mr. Waterman, in his testimony, on page 181 of the Printed Record, has very clearly stated that the coil which he has shown in red and black has only one winding, but that the two colors are used simply to distinguish the two circuits, viz., the open circuit and the closed circuit, both of which go through this coil, from each other. It appears, therefore, that Mr. Loftin's statement on page 1118 of the Printed Record is without justification from the testimony of Mr. Waterman.

Q. 220. Referring to Mr. Loftin's testimony concerning the apparatus at the receiving station, involving the Telefunken type and the Foote-Pierson type of apparatus,

please state whether or not you agree with Mr. Loftin that these receivers "had untunable secondary circuits". Please consider "Plaintiff's Exhibits Nos. 79" and "102" and Mr. Loftin's testimony on Printed Record page 1119 relative thereto.

A. Mr. Loftin has referred to these two receivers illustrated in "Plaintiff's Exhibit No. 79" as E 4, and "Plaintiff's Exhibit No. 102", the right hand figure, the former being the Telefunken receiver, and the Foote-Pierson Pack Set.

The drawing E 4 shows a variable secondary winding and happens to be a type of Telefunken receiver with which I am familiar, and which I have tested numerous times. This secondary receiver has taps brought out to a plug-type of switch and the length of winding is so adjusted for each tap that it is broadly tuned over a certain range; the different taps in the coil serve to cover the entire range which the receiver is designed for.

The Foote-Pierson type shown in "Plaintiff's Exhibit [fol. 1310] No. 102" is direct-coupled, and the antenna circuit is tunable by means of the variable contact point 4, while an adjustment of the variable contact point 5 will connect in circuit a number of turns which, in connection with their own capacity, will tune the circuit.

In general it will be found that more of the coil will be included by tap 5 than by tap 4, when the circuits are in tune.

I therefore disagree with Mr. Loftin's statement to the effect that these two receivers have secondaries of the untunable type, and state, on the contrary, that I consider both of these secondaries to be tunable, and to have the means necessary for tuning described in the Marconi patent 763,772.

Q. 221. On page 1120 of the Printed Record, Mr. Loftin refers to the testimony of George H. Clark as found on page 239 of the Printed Record, concerning wave changers. And on page 1121 of the Printed Record he states that the adjustment of the inductance of the two circuits in which the device was connected, does not mean that the adjustment was for the purpose of securing resonance between these two circuits, as contended by Mr. Waterman. Will you please state briefly what experience you have had with such wave changers as referred to by Mr. Waterman and Mr. Loftin and in view of your knowledge of the operation

of wave changers, will you please state in what respects you may disagree with Mr. Loftin? Please also refer to the rebuttal deposition of George H. Clark wherein, in answer to Q. 40, he refers to the same subject, and state whether you agree with Mr. Clark.

A. It happens that I have had a great deal of experience with the type of wave changer referred to by Mr. Clark in his testimony and, in fact, designed by him.

During the War the Marconi Wireless Telegraph Company of America built large numbers of quenched spark-gap transmitters of the type referred to, having wave changer switches and during this time I was Chief Engineer of the Marconi Company, and supervised the work of design, manufacture and testing of these wave changers.

Mr. Loftin, in his comment on Mr. Clark's testimony, goes rather extensively into a description of the apparatus and then states, Printed Record, page 1121, as follows:

"* * * The mere fact that these wave changers included arrangements for adjusting the inductance of the two circuits in which the device was connected does not mean that the adjustment was for the purpose of securing resonance between the two circuits as contended by Mr. Waterman, for in the quenched-gap type, resonance between the two circuits is not used, and the adjustments are for an entirely different purpose."

This statement is merely Mr. Loftin's oft-repeated contention that the circuits of the quenched-gap transmitter are not tuned, and it seems sufficient for me to state that I know from my own long experience, that they are tuned.

Mr. Loftin makes the statement to the effect that if the wave changers were for the purpose of securing resonance, they would apply equally well to the prior art, but it does [fol. 1311] not appear to me that there is any particular connection between the wave changer switch and the prior art on the Marconi patent No. 763,772.

The wave changer switch is simply a convenient means of connecting the right number of turns in the primary circuit and the right number of turns in the secondary circuit for different wave lengths, in order that these two circuits may be in tune.

* * * * * * *

Q. 222. Will you please refer to Mr. Loftin's answer to Q. 33 on page 1124 of the Printed Record and "Loftin Sketch P", inserted opposite said page, and after examining "Plaintiff's Exhibit No. 98" will you please state whether Mr. Loftin's diagram purporting to illustrate the circuits of the Foote-Pierson Pack Set is correct, and if not, please state how it is incorrect, and submit a correct diagram?

A. I have examined "Plaintiff's Exhibit No. 98", which I understand represents the Foote-Pierson Pack Set", and contains a wiring diagram of the transmitter and receiver connections. I have traced out these connections and I find that the receiver circuit connections shown on "Loftin Sketch P" do not correspond to the receiver connections shown in "Plaintiff's Exhibit No. 98".

I produce "Weagant Sketch No. 3" (Claimant's Ex. 251), which sketch shows the receiver connections as I find them in "Plaintiff's Exhibit No. 98". An examination and comparison of the two sketches, viz., "Weagant Sketch No. 3" and "Loftin Sketch P" shows that in the former there is a circuit P, R, connected around the stopping condenser H and in the latter that this same circuit is connected around the detector.

It will also be noted in "Weagant Sketch No. 3" that the telephones have one terminal which connects directly to ground; whereas, in "Loftin Sketch P" one terminal of the potentiometer is connected to ground.

Q. 223. In view of the differences you have pointed out between "Loftin Sketch P" and "Weagant Sketch No. 3" which, you have stated, shows correctly the circuit connections of "Plaintiff's Exhibit No. 98", will you please point out whether or not the circuit at the "Receiving Station" of "Weagant Sketch No. 3" is within the terms and spirit of the claims of Marconi patent in suit No. 763,772, relating to receiving apparatus?

A. The receiving apparatus of "Weagant Sketch No. 3" complies with the requirements of the claims of the Marconi patent No. 763,772, particularly claims 2, 13, 14, 16, 17, 18 and 19.

Mr. Vaill: Counsel for claimant offers in evidence the [fol. 1312] sketch produced by the witness and marked "Weagant Sketch No. 3", as "Claimant's Exhibit No. 251".

(Said exhibit so marked.)

Q. 224. Will you please refer to Mr. Loftin's answer to Q. 35, beginning on page 1125 of the Printed Record, and state wherein you may agree or disagree with the statements in the publications referred to by Mr. Loftin in that answer?

. . . . . .

A. Before taking up in detail the publications referred to by Mr. Loftin in his answer to Q. 35, there are certain facts characteristic of a number of them, to which I wish to call attention.

Examination of the article by Fleming, in the London "Electrician", June 11, 1909 ("Defendant's Exhibit B-5"), the article in "Electrician", November 10, 1911 ("Defendant's Exhibit C-5"), which is unsigned, the Zenneck "Wireless Telegraphy", 1915, translated by Seelig, page 94 ("Defendant's Exhibit D-5"), and the book entitled "Wireless Telegraphy and Telephony", by Eccles, 1918 ("Defendant's Exhibit E-5"), discloses the fact that the diagram entitled Fig. 1, in the article by Fleming, which purports to show the action taking place in closely coupled transmitting circuits with an open spark-gap and closely coupled transmitting circuits with a quenched spark gap, is the same in all of these articles.

The same figure is also used in the article by Count Arco, referred to by Mr. Fleming in his paper of "Defendant's Exhibit B-5". This examination also discloses the fact that the information contained in these articles is of substantially the same nature and these facts bring out the important point, well known to technical workers, that technical writers have the habit of embodying in their own works information which is largely obtained from some other writer and which is based on very little in the way of actual experience of their own.

In none of these articles is there any statement of extensive use of the quenched spark-gap system, or anything suggestive of such extensive use, except the unsigned article in the "Electrician" of November 10, 1911, "Defendant's Exhibit C-5".

This is in striking contrast with the sort of thing which is back of the statement, for instance, in the Navy Manuals, and which I have previously quoted. Also a very different thing from the long practical experience, such as that of

the witness, George H. Clark in this case, and of the present witness.

[fol. 1313] Gentlemen like Dr. Eccles, Prof. Fleming and Dr. Zenneck, are College Professors, and when investigating a subject like that of the quenched spark-gap transmitter as a rule, have neither the time, interest or facilities approaching those of the practical man working for a large institution such as the Government, or a commercial organization, and whose work is dominated by the necessity of making the apparatus work as efficiently as possible.

Referring once again to the diagram of Fig. 1, I wish to point out that this particular diagram has been used by practically everyone who has written about the quenched spark-gap, and it seems to me of interest at this point to present a few facts relative to its origin.

A search of the literature seems to indicate that its first appearance was in Zenneck's book on "Wireless Telegraphy", page 94, of Seelig's translation, "Defendant's Exhibit D-5", and the only supporting technical data for Fig. 131 is the oscillograph photograph of Fig. 132, and supporting technical data is given for Fig. 130 in Zenneck, namely, an oscillogram by Diesselhorst. I find, also, in the paper by Count Arco, the statement to the effect that the same figure in his paper is based on an oscillogram by Diesselhorst.

It will be noted that in Fig. 130 and Fig. 131 the number of oscillations in the primary circuit is the same,—which, to say the least,—is a most remarkable coincidence. That two different experimenters, working independently, should so adjust their circuits, and particularly the coupling, as to correspond in this exact way, is incredible.

The oscillogram of Fig. 132 is stated by Zenneck to have been due to H. Rau, but an examination of his paper fails to disclose the necessary technical data to enable an Engineer to determine the nature of the apparatus; that is, the quenched-spark apparatus, from which this oscillogram was made, and from my experience with matters of this kind, I unhesitatingly pronounce the oscillogram of Fig. 132 as without significance.

Fig. 130, as previously mentioned, is based on an oscillogram by Diesselhorst which is shown by Zenneck on page 89 of "Defendant's Exhibit D-5", Fig. 124 and it is evident from an inspection of this figure that it is rather difficult to identify, with any degree of exactness, the curves

of Fig. 130 with the result shown in the oscillogram of Fig. 124.

In spite of the lack of sound fundamental technical data on which to base Figs. 130 and 131, these two diagrams have been used to explain the quenched spark-gap action and its relation to the open spark-gap for many years, and have created impressions relative thereto which, in my opinion, are not in accordance with the facts.

As an illustration of the general nature of the phenomena when a closely coupled open spark-gap and a closely coupled quenched spark-gap are used, it is all right in that it brings out the fact that the quenched spark-gap cuts off at the first point of zero amplitude of the primary oscillations, but it is quite incorrect, in so far as showing the actual number of oscillations which take place in the primary circuit.

[fol. 1314] While I do not find in any of the literature any statement that the number of oscillations so shown is representative of the actual facts, nevertheless, I do know that this diagram has been accepted by many workers in the art as such an actual representation.

My own experience indicates that in the quenched spark-gap circuit the number of primary oscillations is some nine or ten and I recollect that Dr. Zenneck, the author of the text-book "Wireless Telegraphy", testified in the Kilbourne & Clark case, as follows (Printed Record, p. 3615):

"Q. You testified in that case as follows, did you not:

'X Q. 47. How many complete periods of oscillations in the primary circuit of the Sayville transmitter do your decrement measurements prove to have existed before the oscillations were damped down to 10 per cent of the maximum?

'A. I have not calculated this.

'X Q. 48. Could you do so?

'A. Yes, I could do it, but it would take some time. It is very easy to calculate it.

'X Q. 49. Could you do so in a few minutes?

'A. I can give you the formula and perhaps you could calculate it yourself.

'X Q. 50. I would prefer, Dr. Zenneck, if you would calculate it and state what the result is from your own formula?

'A. Yes, I can do it. If I have not made a mistake the result is 9.2. That would mean that after nine periods, the amplitude of the current is about one-tenth or 10 per cent of the initial amplitude.'

"You remember so testifying?

"A. I remember that I testified in this way." • • •

I also recollect that I heard Dr. Zenneck give this testimony in the suit of the Marconi Wireless Telegraph Company of America *vs.* The Atlantic Communication Company, which testimony was introduced into the Kilbourne & Clark case and is quoted above.

The Sayville station, as I have previously pointed out, employed a quenched spark-gap transmitter of large power, and I have personally inspected the apparatus and seen it in operation.

As will be seen, Dr. Zenneck's own statement while testifying under oath, corresponds with my own figure, and is quite different from his own diagram of Fig. 131, which shows only three and a half oscillations.

The article in the "Electrician" of November 10, 1911, which is unsigned, is one with which I have long been familiar, and is in the nature of advertisement and propaganda, such as is commonly employed by commercial companies to bring their goods to the attention of the public.

There is also a further point to be considered in connection with this article, viz., that the Telefunken Company, whose apparatus is herein described, was a large German commercial organization and, in the employment of their system, that is, the quenched spark-gap system, was obliged to meet the situation created by the existence of the Marconi tuning patent, No. 763,772, and corresponding patents in foreign countries. There was obviously, therefore, the strongest possible reason for the presenta- [fol. 1315] tion of statements tending to differentiate their system from that of the Marconi Company, and the Marconi patent.

Since tuning between all four circuits is such a vital part of the Marconi system, any lack of such tuning which could be shown in the Telefunken system would support their position. Fig. 3, on page 172 of the "Electrician" of November 10, 1911, "Defendant's Exhibit C-5", is a curve which purports to show the necessity for mistuning

and is, I believe, the basis for the widespread belief amongst many technical radio workers that such a mistuning was a necessity and one of the first things which I had to determine when I first took up quenched spark-gap work—some time about 1911 or 1912—was the correctness, or otherwise, of this curve.

My experimental work very soon showed that the curve was incorrect; a fact which has been further conclusively substantiated by many years of extensive practical experience with the quenched spark-gap. Not only did this experience show that the information contained in Fig. 3 was false, but it also showed just how this information was obtained.

Referring now to Zenneck's "Wireless Telegraphy", "Defendant's Exhibit D-5", there are two statements of great significance, one of which is that quoted by Mr. Loftin on Printed Record, page 1130, as follows:

"The pureness of the pulsations probably also plays a part in the explanation of the fact that by bringing the primary and secondary circuits slightly out of resonance, a pure quenching can be obtained, after the quenching has been spoiled with primary and secondary entirely in tune."

and which he contends supports his statements relative to mistuning, and another, which is quite different, from page 96 of his book:

"b. Pureness of the Pulsations. It is most favorable for the quenching action if the amplitude of the resultant oscillation in the primary circuit really becomes *zero* after the first half pulsation, that is, if the pulsations are pure. The essential condition for this, however, is that both oscillations, after half a pulsation, have the same amplitude but are opposite in phase.

"Whether this condition obtains depends upon the accuracy of the tuning between the primary and secondary circuits; the more exact the tuning, the purer will be the pulsations, other things being equal." (Fig. 133.)

* * * * * * *

"Moreover, even with perfect tuning, it is evident that the pureness of the pulsations depends upon the initial amplitude of the two oscillations and their decrements."

This latter statement is perfectly clear to the effect that in order to obtain a pure pulsation, that is, in order that the primary current may be reduced at zero, which is the condition stated by Zenneck for good operation of the quenched spark-gap, the circuits must be perfectly tuned.

The first statement by Zenneck, referred to by Mr. Loftin, [fol. 1316] has a totally different significance and means that if an incorrect coupling is used with the quenched spark-gap, a slight mistuning will cause it to quench. This is the condition of affairs which Fig. 3 of the "Electrician" of November 10, 1911, "Defendant's Exhibit C-5" illustrates, and it is the condition which has formed the only technical basis for the contention that the quenched spark-gap circuits must be de-tuned. While this is a condition which can be obtained in the operation of the quenched spark-gap transmitter, it is not the condition which obtains in actual practice, for the simple reason that when the circuits of the quenched spark-gap transmitter are tuned, and the coupling is correct, the results are superior to those obtained when the coupling is incorrect and the circuit slightly mistuned. This latter, which is the adjustment referred to in Mr. Loftin's quotation from Zenneck, merely illustrates the fact that the mis-adjustment of one of the adjustments of a quenched spark-gap transmitter, viz., coupling, can be partially compensated for by another mis-adjustment; a state of affairs quite common in radio circuits, but one which is never employed for the purpose of properly operating the apparatus.

Prof. Fleming, in the paper of "Defendant's Exhibit B-5", referred to by Mr. Loftin, gives merely a brief explanation of some little experience which he has had with the quenched spark-gap, which follows largely the paper by Arco, and which does not contain anything additional to that paper, except the curious statement that when he placed his cymometer alongside of the primary circuit in the quenched spark transmitter, it failed to show any oscillations therein, and he concludes from that that there are no oscillations taking place in this circuit.

There is an obvious mistake of some sort, since it is a fact well-known to every worker in radio, that a wave-meter, which is the ordinarily employed equivalent of Fleming's cymometer, responds very vigorously to the oscillations in the primary circuit, and I have myself made this test very many times.

The mistake in Prof. Fleming's tests is undoubtedly responsible for his statements, such as the following: "excites the free oscillations in the secondary circuit by shock", and I am quite sure that Prof. Fleming's comments along this line would have been quite different had he succeeded in getting his cymometer to work properly when coupled to the primary circuit.

Mr. Loftin, in referring to the second paper by Prof. Fleming in the London "Electrician" of June 11, 1909, "Defendant's Exhibit B-5", entitled "The Utilization of the Total Radiation from an Inductively Coupled Antenna in Radio Telegraphy," quotes the following (Printed Record, p. 1127):

"The primary spark is then quenched with great rapidity and the action upon the secondary or antenna circuit is of the nature of a blow or shock, setting up the free oscillations of the secondary. For this reason this method of excitation is called, in Germany, 'Stosserregung'."

Reference to the paper by Count Arco shows that this statement by Dr. Fleming is somewhat careless, since the following appears in the Arco paper:

[fol. 1317] "When, however, the idea of the 'Stosserregung' is taken up, these six half

Fig. 2.

oscillations have to be combined into one blow. Zenneck defines a good sender for 'Stosserregung' by saying that the oscillations in the primary system must be quenched after the first period and after the primary system has given up all its energy to the secondary system. For this reason the Wien arrangement belongs naturally to this class; but in spite of this there arises the question whether it could be called a 'Stosserregung' pure and simple. The arc lamp with a large primary condenser is much more a 'Stosserregung', as the quenching can be obtained after the second half oscillations, and tuning between the two circuits is hardly necessary."

This quotation indicates that even Count Arco, who was the technical head of the Telefunken Company, was not prepared to assert that the quenched spark-gap system employed by his Company, was capable of functioning on a

shock-excitation basis. In fact, it brings out that he considered another arrangement, viz., an arc lamp with a large primary condenser, as being much more a shock excitation device.

I have already discussed Fig. 3 of the "Electrician" of November 10, 1911, and I note that, in referring to this exhibit ("Defendant's Exhibit C-5"), that Mr. Loftin has quoted the following statement (P. R., p. 1128):

"To give the best result it is necessary that the reaction of the secondary circuit should assist the quenching in the primary, and for the reason the two circuits are slightly mistuned, namely, to the extent of about 2 per cent. The closer the coupling the greater must be the mistuning."

This is a statement in words of the facts disclosed in Fig. 3 of this exhibit, and which is based on the action of the quenched spark-gap when an incorrect coupling is used.

While the technical facts which form the basis for this statement are contained in Zenneck's book, I consider it very significant that his book contains no statement of the sort just quoted, and to the effect that this is a necessary adjustment.

It is also significant that this statement, which refers to a possible, but inferior, adjustment as being the necessary adjustment, is not made over the signature of any recognized radio authority.

The Seibt patent, No. 1,216,615, "Defendant's Exhibit C-3", cited by Mr. Loftin on pages 1128 and 1129 of the Printed Record, in answer to Q. 35, has already been discussed in answer to Q. 199 of my deposition, and various statements from the File Wrapper and Contents quoted. One of these statements at this point seems sufficient to again call attention to the fact that Seibt considered that his invention employed the disclosures of the Marconi patent 763,772, and is as follows:

"• • • Wien did not disclose what applicant discloses—namely, means for producing powerful slowly damped free oscillations in the secondary circuit. In order [fol. 1318] to accomplish this result, which turned applicant's invention from a laboratory experiment into a practical, useful and commercial device, applicant brought the two oscillating circuits in tune with each other, coupled them in the manner described, employed a very short spark-

gap having electrodes of high thermal conductivity and used a source of electrical current having a potential capable of quickly effecting a disruptive discharge across the spark-gap." ("Claimant's Exhibit No. 245.")

Mr. Loftin next takes up Zenneck's book of "Wireless Telegraphy" and, among other things, cites a quotation, which I have already answered, relative to the slight detuning. I note, however, that he does not include the quotation from this same book and, in fact, the same page, which distinctly specifies that the circuits shall be tuned for best operation. He also refers, at the bottom of Printed Record, page 1129, to the similarity bewteen Zenneck's language and that of Lodge in his 1898 patent. It seems sufficient to point out that, as I have already shown in answer to a previous question, while language may be employed by technical writers which is similar to that in the Lodge 1898 patent, and intended to be descriptive of the action of the quenched gap, this similarity ceases when we step from the language of statements to the facts disclosed by actual operation.

Mr. Loftin also refers to Fig. 132, page 94 of Zenneck's book, and the photograph there of oscillations in a quenched-gap circuit. It would be interesting to see an Engineer attempt to build a quenched spark-gap transmitter from the information contained in the Rau article, from which Fig. 132 is taken, and which purports to be an illustration of the action in a quenched spark-gap transmitter.

In so far as any information in that article is concerned, I find it entirely impossible to form any intelligent idea as to the nature of the supposed quenched spark-gap employed for the test, and therefore consider it to be worthless.

Mr. Loftin next takes up the references to the quenched-spark methods in the book by Eccles, entitled "Wireless Telegraphy and Telephony" 1918 ("Defendant's Exhibit E-5").

The statements referred to by Mr. Loftin are little more than a re-statement of the same remarks found in Fleming's paper, Zenneck's book, Count Arco's paper and the unsigned article of "Defendant's Exhibit C-5", and are very good illustrations of the point which I have already brought out, viz., the habit which technical writers have of including in their work matters which are primarily due to someone else.

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Vol. III

TRANSCRIPT OF RECORD

Supreme Court of the United States

OCTOBER TERM, 1942

No. 369

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA, PETITIONER,

vs.

THE UNITED STATES

No. 373

THE UNITED STATES, PETITIONER

vs.

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA

ON WRITS OF CERTIORARI TO THE COURT OF CLAIMS

PETITIONS FOR CERTIORARI FILED (SEPTEMBER 2, 1942.
(SEPTEMBER 3, 1942.

CERTIORARI GRANTED DECEMBER 14, 1942.

SUPREME COURT OF THE UNITED STATES

OCTOBER TERM, 1942

No. 369

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA, PETITIONER,

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ON PETITIONS FOR WRITS OF CERTIORARI TO THE COURT OF CLAIMS

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	Original	Print
Arthur A. Isbell—		
Direct	1100	1407
T. Johnson, Jr.—		
Direct	1153	1478
Cross	1156	1483
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William J. Kinsley—		
Direct	979	1230
Cross	985	1239
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Roy A. Weagant—		
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Joseph B. Baker—		
Direct	598	734
Cross	604	743
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Walter C. Dean—		
Direct	680	847
Cross	683	852
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Edward H. Loftin—		
Direct	687	856
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Cross	840	1062
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Redirect	861	1090
Robert H. Marriott—		
Direct	932	1175
Cross	940	1185
Joseph O. Mauborgne—		
Direct	891	1128
Cross	919	1162
Redirect	931	1174
John M. Miller—		
Direct	492	585
Cross	568	683
Robert A. Millikan—		
Direct	577	706
Cross	585	717
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	Original	Print
Greenleaf W. Pickard—		
Direct	882	1118
Cross	889	1126
Frederick M. Sammis—		
Direct	952	1200
John Stone Stone—		
Direct	612	754
Cross	630	778
Redirect	674	839
	679	847
Recross	678	845

SURREBUTTAL

Edward H. Loftin—		
Direct	1693	2184
	1786	2307
Cross	1779	2298
	1786	2307
Joseph O. Mauborgne—		
Direct	1641	2116
Cross	1651	2127
John M. Miller—		
Direct	1655	2131
Cross	1672	2155

PLAINTIFF'S WITNESSES

George H. Clark—		
Direct	1798	2313
	1991	2422
	2005	2484
	2152	2516
Cross	2001	2482
Greenleaf W. Pickard—		
Direct	1821	2326
Cross	1851	2344
Redirect	1863	2350
Clarence D. Tuska—		
Direct	2007	2485
	2154	2518
	2159	2520
Cross	2136	2507
Redirect	2148	2515

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DEFENDANT'S WITNESSES

	Original	Print
Jennings B. Dow—		
Direct	1876	2357
Cross	1934	2391
Louis A. Hazeltine—		
Direct	2086	2480
Cross	2089	2481
Lester L. Jones—		
Direct	1871	2354
Robert A. Lavender—		
Direct	2157	2519
Lynde P. Wheeler—		
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It thus comes about, as in the present case, that certain statements covering a particular set of facts, are repeated from one author to another, and they therefore are not to be considered in the light of information carrying the authority of the various writers, but merely in the nature of a reprint of the original statements.

I do not find anything in the quotations from Eccles which have not already been answered, in various ways, with the exception of the statement at the bottom of [fol. 1319] Printed Record, page 1131 and top of page 1132, relative to a test showing a detuning of approximately ten per cent.

I have no hesitation in stating that this particular test is not illustrative of the fact that quenched spark-gap circuits can be detuned ten per cent. and operated efficiently, but simply is a record of the fact that Eccles made a test in which the circuits were detuned ten per cent.

There is no statement in the article that this represented the best attainable adjustment, and if there were such a statement, I should not hesitate to say that the apparatus had not been correctly handled.

Almost any result in the matter of detuning is possible in a laboratory experiment, but in actual practice only the best result is tolerated, and follows only when the circuits are tuned as accurately as possible.

Mr. Loftin's next reference is to a book entitled "Principles Underlying Radio Communication", 2nd Edition, Signal Corps United States Army, published at Washington by the Government Printing Office ("Defendant's Exhibit F-5").

He quotes from this book as follows (P. R., p. 1132):

"It is well to note that the principles of operation of the quenched gap and plain gap are exactly opposite. The former aims to stop the primary oscillations quickly, after the secondary has been brought to full activity. The latter aims to keep the primary oscillations going as long as possible, all the time giving energy to the secondary as it is radiated away; the coupling is loose and the primary decrement is kept low. The rapid decrease of the oscillations in a quenched-gap circuit is assisted by having a large ratio of capacity to inductance. This has the incidental advantage that the voltages across the condenser and coil are thus kept low."

It will be noted that this quotation does not make any distinction between the open gap and the quenched-gap in the matter of tuning, while various other Governmental publications to which I have referred in my answer to Q. 201 of my deposition, specifically direct the tuning of quenched spark-gap circuits.

It is also incorrect in point of fact in stating that the open gap arrangement aims to keep the primary oscillations going as long as possible; whereas, as a matter of fact, the actual adjustment of a plain gap set is always in such a way as to have the primary oscillations last as short a time as possible, without spoiling the wave form.

The difference in the quenched-spark arrangement and the open-spark arrangement is simply that it is possible to transfer the energy more quickly with the quenched spark-gap than with the open spark-gap, without spoiling the wave form.

I might also add that it is quite possible to use a coupling which is too close for the quenched-gap, and which will result in spoiling the wave form, just as in the case of the open spark-gap.

Both kinds of gaps are alike, and not opposite in their [fol. 1320] action, viz., that of recovering their initial high resistance and requiring some particular voltage to break it down again.

The quenched spark-gap is the result of some years of work in endeavoring to improve this characteristic of the open spark-gap, and does represent a substantial improvement.

Mr. Loftin next refers to a book entitled "Wireless Telegraphy," by Leggett, 1921 ("Defendant's Exhibit G-5"), and emphasizes considerably the fact that the author is an Englishman, also bringing out some statements in the book relative to the superior results obtained by a German Warship using the Telefunken apparatus, as compared to the results obtained by an English steamer under the same conditions.

He neglects, however, to point out that Mr. Leggett was formerly with the Technical Staff, Messrs. Siemens Bros. & Company, Ltd., which company is the agent for the German Telefunken Company.

While Mr. Loftin has included Mr. Leggett's name amongst his list of authorities, I may say that prior to taking up the work of this case, I had never heard of him

before, although I am familiar with most of the literature of this art and personally acquainted with the majority of the writers and workers of note in this art.

The statements referred to in the Leggett book do not appear to contain anything new, and which has not already been answered, but he does give one quotation which brings out a fact apparently overlooked by Mr. Loftin. This quotation is as follows (P. R., p. 1134):

"In the case of the open-gap curves when quenching does not occur, the curve will be found to have two distinct peaks of very different wave length and low current value, which is proportional to the energy radiated."

It will be noted in the above quotation that there is a qualifying phrase as follows:

"when quenching does not occur"

and the quotation expresses the fact that when an open gap is used and it does not quench, two wave lengths will be radiated. The qualifying phrase seems to indicate a recognition on the part of the writer that quenching may occur in an open gap. This is in accordance with the point which I have endeavored to make clear, viz., that quenching does occur in the open gap, but less perfectly and effectively than with the so-called quenched-gap.

Mr. Loftin then proceeds to summarize his remarks to the effect that the literature of the art supports his views. My own conclusions, for reasons already given in this answer is that even the literature which he cites contains no fundamental matters in support of his views, is largely a repetition of the same statements by these various writers which are founded not on extensive actual experience but, at most, a few laboratory experiments.

Furthermore, the major portion of the references cited derive their information from the works of Zenneck, Wien [fol. 1321] and Arco, all of whom, in one way or another, were used by the German Telefunken Company in the commercial exploitation of their apparatus.

It is further my opinion that the work of the gentlemen referred to, all of whom I recognize as men of the highest standing in this art, has been correlated and presented for commercial purposes in the article from the London "Electrician" of November 10, 1911 ("Defendant's Exhibit

(.5"), in a manner suitable to that purpose, and carrying impressions, particularly that conveyed by Fig. 3, quite different from the true significance of the work on which it was based.

It is also to be noted in connection with the references cited by Mr. Loftin, that they are all based on work done when the quenched spark-gap was new.

In contrast to these references are the Navy Manuals and Signal Corps publications which are based on years of actual experience in the use of the quenched spark-gap system, and which, as pointed out in my previous answers, state definitely and specifically that the circuits of a quenched spark-gap transmitter must be tuned.

Technical men may differ as to theories of operation, but the facts of long practical experience cannot be denied, and the published articles which have this background and source of information, and which are not written for exploitation purposes, are in agreement with each other and with my testimony, to the effect that the circuits of the quenched spark-gap transmitter are tuned.

* * * * * * *

Mr. Vaill: Counsel for claimant offers in evidence photostat copies of pages 370 to 374, inclusive, of the "electrician" (London), for June 18, 1909, containing the quotation in the last answer from page 371 and requests that the same be marked "Claimant's Exhibit No. 252."

(Said exhibit marked as requested.)

Q. 225. Will you please consider Mr. Loftin's answer to Q. 36, beginning on page 1137 of the Printed Record, and state, according to your knowledge and experience, to what extent the history of the open-gap type and quenched-gap type of transmitters correspond with Mr. Loftin's statements? Please include in your answer the significant facts concerning the Government use of such gaps, as well as those used for commercial purposes.

A. I note that Q. 36 refers to the commercial history of the *persistent* open-gap type and of the quenched-gap re- [fol. 1322] spectively, and the word "persistent" as a characterization of the open-gap type I am unable to accept. My reply will be based upon the use of what I understand to be the open gap transmitter.

Prior to the advent of the quenched gap, the open-gap type of transmitter was in very extensive use commercially, and this use continued long after the development of the quenched gap.

Practically the entire British Merchant Marine, the largest in the world, was equipped with the open gap transmitter, and it was also employed extensively on most of the Naval ships of the world, with the exception of the German Navy.

It also found employment in the United States Naval Service.

In addition to being used extensively for Marine work, the open gap type of transmitter was the pioneer in long-distance Trans-Oceanic communication and must be credited with some notable performances in this field. Messages up to some sixty-six hundred miles were transmitted by this system, and a commericial service using it, existed between England and Canada, the United States and the Island of Hawaii and also between Hawaii and Japan.

During the war, communication was maintained between England and Russia by means of this system, as well as ships at sea great distances away from England.

In the United States the United Fruit Company operated an open-spark system at New Orleans, which communicated with their ships at sea, and by means of a relay station at Swan Island, also employing an open-spark system, with Santa Marta, South America.

The Marconi Wireless Telegraph Company of America, prior to the war, had a large number of coast stations along the Atlantic and Pacific Coasts, as well as the Caribbean Sea, which stations were taken over by the Government during the war. The Marconi Company also operated a radio station at Astoria in Oregon, and Ketchikan in Alaska.

In long-distance communication the quenched spark-gap was employed at only one station in the United States, viz., Sayville, Long Island, which was constructed by the German Telefunken Company.

While the quenched spark-gap was employed by the United States Navy, they also made considerable use of the open spark-gap and the very well-known station at Arlington, Va., employed an open spark-gap of the rotary type of very large power, viz., 100 kilo-watts

This installation is the subject of a paper by Capt. (now Admiral) William H. G. Bullard, United States Navy in the Proceedings of the Radio Engineers, October, 1916. I happen to be personally familiar with this installation, since the apparatus was built by the National Electric Signaling Company, for whom I was working at the time of its construction and test.

This particular transmitter was operated for many years to communicate with Naval ships at sea, and to send out Time signals.

As has already been brought out by the witness George H. Clark, an extensive use of the open gap transmitter by the Navy continued, even when the quenched spark-gap was [fol. 1323] employed, since most of the quenched spark-gap equipments employed an open rotary gap of the non-synchronous types. Mr. Clark's testimony is found on page 231 of the Printed Record, with an illustrative diagram on page 249, and his statement relative to their use by the Navy is one which I can confirm from my own experience, as the result of building a very large number of these while Chief Engineer of the Marconi Company, and of having seen many of them built by other companies in the Navy yards.

Mr. Clark's statement on page 231 relative to the use of the rotary gap entirely during the war, is rather interesting. It happens that I was familiar with this fact during the war and the reason therefor, viz., that the interference created by the quenched spark-gap was so great as to prevent other ships communicating when it was used.

Mr. Loftin, at the bottom of Printed Record, page 1137, refers to this use in the following statement:

"* * * This of course, was a use in which dependence was being placed upon inefficiency in the matter of communication and the open-gap type was particularly suitable."

It would seem that his criterion of efficiency was rather a peculiar one and that he considers a system which could be used to maintain communication was inefficient, while one which could not be used was efficient. The actual facts of this situation are perhaps best brought out by a reference to the diagram illustrative of the quenched-spark action, such as Fig. 131. It will be noted in this diagram that the oscillations in the secondary circuit increase very rapidly

from zero to a maximum, during which time the primary decreases very rapidly.

It has already been explained that a rapid decrease in the amplitude of oscillations causes a broad tuning, but it is also equally true that a rapid increase causes the same broad tuning.

It results from this fact that a properly operated open spark-gap transmitter in which the oscillations in the primary die down more slowly, while the oscillations in the secondary increase more slowly, greater selectivity is obtained. This is a theoretical point which had been confirmed practically by the radiomen of the British Navy, and I recollect discussing the subject with a British Naval officer during the war.

It follows from this that while the quenched spark-gap transmitter is superior to the open spark-gap transmitter in so far as obtaining maximum power output with a given power input, it is inferior to the open spark-gap in so far as selectivity is concerned.

In connection with Mr. Loftin's contentoin relative to the inefficiency of the open spark-gap, referred to above, and frequently in connection with his discussion of the open spark-gap, it is of interest to note the performance of the Arlington transmitter. In a paper which appears in the "Electrical World", Vol. 61, of 1913, page 722, some technical data is given relative to this installation and the following quotation:

"The oscillations are particularly persistent, the logarithmic decrement per complete period being only .031." [fol. 1324] This represents some 150 oscillations in the antenna circuit and means extremely good selectivity, while at the same time a very large power was radiated.

While the paper referred to does not give the antenna current, I have personally seen a radiation in excess of 75 amperes, which is a radiation of the same order of magnitude as that of the Sayville transmitter employing a quenched gap.

It is thus seen that the open gap type of transmitter, when correctly coupled to give a pure wave, is still capable of a high order of efficiency in the matter of the transfer of energy from the closed circuit to the open circuit. There also appears in the paper above referred to the following statement:

"The character of radiation sent out by this equipment is very pure in its wave form, being practically seven times as good as that fixed as the legal limit by legislation which became effective last summer."

The "legal limit" referred to in this quotation is that set by the radio law, to which Mr. Loftin has several times referred.

* * * * * * *

Q. 226. To what extent are you personally familiar with the evidence taken on behalf of the parties in the case of Marconi Wireless Telegraph Company of America *vs.* Kilbourne & Clark Manufacturing Company, in the United States District Court for the Western District of Washington, Northern Division, which involved the Marconi patent No. 763,772 and Lodge patent No. 609,154, here in suit?

A. I was a witness in that case and conducted and took part in numerous tests for the plaintiff. I also witnessed various tests conducted by the defendant, including demonstrations at the University of Washington. I also witnessed tests at Harvard University, conducted on behalf of the plaintiff.

I was present practically every day in Court during the taking of the testimony at the trial.

Q. 227. In answer to Q. 37 (Page 1139 of the Printed Record), Mr. Loftin has referred to the transmitters and receivers charged to be infringements in the case of Marconi Wireless Telegraph Company of America *vs.* The Kilbourne & Clark Manufacturing Company, referred to in my previous question. How were the various transmitters designated in that suit?

A. There were three types of transmitters involved in the Kilbourne & Clark case,—one known as the "Thompson Transmitter", the second, known as the "Simpson Mercury Valve Transmitter", and a third type, installed on board [fol. 1325] the steamship Achilles, and referred to by that name.

Q. 228. I will ask you to refer to "Plaintiff's Exhibit No. 9" in the Kilbourne & Clark case and will ask you to state what connection you had with the production of that diagram.

A. The diagram referred to was made under my direction and represents the apparatus which I saw on the steamship Achilles.

Q. 229. Please now refer to "Plaintiff's Exhibit No. 95" in the present case, and I will ask you to state what connection you had with that diagram.

A. This diagram was made under my direction and is a copy of the diagram of "Plaintiff's Exhibit No. 9" in the Kilbourne & Clark case.

Q. 230. I hand you two other sheets of diagrams and ask you what these diagrams represent as concerns the Kilbourne & Clark case above referred to.

A. "Plaintiff's Exhibit No. 2" in the Kilbourne & Clark case (Claimant's Ex. =253) represents the transmitter and receiver of the apparatus installed on board the steamship Alameda. The transmitter is of the type known as the "Thompson" transmitter, and the receiver of the type known as the Kilbourne & Clark standard receiver.

"Plaintiff's Exhibit No. 68" in the Kilbourne & Clark case (Claimant's Ex. =254) represents the Kilbourne & Clark transmitting and receiving arrangement. The transmitter is known as the Simpson mercury valve transmitter, and the receiver is the standard Kilbourne & Clark receiver.

Mr. Vaill: Counsel for claimant notes that a copy of "Plaintiff's Exhibit No. 95" in the present case is found opposite page 183 of the Printed Record, which the witness has identified as the same as "Plaintiff's Exhibit No. 9 opposite page 225 of the Printed Record, in the Kilbourne & Clark case.

Mr. Vaill: Counsel for claimant offers in evidence a printed copy of "Plaintiff's Exhibit No. 2" in the Kilbourne & Clark case and requests that the same be marked "Claimant's Exhibit No. 253."

Also a copy of "Plaintiff's Exhibit No. 68" in the Kilbourne & Clark case and requests that the same be marked "Claimant's Exhibit No. 254."

(Said exhibits marked as requested.)

Q. 231. Are you familiar with the construction and mode of operation of the transmitters and receivers referred to in your last answer?

A. I am.

Q. 232. What disposition was made by the District Court in the Kilbourne & Clark case of the question of infringement by the transmitter of the S. S. Achilles and the receiver used therewith?

A. This apparatus was installed on the steamship Achilles of the Panama Steamship Company Line, which was owned by the Government.

Because of the fact that the apparatus was therefore Government apparatus, the Court held that in the light of the Act of 1910, the Court had no jurisdiction, its ruling being as follows:

[fol. 1326] "As to the apparatus furnished to the United States, this court, in view of the act of 1910 (Act June 25, 1910, c. 423, 36 Stat. 851 [Comp. Stat. 1913, § 9465]), has not jurisdiction, either over a suit for an injunction, or for an accounting. Fester Hose Supporter Co. *vs.* Taylor, 191 Fed. 1003, 111 C. C. A. 667." (239 Fed. Rep., 355.)

Q. 233. Will you please compare the transmitter and receiver of the Achilles apparatus of "Plaintiff's Exhibit No. 95" in this case with the Wireless Specialty Apparatus Company transmitter and receiver of "Plaintiff's Exhibit No. 87" in this case, and state the similarities or differences in circuit arrangements and mode of operation?

A. Both the transmitting station and the receiving station of "Plaintiff's Exhibit No. 87", the Wireless Specialty Apparatus Company type, and "Plaintiff's Exhibit No. 95", the Kilbourne & Clark type, are substantially the same: they differ in detail in the transmitter merely by the inclusion in "Plaintiff's Exhibit No. 95", Kilbourne & Clark type, of the variable inductance *d''*; the total inductance in the closed oscillating circuit in most quenched spark-gap transmitters is built in a single coil, as *d* in "Plaintiff's Exhibit No. 87", but occasionally it is split into two parts, as *d*, *d''* in the Kilbourne & Clark arrangement on the steamship Achilles, "Plaintiff's Exhibit No. 95". The receivers differ in detail by the inclusion in "Plaintiff's Exhibit No. 95" of the condenser *h*. This provides an auxiliary means of tuning the antenna circuit, but the means provided in the Wireless Specialty Apparatus type, viz., the variable inductance *a* and *f* is, in general, sufficient.

In both exhibits the secondary of the receiving system is tuned and the transmitting and reiving stations together in

both exhibits, employ four circuits, all in tune with each other.

Q. 234. Will you please make a similar comparison between the Achilles apparatus of "Plaintiff's Exhibit No. 95" and the apparatus of the type manufactured by the Navy of "Plaintiff's Exhibit No. 93"?

A. The apparatus of "Plaintiff's Exhibit No. 93" is substantially the same as "Plaintiff's Exhibit No. 95", Kilbourne & Clark type apparatus of the steamship Achilles. It differs in detail in the transmitter by having all of the inductance in the closed circuit in one coil, viz., *d*, instead of in two coils, as in "Plaintiff's Exhibit No. 95".

The receiver differs in detail by having all of the antenna inductance in one coil *j'*, instead of in two coils, in "Plaintiff's Exhibit No. 95", *j'* and *g'*, and also by having the condenser *h* connected only in series in the antenna, instead of alternatively in series or in parallel in "Plaintiff's Exhibit No. 95".

The telephone circuit shown in green in "Plaintiff's Exhibit No. 93" differs from the same circuit in "Plaintiff's Exhibit No. 95" by the omission of the battery B and potentiometer *y* of "Plaintiff's Exhibit No. 95". These differences represent merely differences in details of construction, but do not affect the mode of operation, and in both exhibits there is shown a complete transmission and reception system, embodying four tuned circuits, all four circuits being tuned together.

[fol. 1327] Q. 235. Will you please make a similar comparison between the Achilles apparatus of "Plaintiff's Exhibit No. 95" and the apparatus of the National Electric Signaling System as illustrated in "Plaintiff's Exhibit No. 105" in this case, which has been referred to *By* Mr. Loftin in answer to Q. 37 of his deposition, beginning on Printed Record, page 1139?

A. The apparatus of "Plaintiff's Exhibit No. 105" is substantially the same as the apparatus of the Kilbourne & Clark type of the Achilles installation, "Plaintiff's Exhibit No. 95". The transmitting diagram of "Plaintiff's Exhibit No. 105" shows three types of spark-gaps, viz., the plain spark-gap, the rotary spark-gap and the quenched spark-gap.

The circuit containing the quenched spark-gap differs from the Achilles, Kilbourne & Clark type only in the fact that all of the inductance in the closed circuit is contained

in one coil *d*, instead of two separate coils, *d*, *d''* of the Achilles set, which difference has no bearing on the mode of operation.

The receiving circuits of the two systems are identical, except that the condenser *h* of "Plaintiff's Exhibit No. 95" is in series with the antenna in "Plaintiff's Exhibit No. 105", instead of alternatively in series or in parallel, as in the former exhibit.

Both arrangements show a complete transmitting and receiving system with four circuits, all in tune.

I am personally familiar with the apparatus which is illustrated in "Plaintiff's Exhibit No. 105", as I testified relative to it in the National Electric Signaling Company case, and was formerly an Engineer for the National Electric Signaling Company, and took part in the design and manufacture of this apparatus.

The three different types of gap, shown in the transmitting station diagram of "Plaintiff's Exhibit No. 105", all function in the same manner; that is to say, the spark-gap has cooling and quenching capabilities, the plain spark-gap having the least, the rotary spark gap being next in order, and the quenched spark-gap having the most.

Q. 236. Will you please consider the paragraph at the middle of page 1139 of the Printed Record as to Mr. Loftin's conclusions concerning what types of spark-gaps were included in Judge Veeder's decision in the National Electric Signaling Company case and state, according to your knowledge, what types of spark-gaps were included in "Plaintiff's Proofs as involved in Defendant's apparatus, and also please refer to your testimony in the National Electric Signaling Company case, which substantiates your personal knowledge of the matter?

A. Three types of spark-gaps were in the National Electric Signaling Company case, viz., the plain spark-gap, the rotary spark-gap and the quenched spark-gap, and I recollect that I personally testified relative to them.

Fig. 1 of "Complainant's Exhibit No. 11" in the National Electric Signaling Company case (Claimant's Ex. =255) shows a circuit diagram of the transmitter and on page 14 of the plaintiff's record in that case (Page 46 of the Transcript in the Court of Appeals, Second Circuit), I testified as follows:

"The spark-gap C was ordinarily one of three types; first, [fol. 1328] two metal balls or rods arranged so that the distance between them could be varied and each insulated from the other; second, a rotary spark-gap, consisting of a metal disk mounted on the shaft of generator G, having thereon radially projecting spokes and two electrodes insulated from each other and from the above mentioned spokes, so arranged that their distances from these spokes could be varied and so that their circumferential position could be adjusted; third, a quenched spark-gap, consisting of a series of metal plates insulated from each other and so arranged that the discharge through them was broken up into a number of small sparks, all in series with each other. These plates were so mounted and arranged that they could be cooled by means of a blower."

"Complainant's Exhibit No. 11" in the National Electric Signaling case was made and produced by me in connection with the description of the apparatus made by the National Electric Signaling Company during my employment with that Company, which terminated in March, 1912.

Q. 237. Please state whether or not the "Plaintiff's Exhibit No. 50" in the National Electric Signaling case and "Plaintiff's Exhibit No. 105" in the present case are correct diagrams representing the circuits of "Plaintiff's Exhibit No. 11" in the National Electric Signaling case, when taken in connection with your testimony in the later case, concerning the spark-gaps used with said circuits of the National Electric Signaling Company apparatus of "Plaintiff's Exhibit No. 11".

A. Yes, they are.

Q. 238. Referring to the three types of spark-gaps illustrated in "Plaintiff's Exhibit No. 105" in the present case, will you please state during what period these types of spark-gaps were made and sold, and to whom?

A. These spark-gaps were manufactured between 1908 and 1912 and sets involving the rotary spark-gap and the quenched spark-gap were sold to the United States Government. The period during which these latter sets were sold was, according to my recollection, between 1910 and 1912.

As an example of one of the rotary spark-gap transmitters sold to the Government, I will refer to the 100 k. w.

transmitter illustrated on pages 424 and 425 of the "Proceedings of the Institute of Radio Engineers", "Plaintiff's Exhibit No. 81".

* * * * * * *

Mr. Vaill: Counsel for claimant offers in evidence a photostat copy of "Complainant's Exhibit No. 11, Drawing of Defendant's Apparatus" produced by the witness in the [fol. 1329] case of Marconi Wireless Telegraph Company of America *vs.* National Electric Signaling Company in the United States District Court, Eastern District of New York, and requests that the same be marked "Claimant's Exhibit No. 255".

(Said exhibit marked as requested.)

Q. 239. Referring to Mr. Loftin's testimony beginning at the bottom of page 1139 of the Printed Record, concerning the two transmitters referred to in the Court's opinion (239 F. R., 328), one known as the "Simpson mercury valve" transmitter, and the other referred to as the "impulse" transmitter, will you please refer to "Claimant's Exhibit No. 253" and "Claimant's Exhibit No. 254" in the present case (respectively "Plaintiff's Exhibits 2 and 68" in the Kilbourne & Clark case), and compare the same with respect to construction and operation with transmitters relied upon as infringements in this case; particularly the Wireless Specialty Apparatus type of "Plaintiff's Exhibit No. 87", the type manufactured by the Navy of "Plaintiff's Exhibit No. 93" and Wireless Improvement Company type of "Plaintiff's Exhibit No. 88"?

A. There are a number of important differences between the apparatus of the Kilbourne and Clark case "Claimant's Exhibits 253 and 254" and the "Plaintiff's Exhibit 87, 88 and 93", which are the infringing apparatus in the present case.

Referring now to "Claimant's Exhibit No. 253", the transmitter shows a single turn of inductance without any means of adjustment in the closed circuit. This is indicated by the red line circuit G, *c*, *d*. The receiver drawing similarly shows a secondary coil *f*² having a fixed number of turns. Both of these arrangements constituted exceptions to the universal radio practice, and there is no other commercial apparatus that I am aware of which was without variation or rather, variability, in these two circuits.

I might also add that this use by the Kilbourne & Clark Company of this arrangement constituted a negligible percentage of the radio installations in the United States.

The fact which made possible at all the employment of this arrangement was the fact that they were used principally for one wave length only, viz., 600 meters. As a result of this the secondary coil *j'* was broadly tuned in this particular region. The primary circuit of the transmitter was deliberately operated out-of-tune by a sufficient amount to form a basis for the contention of the defendant in this case, to the effect that the circuit was not in tune.

As a matter of fact, however, it was sufficiently near to being in tune, so that a considerable benefit was derived from this particular adjustment and had the set really been capable of a so-called impulse excitation, it could have been operated very widely out of tune, which was not the case.

Judge Netterer, in his decision (pages 348 and 349 of F. R. 239) states that the Thompson transmitter shown in "Claimant's Exhibit No. 253" carries out the Lodge idea. With this decision I am obliged to disagree from my knowledge of the operation of the Thompson set and the Lodge arrangement.

[fol. 1330] As I have frequently pointed out in the course of my deposition, Lodge's idea was not realized in any way whatsoever by his arrangement of Fig. 4 nor, so far as I am aware, has any apparatus ever been made commercially which has succeeded in carrying out this idea.

The Thompson transmitter was very far from realizing this action. It was shown by tests which I conducted first, that the efficiency of the transmitter was materially improved by bringing the circuits into exact practical tuning, and also that as operated, the circuits were not greatly different from the adjustment required for exact tuning.

I might also point out that these facts are substantiated by a chart drawn by Mr. Kolster, which is Defendant's Exhibit K-9", (Claimant's Ex. =256) and which gives resonance curves of the secondary circuit and the primary circuit; the former of which has its peak at 590 meters, while the secondary has its peak at 650 meters.

If this were a real "impulse" transmitter, it would not be necessary to have the period of the primary circuit so near that of the secondary circuit but, on the contrary, it might have been some 200 or 300 meters instead of 650 meters.

It will be noted that resonance curve No. 3 of the primary circuit is very broad, and extends from about 550 meters to something over 800 meters.

As I have previously explained, when the form of an electrical oscillation is not that of the sine wave, it may be analyzed into a number of such sine waves. In the present case the fact that the resonance curve extends over the wide range indicated, means that there are components of sine form of all the intermediate frequencies, and it will be noted that at 590 meters the height of the curve is about half the height of the peak. This means that there is a sine component of that wave length which is about half as strong as the 650-meter component, and when the secondary circuit is tuned to this, responds to this particular component.

Were the Thompson transmitter a true impulse transmitter, it would not be necessary to have any particular relation between the time constants of the open and closed circuits.

Lodge, of course, not only does not realize this "impulse" action, but fails to even perform in a way that is of any practical use.

Referring now to "Claimant's Exhibit No. 254", the defendant's Simpson mercury valve transmitting station, the diagram of the transmitter shows that this differs from the defendant's apparatus in the present case by the inclusion in the antenna circuit of the condenser *d d'*, and the mercury valve Z, in the power circuit.

The receiving circuit employs a secondary coil j^2, *having a fixed number of turns.*

Judge Netterer, in his decision relative to the Simpson mercury valve transmitting station 239 F. R., page 346, states as follows:

"This circuit has enormous decrement, and is non-persis- [fol. 1331] tent. It is not, as in the Marconi patent in suit, *primarily* a reservoir or persistent oscillator, and does not co-operate with the antenna on the principle of resonance."

It so happens that I personally conducted tests on this transmitter and I found that the closed circuit, shown in red in "Claimant's Exhibit No. 254", was in resonance with the antenna circuit shown in black, and I recollect also seeing a report by the Bureau of Standards on this transmitter, which showed that they had found the same things.

In view of these facts, I am obliged to disagree with Judge Netterer's decision, quoted above.

During the trial of the Kilbourne & Clark case, certain tests were conducted at the University of Washington, purporting to show what was taking place in the oscillating circuit of a Simpson mercury valve transmitter and certain other tests were made at Harvard University on behalf of the plaintiff.

Judge Netterer, in his decision, refers to these tests as follows (239 F. R., pp. 346 and 347):

"The contention of the plaintiff with relation to the Massachusetts test, in which it was shown that there were two and one-half oscillations in the aatenna circuit, and that this must refute the contention of the defendants with relation to the Washington University photographic test, may be answered by the suggestion that the Washington University result was obtained, the photograph speaks for itself, and defendant's witnesses to that extent are corroborated."

I was personally present at the tests referred to and understood exactly what was being done in both cases, and the arrangement used at the University of Washington test was incapable of indicating what was taking place in the closed oscillating circuit of the Simpson mercury valve transmitter.

Unfortunately, this was a highly technical matter, which apparently was not understood by the Court and the statement by the Learned Judge to the effect that the photograph spoke for itself, is not in accordance with the technical facts involved.

Whether or not a photograph of this sort means anything, depends entirely upon the nature of the apparatus and its method of use, and in the tests at Washington University the requirements of this sort were not met by the apparatus used. On the other hand, the tests at Harvard University were technically correct, and showed that there were at least two and one-half oscillations in the primary circuit.

It happens that this matter of showing directly the number of oscillations in a high-frequency oscillating circuit is an extremely difficult one and seldom attempted, and while the tests at Harvard showed at least two and a half

oscillations, the way in which the circuits tuned indicated to me that there were considerably more than the two and a half.

The mercury valve Z used in this transmitter served no useful purpose whatever. During the course of the tests which I made on the Simpson transmitter I removed the [fol. 1332] mercury valve Z and operated the set without it, and found that the operation was then slightly better.

Referring once again to the Thompson transmitter, I neglected to point out that inductance d was made in the form of a loop of wire which was readily removable, and that with this particular construction it was an easy matter for the operator to remove the loop supplied with this set and substitute another, which would make the closed circuit more perfectly in tune.

On page 348, 239 F. R., there is shown a diagram of the Thompson transmitter, which differs in some non-essentials, from the diagram of "Claimant's Exhibit No. 253". The spark-gap is shown at h^3 and h^4, in two parts, which arrangement is not different electrically from that shown at G.

The condenser indicated by j is shown in two parts in series, and this electrically is equivalent to one condenser, as shown at c in "Claimant's Exhibit No. 253". Also the inductance in the antenna circuit is divided into two parts h^1 and h^2, instead of being all one coil d' in "Claimant's Exhibit No. 253". This difference has no electrical significance, but is merely a matter of convenience in mechanical construction.

Q. 240. Referring to your last answer, where you mention the photographs which were taken during the tests at the University of Washington, purporting to show what was taking place in the oscillating circuit of the Simpson transmitter will you please state what, according to your knowledge, these photographs did show as concerns the oscillating circuit of the Simpson transmitter?

A. This oscillogram merely showed the charging of the condenser d, d' by the rectifier Z, and it was incapable of showing what took place in the red circuit after the spark-gap G broke down, and therefore incapable of telling anything whatsoever relative to the oscillations in that circuit.

Mr. Vaill: Counsel for claimant offers in evidence a photostat copy of the Kolster chart referred to by the wit-

ness ("Defendant's Exhibit K-9" in the Kilbourne & Clark case, Printed Record, page 1266), and requests that the same be marked "Claimant's Exhibit No. 256."

(Said exhibit marked as requested.)

Q. 241. In answer to Q. 38 (Page 1147, P. R.), Mr. Loftin was asked to consider the Act of August 13, 1912, and to state what effect the Act had upon the system described in Marconi patent 763,772, and upon the quenched-gap system. Will you please state wherein you may agree or disagree with Mr. Loftin's answer to that question?

A. Mr. Loftin has attempted to differentiate between the quenched-gap system and the Marconi system of patent No. 763,772 by drawing distinctions between the operation of the quenched-gap transmitter and a transmitter having an open gap, these distinctions being largely based on his statements to the effect that the open gap type of transmitter, in order to be usable under the Act of August 13, 1912, must be employed with so loose a coupling that practically it will be very inefficient.

[fol. 1333] With these statements and conclusion I do not agree, for I have seen in operation numbers of open spark-gap transmitters operating within the requirements of the law; that is, the Act of August 13, 1912, and at the same time having a satisfactory over all efficiency.

In so far as the tuning is concerned, some of these open spark-gap sets are superior to the quenched-spark set and as an illustration of the transfer in an efficient manner of a very large amount of power from the closed circuit to the open circuit, I will refer to the Arlington transmitter shown in Admiral Bullard's paper in the Proceedings of the Institute of Radio Engineers, "Plaintiff's Exhibit No. 81", beginning at page 421.

This transfer of power from the closed circuit to the open circuit takes place without a bad wave-form resulting in the antenna, but, on the contrary, an extremely good wave-form having, as pointed out in my answer to Q. 225, the decrement of which is only about one-seventh of that permitted by law, which means that the wave-form was seven times as good as is necessary to comply with the law.

In the article in the "Electrical World," Volume 61, of 1913, page 722, which, I believe, was written by Mr. S. M.

Kintner and others connected with the National Electric Signaling Company, there occurs the following statement:

"The character of radiation sent out by this equipment is very pure in its wave form, being practically seven times as good as that fixed as the legal limit by legislation which became effective last summer. This purity of radiation is due in a large measure to the low resistance of the antenna, but in order that best advantage may be taken of this condition very accurate tuning of the oscillation circuits in the sending apparatus is required."

I might add that at the time the radio law in 1912 came into effect there was a considerable number of open-gap transmitters in the stations of the Marconi Wireless Telegraph Company of America, both on shore and at sea, and no difficulty was perienced in so adjusting this apparatus that it complied with the law while, at the same time, rendering satisfactory communication service.

Mr. Vaill: Counsel for claimant offers in evidence a photostat copy of page 722 of the "Electrical World" of 1913, referred to by the witness in his last answer and in answer to Q. 225, and requests that the same be marked "Claimant's Exhibit No. 257."

(Said exhibit marked as requested.)

Q. 242. I invite your attention to Mr. Loftin's answer to X Q. 59 on page 1155 of the Printed Record, and will ask you to state according to your knowledge and recollection of the prior litigation and the patents involved in this suit, whether or not any new prior art was considered by Mr. Loftin that was not involved in the prior litigation.

A. Mr. Loftin has not cited any prior art which was not involved in previous cases.

* * * * * * *

[fol. 1334] Q. 243. In answer to Q. 4 of his deposition, Dr. John M. Miller referred to the demonstrations before Judge Mayer (Printed Record, page 758), in the case of Marconi Wireless Telegraph Company of America *vs.* DeForest Radio Telephone & Telegraph Co., on the Fleming patent 803,684 in the Southern District of New York, the supplemental record of which under the supplemental bill has been included in this case as "Plaintiff's Exhibit

No. 171." Are you the Roy A. Weagant whose testimony is printed in said exhibit on pages 37-41, inclusive?

A. I am.

Q. 244. Were you present at the demonstrations before Judge Mayer in the case just referred to, and is the testimony you gave therein correct as set forth in said "Plaintiff's Exhibit No. 171"?

A. I was, and it is.

Q. 245. Dr. Miller, in his answer to Q. 4 (P. R., p. 758), states that:

"In the demonstrations before Judge Mayer advantage was taken of an obscure, freak, impractical phenomenon in order to demonstrate the alleged inherent capacity of the two-element device for generating radio waves. Even this freak operation of the two-element device is basically different from that of the three-element device. These facts were not presented in the record in the case referred to. On the other hand, testimony was given which was not in accordance with the facts."

Please state from your knowledge of the proceedings in the trial before Judge Mayer, which included the demonstrations referred to, whether or not deficient testimony was given, as stated by Mr. Miller, or whether the testimony was not in accordance with the facts.

A. I am unable to understand Dr. Miller's reference to testimony not in accordance with the facts, and I note particularly that he fails to point out in detail in what respect testimony given differed from his idea of the facts. I was present during the taking of all the testimony in the case before Judge Mayer and took part in all the tests and demonstrations.

From my recollection of the testimony, and from a recent reading of it, I am quite certain that no testimony was given which was contrary to the facts within the best knowledge and understanding of the witnesses for plaintiff.

From the stress which Dr. Miller has laid on the difficulty which he personally has had in making a two-element tube to oscillate, it occurs to me that perhaps it is his impression that the witnesses gave misleading testimony in this respect.

No statements, however, were made to the effect that the two-element oscillating valve was a proven commercial device nor, so far as I can recollect, any statement tending [fol. 1335] to indicate that it was particularly reliable; while, on the contrary, there was testimony which indicated that the results were secured with some difficulty.

I recollect distinctly, when I was asked to make the tests and demonstrations of the oscillating two-electrode Fleming valve, that I was informed that the essential thing was simply to demonstrate that it had the capability of generating high frequency oscillations.

It was, furthermore, my understanding that this was in accordance with the wishes of the Court and that the question of reliability, or otherwise, was not involved. I may also state from my recollection of the trial and my technical knowledge and experience that, in my opinion, no facts within the knowledge of the witnesses were withheld either on direct, or cross examination, and no demonstrations or statements made which would tend in any way to mislead the Court as to the facts presented.

It is, of course, to be understood by this reply, that the above remarks relative to the action of the tube apply to the tests before Judge Mayer and not to the recent demonstrations which I made with the high vacuum two-electrode tube.

Q. 246. Will you please refer to pages 87 and 88 of the Supplemental Proceedings in the case of Marconi Company vs. the DeForest Company above referred to, "Plaintiff's Exhibit No. 171" in the present case, and state whether the diagrams shown on said pages as "Plaintiff's Exhibit No. 2" and "Plaintiff's Exhibit No. 3" illustrate the connections of the circuits used in the demonstrations before Judge Mayer?

A. Yes, they do.

Q. 247. Will you please state whether or not you agree with Dr. Miller's statement on P. R., p. 758, that:

"The two-element valve does not possess inherently the same capacity for generating radio waves as is possessed by the three-element device: * * *."

In giving your answer will you please state your reasons and explain to what extent the two-electrode and three-electrode valves inherently possess, of and by themselves, the capacity of generating radio waves or oscillations?

A. Neither the three-element valve nor the two-element valve possesses, by itself, the capability of oscillation. On the contrary, both devices require connections and associations with additional devices, such as coils, condensers and batteries, which additional devices must be connected and associated in a particular manner, in order to accomplish the result.

With reference to Dr. Miller's statement, I will say that I am quite in disagreement, for the simple reason that, as shown by my recent tests, the two-electrode tube, when associated with the proper circuits, batteries, etc., has the same capability of oscillating as is possessed by the three-electrode tube.

Q. 248. Please state, according to your knowledge, and the results of the tests which were made before Judge Mayer, and the tests which you have referred to in the last answer, to what extent the two-electrode and the three-electrode valves, respectively, possess the capacity for generating radio waves or of oscillating when associated with the proper devices and circuits.

A. Both valves, when connected in suitable circuits and [fol. 1336] arranged in proper electrical association, have the same inherent capability for generating oscillations.

Both devices are capable of acting by what is termed "gas action," and both devices are capable of oscillating when vacuum is extremely high, that is, so high that "gas action" is no longer possible.

Under these latter conditions, both devices function as the result of the electrostatic control of the electron stream and a suitable means for transferring some of the energy in the output circuit back into the input circuit.

In the recent tests which I conducted and testified to in the first part of this deposition, the two-electrode vacuum tube, connected in what was substantially the circuit of Fleming patent No. 803,684, oscillated in a manner identical with that of the three-electrode high-vacuum tube.

The vacuum in the tubes used in these tests was very high—so high, in fact, that the so-called "gas oscillations" could not be obtained with them.

This demonstration was made in order to show that the contention of Defendant's Experts that a two electrode high-vacuum tube would not oscillate, was incorrect. There is, in this respect, an interesting resemblance to the case before Judge Mayer, in which Experts for the Defendant

testified, somewhat emphatically, relative to the impossibility of making any two-electrode Fleming valve oscillate.

In both of these cases, that is the one before Judge Mayer, and the present one, the contention has been met by a demonstration showing that the two-electrode Fleming valve possesses inherently the same capabilities as the three-electrode valve.

It is also of importance to note that the expressions "freak action," "great instability," "impossibility of commercial employment"—which have been used by Defendant's Experts in this case to characterize the device before Judge Mayer, are entirely inapplicable to the recently made tests.

The oscillations obtained with this high-vacuum two-electrode tube are as stable and controllable as those obtained with the three-electrode tube and were the latter unknown, the two-electrode tube so used would have very important commercial usefulness.

Defendant's Experts, in explaining the action of the three-electrode valve, and in attempting to differentiate it from the three-electrode valve, have laid great stress on the electrostatic control of the electron stream, and have contended that this control was an inherent part of the three-electrode structure.

They have neglected to point out, however, and to recognize, that the two-electrode tube was capable of being influenced and operated by an electrostatic control of the electron stream between the electrodes, and that in the three-electrode tube the grid was merely the mechanical arrangement by means of which the controlling electrostatic field was brought within the electron stream to the place of greatest effectiveness.

They have entirely neglected to differentiate between the grid as a part of the valve structure and the electrostatic field, which is the vital thing in the controlling action.

[fol. 1337] DeForest made a particular sort of an invention when he put the grid in the Fleming valve. He did not discover the electron stream, as that was known previously, and the Fleming valve embodied the best method of producing it which is known up to the present time, the hot electrode and the cold electrode. He did not discover that such an electron stream could be modified by an electrostatic field, because that also was known before his invention.

Statements of Defendant's Experts which tend to create the impression that the grid and the electrostatic control are one and the same thing are, therefore, not founded on the facts.

The grid as a structural device in a Fleming valve is DeForest's invention, and one of very great importance; but, while this invention added greatly to the usefulness of the Fleming valve, it did not add to it any mode of operation which is not possessed by the two-electrode tube without the third or grid-electrode.

That DeForest was familiar with Fleming's work is shown by his statement in his patent, No. 823,402 (page 3, lines 7-30, inclusive):

"The device V' (shown in Fig. 1), connected between the antenna at the point *b* and earth, is an asymmetric resistance or electric valve which has been fully described by J. A. Fleming in a paper published in the *Proceedings of the Royal Society of London*, March 16, 1905, to which reference may be had for a more complete description thereof than need be set forth herein. Suffice it to say that the exhausted glass vessel Q'' contains the filament F', heated to incandescence by the battery B', and a metal cylinder D', which surrounds said filament F'. This type of valve passes positive electricity from the cold terminal D' to the heated terminal F' more readily than in the opposite direction, and hence when the switch S' makes contact, as shown in Fig. 1, with the contacts 5 and 6 positive static effects will pass to earth by way of the elements D' and F' of said valve, while if the connections be reversed by throwing the switch so as to contact with 4 and 5 negative static effects will pass to earth by way of the elements F' and D' of said valve."

It will be noted that this application was filed in December, 1905, considerably earlier than the date of application of the DeForest patent No. 879,532, which discloses the grid, and which was applied for January 29, 1907.

Mr. Vaill: Counsel for claimant offers in evidence a printed copy of Patent No. 823,402, dated June 12, 1906, to Lee DeForest, and requests that the same be marked "Claimant's Exhibit No. 258."

(Said exhibit marked as requested.)

Q. 249. Will you please state, from a physical standpoint, what are the essential elements and mode of operation of the two-electrode and three-electrode vacuum tubes, which give them the inherent capability when associated with [fol. 1338] proper circuits, to produce radio waves or to oscillate?

A. Both the two-electrode Fleming valve and the three-electrode Fleming valve have the capability of oscillating in the same manner, and their ability to oscillate depends on two things, assuming that the vacuum is high, and that we have no "gas action" to consider, first, that an electron stream shall flow between the hot electrode and the cold electrode, and that an electrostatic field shall be associated with this electron stream in a manner which permits it to have an influence upon the electron stream. The nature of this influence must be such that the energy involved in the influencing action shall be less than the energy released by the resulting variation in the electron stream.

The second requirement is that a circuit in which electrical currents are flowing, caused by the variation of the electron stream, shall be associated with the electrostatic field, which controls the electron stream, in such a way that variations of this electrostatic field are supported by variations of the current produced by the electron stream variations.

Both the two-electrode arrangement, as shown in my recent tests, and the three-electrode arrangement now fulfill these requirements, and they differ only in the degree of perfection with which the control of the electron stream is obtained.

In the three-electrode tube this field is brought into the midst of the electron stream and in a position where it has the maximum effect.

In the case of the two-electrode tube the field is external. It is not so advantageously situated with respect to the electron stream and its control, therefore, is less, but nevertheless, as the tests demonstrated, it is sufficient both for oscillation and amplification. Both tubes, that is, the two-electrode valve and the three-electrode valve, oscillate with an equal degree of stability and controllability, and both are entirely reliable for commercial purposes.

Both the two-electrode valve and the three-electrode valve possess the fundamentally important thing, viz., an

electron stream originating in a hot cathode and flowing to a cooled anode, which electron stream in both devices, can be influenced by an electrostatic field in such a way that both amplification and oscillation are secured.

Q. 250. Please refer to the paragraph at the bottom of page 760 of the Printed Record, where Dr. Miller criticises Mr. Waterman's deposition, and concludes by stating that:

"The high vacuum two-electrode tube does not have this 'falling characteristic' and will not generate oscillations."

Will you please state whether, and under what conditions, a high-vacuum two-electrode tube does involve an action having a falling characteristic.

A. Dr. Miller's criticism of Mr. Waterman's deposition is incorrect, both with respect to the falling characteristic and his statement that it will not generate oscillations. That the high-vacuum two-electrode tube will generate oscillations was, of course, conclusively demonstrated in my recent tests, and when either a two-electrode or a three-electrode device is oscillating, it has a negative char- [fol. 1339] acteristic or, as it is often stated, a negative resistance reaction.

Mr. Miller's statement, quoted above, and Dr. Milliken's statements made in the course of his deposition, to the effect that neither the hard two-electrode tube nor the hard three-electrode tube has a falling characteristic, seems to be based on a consideration of the tube by itself and these statements fail to take into account the fact that it is a characteristic of the tube, when associated with the actual operating circuits that is of real consequence.

Neither the two-electrode tube nor the three-electrode tube, when taken alone, is capable of oscillating, and consequently it cannot be said that either of these is a generator of electrical oscillations except when associated with, and connected to, suitable circuits. When such a connection and association is made, however, both of these devices can oscillate and they do so because of the possession of this negative resistance reaction.

The accompanying sketch, being "Weagant Sketch No. 4" (* * * Claimant's Ex. 259), forms the basis for illustrating in a simple manner the negative resistance reaction of the three-electrode tube.

In this sketch, A is the filament, G is the grid, B is the plate, D is the battery, while the coil E and the condenser F

constitute an oscillating circuit. Attached to the grid G is a variable connection indicated by the line terminating in an arrow.

If the oscillating circuit E, F, has its resistance measured when the three-electrode valve is completely disconnected from it, a certain value will be found. If, then, the three-electrode valve is connected in the circuit as shown, a measurement of this resistance under these circumstances will show that the resistance of the circuit E, F, has increased, showing that the attachment of the valve in the manner indicated in the sketch results in adding a certain amount of the resistance to the resistance of the circuit E, F.

If, then, the pointer I is attached to the coil E at a point determined by experiment, which will be slightly below the point H, a point can be found such that a further measurement of the oscillating circuit E, F will show that it has the same resistance as it had when the valve was completely disconnected, and this means that under these conditions the valve is equivalent to a zero resistance inserted in the circuit E, F.

Another way of expressing this is to say that under these particular circumstances, the valve gives rise to no loss in the circuit E, F.

If, next, the point I be moved somewhat farther down the coil E, and another measurement of the resistance of the circuit E, F, be made, it will be found that its resistance is less than the resistance of the circuit taken alone and with the valve entirely disconnected. This very remarkable fact indicates that with this particular connection the valve has actually removed some of the positive resistance of the circuit E, F; or, in other words, it has developed a negative resistance reaction of some particular value.

If once again, the point I be moved further down the coil E, a point will be reached where the circuit E, F, will begin to oscillate, and this means that the negative resist- [fol. 1340] ance reaction due to the valve, has increased to the point where it exceeds the positive resistance of the circuit E, F.

This particular circuit is the well-known Hartley circuit shown as Fig. 2 in Miller Drawing J, opposite page 804 of the Printed Record.

That this particular action and capability of the three-electrode valve is recognized by workers in this art is shown by patent No. 1,334,165 to M. I. Pupin and E. H. Armstrong. These two gentlemen, both of whom are recognized authorities in radio, have disclosed herein a radio system which depends for its action and results upon the negative resistance reaction of the three-electrode tube. Various curves are given, such as Fig. 2a, and Fig. 5, illustrative of the negative resistance effects and it will be noted that there is a horizontal line which is marked O; above this, numbers are given representing positive ohms and below it, numbers representing negative ohms, and the ohm is the electrical unit of resistance.

The diagrams, Fig. 1, Fig. 3, Fig. 4, and others, clearly show that it is the three-electrode device which is being used for this purpose.

Examination of the specification shows many references to the fact that the arrangement is intended to develop a negative resistance reaction, and on page 1, lines 59 to 86, inclusive, there is a description of the arrangement of Fig. 1, and this description is followed by the following statement, lines 87-90:

"It is this transfer of energy which manifests itself through a reaction between 2, 5, which has all the properties of a negative resistance reaction."

The particular kind of negative resistance exhibited by the three-electrode tube when oscillating, or when used in the manner of Pupin and Armstrong, might be properly called "the alternating current negative characteristic," since it is not manifest in any way when a direct current or potential is applied to the device.

This, however, is not the only sort of negative characteristic or resistance reaction of which the electrode tube is capable.

In patent No. 1,393,594 to White (• • • Claimant's Ex. 261), a type of negative characteristic possessed by the three-electrode tube is shown, which results from the application of a direct current or potential to the grid of the device.

Fig. 2 represents a curve obtained by applying a negative voltage to the grid, and it will be seen that at point B,

where the negative voltage approaches zero, that the distance of the curve below the line marked "Grid Voltage" is much greater than at the point C, where the negative voltage is much greater. That is to say, increased voltage is associated with decreasing current, which is the condition referred to by Mr. Miller as the characteristic action of an arrangement to which the name of "Negative resistance" or name of "Negative Characteristic" applies.

Mr. White, in his patent, lines 32 to 50, page 1, brings out this action, as follows:

"In carrying my invention into effect, however, I employ a materially different principle. I have found that under [fol. 1346] certain conditions with devices of this type the current in the grid circuit may have a dropping characteristic, that is, as the voltage impressed upon the grid increases the current in the grid circuit will decrease. With the proper conditions for operation a circuit having current characteristic of the type described may be so organized that oscillations will be produced therein, the essential condition for the production of oscillations being that the circuit shall contain capacity and inductance and that the L resistance of the circuit shall be less than $2\sqrt{\frac{L}{C}}$ where L represents the inductance and C the capacity of the circuit."

It will also be noted that Mr. White makes use of this particular characteristic for the purpose of generating oscillations in a manner which is quite different from the usual feed-back arrangement.

It is also to be noted that this is a characteristic possessed by tubes of relatively high vacuum, such as are used in every-day practice.

This I know from my own experience, and a statement by Mr. White, page 2 of his patent, lines 52 to 60, is indicative of the fact that the tube therein referred to was worked with a plate potential of 375 volts, which is a voltage that cannot be employed except with very good vacuum.

The particular negative characteristic just illustrated by Mr. White's patent is obtained as the result of applying a negative potential to the grid, but a similar negative characteristic is obtainable through applying a positive potential to the grid.

This is illustrated in the paper by Albert W. Hull, entitled "The Dynatron," a vacuum tube possessing negative resistance in the Proceedings of the Institute of Radio Engineers, February, 1918, Vol. 6, No. 1, pages 5 to 36, inclusive (• • • Claimant's Ex. 262).

This device is a three-electrode vacuum tube which requires merely that the potential applied to the grid shall be considerably higher than the potential applied to the plate, in order to develop the negative resistance reaction.

Fig. 3 shows a curve and the voltage increases from zero to 150 volts and more. It will be seen that, while the voltage is increasing from zero to the point A_0 that the current increases, after the fashion of any ordinary device having positive resistance, and from the point A_0 to the point 100, increasing voltage is associated with decreasing current, and between the point- B and C_0 the current actually flows in a direction opposite to the applied voltage.

The device, therefore, between the points A_0 and C_0 is, as stated, just above the figure, a true negative resistance.

The arrangement described by Dr. Hull in his paper, forms the subject-matter of his patent No. 1,385,873, which was applied for June 5, 1916, and issued July 26, 1921.

While in physical construction this device appears different from the conventional three-electrode, this is due largely to the fact that the device as illustrated was in- [fol. 1342] tended to handle suitable power, and also because, due to the relatively high voltage applied to the grid, the conventional three-electrode tube construction would seriously overheat if used this way.

The same characteristic is, however, inherent in the conventional three-electrode tube, and is recognized by Dr. Van der Bijl in his book "Thermionic Vacuum Tube"; Fig. 75, page 153 (• • • Claimant's Ex. 263), shows a curve marked at its right-hand extremity Ep = 200. This curve from a point represented by about 15 volts to something over 35 volts, is a characteristic which is the same as that shown by Dr. Hull.

Still another manifestation of the negative resistance reaction of the three-electrode tube is to be found in a work entitled "Radio Engineering Principles" (by Lauer and Brown). On page 177 there is the following statement:

"If now the grid potential Eg is varied so as to increase the current Ip in the plate circuit, it is seen that

the resistance drop RIp in the external plate circuit will correspondingly increase. It then follows from equation (30) that, with the battery voltage EB remaining constant, the plate potential Ep will decrease. Conversely, if the current Ip is decreased by decreasing the grid potential, the plate potential Ep will increase. Thus, on account of the external resistance of the plate circuit, the plate potential is no longer constant, but is a function of the plate current, and varies in opposite direction to the latter. In other words, the tube, operated under such conditions, has a negative plate resistance r ction as defined in connection with the oscillating arc, Chapter V."

The circuit diagram which goes with this statement is Fig. 145, page 175.

Mr. Vaill: Counsel for claimant offers in evidence the following exhibits and requests that the same be marked as indicated:

"Weagant Sketch No. 4," "Claimant's Exhibit No. 259."

U. S. Patent to Pupin and Armstrong, No. 1,334,165, March 16, 1920, "Claimant's Exhibit No. 260."

U. S. Patent to White, No. 1,393,594, October 11, 1921, "Claimant's Exhibit No. 261."

Photostat copies of pages 5 to 11, inclusive, of the "Proceedings of the Institute of Radio Engineers for February, 1918, being the first seven pages of the article entitled "The Dynatron" by Albert W. Hull, as "Claimant's Exhibit No. 262."

Photostat copy of page 153 of the book entitled "The Thermionic Vacuum Tube" by Van der Bijl, as "Claimant's Exhibit No. 263."

Photostat copies of pages 175, 177 and 178 of the book entitled "Radio Engineering Principles" by Lauer and Brown, First Edition, Third Impression, 1920, as "Claimant's Exhibit No. 264."

(Said exhibits marked as requested.)

Q. 251. Will you please refer to Dr. Miller's answer to [fol. 1343] Q. 5 of his deposition, page 763 of the Printed Record, regarding the case of Hewitt *v.* American Telephone & Telegraph Co., and state whether you consider, from a technical standpoint, the devices and mode of operation disclosed in the Hewitt patents Nos. 781,001 and 781,002

("Defendant's Exhibits O and P"), are the same thing as the gaseous two-electrode tube demonstrated before Judge Mayer in the case of Marconi Wireless Telegraph Company of America *vs.* De Forest Radio Telephone and Telegraph Company? You may refer to any part of Judge Mayer's opinion which tends to confirm your understanding of the Hewitt patents.

* * * * * * *

A. The device illustrated in the Hewitt patents Nos. 781,001 and 781,002 is a very different thing from the vacuum valve of Fleming, both in structure and in usefulness. The Hewitt arrangement involves the use of a metallic vapor, viz., the vapor of mercury, and it does not have the hot electrode of the Fleming valve, and is not capable of providing a pure electron stream whose motion is unimpeded by the presence of gas, as is the case in a properly exhausted Fleming valve.

While Judge Mayer, in the part of his decision quoted by Mr. Miller, distinguishes the operation of this Hewitt device from that of the DeForest three-electrode tube, this distinction is not one which is applicable to the Fleming valve, since, as has been conclusively demonstrated by the tests which I made, the Fleming valve with only two electrodes, is capable of acting on the so-called relay principle.

Judge Mayer, in his opinion in the case referred to by Mr. Miller, makes a further statement which appears of interest at this point. On page 203, 272 F. R., he states as follows:

"Not only have these two patents been of no practical service in this art, as against the undoubted utility of defendant's devices, but it is plain that, giving them their fullest academic value, they have a different object, principle, mode of operation, and result from these which characterize the audion type of repeater used by defendant."

In considering and comparing the Fleming valve which has a vacuum of a high order, but not of the highest order such as is obtainable today commercially, and the Hewitt devices, there is a most important distinction to be made relative to the nature and function of the gaseous content of the evacuated tube.

In the Hewitt device, mercury vapor is the essential con- [fol. 1344] ducting element, and if not present, the device

ceases to exist, while in the Fleming arrangement the residual air or other gases which exhaustion has failed to remove, are not the essential conducting element, nor do they play any useful part in the operation of the device. They are, on the contrary, in the nature of an obstruction to the flow of the electron stream, and the more perfectly they can be removed, the more perfectly will the device operate.

In the Hewitt device a metallic vapor, viz., that of mercury, is the fundamental basis for the operation, while in the Fleming device an electron stream is the fundamental basis, and the less the electron stream is interfered with by the gas, the better it functions, and in the Fleming patent are explicit instructions for making this vacuum as high as possible.

Q. 252. Referring to Dr. Miller's answer to Q. 6 of his deposition, please state to what extent you may agree or disagree as to the fundamental operation of the two-electrode and three-electrode valves, as explained by him in connection with "Miller Drawing B"?

A. Mr. Miller gives, in his answer to Q. 6, an explanation of the action of the three-electrode valve which is quite in accordance with the usual technical viewpoint in the matter.

In his explanation of the two-electrode tube, he chooses to limit his explanation to the mere rectifying action possessed by the two-electrode tube. He does not, of course, show the two-electrode Fleming valve in the Fleming circuit, nor does he bring out the fact that this two-electrode valve is capable of functioning by means of an electrostatic field control of the electron stream.

In his explanation of the action of the three-electrode device, he shows clearly how the grid serves to control flow of electrons to the plate from the filament, but he omits to point out that a similar control is possible with the two-electrode tube by merely bringing it in the neighborhood of an external electrostatic field.

He also chooses, in his diagram, to show the Fleming valve without a so-called B battery, but while it is true that the Fleming patent does not happen to include such a battery, yet its use with a radio receiving device was well known in the prior art, and Fleming himself, in an article in the "Proceedings of the Royal Society of London," Volume 74, page 476, page 483, gives characteristic curves which clearly show the effect of the application of a battery poten-

tial between the plate and filament and in general discloses in these curves information which would lead to the use of such a battery for radio purposes.

I might mention also at this point that the Fleming valve used as a simple detector in receiving sets manufactured for commercial use, was provided with a means for applying a potential between the plate and filament.

Dr. Miller, in concluding his answer to Q. 6, sums up his explanation as follows (P. R., p. 768):

"This explains the remarkable amplifying property of the three-electrode vacuum tube which is due to the DeForest grid and which is responsible for the important position of the device in the electrical art."

[fol. 1345] With this conclusion of Dr. Miller's I disagree very emphatically, for the very simple reason that the remarkable amplifying property referred to is not, as he states, due to the DeForest grid, but is due to the fact that the electron stream of the Fleming valve can be controlled by an electrostatic field, releasing as the result of this control more energy than is consumed by the controlling action.

The DeForest grid inserted in the Fleming valve is the most efficient way of bringing the electrostatic field into such relation with the electron stream as is required by the conditions of operation, and is an invention which has proven to be of enormous importance.

Q. 253. Referring to Dr. Miller's answer to Q. 7 (P. R., p. 768), will you please comment upon the similarity of action of the vacuum tube when acting as an amplifier of radio-frequency oscillations and of audio-frequency currents?

A. Mr. Miller, in discussing this subject in his answer to Q. 7, has brought out the fact that owing to the lack of inertia of the electron stream, it was capable of responding equally well at high frequencies, or at low frequencies. This, of course, was the discovery of Dr. Fleming, who was the first to show that a vacuum tube with a hot and a cold electrode would operate when acted upon by high-frequency oscillations.

While it happens that the vacuum tube functions in this way with respect to all frequencies, it must be remembered that this is not a characteristic of any and all devices which

have the property of rectifying. Many rectifiers operate effectively on alternating voltages of low frequency, but are quite useless when employed with high frequencies.

Q. 254. Do you agree with Dr. Miller, in his answer to Q. 8 (P. R., p. 769), as to the contrasts which he has stated exist between the uses of the two-electrode valve and the three-electrode valve? If not, please state in what respects, and give your reasons.

A. Dr. Miller, in reply to Q. 8, states that the two-electrode valve can only be used as a rectifier, while the three-element device may be used as an amplifier, a combined amplifier and radio-frequency detector and oscillation generator, and a combined oscillation generator and radio-frequency detector. He, furthermore, refers to what he calls the "freak gas action" as being a useless laboratory "stunt," and of no practical utility.

From the facts disclosed by the recent demonstration which I made of the two-electrode tube, it is apparent that Dr. Miller, in making this reply, has quite overlooked the relay type of action of which the two-electrode tube is capable. These tests disclosed very clearly and unmistakably the fact that the two-electrode Fleming valve is an amplifier, combined amplifier and radio-frequency detector and oscillation generator, and a combined oscillation generator and radio-frequency detector.

In other words, it is capable of all the uses of which the three-electrode tube is capable.

Dr. Miller, on Printed Record, page 770, uses a definition of the word detector, which is limited in a particular [fol. 1346] way, viz., to the conversion of high-frequency current or voltage into another form.

In the Report of the Committee on Standardization for 1922 on behalf of the Institute of Radio Engineers, is given the definition of the word detector which is considerably broader in scope, and which carries the significance more usually associated with this word. This definition is as follows:

"Detector: That portion of the receiving apparatus which, connected to a circuit carrying currents of radio-frequency, and in conjunction with a self-contained or separate indicator, translates the radio-frequency power into a form suitable for operation of the indicator. This translation may be effected either by the conversion of the radio-

frequency power, or by means of the control of local power. The indicator may be a telephone receiver, relaying device, tape recorder, and so on."

It will be noted that the above definition conveys as its essential impression the fact that the detector is a device which, when acted upon by radio-frequency, translates this action into one capable of operating an indicator.

At the bottom of P. R., p. 773, Dr. Miller makes a differentiation between an amplifier and a detector and refers to the latter as distorting the radio-frequency.

As this word is capable, that is, the word "distorts," of misinterpretation, it seems important to point out here that this means merely that the valve is rectifying the incoming wave.

In the strictly technical sense, this statement is perfectly correct, but used in its ordinary significance it seems to infer that the valve is modifying the wave form of the incoming signal in an undesirable way; whereas, as a matter of fact, this modification, rectification or, as it is technically termed, "distortion," is the necessary action in order to make the incoming high-frequency oscillations usefully evident. When an incoming oscillation is rectified, one-half of it is cut off, but the sound resulting therefrom is not distorted.

Dr. Miller, in his further discussion under Q. 8, outlines the various uses of the three-electrode tube as amplifier, oscillator, detector, etc., and enlarges somewhat on the great importance which these things have in the radio art. Statements which are unquestionably true, but which fail to include any reference to the same inherent capabilities, as shown in my tests, of the two-electrode tube.

Q. 255. Please state to what extent, if any, you agree with Dr. Miller's statement regarding the similarity of action of the two-electrode vacuum tube and the arc.

A. Dr. Miller, in replying to Q. 11 (P. R., p. 781), brings out the action of the oscillating arc and the similarity between it and the oscillating Fleming valve demonstrated to Judge Mayer. He also quotes a statement of Mr. Waterman to the effect that the two-electrode tube does not in any way resemble the arc.

There seems to be some confusion which, I think, is readily cleared up. At the time that the demonstration [fol. 1347] was made to Judge Mayer, while we had suc-

ceeded in making the two-electrode tube oscillate, we did not know the mechanism which was responsible for the action.

Both Mr. Waterman and I were familiar with the characteristic of the arc variously known as "falling characteristic," "negative characteristic," but no tests which we were able to make at that time, succeeded in showing the existence of such a characteristic. Since that time, however, greater knowledge relative to the action of both the two-electrode and the three-electrode valve has been obtained, and I have succeeded in making tests which show the falling characteristic to exist in the two-element valve.

Mr. Waterman's statement, therefore, to the effect that the two-electrode tube did not in any way resemble the arc was perfectly true, since the two devices physically, and in their general action, are very different, while the fact that the two-electrode tube possessed the falling characteristic, which is also possessed by the arc, was quite unknown to any of the witnesses for the plaintiff, at that time.

As is usual in scientific work, more and more light is thrown on the action and capabilities of various devices, and so it happens that we understand better the action of the two-electrode tube demonstrated to Judge Mayer, and, in addition, the fact that this two-electrode tube is quite capable of acting in a manner entirely independent of the particular sort of negative characteristic which was responsible for the action of these tubes during these tests.

My recent tests show conclusively that the simple two-electrode tube operating by means of the electrostatic control, not only accomplish all that was shown in the tests before Judge Mayer, but, in addition, all of the characteristic action of the three-electrode tube.

Q. 256. Will you please refer to Dr. Miller's answer to Q. 12, and particularly the last paragraph thereof on P. R., p. 784, and state whether or not you agree with Dr. Miller's conclusions as to the possibility of oscillation when using a hard two-electrode tube?

A. Dr. Miller, in his reply to Q. 12, has apparently elaborated on the difficulties which he experienced in making a two-electrode "soft" tube oscillate, but, as is very often the case, in tests of this sort, he would have found it much easier to do had he followed the demonstration before Judge Mayer.

He also refers t attempts to make the hard two-electrode tube oscillate, and states that the failure experienced is to be expected, since this tube has a rising characteristic. It should be noted that the three-electrode tube also has a rising characteristic and yet, as Dr. Miller points out, is a generator of oscillation.

As a matter of fact, it is perfectly obvious that the tests made by Dr. Miller were not conducted in a proper way to demonstrate the fact that a two-electrode tube is capable of oscillating, but rather in a way which, in the light of the present-day knowledge of vacuum valves, had no possibility of working.

The hard vacuum two-electrode tube employed in the tests which I recently made would, if taken alone, show a rising characteristic; nevertheless, when used in the origi- [fol. 1348] nal Fleming circuit and merely laid on a board in the vicinity of a coil or condenser of that circuit, which arrangement permitted the electrostatic field to operate, oscillations of great constancy and controlability were obtained.

Q. 257. Referring to Dr. Miller's answer to Q. 13 on page 784 of the Printed Record, will you please state from your knowledge of the tests before Judge Mayer, whether they showed that variations in the oscillations were present or not?

A. In the tests before Judge Mayer, one demonstration involved the reception of oscillations from a two-electrode oscillator by a three-electrode oscillating valve and the production in the telephone receivers of a heterodyne beat note. This particular method of detection is very sensitive to variations in the oscillation-frequencies, and were such present, a note of variable pitch would be heard.

I do not recollect that the note heard in the tests before Judge Mayer showed this variation, while I have a distinct recollection of having made tests with the same apparatus in which I noted particularly that the pitch of the beat note was quite constant.

Q. 258. Do you agree with Dr. Miller's statement in answer to Q. 16 (P. R., p. 785), regarding the necessity of gaseous two-electrode tubes having gas present to a definite degree in order to act as an oscillation generator?

A. This question, and Dr. Miller's answer thereto, seem based on the assumption that a two-electrode tube is capa-

ble of oscillating only by means of the gas action. Dr. Miller has already testified to the fact that he was unable to make the hard two-electrode tube oscillate. That was simply because he did not use it in the right way.

There are many ways of associating and connecting circuits with the three-electrode tube of such a nature that oscillations are not obtainable therefrom, and the same is, of course, true of the two-electrode tube.

As I have already pointed out, neither the two-electrode tube, nor the three-electrode tube can, without the association of proper circuits, give rise to oscillations. While, on the other hand, as I have shown in my demonstrations, the two-electrode tube in the proper circuit and association, oscillates very readily when the vacuum is so high that the residual gas plays no part in the action.

Q. 259. Please comment on Dr. Miller's answer to Q. 17 of his deposition (P. R., p. 786), referring particularly to "Miller Drawing F", used by Dr. Miller in explanation of his answer.

A. Dr. Miller, in answer to Q. 17, compares the operation of the three-electrode vacuum tube in the P N circuit and the Fleming valve in the circuit of the Fleming patent. He brings out, of course, his usual distinction between these two devices, viz., that while the Fleming valve is a detector, the three-electrode vacuum valve is an amplifier as well.

Of course, this fails to take into consideration the facts disclosed by my tests, viz., the use of the Fleming valve in the circuit of the patent with, of course, a battery added as a source of power, is also an amplifier.

In Fig. 2 of "Miller Drawing F" is shown a circuit of the [fol. 1349] De Forest patent No. 879,532 and a particularly interesting detail of this is the condenser g^3. It will be noted that there is no grid leak associated with this, after the fashion of Fig. 3, r, and in the present-day hard tube, such an arrangement is practically inoperative.

This is an interesting illustration of the fact that developments of an important invention often lead to radical changes in the operating associations.

When the three-electrode tube was first made, the vacuum was relatively low and the positive ionization was sufficient to act as a leak and prevent the grid from acquiring a negative charge.

With the modern high-vacuum tube, however, this internal condition no longer exists and an external leak is essen-

tial. In connection with Dr. Miller's explanation of the action of Fig. 3, he brings out the fact that the grid-to-filament circuit of the three-electrode tube is a rectifier, a fact which is essential to the operation of the device not only as a detector, but as is frequently lost sight of, to its action as an amplifier. In one way or another, regardless of what purpose the valve is used for, rectification takes place in the grid circuit and the use of a condenser in series with the grid is identical with the common use of such a condenser with the Fleming valve.

In the work by Dr. Fleming, entitled "Wireless Telegraphers Pocket Book", page 249, Fig. 36, there is shown a circuit diagram containing a condenser C_1 which circuit and condenser are substantially identical with the grid circuit j', h', j' of Fig. 2 of "Miller Drawing F". Such a circuit could not operate unless either the valve contained sufficient positive ionization, due to gas, to discharge condenser C_1, or else condenser C_1 was leaky.

I recollect having taken apart a commercial Marconi tuner having such a condenser in its circuit, and of being somewhat puzzled as to how it was operating.

I tried the valve in an external circuit, the same as that in the tuner, but using a different condenser, and it wouldn't work. This led me to investigate the condenser in the instrument and I found it to be leaky to an extent sufficient to render it operative.

Dr. Miller goes on to explain further in his answer to Q. 17, the operation of Fig. 3, which is the regenerative oscillating arrangement of the three-electrode tube, but he omits, of course, to point out that the two-electrode tube in the circuit of Fig. 1 (Drawing F), operates in precisely the same way as was brought out in my recent tests.

While Dr. Miller states that in the Fleming circuit the feeble received oscillations must themselves supply the power to actuate the indicator and that in the three-electrode tube power is supplied by a B battery, he is imposing a restriction upon the Fleming arrangement for which, in my opinion, there is no justification, since the use of a battery with a detector of wireless waves was old and well known at the time of the Fleming patent and it is quite obvious that either the three or two-electrode vacuum valves must have some source of power attached to them [fol. 1350] if they are to generate oscillations, since neither tube, in itself, is a source of power.

On page 790 of the Printed Record, Dr. Miller makes the following statement:

"* * * On the other hand, the three-electrode device in the P N circuit as well as in the regenerative circuit constitutes essentially a different type of vacuum tube connected to two separate circuits neither of which performs the functions of the Fleming circuit. In the P N and regenerative circuits, while the received oscillations are increasing in amplitude, they produce rectified current pulses which charge the grid condenser, which charges leak away when the received oscillations are decreasing in amplitude or are not being received. Such rectification as occurs is not indicated in either circuit. Even if it were possible to observe this rectification it would not reproduce the audio-frequencies which the detector is intended to indicate. The rectification and flow of current is an incidental action of the tube in properly charging and discharging the grid condenser."

The first sentence of the above quotation contends that the three-electrode device is an essentially different one from the two-electrodes, which statement is quite contrary to the facts, as I have brought them out in my various answers, and it is also incorrect in stating that neither of these two circuits of the three-electrode device perform the function of the Fleming circuit. As will be seen by reference to the diagram, Fig. 1, "Miller Drawing F", the Fleming circuit performs the two essential requirements of a device used to detect radio signals. It impresses upon the sensitive device the received oscillations by means of the inductance k, and it contains the indicator I, which operates as the result of the change wrought upon these oscillations by the valve.

In the three-electrode tube with the P N circuit, these two actions are effected by two separate circuits, the oscillations being impressed on the vacuum valve by means of the circuit j^2, h', j^3, while the circuit I B contains the indicating mechanism operated by the action of the three-electrode device upon the oscillatory currents.

His further statement to the effect that such rectification as exists, is not observed, and even if it were possible to observe it, would not reproduce the audio-frequency variations which the detector is intended to produce, is so en-

tirely at variance with the facts that it seems as though Dr. Miller must have been confused in this answer.

When a circuit of the type shown in Fig. 3 is employed for the reception of signals, it is the rectification in the grid circuit which makes these signals audible, and without such rectification there would be no indication of the telephone receiver.

His further statement that the rectification is merely incidental in properly charging the grid condenser, is a case of "putting the cart before the horse" for the simple rea- [fol. 1351] son that the rectification is the fundamental action and the reason why the grid condenser is charged, so that the latter is merely the result of the former.

Were there no rectification in the grid circuit, this charging and discharging of the condenser in the manner explained by Dr. Miller, could not take place, and it constitutes one of the basic reasons for the operation of the three-electrode tube.

* * * * * * *

Q. 260. Please refer to Dr. Miller's answer to Q. 18 (P. R., p. 791), and state to what extent you may agree or disagree with him as to his stated contrasts between the operation of the two-electrode tube and the three-electrode tube, when a battery is employed.

A. Dr. Miller has given an explanation of the action of a biasing battery which is similar to the explanation which I have given in the matter of imperfect electrical contacts, and I note that he includes the Fleming valve as a particular type of detector whose operation may be improved by the addition of a battery.

In referring to the Fleming valve he makes his usual statement to the effect that it is not an amplifier, a statement which, of course, is disproven by the results of the demonstration which I recently made, and which showed quite otherwise.

He confirms my statement to the effect that the use of a battery with an amplifier is obvious and necessary, in the following words at the top of P. R., page 793:

"The use of a battery with a detector is optional; the use of a battery with an amplifier is indispensable by reason of the law of conservation of energy."

As I have previously mentioned, the use of a battery with a detector was part of the teaching of the prior art; as, for instance, in its use with the coherer. In this particular use the action of the battery differed in an important sense from the ordinary detector, such as the crystal detector, because in general the amount of energy released by the incoming signal was considerably greater than that in the signal itself, as is shown by the fact that this released energy was capable of operating a relay device.

It so happens that I have done a considerable amount of work with relay devices operated by the modern three-electrode tube, and I know that a very substantial amount of amplification is necessary for the purpose. From this it follows that the coherer was a species of amplifier; another use of the battery with a detector of electrical oscillations which was prior to the Fleming patent, is shown in the patent to R. A. Fessenden, dated May 5th, 1903, No. 727,331 ("Plaintiff's Exhibit No. 82-5" in Marconi Wireless Telegraph Company of America *vs.* DeForest Radio [fol. 1352] Telephone & Telegraph Company). This is the liquid barreter and was an extremely sensitive detector.

The two illustrations given above, together with the paper by Dr. Fleming, giving the characteristic curves of the two-electrode valve are, in my opinion, sufficient justification for the employment of a battery with a Fleming valve. Another use of a battery with a detector of the electrolytic type is shown in patent No. 780,842, issued to F. K. Vreeland, patented January 24, 1905 ("Plaintiff's Exhibit No. 82-10," in the case of Marconi Wireless Telegraph Company of America vs. DeForest Radio Telephone & Telegraph Co.), while patent No. 755,840, dated March 29, 1904, to J. C. Bose ("Plaintiff's Exhibit No. 82-9" in the same case), discloses the use of a battery with a crystal detector.

In addition to the instruction contained in the prior art to use a battery, I may add that a rather extensive experience in the construction and use of the Fleming valve as a detector has brought out the fact that some of them work best when the oscillatory circuit is connected to the negative side of the filament, as shown in the Fleming patent; that others work best when connected with the positive side, while others, again, work best with a substantial amount of added potential.

In the ordinary commercial use of the Fleming valve as a detector, it was customary to supply a means for varying this potential.

In conclusion, I will sum up my remarks relative to Mr. Miller's answer to Q. 18 by stating that the Fleming valve may not only be improved as a detector by the addition of a separate battery, but may also be effectively used as an amplifier, when such separate battery is employed.

Mr. Vaill: Counsel for claimant offers in evidence printed copies of the patents referred to by the witness, and requests that they be marked as indicated:

No. 727,331, to R. A. Fessenden, May 5, 1903, "Claimant's Exhibit No. 265."

No. 780,842, to F. K. Vreeland, January 24, 1905, "Claimant's Exhibit No. 266."

No. 755,840, to J. C. Bose, March 29, 1904, "Claimant's Exhibit No. 267."

(The said exhibits marked as requested.)

Q. 261. Will you please refer to Dr. Miller's answer to Q. 19, particularly where he criticises Mr. Waterman's statement regarding "Plaintiff's Exhibit No. 110," with especial reference to the three tubes or bulbs T, T^2 and T^3 (P. R., p. 796-; also the statement contained in the first paragraph (P. R., p. 798), and also the statement following said paragraph, pointing out to what extent you may agree or disagree with Dr. Miller in said portions of his answer?

A. Dr. Miller's criticism of Mr. Waterman's statement is evidently based on the particular definition of the word "detector" which he has chosen to employ. If, however, the broader interpretation of the word detector, such as that given by the Standard's Committee of the Institute of Radio Engineers, and to which I referred in my answer to Q. 254, and which, incidentally, was the general understanding in the art until the development of the three-electrode valve technique narrowed its significance, Mr. Waterman's statement appears as anything but nonsensical.

[fol. 1353] As will be seen from a reference to the definition given, the function of the detector is to translate the energy of the incoming signal into a form of energy which will operate the indicator, and this translation may be accompanied by, or result in, the release of local energy.

The three detector bulbs referred to by Mr. Waterman operate in this identical way, since their action is to translate the effect of the incoming oscillations into a form of energy which will operate the telephone receivers, and this translation is accomplished through the release of local energy.

This action may be viewed also in another light, as follows:

In the early days of radio, a detector was any arrangement which would, when acted upon by an incoming signal, actuate some indicating device. In the present case, the particular signals with which this device is intended to be used, are of such intensity that three tubes are necessary to supply the required actuating power to the telephone receivers.

Dr. Miller, on page 798 of the Printed Record, states that the two-electrode valve is incapable of such tandem use, but his statement is, of course, entirely contradicted by the evidence of my recent demonstration with the two-electrode tube, which showed that a tandem arrangement of two-electrode tubes amplified in a large and satisfactory manner.

In a statement near the top of P. R., p. 798, Dr. Miller refers to an amplifier which had received signals thousands of times too weak to be received on a detector alone. Under such circumstances, the device which he calls a "detector," would cease to be a detector, because it would be entirely incapable of carrying out the fundamental purpose of a detector, viz., the translation of the energy of the incoming signal into a form which would operate the indicator. If the signal is thousands of times too weak to be received on such a device, it is obviously incapable, under those circumstances, of operating the indicator.

The whole amplifier arrangement being necessary for this purpose, it therefore becomes the detector.

Q. 262. Please refer to Dr. Miller's answer to Q. 20 (P. R., p. 799), and state if there is anything set forth therein regarding the four uses of a three-electrode tube that does not apply to a two-electrode tube.

A. There is no use referred to in Dr. Miller's answer to Q. 20 of the three-electrode vacuum tube which is not also a use which can be made of the two-electrode tube. This statement, of course, results from the tests which I recently

made, and which showed that the two-electrode tube was capable of all the uses here referred to.

Q. 263. Referring to Dr. Miller's answer to Q. 21 of his deposition (P. R., p. 805), please state what bearing, from a technical standpoint, the Edison patent No. 307,031, dated October 21, 1884, has upon the disclosure of the principle of the two-electrode vacuum tube as an instrument for use in radio telegraphy, and also please refer to Mr. Waterman's statement quoted by Dr. Miller, that in the three-electrode device:

"The cold element is divided into two."

In your answer please refer to any publications or patents which indicate that the prior workers in the art so considered the three-electrode tube, indicating, if you will, any examples of instances where the anode was so divided. [fol. 1354] A. The Edison patent No. 307,031 does not, in my opinion, teach anything relative to the use of the two-electrode vacuum tube in a radio system, nor does it disclose any arrangement of this tube which could be usefully employed in a radio system.

Not only is the arrangement disclosed in the Edison patent useless for any radio purpose, but so far as I am aware, the arrangement disclosed therein has no useful purpose of any kind, and has not formed a basis for any commercially used device.

What this patent actually discloses is a rectifying arrangement operating a galvanometer as, for instance, as is shown in Fig. 1. A further purpose of this disclosure is to cause the galvanometer by means of an auxiliary contact shown in Fig. 3, to close the circuit of a regulating mechanism, in order to control the voltage regulation of a generator.

It is to be noted further that the rectifying device of the Edison patent is disclosed in connection with a circuit in which the alternating electromotive force is of low frequency; that is, of the frequency ordinarily employed for lighting purposes. There is, therefore, no indication from the disclosures of this patent relative to the usefulness of the device, or high or radio frequency.

The nature of the Edison invention and its purpose are quite clearly set forth in the specification, for instance (lines 30 to 34, inclusive, page 1), Mr. Edison, after de-

scribing his discovery of what has been termed the "Edison effect," says:

"My invention consists in the utilization of this discovery for indicating or regulating variations in electro-motive force, or for affecting electrical apparatus in any desired manner."

And in lines 8 to 13, page 1, he sets forth the object of the invention as follows:

"The object of my invention is to produce an efficient apparatus for indicating variations of electro-motive force in an electric circuit, preferably for use in connection with systems of electrical distribution to show the changes in pressure in the various parts of the district."

Dr. Miller, on page 805, after quoting Mr. Waterman's description of the grid of the three-electrode tube as follows: "a bit of wire bent back and forth to form a sort of grid," introduces two quotations from Dr. Van der Bijl's book, as follows:

"'In fact, the insertion of the grid into the valve resulted in a device of tremendous potentialities—one that can justly be placed in the same category with such fundamental devices as the steam engine, the dynamo, and the telephone.'

"And on page 42 Van der Bijl states:

"'It is hardly necessary to say that the insertion of the grid has made the audion a device of immense practical importance and enabled it to perform functions that would otherwise have been impossible.'"

While there is no question whatsoever relative to the great importance of the grid, an importance which is justly emphasized in these two quotations, nevertheless, the fact [fol. 1355] should not be lost sight of that the two-electrode Fleming valve is the foundation on which this important structure has been reared and, as has been demonstrated in my recent tests, possesses inherently all of the characteristic capabilities of the three-electrode tube.

In considering Dr. Miller's comment on Mr. Waterman's statement relative to the cold element of the Fleming valve being divided into two parts, it appears to me to be of inter-

est to set forth a few facts of an historical nature, showing how the development of the vacuum valve took place.

Dr. Fleming knew of the Edison effect soon after its discovery by Edison and, in a paper entitled "On Electric Discharges between Electrodes at Different Temperatures in Air and High Vacua," published in the Proceedings of the Royal Society of London, Vol. 47, page 118, of 1890, he describes many of his experiments with apparatus similar to that of the Edison patent No. 307,031.

Later, in the Proceedings of the Royal Society of London, Vol. 74, 1905, beginning at page 476, Dr. Fleming published a paper on the same subject, but involving radio frequencies; showing many other experiments which he conducted, but mainly with the vacuum tube of his patent here in suit. On page 478 (Claimant's Ex. 269) of this publication, which is the one to which I have previously referred, Dr. Fleming illustrates in Fig. 1, three forms of the vacuum tube, referred to as *a*, *b*, *c*, respectively, and on page 477, he refers to this figure 1 as follows:

"The diagrams in fig. 1 show various forms of the arrangement. Diagram *a* shows a bulb with a single carbon filament surrounded by a metal cylinder, *b* shows one with two carbon filaments, and *c* a carbon filament and two insulated metal plates."

The latter illustration, to-wit, *c*, is particularly significant and pertinent to the question at present under discussion, for its shows the anode of the tube split up into two separate plates.

Although Dr. Fleming has not referred to these separate plates being attached to different parts of a radio-frequency circuit, yet it is obvious that such an action would be perfectly practicable and, when the development of this device was taken up by DeForest, it is evident that he recognized this fact. In his patents No. 841,387 (Claimant's Ex. 270) and No. 879,532 ("Defendant's Exhibit K"), of January 15, 1907, and February 18, 1908, respectively, there are illustrated two plates, for instance, Fig. 2 of the first-named patent and Fig. 2 of the second-named patent, arranged in a manner substantially identical with that of *c*, Fig. 1, of Dr. Fleming's article.

DeForest, in these two patents, splits up the cold element into two parts, to one of which he attaches the input cir-

cuit carrying the radio-frequency, and to the other of which he attaches the indicator circuit.

The recognition of this fact is also to be found in the "Hand-Book of Wireless Telegraphy and Telephony" by Eccles, on page 251, where a paragraph appears, as follows:

"The Double Anode Valve

"This form of valve, sometimes called the grid-and-plate valve, consists of a vacuous bulb containing a glowing filament as cathode and two other electrodes. One of these may be regarded as the plate in the valve described above, [fol. 1356] the other is a grid or perforated plate, which is fixed between the filament and the plate. * * *"

A similar recognition of this fact is to be found in the work by Van der Bijl, entitled "Thermionic Vacuum Tube." On page 145, the following statement is found:

"* * * This third electrode can, however, be of any form, since a controlling effect on the discharge can be obtained by so positioning a conductor with respect to the path of the discharge that potential variations applied to it will cause variations in the current flowing between cathode and anode. The controlling electrode may, for example, be in the form of *a plate placed on the side of the cathode opposite to that of the anode* or in the form of a wire or a plurality of wires galvanically connected and placed in the plane of the cathode parallel to that of the anode. * * *" (Italics mine.)

There are further points indicating that the grid and the plate are simply a splitting up of the plate electrode which are indicated by properties common to both; both elements, when connected to the filament circuit, give rectifying action, both control the flow of electrons from the hot filament in accordance with the potential impressed upon them, and both are commonly employed with a constant potential, that is to say, the plate with a positive potential and the grid with a negative potential.

The quotation by Dr. Miller from Van der Bijl, as follows:

"It is hardly necessary to say that the insertion of the grid has made the audion a device of immense practical im-

portance and enabled it to perform functions that would otherwise have been impossible."

is most significant, indicating, as it does, that the three-electrode tube was simply a two-electrode tube in which a grid was inserted.

Dr. Miller's reference to the Eccles publication, entitled "The Three-Electrode Thermionic Tube and the Revolution in Wireless Telegraphy" is, to a large extent, correct, but the following sentence brings out some facts of importance:

"That it has been a veritable revolution can be seen by comparing the common practice in wireless telegraphy of 1914 with that of 1919."

It is to be noted that the three-electrode tube was fully known in 1914 and that the revolution referred to was not the result of discoveries made during that time, but of the tremendous application and use of the discoveries already made.

In the quotation given from Dr. Van der Bijl's book on page 145, is a reference to the fact that the third electrode is capable of exerting a controlling action when it is not between the filament and the plate, and I have seen and tested a practically operative tube which I understand was made either in Germany or Holland, in which this arrangement of two plates, one on either side of the filament, was employed.

In considering the inventions of both Fleming and DeForest, it is important to bear in mind that neither of these [fol. 1357] gentlemen, at the time of application for their patents, realized the full capabilities of their devices such, for instance, as their use for the production of oscillations. It was some six or eight years after the DeForest patents had been granted before the facts relative to this action were known.

While this discovery was made first in connection with the three-electrode tube, the two-electrode tube both as demonstrated before Judge Mayer and in my recent demonstration in this case, have inherently this same capability, so that Dr. Miller's enumeration of the differences between these two tubes should be converted to an enumeration of the likenesses between them.

It is thus apparent that DeForest's discovery of the advantage of inserting a third electrode directly in a two-electrode vacuum tube, important though it was, was not alone the cause of the "revolution," but the discovery and development of the full capabilities of this device, such as that of oscillating.

These discoveries, however, are equally applicable to the two-electrode tube, as I have already shown.

It seems to me that Dr. Miller's quotation from Dr. Eccles may convey an incorrect impression of what Dr. Eccles actually meant. It must therefore be appreciated that the period referred to by Dr. Eccles from 1914 to 1919, was the exact period of the World War, and that owing to the necessity of complete and accurate transmission and reception between sections of the forces of the Army and Navy, and also between the Naval and Land forces, great impetus was given to the development of the vacuum tube both for transmitting and receiving purposes.

It has been estimated that had not this impetus been given to the development of the vacuum tube under conditions of the World War, its final development would probably have been delayed at least ten years.

All of these facts above referred to, clearly indicate that the fundamental invention was that of Fleming, when he discovered that the electron stream between a hot and a cold electrode could be controlled by radio-frequency oscillations.

I think, therefore, it is quite clear that DeForest in his inventions of the three-electrode tube, divided the anode or positive electrode of Fleming into two parts and used one for the incoming radio-frequency oscillations, and the other for the operation of the indicating mechanism.

* * * * * * *

Dr. Miller has somewhat at length disagreed with Mr. Waterman's statements to the effect that the P N circuit is usable with the Fleming valve. His entire contention rests on his designation of the P N circuit as a three termi- [fol. 1358] nal circuit and from this premise he proceeds to argue that a two-terminal device is not usable in the three-terminal circuit. In this argument he fails, however, to bring out the fact that the so-called P N circuit did not originate with the three-electrode tube, but was simply borrowed by DeForest from the prior art.

In "Weagant Sketch No. 5" (Claimant's Ex. 273) is shown in Fig. 1 the circuit arrangement of Marconi patent No. 627,650, in which an input circuit consisting of a coil j^2 and a condenser K' is shown. These two elements correspond to the coil j^2 and the condenser j^3 of "Miller Drawing F," Fig. 2. The condenser h', which is the tuning condenser in this circuit, of course is not shown in the Marconi patent, because the tuning of this circuit had not been accomplished at the date of this patent.

This difference, however, does not change the circuit with respect to the point at present under consideration.

On the right-hand side of Fig. 1 "Weagant Sketch No. 5," is shown a battery B, an indicator R and two choke coils C' and C^2. This circuit corresponds to the right-hand circuit of Fig. 2 of "Miller Drawing F," with the exception that the latter does not require the choke coils. Both circuits are for the purpose of supplying battery power to the detector, and for the purpose of containing the indicator.

A comparison of these two sketches shows at once that DeForest simply took the connection which runs from condenser K' to the detector T and transferred it to the grid. After this transfer has been made, the circuit may be said to have three terminals which are separate and distinct, but in its original form two of the terminals coincided on the detector T of Fig. 1 of "Weagant Sketch 5." These two terminals are the connection from the condenser K' and choke coil C', to the detector T. While the terminal conditions of the two circuits naturally change when this circuit is transferred from a two-terminal device to a three-terminal device, the circuit itself and its function, which is to conduct the radio-frequency energy to the detecting tube, remains unchanged.

In "Miller Drawing L" the two-electrode tube is shown in the P N circuit, and I have reproduced it as Fig. 3 of "Weagant Sketch 5," and it will be noted that it corresponds very closely with Fig. 1 of "Weagant Sketch No. 5," differing only in the fact that, instead of two choke coils in the battery circuit, there is only one, indicated by L, and these two arrangements are alternative, and no difference in the action results from the use of one coil as compared to two.

Fig. 3 of "Weagant Sketch 5" represents an arrangement of the two-electrode tube in the P N circuit which I

have frequently used, while "Weagant Sketch No. 6" (Claimant's Ex. 274) is the same circuit with the choke coil L omitted, due to the fact that the telephone receiver I provided a sufficient choking effect without the employment of an additional choke coil. This circuit I have actually used a great deal, and it will be noted that it corresponds exactly with the circuit of Fig. 2 of "Miller Drawing F," with the exception that both the right-hand circuit and the left-hand circuit terminate on one electrode, instead of on two.

Dr. Miller's statement, as follows (P. R., p. 810):

"The circuits are distinct and separate because they ter- [fol. 1359] minate respectively in the grid and plate terminals which are points having different potentials both steady and varying."

appears to make a distinction between the use of the P N circuit with the three-electrode tube with the same circuit used with the two-electrode tube, based on the fact that these two points in the three-electrode tube are at different potentials, while in the two-electrode tube they are at the same potential.

While this is true, it is not the result of any difference in the circuits, but merely a difference in the terminal conditions.

In connection with Fig. 3 of "Miller Drawing L," Dr. Miller states (P. R., p. 810):

"The way Figure 3 is drawn, with the low frequency branch to the right of the bulb and the high frequency branch to the left, makes it appear that the separation has been made into two circuits. Figure 3a dispels this illusion: this is the same identical circuit as Figure 3 and shows that the separation has been merely into two branches which are in parallel between the points *a* and *b*."

It is the function of a circuit drawing to make as clear as possible all of the facts which such a drawing is capable of presenting. In Fig. 3 the arrangement of circuits clearly indicates the facts of operation, viz.: that the circuit at the left is for the purpose of putting the high frequency energy into the tube, while the circuit to the right is for the purpose of supplying the battery power to the detector and for containing the indicating instrument.

Redrawing the circuit as Dr. Miller has in Fig. 3a, merely results in a type of drawing which is much less clear than it might be, and which, to any but a skilled technical man, would be confusing.

I may state further that, were a drawing of these circuits presented to me in this form by an assistant engineer I should immediately require him to re-draw these circuits after the fashion of Fig. 3.

Of course, when the P N circuit is drawn as in Fig. 3a, its appearance differs markedly from that of the P N circuit attached to the three-electrode tube, as shown in Fig. 4, but, since the purpose and functioning of the circuit is identical in both cases, that is to say, the left-hand side puts the energy on the incoming signal into the valve, while the right-hand side supplies the battery power and the indicating mechanism; the drawings representative of the employment of this circuit with the two types of tubes should, as nearly as possible, have the same identity of appearance as they have in fact.

Examination of the two drawings Fig. 3 and Fig. 4 of "Miller Drawing L" shows, very clearly, without the necessity of a lengthy explanation in words, the point brought out by Mr. Waterman, viz., that the three-electrode tube constituted the splitting up of the cold electrode of the Fleming valve into two parts corresponding with the two functions, viz., the input of signal energy and the indication of the presence of that energy.

Dr. Miller's reference to the World War and the revolution in radio which accompanied it, suggests an analogy between the cause and the ultimate development of the World War, and the work of Dr. Fleming, and the subsequent development of the vacuum valve.

[fol. 1360] A single shot from an assassin was followed by a conflict which involved the whole world, and consequences of colossal magnitude.

The discovery by Dr. Fleming that an electron stream between a heated cathode and a cold plate or anode could be controlled by an applied radio-frequency voltage, was a fundamental work which led to a development which, at the present day dominates the whole radio art.

It is usually very easy, after an invention has been made, to see how it should obviously have followed from the work of someone else, but it was some eighteen to twenty years after the discovery of the "Edison effect," during

which time Fleming and others conducted extensive research work on this "effect," before the invention of the Fleming valve was made.

It is also interesting to note that some time and work was required before DeForest, working with the device of Fleming, hit upon the idea of splitting the anode into two parts, so as to separate one terminal of the input circuit from one terminal of the output circuit.

With this change in structure and the subsequent discovery of the capabilities of the resulting device, as well as the original device in the matter of producing oscillations, the final step was taken which has resulted in a complete revolution in radio technique. So complete is this victory of the development of the Fleming invention, that today the vacuum tube may well be termed the "heart" of radio.

Mr. Vaill: Counsel for claimant offers in evidence the following as exhibits, and asks that they be marked as follows:

"Proceedings of the Royal Society of London," Vol. 47, pages 118 to 126, inclusive, being the Fleming article on "Electric Discharge between Electrodes at Different Temperatures in Air and in High Vacua," received December 16, 1889, published under date of January 9, 1890, as "Claimant's Exhibit No. 268."

"Proceedings of the Royal Society of London," Vol. 74, pages 476 to 487, inclusive (article received January 24, 1905, read on February 9, 1905, published in Pamphlet No. 505, March 16, 1905; Volume 74 being published in April, 1905), article entitled "On the Conversion of Electric Oscillations into Continuous Current by Means of a Vacuum Valve," referred to by the witness in connection with De Forest Patent No. 823,402 ("Plaintiff's Exhibit No. 258"), in connection with his answer to Q. 252, and in connection with his answer to Q. 263, as "Claimant's Exhibit No. 269."

Printed copy of patent No. 841,387, January 15, 1907, to DeForest, referred to in answer to Q. 263, as "Claimant's Exhibit No. 270."

Photostat copy of page 251 of A Hand-Book by W. H. Eccles, entitled "Wireless Telegraphy and Telephony" (December, 1915), as "Claimant's Exhibit No. 271."

Photostat copy of page 145 of the book by H. J. Van der Bijl, entitled "The Thermionic Vacuum Tube" (First

Edition, Second Impression—1920), as "Claimant's Exhibit No. 272."

"Weagant's Sketch No. 5," as "Claimant's Exhibit No. 273."

"Weagant's Sketch No. 6," as "Claimant's Exhibit No. 274."

(Said exhibits marked as requested.)

Q. 264. Please state to what extent you agree or disagree [fol. 1361] with Dr. Miller's answer to Q. 22 of his deposition (P. R., p. 811), concerning "Plaintiff's Exhibit No. 85".

A. Dr. Miller's answer to Q. 22 consists largely of an explanation of the action of the particular amplifying device which is the subject of "Plaintiff's Exhibit No. 85," and which explanation does not, so far as I can see, add anything to similar explanations previously given. He takes occasion again to criticise Mr. Waterman's statement: "Three detector bulbs T^1, T^2, T^3, together constitute the detector," and to again make his particular distinction between a detector and an amplifier.

As I have already pointed out, this particular distinction is one which has arisen in the development of the technical literature of the three-electrode tube, and is one which was not made in the earlier days of radio.

As I have also pointed out, the definition of the word "detector" given in the Report of the Standards Committee of the Institute of Radio Engineers, is much broader in its scope and under this definition, when it is necessary to employ three vacuum tubes such as T^1, T^2, T^3, in the quotation above, this entire combination is properly considered to constitute a detector.

Dr. Miller, of course, makes as much as possible of the amplifying action of the three-electrode tube, but while this action exists, and is of great consequence, nevertheless, it is a property which was possessed by the first of all radio detectors, viz., the coherer and, of course, as I have shown by conclusive demonstrations, by the two-electrode vacuum valve.

Dr. Miller repeats, several times, his statement to the effect that the Fleming valve is not an amplifier and cannot amplify; to which, of course, I must reply that the facts as shown by actual demonstration, are quite otherwise, and the two-electrode Fleming valve is so good an amplifier

that, were it not for the fact that the three-electrode one is better, this two-electrode amplifying Fleming valve would be found in extensive commercial use today.

Dr. Miller's criticism of Mr. Waterman's statement that (P. R., p. 813):

"It should be understood that as a matter of fact not all bulbs, whether they have one cold element as shown in defendant's patent, or two, as in the so-called audion, are able to work efficiently enough to produce an amplification. The bulbs which will amplify have to be selected by trial."

is to the effect that the three-electrode tube always amplifies. Perhaps a brief statement of some of the facts relative to the manufacture of three-electrode tubes may, at this point, make clear the basis of Mr. Waterman's statement.

When the three-electrode tube was first made and sold as a commercial device, for a considerable period of time, these tubes varied so much in their sensitiveness that it was largely a matter of luck if the purchaser got a good one. Almost any of them would detect, but a considerable percentage was quite worthless as either amplifiers or oscillators.

In the present-day commercial manufacture of three-electrode tubes, it is customary to put them through a careful test and inspection before they are marketed, so that [fol. 1362] the tubes which appear on the market are practically all good tubes. This result, however, is accomplished through the rejection of a considerable percentage of the tubes manufactured, and I happen to know from my own personal experience in this work, that the percentage of rejection is sometimes as high as sixty per cent.

In the light of these facts it is quite evident that an amplifying valve has to have something besides the third electrode in order to make it work, and that something is proper construction, together with suitable exhaustion.

The commercial development of suitable methods for exhaustion has consumed some years of intensive work, and it is in the effectiveness of these exhaustion methods that much of the improvement of the three-electrode tube as produced today, over the earlier devices of the same sort, is due.

I think I may fairly sum up this whole matter by stating that both the two-electrode valve and the three-electrode

valve must be properly constructed and exhausted, if they are to function satisfactorily in accordance with present-day technical standards.

Q. 265. Please refer to Dr. Miller's criticism, in his answer to Q. 23 (P. R., p. 814), of Mr. Waterman's testimony regarding the use of a battery with a vacuum tube detector, and state whether you agree or disagree with Dr. Miller's conclusions.

A. Dr. Miller's answer to Q. 23 disagrees with Mr. Waterman's statement to the effect that Paragraph 208 of the "Navy Manual" of 1915 refers to a lamp detector and a battery and, in fact, he denies the correctness of this statement. His denial appears to be not only a contradiction of Mr. Waterman's statement, but of the fact relative to the three-electrode tube which he himself has admitted. That the three-electrode dector may be properly termed a lamp detector, seems most obvious, since, when the filament is heated to incandescence, it gives out a light; sufficient light, in fact, when a number of them are employed, to render working with the apparatus possible at night, without other illumination.

In so far as this device constituting a detector is concerned, we have only to remember that Dr. Miller has given a complete explanation of the detecting action of the three-electrode tube. That a battery was used with this detector is obvious, and I therefore find that I am in agreement with Mr. Waterman's statement relative to the paragraph mentioned.

Dr. Miller further comments to the effect that Mr. Waterman's statement gives rise to the inference that when a detector is supplied with a battery, it becomes an amplifying device. In so far as this inference applies to the two-electrode Fleming valve, it is entirely correct, as I have shown by my tests, and I do not gather from Mr. Waterman's statement any extension of such inference beyond the two-electrode tube.

Mr. Waterman's further statement, "either the two or three-element bulb can be used to amplify when used with a local battery," quoted by Dr. Miller on Printed Record, page 814, is entirely in accordance with the results of my recent tests and demonstrations, and Dr. Miller is quite mistaken in his denial of this statement. He is also mistaken in the following sentence, "The real feature of the

three-element bulb which enables it to be used as an amplifier is the grid-control member."

[fol. 1363] My tests have shown conclusively that the *real feature* of the vacuum tube amplifier is the electron stream originating in the hot electrode, and flowing to the cold electrode, and the inherent capabilities which this electron stream has of being influenced by a properly associated electrostatic field in such a way that the energy in the variations of the electron stream is greater than the energy which must be associated with it for the purpose of producing these variations.

Dr. Miller further differentiates, on P. R., p. 814, between detection and amplification, but the sort of detection which I must assume he refers to is that contained in the definition which he quoted from Dr. Eccles in answer to Q. 8 on P. R., p. 770, which detection is a particular and limited kind of detection, and signifies the conversion of a radio frequency into some other and usually, though not always, audible frequency. This particular significance is useful in a technical analysis of the operation of vacuum tubes, but is not detection in the broad sense of the word, as understood in the earlier radio art, or as defined by the definition contained in the report of the Standards Committee for 1922, of the Institute of Radio Engineers.

Dr. Miller carries this particular thought through his further comment at the bottom of Printed Record, page 814, relative to detection and amplification, and adds the further characterization to detection by calling it a "distortion." This statement is true only in the limited technical sense which he has chosen to employ, but it is quite untrue in the broad sense.

As will be seen from the definition of the Standards Committee, referred to above, detection may be, and in fact actually is, accomplished through the control of a local source of energy. This was the case in the original detector, viz., the coherer, and is also the case with the two or three-electrode valves.

While amplification may be differentiated from detection on the narrow technical basis applied by Dr. Miller, nevertheless, in the broader sense detection may involve amplification. The original coherer was a species of amplifier, and its detecting action was accompanied by an amplification.

The two and three-electrode valves, either singly, or in cascade, act as detectors and amplification accompanies this detecting action.

Dr. Miller, on Printed Record, page 815, refers to the characteristic curve of an amplifier, and states that it should be as nearly a straight line as possible, which is perfectly true, in so far as the particular sort of amplification to which he refers is concerned, and so far as an ideal device is concerned. It so happens, however, that the characteristic curve of the three-electrode tube, while fairly straight over part of its length, is curved in other portions.

The requirement mentioned above, that the device should have a straight line, is important only for that kind of amplification which involves a reproduction in the output circuit of the wave-form of the electromotive force applied to the input circuit. This is the sort of amplification necessary for faithfully reproducing telephone speech, but it is not the only kind of amplification. There is another kind, of which the coherer is an illustration, in which the output energy may be much greater than the input energy, but quite unrelated to it in form, and in this instance the input energy is in the form of an oscillating current of high fre- [fol. 1364] quency, while the output energy is in the form of a direct current.

Q. 266. Please refer to the last paragraph of Dr. Miller's answer to Q. 24 (P. R., p. 817), and state whether you agree with him that the device of the Fleming and the three-electrode vacuum tubes have "nothing in common," when used in transmitting sets, giving your reasons for your answer.

A. I must first, in replying to this question, point out that Dr. Miller's statement, in the first part of this paragraph, is self-contradictory, and that actually it is not a denial of the demonstration before Judge Mayer of oscillations produced by the two-electrode vacuum valve, but an admission that such oscillations were obtained, and a criticism of the method of action and the operating condition.

I am unable to see any real basis which permits Dr. Miller to make even the criticism which he has, for the simple reason that he was not present during this test, and the difficulties, etc., which he himself experienced, form no proper criterion of the demonstration before Judge Mayer.

It is also evident from the concluding part of Dr. Miller's statement in this paragraph, that he was quite unaware of

the fact that the two-electrode Fleming valve with a high vacuum, could oscillate in the manner demonstrated in my tests. Because of the facts disclosed in this test, it is quite obvious that the three-electrode tubes referred to by Dr. Miller, have very much in common with the device of the Fleming valve, and in fact are simply an improvement over this device.

* * * * * * *

Q. 267. Do you agree with the statements made by Dr. Miller in answer to Q. 25 (P. R., p. 817), and Q. 27 (P. R., p. 819), regarding the importance of the Fleming valve in the radio art? Also please refer to Mr. Loftin's testimony on the same subject, as found in answer to Q. 39 of his deposition (P. R., p. 1149), and particularly that part of the answer referring to the "literature of the world on the subject of radio," giving examples of such literature which disprove Mr. Loftin's statement in this respect.

A. Both Dr. Miller and Mr. Loftin, in replying to questions relative to the use of the Fleming valve, merely express the fact that their own personal knowledge of the use of this device is negligible. It happens, however, that others are familiar with such use and have given testimony in this case which shows that the Fleming valve has occupied a position of considerable importance in the radio art. I refer to Messrs. Alexander E. Reoch, Charles J. Weaver, John J. Brennan and Gordon B. Rabbits.

[fol. 1365] As is usual in his replies, Dr. Miller refers to the Fleming valve as a detector only, and incapable of amplifying, and I must again refer to my demonstrations, which have clearly proven the incorrectness of this statement.

He also refers to it as a detector of inferior characteristics as compared with the crystal and to this I shall reply that in its stability, freedom from the effect of shocks, either electrical or mechanical, and its certainty of operation, the Fleming valve, neglecting for the time being, its amplifying property, and considering only its rectifying action, was a detector of outstanding merit.

It would appear from Dr. Miller's statements that he had personally never tested or used a good specimen of the Fleming valve, while on the other hand, I have made and used many of these devices which, when used as simple rectifiers, were equal in sensitiveness to the most sensitive

of all crystals, viz., the galena and which required no adjustments of any kind.

I might state further, that at one period, somewhere about 1915, as I recollect it, I was planning to replace all the crystal detectors in the service of the Marconi Company of America with the simple Fleming valve. The only reason why this plan was not carried into effect was the rapid development of the three-electrode device, including that particular type developed by the witness, having the controlling electrode on the outside.

I have no hesitation in stating that had this plan been carried out, it would have resulted in substantial improvement in the ship service of the Marconi Wireless Telegraph Company of America.

Statements relative to the inferiority of the Fleming valve as compared to the crystals, and considering the Fleming valve from the standpoint of its rectifying action only, and not including its amplification property, are based on a lack of knowledge of the real capabilities of this device, which capabilities I of necessity investigated most extensively, since the Marconi Company owned the Fleming patent and a good detector was essential to its business.

I note in connection with the last part of your question, that Dr. Zenneck, who has been referred to many times by the defendant in this case as a radio authority, in his book entitled "Wireless Telegraphy" (Claimant's Ex. 275), gives a diagram, Figs. 340 and 341, of the Fleming valve and associated circuits, the latter circuit showing an auxiliary battery E, which is the same thing as the "B" battery frequently referred to in this case.

Above the figures is the following statement:

"* * * But in the more recent form of Fleming's 'oscillation-valve,' the anode being a cylinder of carbon and the cathode a tungsten wire, this detector seems to have met all reasonable requirements as to sensitiveness and reliability. This is borne out by the fact that Marconi has been using it, in conjunction with an Einthoven string galvanometer, in his transatlantic stations."

This statement of Dr. Zenneck's brings out the fact that he was aware of a most important use for the Fleming valve, viz., in the Marconi transatlantic stations.

Dr. Miller cites various references on Printed Record,

[fol. 1366] pages 821 and 822, tending to show through the publications referred to therein, the insensitiveness of, and general uselessness of, the Fleming valve.

As it happens that I am very familiar with the development of both the two and three-electrode valves to the point of commercial usefulness, I am able to point out certain facts in connection with references of this kind, which I believe to be illuminating.

Both the two-electrode tube and the three-electrode tube, as constructed at first, were a long, long way from displaying the capabilities inherent in them. When the amplifying and oscillating action of the three-electrode tube were discovered, a tremendous incentive was uncovered for further investigation and development of this device.

To this end the great facilities of such organizations as the General Electric Company, the American Telephone and Telegraph Company and, to a lesser extent, of the American Marconi Company, were devoted and, after the expenditure of probably millions of dollars, the three-electrode tube was brought to its condition of present-day usefulness.

The original Fleming valve, however, partly because its amplifying ability was not recognized by most people, and partly because, in any case, it is not so good as the three-electrode tube, did not receive the attention, so far as I am aware, of any organization, except the American Marconi Company.

Due to the patent situation the two-electrode device was of great importance to this organization, and extensive development work, under my direct personal supervision, was undertaken for the purpose of determining to what extent the original Fleming valve was capable of realizing the benefit of the work which had been done on the three-electrode valve.

So far as I am aware, no one else in the world undertook anything of this kind, and the comments of the various writers referred to by Dr. Miller and Mr. Loftin, apply to odd specimens of the device which happened to come into these writers' hands. Had the three-electrode tube not been subject to a great development, I have no doubt that radio literature would be full of the same sort of disparaging remarks, because I know from extensive personal experience, that this device, in its early form as manufactured by DeForest, was a most unsatisfactory thing to use.

My problem, in taking up the development of the two-electrode tube, was the same as confronted the workers who developed the three-electrode device, viz., to secure maximum sensitiveness and uniformity in the results.

Following in the footsteps of the workers who developed the three-electrode tube, particularly in the matter of securing a good order of vacuum, I succeeded in improving the results obtainable with the two-electrode valve over those obtainable with the same device in its early form, by an amount quite equal to the improvement attained in the work on the three-electrode tube.

As a result of this work, the oscillating and amplifying capabilities of the two-electrode tube appeared, and I was also able to produce a two-electrode device for use as a simple rectifier and detector of sensitiveness equal to the best crystal, and which could be made uniform in results, due to [fol. 1367] the fact that suitable methods of exhaustion were employed.

When, therefore, a comparison is made between the operation of the two-electrode device and the three-electrode device, this comparison is of significance only when it is made clear whether or not, in both cases, the devices have the benefit of modern development in the technique of manufacture.

Dr. Miller (P. R., p. 822) refers to a paper by Dr. Austin relative to the sensitiveness of the Fleming valve, and states that his result indicates a sensitiveness ratio in favor of the crystal detector of from 2 to 10 in favor of the crystal. He neglects, however, to make any reference to Dr. Austin's explanation of the larger ratio, which is as follows, pages 538 and 539 of the paper referred to:

"For a wave length of 900 meters the perikon appeared to be at least ten times as sensitive as the vacuum valve. As there is no reason to believe that the vacuum detector would change its sensitiveness with frequency, this difference is almost certainly due to insufficient coupling."

This statement brings out the fact that the larger ratio in favor of the crystal detector expressed nothing whatever relative to the sensitiveness of the vacuum tube itelf, but is a figure which included a deficiency in the receiving apparatus at the longer wave lengths.

I might further point out that a test of this kind carried out on a few specimens of the Fleming valve, and having back of it simply ordinary scientific curiosity, rather than any constructive purpose, is quite without significance in determining the fundamental capabilities of a device like the Fleming valve. Only extensive investigations—such as that conducted by an industrial organization—is capable of developing this sort of fundamental information.

As illustrative of the significance, or otherwise, of tests of the sort referred to by Dr. Miller and reported in Dr. Austin's paper ("Defendant's Exhibit F-1"), I may call attention to some tests on the three-electrode tube, reported by Dr. Austin in this same paper on pages 540, 541 and 542, in which a sensitive ratio to the electrolytic detector of 1.5 is given.

In spite of the tremendous capabilities of the three-electrode device in the matter of amplification, oscillation and regenerative action, this particular test disclosed nothing which would warrant the use of the three-electrode tube.

I happen to know, furthermore, from my personal contact with Naval radiomen during this period, that on the basis of this test, the fact that the increase in sensitiveness over ordinary detectors was so small and the cost of the auxiliary apparatus, such as batteries, was considered so great, that the Navy declined to employ it in its own service until some two or three years later, when the remarkable capabilities of this device were discovered as the result of some *real* work done elsewhere.

In spite of Dr. Miller's inability to find any literature containing a favorable reference to the Fleming valve or any recognition on the part of technical writers of its [fol. 1368] usefulness, I find in the work entitled "Text Book on Wireless Telegraphy," Vol. 2, Valves and Valve Apparatus, by Rupert Stanley, Chapter 3, page 36, the following statement:

"Fleming Valve.—The first valve detector was patented by Dr. J. A. Fleming in 1904; it had no grid, and simply made use of the unilateral conductivity effect between a heated filament and a plate enclosed together in a vacuum. At that time it was considered so reliable and robust compared to crystal detectors that it was largely adopted on wireless installations by the Marconi Company."

And also on pages 37 and 38, two additional paragraphs:

"Fleming was the first to use the unilateral conductivity effects of an electron discharge, from a heated filament to a plate at a higher potential than the filament, so that his patent may be considered as the parent one of all valves used in wireless receiver circuits."

* * * * * * *

"'Audion' Valve.—Dr. DeForest introduced a grid consisting of a perforated cylinder, or plate, between the filament and anode of what was virtually a Fleming valve, thus producing a relaying valve which he called an 'Audion.' In DeForest's circuit, which is shown in Fig. 13, the valve is used as a detector-relay; the small pulses of potential set up in the receiver circuit act on the grid and cause corresponding pulses of plate circuit current; these are also rectified by employing the valve at the proper point on its characteristic curve."

The first statement quoted indicates that because of the reliability of the Fleming valve, it was largely employed by the Marconi Company, which company had a greater number of radio installations than any other company that I am aware of.

The second paragraph quoted brings out the point to which I have repeatedly referred, viz., that Fleming was the first to disclose the utility of an electron stream or discharge, when influenced by radio oscillations.

The third paragraph brings out the author's point of view relative to the three-electrode valve being the result of the insertion in the two-electrode valve of the third electrode or grid.

I note also that he refers to the three-electrode valve as the "detector-relay," which expression is similar to some of my own statements, indicating that a detector may operate by the control of local energy, as well as by the mere conversion of the form of incoming energy into a form suitable for operating an indicating mechanism.

Mr. Vaill: Counsel for claimant offers in evidence photostat copies of pages 283 and 284 of book entitled "Wireless Telegraphy" by Zenneck, translation by Seelig, 1915, as "Claimant's Exhibit No. 275."

Also the title page and pages 36, 37 and 38 of the "Text-

Book on Wireless Telegraphy", Vol. II, by Rupert Stanley of 1919, as "Claimant's Exhibit No. 276".

(Said exhibits marked as requested.)

[fol. 1369] Q. 268. Referring to Dr. Miller's answer to Q. 28 (P. R., p. 823), please state to what extent you may disagree with Dr. Miller's statements regarding the art prior to the invention of the Fleming valve?

A. Dr. Miller, in reply to Q. 28, sets forth at length various scientific facts known to scientists prior to 1904, but he does not refer to any publication showing that anyone, prior to Fleming, made any use of the so-called "Edison bulb" as a rectifier for high-frequency oscillations.

His statement to the effect that any scientist could have predicted prior to 1904 that the Edison device would operate just the same at radio-frequencies as at audio-frequencies, omits entirely to bring out any evidence that any of these learned gentlemen did make such a prediction, in spite of the fact that at the time of the Fleming patent, radio telegraphy was some eight years old.

Fleming himself was familiar with the Edison device nearly eighteen or twenty years before he made his invention.

As is practically always the case, and as I have learned from a long experience with inventions, the mere existence of the fundamental scientific information necessary for the making of an invention, is without significance in itself. To someone there must occur the idea which results in the utilization of such fundamental information for a useful purpose.

As an illustration of the fallacy of arguing anything in particular from the sort of information referred to by Dr. Miller, I will undertake to show, by the same method of reasoning, that the three-electrode tube was a perfectly obvious device to anyone skilled in the art after Fleming's disclosure. I have several times referred to the fact that an electrostatic control of an electron stream by a third element was old and well known in the art, and I produce herewith pages 237 and 238 (Claimant's Ex. 277) of Dr. Fleming's book, "The Principles of Electric Wave Telegraphy," published 1906, in which, in Figs. 31 and 32, there is shown a device known as the Braun tube.

Reference to Fig. 32 shows that this device, when acted upon by a high potential, produces a cathode fay, which is

another name for an electron stream, which travels from one end of the device, viz., the left hand end, to a screen at the opposite end.

Two exterior electrodes P, P, connected to an oscillating circuit, L, K, S, have impressed upon them the alternating potentials due to the oscillating circuit and the electrostatic field existing on these plates deflects the electron stream and enables the device to be used for delineating condenser discharge curve.

We have here in so far as fundamental scientific information is concerned, the elements of the three-electrode tube, viz., an electron stream and an electrostatic control thereof.

Following the particular method of reasoning involved in Dr. Miller's reply to Q. 28, would lead me to the conclusion that Dr. Fleming, having this particular information, would have immediately applied to his vacuum tube a third electrode capable of producing the electrostatic control.

That this particular method of reasoning has little relation to the actual business of making an invention is, of course, shown by the fact that Dr. Fleming did not do anything of the kind but, on the contrary, it required another individual, viz., Dr. DeForest, to make this invention and [fol. 1370] carry out in a practical device, the fundamental electrical principles clearly shown in the Braun tube with electrostatic control.

Dr. Miller, in further statements in answer to Q. 28, refers to patent No. 328,687 to Valbreuze ("Defendant's Exhibit A-2"), as an illustration of the use of a rectifier in a radio circuit, but it would be more nearly correct to state that the Valbreuze patent discloses merely a paper-and-ink radio system.

I have constructed the device shown in this patent which, of course, does not involve any hot electrode and it is utterly useless for the purpose described. Dr. Miller's statement that the device is even more insensitive than the Fleming valve is hardly a correct expression of the facts, for the Fleming valve, properly constructed, is an extremely sensitive detector, while the Valbreuze arrangement is so insensitive that it is useless practically, and I may also add, has never had any practical use.

Mr. Vaill: Counsel for claimant offers in evidence photostatic copies of pages 237 and 238 of the book by Dr. J. A. Fleming, entitled "The Principles of Electric Wave Teleg-

raphy" of 1906 and requests that the same be marked "Claimant's Exhibit No. 277."

(Said exhibit marked as requested.)

Q. 269. Do you agree with Dr. Miller's conclusion, in his answer to Q. 29 (P. R., p. 828), that:

"* * * there is no connection whatsoever between the detecting function and the functions of amplifying or oscillating."?

A. Dr. Miller's statement, as I understand it, is directed to the three-electrode device, and I am quite unable to agree with it, because a little detailed consideration of the mechanism of the three-electrode tube shows that the same mechanism, viz., its rectifying action, is an important essential of the amplifying action and the oscillating action.

As Dr. Miller himself has pointed out, in his explanation of the action of the three-electrode tube, when an electromotive force is applied to the grid, the positive half of the cycle results in withdrawing more electrons from the hot cathode and thereby increasing the plate current, while the negative half cycle has an opposite effect, and results in the reduction of the plate current. This very action is rectification, because the rectifying action between either of the cold electrodes and the hot filament is the direct result of the fact that the electrons in the filament can only be drawn out by a potential in one direction and therefore, current can only flow in one direction.

If we now examine the action taking place during oscillation, we find that, as explained by Dr. Miller, the current variations in the plate circuit support the current variations in the grid circuit, a fact which is only possible as the result of the rectifying or detecting action of the tube.

A brief inspection of the mechanism shows why this is so. When a positive potential is applied to the grid the plate current increases, and when a negative potential is applied to the grid, the plate current decreases, due to the rectifying action of the grid, as explained above.

Let us, however, assume for a moment, that the grid [fol. 1371] works differently, viz., that either a positive or a negative impulse causes an increase in the current in the plate circuit; then it would follow that for one complete cycle on the grid, one-half being positive, and the other half

negative in the plate circuit, there would be two positive half cycles, which is analyzable into a direct-current component and an alternating-current component of twice the frequency of the electromotive force applied to the grid. This means that the output frequency of the tube under these conditions, would be double the input frequency and could not, therefore, support this input frequency and produce sustained oscillations.

Similarly, the device could not function as an amplifier which operated without distortion but, on the contrary, if it amplified at all, would change the frequency of everything put into it.

From the above simple analysis it is evident that the three-electrode tube, in acting as either an amplifier or oscillator, depends upon the fundamental rectifying action between the cold electrodes and the hot electrode.

Another and less technical way of stating this fact, is to simply point out that the three-electrode tube contains two rectifying circuits, that regardless of what particular manner in which the tube is functioning, it is employing those rectifying circuits and, furthermore, if it did not contain these rectifying circuits, it would be some other kind of a device.

* * * * * * *

There are one or two additional points which illustrate the part played by the rectifying property of the three-electrode tube when it is used as an oscillator or an amplifier.

Dr. Miller has laid considerable stress on the fact that one of the outstanding features of the three-electrode tube is its ability to amplify without distortion, a property of immense importance in wire telephony and in the reception of radio telephony. It is customary in the operation of the three-electrode tube to impress upon the grid a negative voltage, commonly referred to as a biasing voltage, of such magnitude that when the grid circuit is operated upon by an incoming signal the positive half-cycle will not exceed the negative bias applied to the grid. This is necessary in order to reduce distortion to a minimum, for even though the characteristics of the tube may be a straight line, yet as soon as the grid goes positive, it begins to draw current and, as a result, introduces losses into the input circuit. It may therefore happen that, during

the rise of the positive half-cycle of grid electromotive force [fol. 1372] from zero to a maximum, the first half of it may operate on a grid which consumes no energy, while the second half of it, due to current flowing, may operate on a grid which consumes energy.

Such an action will at once result in distortion and is, therefore, avoided in practice. It becomes very important, then, both from the standpoint of distortionless amplification and efficiency of amplification, to keep the grid negative, so that it may consume no energy, *but* this is possible only because the grid circuit is a rectifier, and when a negative voltage is applied, no current can flow through it so long as the positive half-cycle of the incoming voltage does not exceed this negative voltage.

It is thus seen that the rectifying characteristic on which the tube depends for detection, is also vital in obtaining good amplification.

Similarly when the tube is used as an oscillator, a negative bias is applied either with a separate battery or by the use of a grid condenser with a leak. The latter device functions by accumulating a negative charge from the tube's own oscillations and by adjustment at the rate at which this charge leaks off relative to the rate at which it accumulates, any desired negative voltage may be impressed on the grid.

It is thus seen that the rectifying or detecting function of the three-electrode tube has an additional important bearing on the performance of the three-electrode tube as an oscillator.

Q. 270. Have you read, and do you understand, the technical descriptions in the Fleming patent No. 803,684, of November 7, 1905, in suit, "Plaintiff's Exhibit No. 22", particularly as regards claims 1 and 37 thereof?

A. I have read the patent, and believe that I understand it, and the significance of the claims 1 and 37.

Q. 271. Have you read the deposition of Mr. Frank X. Waterman, given during the opening or prima facie proofs in this case, and if so, do you understand the same, and do you agree with Mr. Waterman's position regarding the nature of the invention of the said Fleming patent in suit, and the similarity of the devices and circuits used by the defendant on which infringement is claimed, with the devices and circuits of said Fleming patent?

A. I have read Mr. Waterman's deposition, and believe that I understand it, and I am in agreement with Mr. Waterman's position regarding the nature of the invention of the Fleming patent in suit, and I agree with Mr. Waterman in his opinion relative to the similarity of the devices and circuits used by the defendant, on which infringement is claimed, with the devices and circuits of the Fleming patent.

Q. 272. Will you please state briefly your understanding of the nature of the invention of Fleming patent No. 803,684, referring also to claims 1 and 37 thereof, stating from the technical standpoint whether or not the descriptions of the elements in said claims are confined to the exact devices described and illustrated in the specification and drawings of said patent?

A. Fleming patent No. 803,684 discloses an arrangement consisting of a cold electrode and a heated electrode enclosed within an evacuated glass vessel. It also discloses connections between the cold electrode and the heated electrode an indicating device in this circuit and a coil for associating this circuit with a wireless telegraph antenna; a battery for heating the hot electrode is also shown and described.

[fol. 1373] In the specification, Dr. Fleming points out that this arrangement is particularly adapted to the rectification of high-frequency currents, which are necessary in a wireless communicating system and that, in this respect, it differs from various well-known forms of rectifier.

In referring to the construction of the device, the patent is not limited to a particular arrangement or construction of electrodes, but states a number of alternatives as, for instance, lines 73 to 86, inclusive, page 2:

"In place of using a metal cylinder surrounding a carbon-loop filament I sometimes use a number of carbon filaments. Some of these are heated by means of an electric current and become the hot conductor of the oscillation-valve and the others remain cold and form the cold conductor, or the metal cylinder may be replaced by a cylinder of meerschaum or the like having wound helically upon it a narrow ribbon of metallic foil. In those cases in which a larger alternating current has to be dealt with the hot conductor may be a rod of soft graphitic carbon held in suitable supports."

Dr. Fleming also directs particularly the exhaustion of the valve to a high degree and in line 96, page 1 to line 5, page 2, gives some instructions as follows:

"As a very high vacuum should be obtained in the bulb *a* and as a considerable quantity of air is occluded in the conductors, these should be heated when the bulb is being exhausted. The filament *b* can be conveniently heated by passing a current through it, while the cylinder *c* can be heated by surrounding the bulb *a* with a resistance-coil through which a current is passed, the whole being inclosed in a box lined with asbestos or the like. When, as hereinafter described, the cylinder *c* is replaced by any form of conductor which can be heated by passing a current through it, this method is usually more convenient than that just described."

This instruction is quite clear and indicates that Dr. Fleming intended that his valve should have a vacuum at least as high as was commercially obtainable at that date, and that the electron flow from the hot electrode to the cold electrode might be impeded as little as possible by the residual gases.

As I understand the Fleming patent, it discloses, for the first time, the use of an evacuated vessel containing a hot electrode and a cold electrode in a radio telegraph circuit.

This, of course, is a broad and fundamental disclosure, and one which has resulted in a tremendous development in the radio art and to my mind, obviously is not confined to particular details or methods of use.

Consideration of claims 1 and 37 shows, I think, quite clearly, the breadth of the invention. Claim 1, which reads as follows:

"The combination of a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for heating one of the conductors and a circuit outside the vessel connecting the two conductors."

describes any arrangement employing a vacuum valve in radio, with which I am familiar, and claim 37, which reads as follows:

[fol. 1374] "At a receiving-station in a system of wireless telegraphy employing electrical oscillations of high

frequency a detector comprising a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for heating one of the conductors, a circuit outside of the vessel connecting the two conductors, means for detecting a continuous current in the circuit, and means for impressing upon the circuit the received oscillations."

describes some millions of radio receiving-stations at present in use.

Q. 273. Referring to the demonstrations which you made on December 28, 1926, in the presence of counsel for defendant, showing that the two-electrode valve with a high vacuum would oscillate and amplify, will you please state, in accordance with your understanding of the matter from a technical standpoint ,whether or not the vacuum tubes used in said demonstrations, which comprised circular plates as anodes, separated lengthwise of the tubes certain distances from the respective filaments, were Fleming valves within the terms of the Fleming patent No. 803,684 in suit?

A. Yes, they certainly were, since, while not the literal construction shown in the diagram of said patent, yet they were unquestionably of a construction within the intent of the patent in the matter of variations in structure, as indicated in the quotation, page 2, lines 72 to 86.

I might also point out that the enclosed electrodes of these valves consisted of one hot electrode and one cold electrode.

Q. 274. Referring to Dr. Miller's answer to Q. 30 of his deposition (P. R., p. 828), will you please state whether or not the three-electrode vacuum tube referred to by Dr. Miller as "V T-1" ("Defendant's Exhibit F"), is within the technical description of the invention of the Fleming patent in suit, as stated in the specification of said patent, and in claims 1 and 37 thereof; also when said vacuum tube is used in radio receiving circuits, such as illustrated by the diagram of the "P X" circuit shown in "Plaintiff's Exhibit No. 83." Please give your reasons for your answer and state any personal experience you have had with the use of the V T-1 three-electrode vacuum tube?

A. The vacuum tube referred to by Dr. Miller is the "V T-1" happens to be a vacuum tube of the three-electrode type which I have used for many years, and I have no hesitation in saying that this vacuum tube employed in radio circuits is, in my opinion, completely described by the claims

of the Fleming patent, and its structure and use are of a nature disclosed by this patent.

You have referred in your question to the "P N" circuit, which is a circuit with which I am familiar, and is useful in this answer in showing how the claims of Fleming patent No. 803,684 read on this device. Considering claim 1, the first requirement is a vacuous vessel, which is met by the exhausted glass container of the "V T-1", while the second requirement is two conductors adjacent to, but not touching each other in the vessel; since the "V T-1" tube contains three conductors adjacent to, but not touching each other; it contains, therefore, the two required by this element of the claim.

Means for heating one of the conductors is the next element and this is shown by the battery B′ in Plaintiff's Exhibit No. 83," which illustrates the P N circuit employed with a three-electrode tube.

The final requirement in this claim is a circuit outside [fol. 1375] the vessel connecting the two conductors. In "Plaintiff's Exhibit No. 83" this requirement is met by the circuit from the plate P, through the battery B^2, the indicating mechanism R, to the filament.

It is also met by the circuit from the grid, through condenser f^3, inductance f^2, and the connecting wires to the filament F.

Considering claim 37 and the same diagram of "Plaintiff's Exhibit No. 83," the first requirement is a detector at a receiving station in a system of wireless telegraphy employing electrical oscillations of high frequency, and this is disclosed by the three-electrode tube P G F and all of the associated circuits of "Plaintiff's Exhibit No. 83." The claim also requires that the detector should comprise a vacuous vessel, which is the exhausted bulb T of "Plaintiff's Exhibit No. 83"; two conductors adjacent to but not touching each other in the vessel, which is met by the two conductors F G or F P of the three-electrode tube. Means for heating one of the conductors is the battery B′; the circuit outside the vessel connecting the two conductors, which is the circuit B B^2, the indicator R and the wires to the battery, for the circuit f^3, f^2 and the connecting wires from the grid to the battery B′. Means for detecting a continuous current in the circuit is the indicator R, and means for impressing upon the circuit the received oscillations is

supplied by the coil f' coupled to the coil f, which is in the antenna circuit.

This description and comparison is, of course, based upon the use of the three-electrode tube such, for instance, as the V T-1, in a radio communications system employing high frequency oscillations.

It happens that in my personal experience I have used the V T-1 tube in radio circuits of many sorts, including that known as the P N circuit, and have seen it employed in Government stations in a similar manner.

In Dr. Miller's reply to Q. 30 (P. R., p. 828), he makes a reference to the use of this three-electrode tube, that is, the V T-1, for the purpose of ground telegraphy, or as it was designated, T P S, and I might point out that while some of these V T-1 vacuum tubes undoubtedly were used for this purpose, from my knowledge of the methods of the Government in the purchase of vacuum tubes of this sort, I can say that it was not customary to specify the use which was to be made of the individual tubes; but, on the contrary, it was customary to buy the tubes under a general specification and to use them when received, for radio or any other purpose.

* * * * * * *

Q. 275. Referring to the last paragraph of your preceding answer, where you mention the purchase of vacuum [fol. 1376] tubes by the Government under "a general specification," I hand you a typewritten document consisting of four sheets and ask you what you recognize this to be.

A. I recognize this and the title indicates that it is "General Specification No. 2087 (October 24, 1918), Tubes Type V T-1." This is a specification issued by the United States Government for vacuum tubes to be used either in radio or T P S. It gives various details relative to the construction, performance and shipping of these tubes.

It will be noted that in paragraph 1-(a) it contains the following statement:

"These tubes will be called upon to perform three functions. They must operate as detectors of radio signals, as amplifiers for audio and radio frequency signals, and as oscillators in circuits used for heterodyne reception of radio signals."

On page 4 of this same specification is a paragraph which shows that these V T-1 vacuum tubes must pass an oscillator test, said paragraph is as follows:

"(f) *Oscillator Test.* The standard Signal Corps oscillator set, diagram of which is shown in drawing RL-A-176, shall be used for this test. All blue label tubes shall oscillate in this circuit over the filament voltage range of three and three-tenths (3.3) to three and nine-tenths (3.9) volts with the plate at plus seventeen (17) volts. No vacuum tubes shall be accepted as yellow label tubes that do not pass the oscillator test for blue label tubes."

Mr. Vaill: Counsel for claimant offers in evidence a photostat copy of U. S. Government "General Specification No. 2087" referred to by the witness in the preceding answer, and requests that the same be marked "Claimant's Exhibit No. 278."

(Said exhibit marked as requested.)

Q. 276. Referring again to Dr. Miller's answer to Q. 13 (P. R., p. 784), and the last paragraph of his answer to Q. 24 as found on page 817 of the Printed Record, will you please state from your knowledge of the demonstrations before Judge Mayer in the proceedings on the Supplemental Bill in the case of Marconi Wireless Telegraph Company of America *vs.* De Forest Radio Telephone and Telegraph Company, the length of time that the oscillations continued during such demonstrations and whether the action was such that it could not be reproduced if desired, and under similar conditions?

A. My recollection of the tests before Judge Mayer is that something like one-half hour was consumed in making these tests and that there was no difficulty experienced in getting the tube to oscillate. It is also my opinion, based on work done prior to the demonstrations, that the results of these tests were reproducable.

Q. 277. In your answer to Q. 259, in which you had under consideration Dr. Miller's drawing F, you referred to the leakage away from the grid element of the three-electrode tube. Will you please explain a little more fully under what conditions an external leak is made necessary?

A. This external leak is made necessary whenever there is a grid condenser, such as y^3 of Fig. 2 or Fig. 3, "Miller Drawing F." In order that this condenser may not acquire a permanent negative charge.

[fol. 1377] I might point out in this connection that while it is necessary to employ the grid condenser and grid leak for detection purposes, that a hard three-electrode tube will detect without the use of these devices. When the three-electrode tube is used as a radio-frequency amplifier or as an audio-frequency amplifier, it is not customary or necessary to employ the grid condenser and leak.

Q. 278. Do you agree with Dr. Miller's answer to X Q. 78 (P. R., p. 837), regarding the variations in the electron flow in two-electrode and three-electrode tubes?

A. Dr. Miller, in replying to X Q. 78, states that in the three-electrode tube, potential variations are not impressed upon the electron stream, while they are in the two-electrode tube. His basis for so answering this question is found in his answer to X Q. 79, and rests on the fact that the electron flow does not take place between the cathode and the grid, and hence, potential variations are not impressed upon the electron flow.

There is no justification whatever for this particular presentation of the facts, except for the purposes of the answer to X Q. 78. While it is perfectly true that there is no current flow ordinarily between the grid and the hot cathode, nevertheless the grid is immersed in the electron stream which flows between the cathode and the cold electrode and whatever potential exists upon the grid, influences the space around it. Since the space around the grid contains the electron stream, the potential impressed upon the grid is, therefore, acting upon the electron stream.

In answer to X Q. 79, Dr. Miller states:

"The variations in flow in the three-electrode tube are caused by potentials which are impressed upon the grid of the tube."

This statement, in my opinion, is misleading in the sense that, having stated that the grid potentials were not impressed upon the electron stream, it could be argued from this statement that the important thing was to vary the potentials of the grid.

The actual facts, however, are that the variations of potential upon the grid, in themselves are of no consequence, but are of importance only as they affect the electron stream. The grid itself, while the most effective means for bringing about this control, is not the only way, and my recent tests

have shown that this control is obtainable when the third electrode is dispensed with altogether.

In answer to X Q. 79, Dr. Miller states:

"The action of impressing the potential variations upon the current flow is one which requires power."

Which statement, in my opinion, is misleading, since it is true only of the particular narrow interpretation which Dr. Miller chooses to use, of the significance of the words "impressing the potential variations upon" and which is limited to that particular case in which the electron stream flows from the hot electrode to the cold electrode upon which the potential is impressed. This happens to be the case in the three electrode tube of the circuit between the plate and the hot cathode.

Q. 279. Will you please comment upon Dr. Miller's answers to X Qs. 82 and 83 (P. R., p. 838), as you have done in connection with X Qs. 78 and 79 (P. R., pp. 837 and 838)? [fol. 1378] A. Dr. Miller, in replying to X Q. 82, while admitting that the electron flow from cathode to anode is increased when the grid is positively charged, qualifies his answer by stating that the positive charge on the grid does not directly produce the increased current flow. By this I understand him to mean that the increased current flow does not take place through the grid itself, which action would be undesirable if it did take place. He further states:

"It is merely the controlling effect of this charge upon the current flow between the anode and cathode that permits a greater current flow between these two electrodes."

Since the current flow between the cathode and the anode is the same thing as the electron stream, this quotation is a direct statement to the effect that the potential impressed upon the grid controls the electron stream, which is a complete contradiction of his answer to X Q. 78, as I understand it.

In his reply to X Q. 83, Dr. Miller denies that the difference between the influence of the control of the grid in a three electrode tube and of the anode in the two-electrode tube is that one is indirect, and the other direct. His denial seems to be based upon his dislike of the use of the word control with both electrodes, and he reserves it specifically for the action of the grid of the three-electrode tube.

This reservation, however, in my opinion, is justified only in a narrow technical consideration of the three-electrode tube by itself, but in the broader consideration of the vacuum tubes of different types, it ceases to apply. In my opinion, the two-electrode tube used merely as a rectifier, and without consideration of the outside electrostatic field effect, involves control of the electron stream through the potential variations impressed upon the plate by the incoming oscillations.

Of course, as usual, Dr. Miller differentiates between the two-electrode and three-electrode devices on the ground that the latter is an amplifier, while the former is not, and with this distinction I am forced to disagree, since I have proven by actual tests that the two-electrode tube is an amplifier.

Dr. Miller concludes his answer to X Q. 83 with the following statement:

"This is not an amplifier and the variations in current would not be called control variations."

There is nothing about the meaning of the word "control," so far as I can see, which in any way limits its significance to amplification. On the contrary, this control may, or may not, be accompanied by amplification, and still be the cause of results indicated or made use of.

Q. 280. Referring now to Dr. Robert A. Milliken's deposition on behalf of the defendant, will you please consider his answer to Q. 12 (P. R., p. 845), and state wherein you may agree or disagree with the statements of said answer?

A. Dr. Milliken, in replying to Q. 12, first explains the action of the two-electrode valve when used as a rectifier and then explains the action of the three-electrode tube as a relay type of amplifier. He differentiates between the two devices in the following statement (P. R., p. 846):

"The essential difference between the three-electrode and the two-electrode tubes, for the communications art, is then [fol. 1379] that the well-exhausted two-electrode tube is simply a rectifier, and by virtue of that property can be used as a detector of signals, but it is not and can not be an amplifier, whereas the three-electrode tube was developed primarily for telephone amplification for the very reason that the two-electrode tube could not be so used, and the primary use of the three-electrode tube throughout the war was for the purpose of amplification and is that to-day."

In this statement there is contained a repetition of the same remarks so frequently made by Dr. Miller, in his deposition, to the effect that the two-electrode tube is not, and cannot be, an amplifier, a statement which, however, is completely at variance with the facts developed by my tests.

The concluding paragraph of Dr. Milliken's answer to Q. 12 is as follows (P. R., p. 847):

"The essential difference, then, in a word, between the two-electrode tube and the three-electrode tube, so far as the communications art is concerned, is that they were developed for entirely different purposes and actually fulfill completely different functions, the first being simply a rectifier and detector and incapable of performing either in a scientific or commercial way the function of amplification, while the second was developed for and now serves magnificently the purposes of distortionless amplification."

This statement is quite at variance with the facts as I know them relative to the two-electrode tube and the three-electrode tube. In the first place that the two-electrode tube is an extremely good amplifier I have already demonstrated, and in the second place, I am in a position to deny Dr. Milliken's statement to the effect that the two-electrode tube was developed solely for a purpose different from that of the three-electrode tube, for the reason that extensive work was done under my direction in the development of the two-electrode tube which showed, among other things, that this tube was a good oscillator and amplifier.

Q. 281. Please refer to Dr. Milliken's answer to Q. 20 (P. R., p. 849); also his answer to Q. 23 (P. R., 850), and comment upon his statements relative to what he terms "negative resistance".

A. Dr. Milliken, in his reply to Q. 20, has gone at some length into the particular sort of negative resistance which is possessed by the arc or the two-electrode Fleming valve, having a certain amount of gas present, but seems to have quite entirely overlooked some of the other types of negative resistance, which I have explained in my answer to Q. 250.

In his answer to Q. 23, he differentiates particularly between the gas-filled two-electrode tube of the Cooper-Hewitt type and the three-electrode tube, and denies that the three-electrode tube has a "negative resistance." In his denial

Dr. Milliken seems to have overlooked the above facts relative to the three-electrode tube, since, in my answer to Q. 250, several kinds of "negative resistances" are shown to be possessed by this device.

I might also add that Dr. Milliken, in his reply to Q. 23, holds an opinion relative to the three-electrode tube which [fol. 1380] is not only contrary to that of the witness, but is contrary to the point of view of such eminent and experienced experts in this art as M. I. Pupin and E. H. Armstrong.

Q. 282. Please consider Dr. Milliken's answers to X Q. 27-X Q. 29 of his deposition (P. R., p. 851), and in view of your experience with the manufacture of Fleming valves, will you please state whether you consider his answers correct.

A. My own experience with vacuum valves exhausted by ordinary methods indicates that the vacuum mentioned by Dr. Milliken in answer to X Q. 29, viz., 10^{-3} millimeters of mercury, is approximately correct. He states, in answer to X Q. 27, that the vacuum commercially obtainable at the date of the Fleming patent was 10^{-6} or 10^{-7} millimeters of mercury, and explains in answer to X Q. 28, that he bases his opinion in answer to X Q. 27 on the clean-up effect mentioned by Dr. Langmuir. He overlooks, however, the fact that Dr. Langmuir's statement is made with respect to an incandescent illuminating lamp, and that this lamp has no large metal surface in it which releases a considerable amount of gas. As the vacuum tube gets older this plate releases considerable quantities of gas, and this is an action which runs counter to the clean-up action of the filament.

I might also mention that I have made a great many Fleming valves exhausted to about the vacuum referred to, viz., 10^{-3} millimeters of mercury, which, after extensive use, showed a considerable improvement in the vacuum, but that this improvement never resulted, in any case under my own observation, in the vacuum becoming so good as 10^{-6} or 10^{-7} millimeters.

In answer to Q. 28½, Dr. Milliken refers to methods of obtaining a vacuum as low as 10^{-6} millimeters, but this, of course, was in a laboratory, and from my general knowledge of commercial processes of evacuation, I do not believe that this order of vacuum represented a commercial result at the time of the Fleming patent.

Q. 283. Will you please consider Dr. Milliken's answers to X Qs. 46-51, inclusive (P. R., p. 854), and comment thereon according to your knowledge of detection and amplification?

A. I differ, of course, with Dr. Milliken's statement contained in his reply to X Q. 46, that the Fleming valve is not an amplifier, since I have proven by practical demonstration that it is.

The remaining cross-questions referred to in your question seem to constitute an attempt on the part of the cross-examiner to find out whether or not Dr. Milliken thinks that reception of radio signals is possible without rectification, and his answer appears to indicate that such reception is possible.

I am quite unable to understand any basis for this reply of Dr. Milliken's for the reason that it is a matter of simple observation to determine that such reception without rectification in some form or other, is impossible.

In his answer, Dr. Milliken refers to rectification of the audio-frequency and I must point out that while an incoming radio wave may be modulated at a great many audio-frequencies and contain these frequencies as components of the wave-form, nevertheless, the only frequencies coming into the receiving instrument are radio-frequencies, and the audio-frequency components of the radio-frequency waves [fol. 1381] are not extractable from the waves, except by a process which involves rectification in some form or other.

I must therefore state that Dr. Milliken is mistaken in his replies to the questions referred to.

Q. 284. Do you agree with Dr. Milliken's answer to X Q. 78 (P. R., p. 858), regarding the physical principles underlying thermionic tubes having two electrodes, being applicable also to similar tubes having three electrodes?

A. I note that Dr. Milliken states that both the two-electrode and the three-electrode tubes utilize pure electron discharges produced by heating a filament to a high temperature in an evacuated tube. He differentiates between them, however, by referring to the control of the electron stream by changes in potential upon the grid, and the fact that, in his opinion, the Fleming valve is without this kind of a control. This is a differentiation of the sort with which I have disagreed on numerous occasions in the course of this deposition, for reasons based upon the performance of the Fleming valve in actual practical tests.

I therefore understand both the three-electrode and the two-electrode vacuum valves to employ the same underlying principles.

Q. 285. Please now refer to Dr. Milliken's answer to X Q. 79 (P. R., p. 859), state to what extent you may agree or disagree with him.

A. I must, of necessity, disagree with this statement for the simple reason that the application of any particular potential to the grid of a three-electrode tube results in the same change in the current flowing in the plate circuit, as would be produced by another and greater potential to the plate circuit itself.

This is, as a matter of fact, one way of expressing the fact that the device is an amplifier. For after all, that is all an amplifier is, viz., a device which has currents flowing in its output circuit whose magnitude is that which would result from the direct application to the output circuit of a potential which is greater than that actually applied to the input circuit.

. . . . . .

When, in the three-electrode device a potential is apllied to the plate circuit directly, that is, the plate to filament circuit, the resulting current flow is proportional to the applied electromotive force and the resistance of the tube, and the energy involved is simply the energy which is supplied by the exterior source of power, whatever it may be.

When, however, the plate is split into two parts, one part serving for the application of the power in the form of a direct current, and the other serving for the input of the high-frequency energy, there is a marked change, and the energy which is then involved in the variations of the [fol. 1382] current of the plate circuit, is greater than the energy in the form of oscillations which are applied to the second cold element. This is, of course, one action which makes the device useful, since this action means that the device is an amplifier.

When Dr. Milliken, in his reply to X Q. 79, states:

"It certainly cannot be the equivalent in its result, else the grid might be dispensed with, and two-electrode tubes used as distortionless amplifiers, for example."

he does not reply to the question, but merely states that if the device were used in this way, it would not be an ampli-

fier which, of course, is self-evident from the explanations which have been given of the action of the three-electrode tube and the correct answer to X Q. 79 is "Yes".

Q. 286. Please refer to Dr. Milliken's answers to X Qs. 80 and 81 (P. R., p. 859), and state to what extent you may disagree with his answers.

A. Dr. Milliken, in answer to X Q. 80, which is a question directed to the three-element valve, answers on the basis of two of these electrodes, and states that there cannot be a direct causal relation between the applied potential and the current produced by it. He then qualifies this statement by admitting that interference with this causal relation by some third agency is possible, although, even in this case, he denies the result would be a negative resistance.

Of course, the three-electrode tube has three electrodes, and even if any two of them failed to disclose a negative resistance characteristic, this result would not be of particular significance, provided that the three taken in combination did possess a negative resistance.

Of course, in my answer to Q. 250 I have shown that the grid and filament alone may possess a negative resistance characteristic, and that this has been employed by White in his patent, 1,393,594, and I have also shown that the three electrodes, taken together, display a negative characteristic in various ways.

Dr. Milliken's concluding sentence, in his answer to X Q. 80, seems to express his particular and very limited definition of negative resistance as follows:

"At any rate, this is something quite distinct from the negative resistance of an arc which is due to copious ionization of gas or vapor molecules."

This seems to indicate rather clearly that Dr. Milliken is satisfied to differentiate the negative resistance of a three-electrode tube from that of an arc on the basis that the latter is due to copious ionization of the gas vapor.

Of course, in the hard three-electrode tube there is no vapor which is ionized, any more than there are two arcing carbon electrodes. The devices are distinct and different, but this fact is neither of consequence nor interest, since we are concerned here merely with a particular sort of electrical characteristic and not the nature of the device which possesses it.

As has already been very clearly brought out in my answer to Q. 250, a negative resistance characteristic may result from a variety of causes, and the only possible reason for attempting to tie it up with the arc is to secure a basis for differentiating between the soft vacuum tube which acts [fol. 1383] similar to the arc, and the hard vacuum tube, which has additional features of behavior.

Q. 287. Please refer to Dr. Milliken's answers to X Qs. 82-85, inclusive (P. R., pp. 859 and 860), and state whether, in view of your experience in the radio art, there was any difficulty in understanding the author's terminology and definitions of the quoted paragraph in X Q. 82 by one skilled in the art at the date Dr. Milliken testified, to-wit, December, 1923, said quoted paragraph forming a part of "Claimant's Exhibit No. 264", introduced during your deposition.

A. So far as I can see, no particular difficulty is involved in understanding the author's terminology and definitions.

Mr. Miller, in his testimony on pages 776 to 780 of the Printed Record, has a great deal to say about negative resistances and the particular action referred to in the Lauer and Brown book is explained by Dr. Miller at the bottom of page 776 and the top of page 777 as follows:

"In the case of such devices as have a falling characteristic or negative slope, when the current through the device increases, the opposing voltage decreases, when the current decreases the opposing voltage increases."

This statement by Dr. Miller is almost identical with the statement by the authors of the Lauer and Brown book and brings out the fact that when an increase in current flow through a device is associated with a decrease in voltage, and *vice versa*, the device is referred to as a "negative resistance", or is said to have a falling characteristic.

Q. 288. Please now refer to the deposition of Major Joseph O. Mauborgne, given on behalf of the defendant, and state to what extent you may disagree with his answer to Q. 15 as found on pages 1222-1224, inclusive, of the Printed Record, in which answer please refer to "Defendant's Exhibit H-5", and state to what extent the circuit No. 3 of this exhibit involves the apparatus and circuits of the patents in suit in this case.

A. The first part of Major Mauborgne's reply to Q. 16 consists largely of a brief reference to the work of Marconi,

Brandy, Popoff, Tesla and Lodge, all of which has been covered in detail in my replies to various questions relating to the Marconi and Lodge patents. He next refers to early work by the Signal Corps of the United States Army and their attempts to establish communication over one hundred miles in Alaska.

While Major Mauborgne states, near the bottom of Printed Record page 1222, that some of the Signal Corps attempts to work in Alaska involved Marconi apparatus, yet his quotation from the report does not include a reference to Marconi apparatus, which leaves much uncertainty in my mind as to whether or not Marconi apparatus was actually used.

That Marconi apparatus was capable of signaling over the required distance would appear from the paper by Capt. H. B. Jackson, entitled "On some Phenomena affecting the Transmission of Electric Waves over the Surface of Sea and Earth." Proceedings of the Royal Society of London, 1902, Volume 70, page 254. This paper contains a table entitled "Table No. IV" which gives distances over which working was had and included amongst these distances is [fol. 1384] one of 135 miles and another of 105 miles, both of which are greater than the requirement of the Alaskan situation.

In considering a report of the nature of that of the Chief Signaling Officer, referred to by Major Mauborgne, relative to the state of the art at this time, I am obliged to recognize some facts, gained as the result of long experience in dealing with the United States Government in radio matters.

I have learned, as the result of this experience, that it is common practice for the Government personnel, after becoming familiar with the work of commercial companies through the purchase of their apparatus, to condemn all of the purchased apparatus and proceed with the development of something which they then call their own.

I have usually been forced to the conclusion that the real reason for this procedure has been the desire of the Government Bureaus to get hold of some interesting work and I have in general found that the apparatus so developed by the Government Bureaus involved little or nothing that was essentially new, but, on the contrary, employed the devices, patents, etc. of the commercial companies.

An illustration of this sort of thing, I think, is to be found in the arrangement used by Capt. Wildman, shown in the "Electrician" of October 20, 1905. The diagram of connections contained in this article appears to involve both the Marconi and Lodge patents. There is a closed circuit consisting of two condensers marked "Capacity", a spark-gap and a portion of the coil, marked "Linking Coil". There is also an antenna system involving an elevated conductor, a portion of the linking coil, a second coil and an arrangement marked "Wire Net", which is merely a form of what is known as the counterpoise earth connection.

The descriptive article specifically states that the closed circuit and the open circuits were in resonance, which fact was determined by the hot wire ammeter, and from this fact and the description just given, this arrangement is evidently nothing more than that of the Marconi tuning patent, and it includes the Lodge variably-acting inductance coil.

It is furthermore perfectly obvious that all Wildman did was to employ the Marconi arrangement with a considerable amount of power. The specification specifically refers to 3 Kilo-watts which, at that time, was a very substantial power to use in radio.

I am therefore unable to find that the work of Wildman added anything new to the knowledge of the radio art, or that it can be considered in any way as a particularly material contribution to the development of the art.

Further evidence of the capabilities of the Marconi apparatus in the matter of distance working is contained in Mr. Marconi's testimony (P. R., p. 504), wherein he testifies relative to the working between the station at Poldhu and the Steamship Philadelphia in 1902, over a distance of 2,099 miles.

Similarly on pages 571 and 572 of the Printed Record, Mr. Marconi testified relative to the transmission of messages from Canada to England in 1902. The distances referred to in Mr. Marconi's testimony are very great, compared to the distance which had to be covered in Alaska and it is rather difficult to see any legitimate basis for [fol. 1385] assuming that the Signal Corps had to improve on Marconi's work, in order to carry out their required communication system.

I note a diagram in "Defendant's Exhibit H-5" which is a photostat copy of blueprint No. 3, Wiring Diagram,

Massie Wireless Telegraph Company, of apparatus furnished on Signal Corps Order No. 3428, as installed at Fort Gibbon, Alaska, 1908. The transmitting diagram of this station is substantially the same as that of the Wildman arrangement, referred to above, with the exception that all of the antenna inductance is contained in a single coil. This coil serves as inductance for both the open circuit and the closed circuit, and as a means of linking the two circuits together; that is, as a direct coupling, and it is quite obviously a tuned coupled circuit arrangement of the sort disclosed by Marconi in his tuning patent. This drawing was introduced by Major Mauborgne in answer to Q. 8.

In further developing his historical treatment of the development of radio, Major Mauborgne refers to the introduction of detectors of the electrolytic and crystal types and the extension of their use all over the world. He neglects, however, at this point, to refer to the invention and development of that detector which was destined to lay the foundation for the whole of the present day radio. I refer, of course, to the Fleming valve, which Dr. J. A. Fleming gave to the world in 1904.

While Major Mauborgne does refer to the introduction of continuous-wave telegraphy in 1913 and the introduction of the three-electrode vacuum tube, about which, as he himself states, the whole radio art of today revolves, he again neglects to point out the fact that all of this development was made possible by the discovery and invention of the Fleming valve.

He makes a further statement to the effect that the advance made by Marconi over his predecessors cannot in any way be compared with the advance made by the introduction of the three-electrode tube, but his statement in this regard is not at all impressive to me, for the simple reason that Marconi is the father of radio, and that, regardless of what the subsequent developments of radio may be, they do not detract from the credit due Marconi for his original conception and execution, but, on the contrary, merely add to his undying fame.

I do not think that any work in the development of a great art, no matter how important it may be, can ever be considered in the same light or as of equal importance with that work which gave birth to the art, and I must, therefore,

disagree with Major Mauborgne in his assignment of relative values to the work of Marconi and others.

Q. 289. Although you have already fully treated the subject-matter of Major Mauborgne's answer to Q. 17 (P. R., p. 1224) of his deposition, I will ask you to refer to the concluding paragraph of his answer and state briefly in what respects you differ from his conclusions.

A. I must, of course, disagree with Major Mauborgne's statement to the effect that the two-electrode tube is not inherently capable of either oscillating or amplifying, since I have shown so conclusively that it possesses both of these capabilities.

Major Mauborgne describes somewhat at length various tests which he made, most of which failed to give any results in the matter of oscillating, but I am afraid that these tests are not particularly impressive, for the simple reason [fol. 1386] that it is a very easy matter to conduct tests which are unsuccessful, and when once it is shown that a thing can be done, the only significance of unsuccessful tests is that they indicate a failure on the part of the experimenter to appreciate the correct way of getting results.

I note that on Printed Record, page 1230, in concluding his answer, Major Mauborgne refers to a gas filled tube of the Fleming type, a characterization to which I much take exception, since a tube exhausted in accordance with the instructions of the Fleming patent would have a very good vacuum, and would be anything but "gas filled".

Mr. Vaill: Counsel for claimant offers in evidence a photostat copy of the title page and the subsequent pages of the "Proceedings of the Royal Society, London", Volume 70, 1902, beginning page 254, which contain an article "On some Phenomena affecting the Transmission of Electric Waves over the Surface of Sea and Earth", by Capt. H. B. Jackson, and requests that the same be marked "Claimant's Exhibit No. 279".

Also a photostat copy of the letter to the Editor of the "Electrician" of London, by Capt. Leonard D. Wildman, dated September 30, and published in the "Electrician" (London) on October 20, 1905, as "Claimant's Exhibit No. 280", and requests that the same be so marked.

Mr. Vaill: I also offer in evidence a photostat copy of the title page of the Proceedings of the Physical Society of

London, Vol XIV of 1896, together with photostat copies of pages 187 to 242, inclusive, containing an article by J. A. Fleming, entitled "A Further Examination of the Edison Effect in Glow Lamps" (Read March 27, 1896), being a copy of "Plaintiff's Exhibit No. 18" in the suit of the Marconi Wireless Telegraph Company of America *vs.* De Forest Radio Telephone and Telegraph Company in the Southern District of New York, on Fleming patent 803,684, as "Claimant's Exhibit No. 281".

(Said exhibits marked as requested.)

* * * * * * *

Q. 290. Referring further to the use of the two-electrode Fleming valve in connection with a battery potential on the plate or anode, please give any further instances of prior art publications which show that such a use was well known.

A. The British patent to Brown & Neilson, No. 28,955, of 1896, discloses an arrangement involving the use of a coherer and in Fig. 9 this coherer is shown connected with a telephone receiver, and the specification refers to it on page 7, lines 24 to 33, as follows:

[fol. 1387] *** * * We find that a Telephone Receiver used in this way, in conjunction with a Coherer, having preferably but not necessarily, carbon granules, forms a very sensitive receiving set for detecting very weak radiant energy as when coming from a long distance, *etc.*, because the Telephone is able to appreciate far more minute and temporary (but sudden) changes in the resistance of the Coherer than are required to vary a battery current sufficiently to operate any other telegraphic instrument. Used in this way also no restoring vibrator is required for the coherer, or at most only an arrangement to give a few momentary taps at long intervals, but this can be conveniently done by hand. * * ***

This patent indicates not only that a battery was used with a detecter prior to the Fleming patent in suit, but also that the coherer was used with a telephone receiver and without a tapper.

In "Claimant's Exhibit No. 281", pages 234 and 235 (Claimant's Ex. 281), experiments 24 and 25 bring out certain effects resulting from the use of a battery with a Fleming valve. This exhibit is a paper by Dr. Fleming in the

"Proceedings of the Physical Society of London," Vol. 14, 1896. Experiment 24 illustrates the fact that the single battery cell causes an appreciable current to flow through the experimental form of the Fleming valve, provided that the cold electrode is made positive with respect to the filament, while in experiment 25, twenty-five cells were connected in series, and it was found that when the negative pole of the combination was attached to the cold element there was no greater current flow than was obtained with the single cell; whereas, when the positive pole was connected to the cold element, the current flow was much greater than with a single cell.

These two experiments bring out two essential facts relative to the device, first, that it conduets in one direction only; secondly, that a greater current flowed through it when the potential was increased.

In "Claimant's Exhibit No. 269", which is also a paper by Dr. Fleming in the "Proceedings of the Royal Society of London", Vol. LXXIV, 1905, page 483, there is shown a curve which is an extension of experiment 25 of "Claimant's Exhibit No. 281" (which is Fleming's 1896 article), and in which the complete relation between applied potential and current flow through the Fleming d vice is exposed, and curves are plotted which illustrate this relation.

It will be noted that these curves are of irregular form and their shape is such as would indicate to one skilled in the art that the application of some particular potential to the device might result in an improvement in its action as a rectifier. There is indicated, for instance, on the curve between the points 10 and 20 a curvature of the sort which is common to detectors.

Judge Mayer, in his decision reported in 236 F. R., page 942, as found on page 952, makes the following and interesting comment relative to the use of a battery with a Fleming valve:

"The local battery is used to bring the lamp detector to the sensitive point of its characteristic curve, and the potentiometer is the simple and effective device which, varying the local battery, accomplishes the task. Nearly all prior art detectors were used in this way—the coherer of [fol. 1388] Marconi and Lodge; the microphone of Hughes and Branly; the electrolytic of Fessenden, Vreeland and others; and the crystal of Bose. Plaintiff's Exhibits 77 and 82.

"The use of the local battery to locate the sensitive point on the characteristic curve was well known and accepted as of Fleming's time, and, as appears by his 1905 lecture, was fully understood by him."

Mr. Vaill: Counsel for claimant offers in evidence a photostat copy of British Patent 28,955 of 1896, to Brown & Neilson, referred to in the last answer as "Claimant's Exhibit No. 282".

(Said exhibit so marked.)

* * * * * * *

[fol. 1389] Q. 293. Referring to Dr. Miller's answer to Q. 18 of his deposition (P. R., p. 791), regarding the operation of the two-electrode valve without a biasing battery, as compared with is operation when a biasing battery is used, and also contrasting the same with the three-electrode tube, will you please refer to any patents which indicate that the operation of a two-electrode tube and a three-electrode tube is similar in the respects mentioned?

A. British Patent No. 13,518, A. D. 1908, (Drawings Reproduced Opposite as part of Claimant's Ex. 287) discloses an arrangement due to Dr. Fleming, in which there is a radio receiving circuit including a Fleming valve, to which is applied variable potential between the anode and the cathode, derived from the heating battery. The mechanism for varying this potential is a potentiometer and is illustrated in the drawing by *j*, *k*. This potentiometer allows of the application of a biasing potential to the Fleming valve which enables detection to take place at the most sensitive point of the characteristic curve.

This is an arrangement frequently, in fact, generally, employed with the commercial sets manufactured by the British Marconi Company.

In British Patent No. 887 of 1907 (Drawings Reproduced Opposite as part of Claimant's Ex. 288) and the corresponding United States Patent No. 896,130 of August 18, 1908, there is shown an arrangement of the Fleming valve in a radio receiving set, the particular feature of which is the telephone transformer shown in the diagram of the United States patent as *n*, whose primary circuit is included in the valve circuit, and whose secondary circuit includes the telephone receivers, shown at *s*.

This particular arrangement of the telephone transformer was frequently employed in Marconi apparatus in

connection with the potentiometer of patent No. 13,518 of 1905, above referred to, and when so employed the battery potential used for biasing the Fleming valve does not flow through the telephone receivers, and this particular use is evidence of the fact that the effect of the battery potential is to increase the sensitiveness of the Fleming valve and not to affect the telephone receiver.

Mr. Vaill: Counsel for claimant offers in evidence photostat copy of British Patent No. 13,518 of 1908, to J. A. Fleming as "Claimant's Exhibit No. 287."

Also photostat copy of British Patent No. 887 of 1907, to G. Marconi as "Claimant's Exhibit No. 288."

Also printed copy of United States Patent to G. Marconi, No. 896,130 of August 18, 1908, as "Claimant's Exhibit No. 289."

(Said exhibits were so marked.)

Q. 294. Referring to Mr. Mauborgne's statement (P. R., p. 1231), in answer to Q. 18, that he had unsuccessfully examined publications regarding statements as to the two-electrade tube being capable of oscillation, can you refer to any publications which Mr. Mauborgne apparently over-[fol. 1390] looked?

A. In the work entitled "Themionic Vacuum Tube" by Van der Bijl, on pages 269, 270 and 271 Claimant's Ex. 290), there is a description and a circuit diagram, Fig. 151, of a two-electrode oscillating arrangement. Dr. Van der Bijl outlines the mathematical conditions which must be fulfilled in order that the two-electrode device shall operate and on the top of page 271 he gives his conclusions as follows:

"From this we see that in order to obtain sustained oscillations from a device having only two electrodes, it is necessary that the device shall have a negative resistance."

The arrangement shown and described by Dr. Van der Bijl is capable of oscillating at radio frequencies.

I note, also, that British Patent No. 104,566 of 1916 to Brown Claimant's Ex. 291), discloses a two-electrode valve connected in circuits designed to produce oscillations and an arrangement which, according to the specification, will produce oscillations of frequencies corresponding to the voice frequencies.

The principle of operation of this device is different from that of the arrangement described by Van der Bijl, in that it depends upon a variation of the filament temperature and not upon a negative resistance.

It is noted that the British patent to Brown, No. 104,566, of 1916, is referred to on page 200 of the book by Leggett, entitled "Wireless Telegraphy" of 1921, from which "Defendant's Exhibits N, G-5 and I-6" were taken, and also on page 53 of the book by Scott Taggart, entitled "Thermionic Tubes" of 1921, from which "Defendant's Exhibit M-5" was taken.

Mr. Vaill: Counsel for claimant offers in evidence photostat copies of pages 269, 270 and 271 of Van der Bijl's book "Thermionic Tube" of 1920, as "Claimant's Exhibit No. 290."

Also photostatic copy of British Patent No. 104,566 of 1916, to Brown, as "Claimant's Exhibit No. 291."

(Said exhibits so marked.)

Q. 295. Referring to Mr. Loftin's statement in the middle of page 1149 of the Printed Record that:

"I have read a large part of the literature of the world on the subject of radio and do not recall a single reference to the practical use of the two-electrode tube."

Can you give an instance of such a reference in the literature which Mr. Loftin apparently overlooked?

A. In the work entitled "The Principles of Electric Wave Telegraphy and Telephony" by J. A. Fleming, 3rd Edition, 1916, page 891, I find the following statement relative to the use of the Fleming valve:

"Using his liquid microphone as above described and a Fleming glow lamp oscillation valve as a receiver, Prof. Vanni achieved the feat of speaking clearly by radiotelephony from Rome to the Island of Ponza (120 km.), to Maddelena (260 km.), to Palermo (420 km.), to Vittoria (600 km.), and finally to Tripoli (1,000 km.). The timbre or [fol. 1391] quality of the voice is said to be reproduced with great accuracy."

It is noted that "Defendant's Exhibit U" was taken from this same Fleming book.

The 1,000 kilometers referred to in the above quotation is a distance somewhat over 600 miles.

Mr. Vaill: Counsel for claimant offers in evidence a photostat copy of page 891 of the book by J. A. Fleming, entitled "The Principles of Electric Wave Telegraphy and Telephony", 3rd Edition, 1916, as "Claimant's Exhibit No. 292."

(Said exhibit so marked.)

Q. 296. On page 1039 of the Printed Record, near the top, Mr. Loftin has stated as follows:

"In the actual example above I have shown that if the interlinkage is such as to result in a coupling of 3 per cent., for all practical purposes, there may be considered to be but one frequency."

And at the bottom of page 1157 and the top of page 1158 of the Printed Record, in answer to X Q. 72, he states as follows:

"In the open-gap type of system, when the coupling is loosened to the neighborhood of 3 per cent., it is found in practice that ordinary receiving apparatus will detect but one frequency, and in practical operation such a coupling is commonly known as loose, though couplings less than 3 per cent. are sometimes employed for extreme selectivity."

And in answer to X Q. 109 on Printed Record page 1166, he states:

"It is my opinion that to use the Marconi apparatus to accomplish the object set up in the manner set up, as I have quoted in my answer just previous, that the coupling should not exceed 3 or 4 per cent."

Will you please give an instance in the literature of practical operation of an open spark-gap with which greater coupling than this was used?

A. In the September 8th, 1911 "Engineering", there is an article entitled "Recent Developments in Radio-Telegraphy" by Prof. G. W. O. Howe (* * * Claimant's Ex. 293), relative to some experiments with coupled circuits having a local spark-gap.

In Fig. 7 a number of curves are shown which illustrate the resonance curves resulting from the use of various couplings, and curve C is representative of a good wave form and as shown by the table which is a part of Fig. 7,

resulted from a coupling of 7.8 per cent. This figure is considerably in excess of the figure given by Mr. Loftin and quoted in your question.

The article also contains an interesting statement illustrative of the quenching action of the open gap, to which I have frequently referred. This statement is as follows:

"In the experiment to which Fig. 7 refers, the spark-gap was exposed to an air-blast, so that whenever the amplitude [fol. 1392] of the current in the primary oscillating circuit was small, there was a tendency for the air-blast to remove the column of hot air and metallic vapour, and thus extinguish the spark. This will obviously occur at a moment when all the energy is oscillating in the aerial, and will prevent it surging back into the primary circuit. The aerial will now continue to oscillate at its natural frequency until the energy is all radiated or dissipated. In Fig. 7 not only was there an air-blast, but the electrodes were comparatively large, and the spark-gap short, so that no part of the spark was far removed from a large mass of cold metal tending to cool the heated air and condense the metallic vapour, and thus lower the conductivity of the spark."

Mr. Vaill: Counsel for claimant offers in evidence a photostat copy of page 336 of "Engineering" of September 8th, 1911, article by Prof. G. W. O. Howe, as "Claimant's Exhibit No. 293."

(Said exhibit so marked.)

* * * * * * *

Q. 297. Referring to your answer to Q. 288 of your present deposition, in which you consider Major Mauborgne's answer to Q. 16 of his deposition, in which he quotes from the report of the Chief Signal Officer of the Army for the year 1904, regarding instruments purchased from the Lodge-Muirhead Wireless Telegraph Co. (Ltd.) of Great Britain, and of others, will you please give any instances which have come to your attention showing the transmission of commercial wireless telegraph messages over a distance greater than one hundred miles, referred to in the report as the distance of transmission required in Alaska?

A. In the work entitled "A Handbook of Wireless Telegraphy" by J. Erskine-Murray, D. Sc., 1907, there is a de-

scription of the Lodge-Muirhead system and some information relative to a practical installation of this system, which shows that it was employed over distances of more than three hundred miles.

On page 163 (* * * Claimant's Ex. 294), Fig. 94 shows a map and on this map is a dotted triangle, and the apices of this triangle indicate the location of three radio stations between which communication was to be maintained. The following quotation from pages 162 and 163 indicates the nature of the operations:

"Towards the end of August 1904 operations commenced for linking up the Settlement of Port Blair in the Andaman Islands with the general telegraph system of India by establishing wireless telegraph stations at Port Blair and at Diamond Island, which is already connected by a short cable [fol. 1393] to the mainland. The distance to be spanned is 305.2 miles. Between Port Blair and Diamond Island is situated Table Island, on which is a lighthouse and close to which ships pass on the voyages to Rangoon and Colombo, and Calcutta to the Straits. It was therefore decided to take the opportunity of establishing a station on Table Island which it was hoped would prove useful in the shipping and to the Meteorological Department. This distance from Diamond Island to Table Island is 130.2 miles, and from Table Island to Port Blair 177.5 miles. A map

(Fig. 94)

is attached (Fig. 94) which shows the positions of the stations."

The success of the installation seems to be indicated by the following statement on page 167:

"Since April statistics were kept of the traffic exchanged; and a copy of the records for the months of April, May and June is appended. The installation was only opened in a limited degree for State traffic, and the actual number of messages tended and dealt with in April was only fifty five sent from Port Blair, and thirty-nine received for Port Blair, but a great deal was sent in addition to these messages, and the traffic during the month amounted to nearly 10,000 words, and more could easily have been done had it been required. It will be noticed there were no interruptions during the month of April. During the month of May traffic exchanged amounted to nearly 14,000 words.

The traffic during July, August, September, October, and November has amounted to 18,542, 21,286, 21,408, 27,398 and 26,938 words of actual messages. More could, of course, have been dealt with had it been tendered."

In evaluating the performance of the Lodge-Muirhead system, referred to in the above quotation, it is of importance to note that this work took place in a tropical climate and was, therefore, under much more adverse circumstances than the conditions of operation to be found in the Alaskan situation, where the transmission was over Norton Sound, from the neighborhood of Nome to St. Michaels, according to the report of the Chief Signal Officer.

In a paper by G. Marconi, communicated by Dr. J. A. Fleming, to the Royal Society of London (Proceedings, Vol. 70, 1902, pages 341, 342 and 343), entitled "Note on a Magnetic Detector of Electric Waves, which can be employed as a Receiver for Spaced Telegraphy", read June 12th, 1902, there is a description of a type of detector known as a magnetic detector.

After describing the detector, the paper gives some information relative to its use in actual radio-communication, as follows:

"This detector has been successfully employed for some time in the reception of wireless telegraphic messages between St. Catherine's Point, Isle of Wight, and the North Haven, Poole, over a distance of 30 miles, and also between Poldhu, in Cornwall, and the North Haven, over a distance of 152 miles, of which 109 are over sea and 43 over high land."

[fol. 1394] This quotation shows clearly successful radio telegraphic communication over a distance considerably greater than that of the Alaskan situation, at a date prior to the date of the report by the Chief Signal Officer, relative to the failure of commercial apparatus to prove satisfactory.

Mr. Vaill: Counsel for Claimant offers in evidence a photostat copy of pages 162, 163 and 167 of "A Hand Book of Wireless Telegraphy" by J. Erskine-Murray, of 1907, giving transmission by the Lodge-Muirhead system, as "Claimant's Exhibit No. 294."

Also a photostat copy of pages 341, 342 and 343 of the Proceedings of the Royal Society of London, Vol. 70, of

1902, containing an article on the Magnetic Detector by G. Marconi, as "Claimant's Exhibit No. 295."

(Said exhibits marked as above.)

Q. 298. Will you please compare the structural and operating features of the VT-1 three-electrode tube, referred to and produced by Dr. Miller during his deposition as "Defendant's Exhibit F", with the tubes held to be an infringement of the Fleming patent No. 803,684, in the case of Marconi Wireless Telegraph Company of America vs. De Forest Radio Telephone and Telegraph Company, in the Southern District of New York, which tubes have been offered in evidence in the present case as parts of "Plaintiff's Exhibit No. 82", which were also part of "Plaintiff's Exhibit No. 2" in the DeForest case, and state whether said VT-1 tubes of "Defendant's Exhibit F" are similar or differ in any substantial point?

A. The VT-1 tube produced by Defendant's expert is fundamentally identical in structure and mode of operation with the three-electrode tube of "Plaintiff's Exhibit No. 82." Both devices consist of an evacuated glass vessel enclosing a filament which can be heated to incandescence by a battery, a cold electrode in the form of a plate and a second cold electrode in the form of a grid interposed between the hot and cold electrodes.

Both of these devices are capable of the usual uses of the three-electrode tube, viz., detecting, oscillating and amplifying. Structurally they differ in the details of manufacture, the VT-1 having all three electrodes of larger dimensions than the three-electrode tube of "Plaintiff's Exhibit No. 82" and also the BT-1 tube is so constructed that part of the plate element and part of the grid element is on each side of the filament.

The vacuum in the VT-1 tube is of a somewhat higher order than the vacuum of "Plaintiff's Exhibit No. 82."

Q. 299. Please state, according to your knowledge of prior litigation relating to the Fleming patent in suit, No. 803,684, whether or not any alleged additional anticipatory matter has been introduced by the Defendant in the present case, that was not in evidence in the prior litigation.

A. No new evidence relating to prior inventions has been introduced by the Defendant in this case, which was not in prior litigation.

* * * * * * *

[fol. 1395] Q. 300. You have already stated, in answer to Q. 243 of your present deposition, that you were present and testified in the suit of Marconi Wireless Telegraph Company of America vs. DeForest Radio Telephone and Telegraph Company on the Fleming Patent No. 803,684 during the supplemental trial and demonstrations before Judge Mayer, as set forth in "Claimant's Exhibit No. 171" in this case. Did you testify in the original trial in that case and to what extent were you present during the trial?

A. I was present throughout the greater part of the original trial, and took part in this trial in the suit of the present claimant against the DeForest Company on the Fleming patent, and testified therein.

Q. 301. The opinions of Judge Mayer in the District Court and of the Circuit Court of Appeals of the Second Circuit, refer to the "P N detector", and Judge Mayer's opinion (236 Fed., 942, 956), in the case referred to in the previous question, contains illustrations entitled "Simplified Circuits of 'P N' Detector", and also one entitled "Fleming & DeForest Compared". What similarity exists between the P N detector referred to and illustrated in the circuits of the opinions above mentioned and the P N circuit mentioned by Dr. Miller in answer to Q. 17 of his deposition, and which you and Mr. Waterman have each referred to in your depositions in this case?

A. The P N circuit referred to by Dr. Miller, Mr. Waterman and myself is the circuit of the P N type of audion detector referred to and illustrated in the decision of the Court in the Marconi-DeForest case, and which was held in that case to be an infringement of claims 1 and 37 of the Fleming patent 803,684.

Q. 302. In what respects, if any, do the contentions of Defendant's Experts in the present case differ from those of Defendant's Experts in the Marconi Co. vs. DeForest Co. suit in respect to the P N type of audion detector and its circuits, as compared with the circuits shown in the Fleming patent in suit?

A. The contentions of the Defendant's Experts in respect to the P N audion in this and the Marconi-DeForest case are substantially the same, as appears from the record and the opinion of the Court in the latter case.

Q. 303. Judge Mayer, in his memorandum opinion filed July 11, 1917, in said case of Marconi Co. vs. DeForest Co., holding that the decree and injunction filed and granted in

the original case covered and included the DeForest amplifier (see "Claimant's Exhibit No. 171", page 72), refers to some audion detector amplifier sets sold by the DeForest Company. According to your knowledge of the proceedings in that suit, please state whether or not any of those sets were in evidence and tested during the trial of that case. If so, please state how they were tested and with what results.

A. There was in evidence at the original trial as "Defendant's Exhibit A-4" a combination P N audion, ultra-audion and two-step amplifier employing three audion tubes. [fol. 1396] The circuit arrangement, when the P N circuit was used, was substantially the same as "Plaintiff's Exhibit No. 110", Fig. 88-A from the Navy Manual of 1915. This apparatus was tested before Judge Mayer at the original trial. Signals were received on the telephone by inserting the telephone plug in the three different sockets of the set. When the telephone plug was inserted in the first socket, the signal was detected and amplified by the first tube; when the telephone was placed in the second socket, the signal was then detected and further amplified by the second tube, and when the telephone plug was placed in the third socket the signal was detected and still further amplified.

Q. 304. Referring further to the use of local batteries in detectors for radio frequency signals prior to the invention of the DeForest three-electrode vacuum tube, will you please refer to any further instances showing such use, and also indicate, by appropriate diagrams, how the Fleming valve may be substituted in prior detecting circuits without other substantial change in such circuits?

A. I produce a drawing (Claimant's Ex. 298) showing diagrams taken from nine patents in which a battery is used with a detector; accompanying these diagrams is a corresponding diagram showing a Fleming valve inserted in the place of the detector illustrated in the diagram of the patent.

The patents referred to, from which these circuit diagrams are taken, are as follows:

Ledge, No. 609,154, Fig. 3, issued August 16, 1898, on application filed February 1st, 1898, "Plaintiff's Exhibit No. 20".

Marconi, No. 627,650, Fig. 1, issued June 27, 1899, on application filed January 5, 1899, "Defendant's Exhibit B-6"; also the same patent, Fig. 2.

Branly, No. 796,880, Fig. 1, issued August 8, 1905, on application filed September 4, 1902.

Fessenden, No. 727,331, Fig. 1, issued May 5, 1903, on application filed April 9, 1903, "Claimant's Exhibit No. 265".

DeForest & Smyth, No. 716,203, Fig. 1, issued December 6, 1902, on application filed September 1, 1900, "Defendant's Exhibit X-4".

Hogg, No. 763,894, Fig. 3, issued June 28, 1904, on application filed February 9, 1903.

Bose, No. 755,840, issued March 29, 1904, on application filed September 30, 1901, "Claimant's Exhibit No. 267".

Vreeland, No. 780,842, Fig. 4, issued January 24, 1905, on application filed August 1, 1904, "Claimant's Exhibit No. 266".

All of these patents were in evidence in the case of Marconi Wireless Telegraph Company of America *vs.* De Forest Radio Telephone & Telegraph Company, above referred to.

Mr. Vail: Counsel for claimant offers in evidence the patent to Branly, No. 796,880, of August 8, 1905, as "Claimant's Exhibit No. 296".

Also patent to Hogg, No. 763,894, of June 28, 1904, as "Claimant's Exhibit No. 297".

The chart produced by the witness is offered in evidence as "Claimant's Exhibit No. 298", and it is requested that said exhibits be marked accordingly by the Notary.

(Said exhibits so marked.)

[fol. 1397] Q. 305. Will you please refer to, and quote from, any technical publications where the authors state their opinions of the identity between the Fleming valve and the so-called DeForest audion detectors?

A. The first publication to which I shall refer is the Bureau of Standards Bulletin No. 140, containing an article entitled "The Comparative Sensitiveness of Some Common Detectors of Electrical Oscillations," by Dr. Austin, physicist in charge, United States Naval Wireless Laboratory. This is contained in "Defendant's Exhibit

F L". At page 538 of this publication he first refers to the Fleming vacuum valve detector and describes its construction. On page 539 he shows the connections. On page 540 he refers to the audion and shows a diagram of the so-called P N circuit. On page 541 he states as follows in the first omplete paragraph:

"The action of the detector appears to be as follows: The heated filament F is charged negatively by the battery B and a steady stream of negative electrons flows from the hot filament to the cold plate producing a direct current through the telephone. When an oscillatory electromotive force is impressed on the circuit F L' G, the negative current can flow from F to G inside the bulb and not in the reverse direction, just as in the Fleming detector. The grid G thus becomes negatively charged and as it lies between F and P the direct current through the telephone is decreased as may be shown by placing a galvanometer in the telephone circuit."

Next I desire to refer to the U. S. Government publication entitled "Manual of Wireless Telegraphy for the Use of Naval Electricians", by Lieut.-Commander S. S. Robison. This was published in 1909. I invite particular attention to the paragraph on page 102, under the heading "Vacuum Tube Rectifiers", which is as follows:

"151. It has long been known that under certain circumstances negative electricity can be made to flow from an incandescent electrode to a cool one more easily than in the opposite direction. Prof. Fleming has taken advantage of this fact to construct a rectifying detector for electrical waves. This is essentially an incandescent electric light bulb into which a second electrode, in the form of a plate or of a cylinder surrounding the filament, is introduced. The filament is kept at a white heat by means of storage cells. If then the receiving circuit is connected to the filament and the cold electrode, the high frequency oscillations are able to pass only in one direction; i. e., they are converted into direct currents, which may be made to act upon a galvanometer or telephone. The rectifier can be made somewhat more sensitive by applying an external electromotive force in series with it and the telephone."

"Dr. DeForest has also devised a detector called the audion, which rests apparently upon the same general principles."

In the 1913 edition of the Navy Manual which has been offered in evidence as "Plaintiff's Exhibit No. 78", I refer [fol. 1338] to pages 133 and 143. Page 133 shows the so-called Marconi and Fleming diagrams, and I invite attention to the statement on page 143 under the caption "Vacuum Tube Detectors", particularly the first two sentences, which state:

"The two forms in use are Marconi *valve* detectors and the DeForest audion. This detector invented by Fleming *is a rectifier* permitting the passage of current in one direction only."

Explanation of unilateral conductivity is then made and the figures of the diagrams described. Figure 84, which is referred to, is to be found on page 134.

Referring now to the 1915 edition of the Navy Manual, which is also a part of "Claimant's Exhibit No. 78", I invite attention to pages 133, 134 and 143, which contain similar statements, but are somewhat more elaborated.

The next publication to which I refer is the article by Major Edwin H. Armstrong, published in the "Electrical World" of December 12, 1914, entitled "Operating Features of the Audion". This article is "Claimant's Exhibit No. 230". Major Armstrong goes into the details of the operation at considerable length and he points out in the first column of page 1149:

"The audion is essentially an electron relay: that is, the exhaustion is carried to such a point that the amount of gas present is exceedingly small, and the current between the hot and cold electrodes is entirely thermionic, the absence of gas making impossible the presence of positive ions."

In this paragraph Major Armstrong says that the action, which is the essential or fundamental action, is the thermionic or electronic conduction. On page 1151 Major Armstrong speaks of the simple or fundamental action of the device: namely, its valve action. I will refer first briefly to page 1150, at the bottom of the first column, where he says, referring to Fig. 7:

"The action is much the same as in one of Prof. Fleming's methods of using the valve."

Then, passing to the first column on page 1151, he says:

"To make use of the 'valve' action between hot and cold electrodes for the detection of high frequency oscillations a connection as shown in Fig. 13 is used.

"In this case a condenser C is inserted somewhere in the circuit between the grid and filament to prevent the flow of a continuous current between them, and the grid is therefore left free to assume a potential determined by its position with respect to the filament and wing. Usually this will be somewhere near the center of the operating part of the curve of Fig. 1; that is, near point P. Now the action for incoming oscillations, as far as the closed oscillating circuit, filament, grid and condenser C2 are concerned, is identical with the rectifying action of the Fleming valve."

The next publication to which I refer is "The Electrician" for November 21, 1913, containing the editorial pages where [fol. 1399] the editor reviews the paper by Dr. DeForest under the title "The Audion as a Relay". This paper was presented by Dr. DeForest before the Institute of Radio Engineers, and describes the audion as a Fleming valve with an additional electrode. The last two sentences of the editorial are particularly interesting as being a comment upon Dr. DeForest's attitude toward Prof. Fleming's process valve. They read:

"In passing, we must confess we have no affection for the name 'audion' to which exception was taken at the time it was introduced, and we think that Dr. DeForest might be more generous in his acknowledgment of the work of Dr. J. A. Fleming. Our readers generally will probably agree that the audion, although differing widely from the Fleming valve, is an offshoot of it."

All of these publications were in evidence, together with several others, in the case of Marconi vs. DeForest Co. on the Fleming patent and the Court of Appeals of the Second Circuit in its decision on appeal, referred to the editorial in "The Electrician," as above quoted.

Mr. Vaill: Counsel for claimant offers in evidence a photostat copy of pages 102 and 103 of the "Manual of Wireless Telegraphy for Use of Naval Electricians," by Lieut.-Commander S. S. Robison, for the year 1909, and requests that the same be marked "Claimant's Exhibit No. 299."

(Said exhibit marked as requested.)

Mr. Vaill: Counsel for claimant offers in evidence the first and second pages of the November 21st, 1913, issue of "The Electrician" (London), and requests that the same be marked "Claimant's Exhibit No. 306."

(Said exhibit marked as requested.)

Q. 306. Referring to your answer to Q. 275 of your present deposition, in which reference is made to "Claimant's Exhibit No. 278," which is Government Specification entitled "General Specification No. 2087" (October 24, 1918) "Tubes Type VT-1," please state what difference in the use of the tubes referred to as "blue label tubes" and "yellow label tubes" was intended by the Government.

A. The following sentences 1 (a) of the specification of "Claimant's Exhibit No. 278" state as follows:

"This specification covers blue label and yellow label tubes. Blue label tubes are those that are free from all mechanical defects and pass all tests herein specified. Yellow tubes are those tubes which are slightly imperfect but which are suitable for training purposes in the United States. No vacuum tubes shall be accepted as yellow tubes which do not give reasonable assurance of satisfactory operation in any kind of service to which they may be put."

These sentences show that the Government divided the tubes into classes; that is, first grade and second grade, the blue tubes or first grade tubes being intended for general [fol. 1400] uses, while the yellow tubes or second grade tubes, were intended for training purposes only.

Q. 307. Dr. Miller states, in answer to Q. 25 of his deposition (P. R., p. 817), that the circuits the Government has used, and as shown in "Plaintiff's Exhibits Nos. 113, 114 and 115" are the so-called regenerative circuits, which utilize the amplified radio-frequency currents discarded in the P. N. circuit through the medium of the tickler or feed-back coil and enabled the operator to obtain signals twenty or thirty times louder than by use of the ordinary P N circuit, this result being made possible because of the amplifying property which he alleges to be possessed only by the three-electrode vacuum tube.

Dr. Miller also states that the tickler or feed-back coil can be used only with the three-electrode vacuum tube. Please state to what extent you may disagree with Dr. Miller's answer in these respects, and what is your per-

sonal experience with the use of the feed-back or tickler coil in connection with the two-electrode tube of the Fleming patent in suit.

A. The so-called regenerative circuits which Dr. Miller states can only be used with the three-electrode tube, are usable with the two-electrode tube.

In the recent demonstrations which I made and in which the oscillating property of the two-electrode tube was shown, the circuit and arrangement used constituted a form of regenerative circuit. I have also used with the two-electrode tube a circuit which is the same as the circuit of "Plaintiff's Exhibit No. 114," with the exception that the grid leak and condenser of this exhibit and the connecting wire thereto, were omitted. When used in this way, the coil j^2 is placed close to the glass tube of the two-electrode device. I produce a sketch (Claimant's Ex. 301) showing these connections.

In this sketch I have used the same designating letters that are used in "Claimant's Exhibit No. 114," and it will be noted that the grid leak L, and the stopping condenser h^3 and the connecting lead are missing. This, of course, is because there is no grid. In the actual arrangement of the apparatus the upper end of the coil j^2 is placed as closely as possible to the space between the cold plate P and the filament F.

Under these circumstances, the electrostatic field existing at the terminus of this coil influences the electron stream in the valve, and this, in conjunction with the feed-back action between the coils j^3 and j^2, results in the production of sustained oscillations.

Mr. Vaill: Counsel for claimant offers in evidence the sketch produced by the witness as "Weagant Sketch No. 7" and requests that the same be marked "Claimant's Exhibit No. 301."

(Said exhibit marked as requested.)

[fol. 1401] Q. 309. Will you now please refer further to Dr. Miller's answer to Q. 20 of his deposition (P. R., p. 799), as it relates to "Plaintiff's Exhibit No. 109," referring to your knowledge of the so-called DeForest "ultra-audion" circuit as being applicable to the two-electrode high vacuum Fleming valve? Also please state your opinion as to what bearing this may have upon the question of whether the

three-electrode valve when used in the "ultra-audion" circuit comes within the technical description of claims 1 and 37 of the Fleming patent in suit.

A. The "ultra-audion" circuit of "Plaintiff's Exhibit No. 109" can be used with the two-electrode tube. I have used this circuit with the two-electrode tube and I produce a sketch (Claimant's Ex. 302) illustrative of this use.

In drawing this sketch I have used the same designating letters as are used on "Plaintiff's Exhibit No. 109." It will be noted that condenser j^3 of this exhibit and the connecting wires thereto, are omitted, since, in the two-electrode tube the grid is missing and there is no necessity for this connection. I have marked this sketch "Weagant Sketch No. 8." The upper part of the coil j^2 in this arrangement is placed close to the walls of the two-electrode tube T, at a point between the plate P and the filament F. Under these circumstances, the electrostatic field existing on this coil affects the electron stream between the two electrodes of the two-electrode tube, and this action, in conjunction with the feed-back action, due to condenser C, results in the tube generating sustained oscillations.

In my use of this arrangement I have received continuous oscillations and produced the well-known beat note, which is the usual indication that the tube is oscillating.

Dr. Miller, in his deposition, in answer to Q. 20, has expressed the opinion that the "ultra-audion" circuit arrangement of the three-electrode tube was a use of the three-electrode tube of which the two-electrode tube was incapable, which statement is not in accordance with the results of the tests which I have made, and which, as stated above, show that the two-electrode tube is entirely capable of operating in the ultra-audion circuit.

It is my opinion that the ultra-audion arrangement of the three-electrode tube comes within the scope of claims 1 and 37 of the Fleming patent in suit.

Mr. Vaill: The sketch produced by the witness as "Weagant Sketch No. 8," is offered in evidence as "Claimant's Exhibit No. 302" and it is requested that it be so marked.

(Said Exhibit marked as requested.)

Q. 310. Referring further to Dr. Miller's answer to Q. 20 (P. R., p. 799), as it relates to "Plaintiff's Exhibit No. 116," will you please state your opinion as to whether the

three-electrode valve, when used in the circuits illustrated [fol. 1402] in said exhibit, when correctly drawn, as testified to by Mr. Clark in answer to Q. 78 of his deposition (P. R., p. 1507), comes within the technical description of claim 1 of the Fleming patent in suit, in view of your present knowledge of the oscillating property of the high vacuum two-electrode Fleming valve, in addition to the oscillating property of the valve, as testified to by Mr. Waterman in answer to Q. 2 of his deposition of December, 1922, in this case (P. R., pp. 259-261)?

A. "Plaintiff's Exhibit No. 116" shows four circuit arrangements in which the three-electrode tube is connected for the purpose of generating oscillations for radio-transmitting purposes. While these circuits differ in detail, their object and result is the same, viz., to enable the three-electrode vacuum tube to produce electrical oscillations of the sort suitable for radio transmission.

As has already been testified to by Mr. Waterman, and further proven by tests which I have made in this case, the two-electrode vacuum valve also possesses the capability of producing oscillations suitable for radio transmission. "Plaintiff's Exhibit No. 116," therefore, does not disclose any fundamental mode of operation of the three-electrode tube which is not also possessed by the two-electrode tube, and I am of the opinion that the arrangements disclosed in this exhibit come within the technical description of claim 1 of the Fleming patent in suit.

Q. 311. Referring again to "Plaintiff's Exhibit No. 85," three-stage amplifier used by the Navy, will you please state how the operation of such amplifier, when combined with an audion detector circuit, as indicated in the evidence of Mr. Clark, referred to by Dr. Miller, compares with the operation of the apparatus of "Plaintiff's Exhibit No. 110," as previously set forth by you herein?

A. Dr. Miller, in his answers to Qs. 19 and 22 of his deposition, criticizes Mr. Waterman's treatment of "Plaintiff's Exhibit No. 85," because he disagrees mainly to a consideration of "Plaintiff's Exhibit No. 110," which I have already considered. This treatment of "Plaintiff's Exhibit No. 85" by Mr. Waterman is fully justified by the testimony of Mr. Clark, who stated that the amplifier of "Plaintiff's Exhibit No. 85" was used by the Navy with an audion detector tube. Mr. Clark does not state, as a matter of fact, that the use of this amplifier was customary with a crystal

detector, although he does state that it had been used to some extent with a crystal detector.

My consideration of "Plaintiff's Exhibit No. 110," in which I give reasons for the arrangement therein shown as coming within the Fleming patent, applies with equal force to "Plaintiff's Exhibit No. 85," when used with an audion detector, or a crystal detector. In other words, the whole combination of a detector with the amplifier of "Plaintiff's Exhibit No. 85" constitutes as a whole a detector, as previously set forth by me.

Q. 312. In Q. 17 (P. R., p. 786), Dr. Miller was asked to compare the operation of the two-electrode valve detector in the circuit of the Fleming patent with the operation of the three-electrode vacuum tube or audion in the P. N. circuit of "Plaintiff's Exhibit No. 83." Will you please state wherein you differ with Dr. Miller in his conclusions in answer to that question, giving your reasons for your [fols. 1403-1404] opinion?

A. Dr. Miller, in his answer to Q. 17, distinguishes between the operation of the three-electrode tube in the P N circuit, which he states is essentially the same as "Plaintiff's Exhibit No. 83," and the two electrode device on the basis that the three-electrode tube is an amplifier, while the two-electrode tube is not.

As I have already shown by my demonstration, the two-electrode device is also an amplifier and Dr. Miller's distinction, therefore, is not in accordance with the basic facts. He also, at the top of page 791 of the Printed Record, expresses the opinion that in the Fleming circuit the power actuating the indicator must be less than the power of the received signals, while in the P N circuit this power may be greater than that of the received oscillations.

This, of course, is merely another way of stating that the three-electrode device is an amplifier, while the two-electrode device is not and, as already pointed out, the facts of actual operation are otherwise.

Q. 313. When, where and under what circumstances did you first receive wireless telegraph signals with the two-element bulb acting as an oscillating heterodyne, and what kind of wireless signals were received?

A. My recollection is that I first used a two-electrode Fleming valve as a heterodyne receiver of continuous oscillations while I was experimenting with the two-electrode valve for the purpose of determining its capabilities. My

recollection is that this was during the latter part of 1914, or the early part of 1915. These experiments were conducted at the laboratory of the Marconi Wireless Telegraph Company of America at Aldene, New Jersey, and I remember that signals were received from a continuous wave station at San Francisco, California.

Q. 314. From your personal experience and expert knowledge of the radio art, can you state about the time when it first became known that vacuum tubes had the capacity to oscillate and whether it was in using such tubes as detectors that such capacity to oscillate was first discovered?

A. My first knowledge of the fact that a vacuum tube would oscillate was derived from experiments which I conducted in February of 1914, with the three-electrode vacuum tube, during which time I discovered that the vacuum tube would oscillate. The vacuum tubes, when this discovery was made, were being used as receivers of wireless signals. I later found out that this same property had been discovered some time in 1912 or 1913 by other workers, and it is my understanding that the three-electrode tube, when this discovery was made, was being used as a detector of wireless signals.

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[fol. 1405] Cross-examination.

By Mr. Edwards:

X Q. 315. Do you own, or have you owned, any stock, securities or obligations of the claimant, Marconi Wireless Telegraph Company of America?

A. I have at times owned a few shares, but do not at the present time.

X Q. 316. For how long has it been since you have owned stock of the claimant?

A. As near as I can recollect, I sold my Marconi stock about the time the Radio Corporation was organized; some time in 1919, I think.

X Q. 317. Are you a stockholder in the Radio Corporation?

A. I own a few shares of the stock of the Radio Corporation.

X Q. 318. That corporation took over the business and physical assets of the claimant company, did it not?

A. It did.

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[fol. 1406] X Q. 332. Will you refer to your diagram, "Claimant's Exhibit No. 225" opposite printed page 1527 of the record? Do you consider that this diagram, as it stands, and not accompanied by explanation, would indicate to one skilled in the art that the two-electrode tube is placed close to the condenser R?

A. As is usual in wiring diagrams, the physical arrangements and their relation to one another, are not particularly indicated. The diagram as it stands, does not show the actual physical relation existing between the condenser R and the two-electrode valve *a*.

X Q. 333. May we assume that your answer to the last question is in the negative?

A. The answer appears to me to state clearly that the wiring diagram of "Claimant's Exhibit No. 225" does not show the physical relation or proximity of the two elements referred to in your question.

X Q. 334. Can you answer either of my last two questions categorically?

A. The categorical answer to X Q. 332 is that the diagram does not indicate that the two-electrode tube is placed close to the condenser R.

X Q. 335. The diagram referred to could have been to so indicate proximity of condenser R and two-electrode tube, could it not?

A. The diagram could have been so drawn that condenser R and the two electrode tube would have been in proximity to each other.

X Q. 336. Is it not a fact that you could not have demon- [fols. 1407-1408] strated the capability of the hard or high vacuum two-electrode tube to oscillate, unless you placed the condenser R sufficiently close to the tube to influence the electrostatic field of the tube?

A. The same result would have been secured if the top portion of the coil *m* were placed close to the two-electrode tube.

X Q. 337. It is not a fact that you could not have made the hard or high vacuum two-electrode tube to either amplify or oscillate in any circuit, unless you had placed either a condenser corresponding to R, or an inductance corresponding to *m*, sufficiently close to the tube to influence the electron space in the tube?

A. As I have pointed out in my testimony relative to the demonstration of the amplifying and oscillating action of

the two-electrode high vacuum tube, the association of a suitable electrostatic field on either a coil or a condenser, or connecting wires, was necessary for the action of the device.

X Q. 338. Will you answer my last question categorically, if you can do so?

A. The answer which I have already given seems to be as near a categorical answer as I am able to make.

X Q. 339. Then may I take it that you answer to X Q. 337 is in the affirmative, and if so, that I can pass on to another subject?

A. The answer is in the affirmative in so far as the particular circuit arrangement used in my demonstration is concerned. I am not able to either affirm or deny the statement contained in your question, in so far as other circuits may be concerned.

X Q. 340. It was also necessary, was it not, for you to employ in your demonstration a battery in the plate filament circuit of the tube, for example, the battery P in "Claimant's Exhibit No. 225", opposite P. R., page 1527, and the battery unmarked, but indicated at 180 volts in "Claimant's Exhibit No. 227", opposite P. R., page 1529?

A. With the particular tube used in the demonstration, the batteries referred to in your question were necessary.

X Q. 341. You do not find any such batteries shown in the Fleming patent in suit, do you?

A. I do not find a separate battery for applying a voltage between the space between the plate or cold electrode and the filament or hot electrode. There is, however, a battery shown for the purpose of heating the filament, which is also capable of being used for the purpose of applying a potential between the cold electrode and the hot electrode.

X Q. 342. If, in your demonstrations, you had omitted the battery U in "Claimant's Exhibit No. 225" and the 180-battery in "Claimant's Exhibit No. 227", how would you have adapted the filament battery *h* in "Claimant's Exhibit No. 225", 12 volts in "Claimant's Exhibit No. 227", to create a difference of potential between the plate and the filament?

A. A difference of potential between the plate and filament in "Claimant's Exhibit No. 225" could have been created by omitting battery P, and connecting the circuit containing the telephone *l*, to the positive side of the fila-

ment *b*; similarly, in "Claimant's Exhibit No. 227" a difference of potential could have been created by omitting the battery marked 180 and substituting simply a direct-connection between the points marked "Plus" and "Minus", these particular plus and minus points being those indicated in the diagram by the figures 180 and the arrows.

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[fol. 1409] X Q. 366. In your answer to Q. 265 you say that your tests have shown conclusively that the *real feature* of the vacuum tube amplifier is the electron stream originating in the hot electrode and flowing to the cold electrode, etc. Are we to understand from this that unless there is an electron stream originating in the hot electrode and flowing to the cold electrode, the tube cannot amplify?

A. It is correct to say with reference to either the two-electrode or three-electrode valve, that the electron stream [fol. 1410] flowing between the cold electrode and the hot electrode is essential in order that the device may amplify.

X Q. 367. Do you agree that in order to have an electron stream flowing from the hot electrode, or filament, to the cold electrode, or plate, suitable for amplification, there must be a difference of potential between the filament and the plate?

A. Yes, I agree.

X Q. 368. Do you find any statement in the Fleming patent in suit, to the effect that there is, or should be, such difference in potential?

A. The patent indicates that the device is to be used for the reception of radio signals, which radio signals produce a difference of potential between the cold electrode and the hot electrode.

X Q. 369. Can you answer my question with a simple affirmative or negative?

A. Yes, I can state that the Fleming patent in suit gives instructions which, when followed, result in the application of a potential between the cold and hot electrodes.

X Q. 370. Will you read any statement that you can in the specification of the Fleming patent in suit, indicating that there is, or should be, any difference of potential between the filament and the plate, other than the potential of the incoming signal itself?

A. There is no instruction that I am aware of, in said patent, directing the application of a potential other than that due to the signal between the two electrodes.

X Q. 371. It is therefore a fact, is it not, that, in order to carry out your so-called demonstrations of amplifying and oscillating two-electrode tubes, you were forced to create a difference of potential between the filament and the plate, and that you do not find any statement in the Fleming patent in suit that there is, or should be, such difference of potential?

A. In the demonstrations which I made, it was necessary, as I believe I stated in my direct testimony, to employ a source of potential between the cold electrode and the hot electrode, in the form of a battery. It is also correct to say that the Fleming patent in suit does not specifically direct the employment of this particular battery.

X Q. 372. Is not the statement in my X Q. 371 substantially correct?

A. Yes, it appears to be correct.

X Q. 373. Do you find any statement in the Fleming patent in suit to the effect that the potential of the plate controls the flow of electrons?

A. The question as it stands is not quite definite, but I assume "by potential of the plate" is meant difference of potential between the plate and the hot electrode, which is the only potential on the plate having a physical significance. The patent, lines 53 to 60, inclusive, states as follows:

"I have discovered that if two conductors are enclosed in the vessel in which a good vacuum is made, one being heated to a high temperature, the space between the hot and cold conductors possesses a unilateral electric conductivity, and negative electricity can pass from the hot conductor to the cold conductor, but not in the reverse direction."

This is a statement to one skilled in the art that an electrical current will flow through the device in one direction, upon the application of an alternating potential.

X Q. 374. Do you find any statement in the Fleming pat- [fol. 1411] ent in suit descriptive of an electrostatic field, or other means, for controlling the electron stream in the manner in which you used such electrostatic field to control the electron stream in your so-called demonstrations?

A. I do not find an instruction directing the employment

of an electrostatic field in the particular way in which I employed it in my demonstrations.

X Q. 375. Do you find the application of an electrostatic field, or other means, for controlling an electron stream, in substantially the same way as you used it in your so-called demonstrations described in the Fleming patent in suit?

A. I do not find the particular method of using the electrostatic field which I used, described in said Fleming patent.

X Q. 376. Do you find described in said Fleming patent any means for controlling an electron stream analogous to the means employed by you for controlling the electron stream, in your so-called demonstrations?

A. Yes, I think I do.

X Q. 377. Will you read on the record any part of the Fleming patent in suit which describes such means?

A. Fig. 1 of the patent is a good description of such a means, since it shows a circuit between the hot and cold electrodes, containing an inductance coil associated with an antenna circuit, radio signals set up electrical currents in the antenna, which induce potentials in the coil *k*, and the result of these potentials is to set up an electrostatic field between the hot electrode and the cold electrode, which varies in the same manner as the signal current, and which, as the result of the inherent and well-known characteristics of this device, produce variations in the flow of electrons from the hot to the cold electrode. This is an electrostatic control of the electron stream which appears to me to be analogous to the method employed in my tests.

X Q. 378. Do you mean to say that the coil *k* of Fig. 1 is located so close to the tube that the electrostatic field created thereby would act upon the electron space in the tube in the same way that the electrostatic field of the coils or condensers located adjacent to the tubes acted upon the electron stream in such tubes in your so-called demonstrations?

A. No, I do not.

X Q. 379. Will you, then, explain how the electrostatic field between the hot and cold electrodes in Fig. 1, is varied by the potentials in coil *k*?

A. The variation results from the fact that one terminal of this coil is connected to the hot electrode and the other terminal is connected to the cold electrode.

X Q. 380. And the incoming signal is relied upon to create the same difference of potential between filament and plate as exists in the signal itself, is it not?

A. The signal is responsible for the variable potential applied between filament and plate.

X Q. 381. That is to say, the difference in potential between filament and plate could be no greater than the difference in potential in the incoming signal current itself in Fig. 1; is not that the fact?

A. That is not quite a correct statement; it is correct in so far as the variable potential is concerned, but due to the fact that coil *k* has one terminal connected to one side of the battery *h*, near the point *c*, there is also a fixed difference of potential existing between the two electrodes, so that, in the actual use indicated by Fig. 1 of the patent, the total potential will always be the sum of this fixed potential and the variable potential.

[fol. 1412] X Q. 382. Is it not a fact that in Fig. 1 the fixed potential created by the battery acts in opposition to the difference of potential in the signal itself, so that the total potential is, in fact, the incoming variable potential minus the fixed potential?

A. No, that is not quite correct, because the fixed potential is in one direction only, and the signal potential, since it is alternating, is in both directions; consequently, one-half of the incoming oscillation adds to the potential of the battery, while the other half subtracts from it.

X Q. 383. In preparing for your demonstrations, or otherwise, did you set up any of the hard vacuum tubes in the circuit of Fig. 1 of the Fleming patent in suit, to ascertain if any of the tubes would amplify or oscillate in that circuit?

A. The circuit actually used in the demonstrations was substantially the circuit of Fig. 1, the variations therefrom being simply such variations as one skilled in the art would naturally make, and consisted of the insertion in the antenna circuit *n*, *m*, *o* of a variable condenser for convenience in tuning and demonstrating. This circuit, of course, was also used in preparation for the demonstrations.

X Q. 384. Will you answer my question in the affirmative or negative, if you can do so?

A. Yes; my answer is affirmative.

X Q. 385. Meaning the identical circuit as shown in Fig. 1 of said Fleming patent?

A. In my understanding of the term "circuit", yes.

X Q. 386. Do you admit that the hard vacuum tubes used by you in your demonstrations would not amplify or oscillate if connected in the circuit shown in Fig. 1, without additions or modifications?

A. Before answering the question, I shall have to ask one, viz.: Does your question mean without additions to the circuit, or without additional elements contained in the circuit? There is a distinction there, to the technical man, which makes this question necessary.

X Q. 387. I have in mind particularly, without adding other means; such, for example, as a means for creating an electron stream by creating a difference of potential between filament and plate, and means, such as additional electrostatic means, for controlling the electron stream between filament and plate.

A. I believe that I can now answer the question by stating that the two-electrode tube will oscillate in the identical circuit shown in the Fleming patent in suit, when a source of potential such as the battery, is included in the circuit between the hot and cold electrodes. I do not consider that the arrangement of coil or condenser (particularly the former), adjacent to this electron space of the tube, constituted any additional means not shown in the patent, but merely a particular arrangement of the elements disclosed in the patent.

X Q. 388. But you admit, do you not, that in order to make your demonstrations, you were forced to do at least two things not shown in Fig. 1? First, the insertion of a battery in the circuit between the hot and cold electrodes and, second, the location of the coil *k* close to the tube?

A. I would not say that I admit it, but rather, that I affirm it, since I clearly stated, as I recollect it, both of these facts in my demonstrations.

X Q. 389. Is there any commercial use of the two-electrode tube controlled by an electrostatic field, as set up in your demonstrations?

A. None that I know of.

X Q. 390. When did the Marconi Company begin the commercial use of the quenched-gap?

A. About 1912, as I recollect.

[fol. 1413] X Q. 391. Since that time the major part, or substantially all of its installations, have employed the quenched-gap, have they not, down to the present time?

A. I can only answer that question to about 1920, and it is my recollection that most of the ships' sets installed between 1912 and 1920 were of the quenched-gap type. The quenched-gap transmitter was not employed in a considerable number of the Land Stations. Since 1920 I have not been in touch with the subject, and have no information.

X Q. 392. What type of transmitter spark-gap was employed in the Marconi land stations up to the time you left?

A. A number of them had rotary gaps.

X Q. 393. When did the Marconi Company begin the commercial use of the three-electrode vacuum tube?

A. My recollection on that is uncertain, but I believe it was prior to 1917.

X Q. 394. Can you say approximately how long before 1917?

A. Not earlier than 1914.

X Q. 395. And to what extent was the three-electrode vacuum tube in commercial use by the Marconi Company in 1920?

A. It was in use, I believe, in most of the land stations, and was beginning to be used on shipboard.

X Q. 396. Was the use of the lateral or local circuit, as indicated, for example, in the Marconi patent 763,772, begun during, or prior, to the time you were connected with the Company?

A. It was in use prior to my connection with the Marconi Company.

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[fol. 1414] X Q. 399. Referring again to Fig. 1 of the Fleming patent in suit, if a battery be inserted in the circuit between the plate and filament, will the statements in your answers to X Qs. 380 to 382, inclusive, still apply?

A. Yes.

X Q. 400. Will you refer to the "Plaintiff's Exhibit No. 85", drawing of DeForest Audion Amplifier, opposite page 225 of the printed record? Assuming an alternating voltage to be applied at the terminals X Y, what, if any, change will be made in this incoming voltage or current between the input terminals X Y and the telephone R?

A. That will depend, of course, on a great many things, such as the frequency of the applied electromotive force, the construction of the transformers and the characteristics of the particular tubes employed. The question is so

general that I have difficulty in answering it and, possibly, it might be simplified if the sort of change you are interested in inquiring about were specified.

X Q. 401. How will the frequency of the incoming current affect the operation?

A. It will affect it, because the drawing indicates transformers with iron cores, and transformers of this kind will pass a certain order of frequency; that is, a relatively low one, in an efficient manner, while the higher frequencies will not be passed so efficiently. They may also introduce distortions.

X Q. 402. Assuming the transformers to be adapted to pass such frequency as is received, and assuming the tubes to be hard tubes what, if any, change is mad · in the incoming signal or voltage between the input X Y and the telephone R?

A. Several changes take place: first, the intensity of the applied electromotive force is increased with each stage; secondly, in the arrangement shown there will be a distortion of the applied e.m.f., resulting in the production of a direct-current component in the output of each tube, this direct-current component being increasingly greater from the first tube to the third tube; there will also be produced harmonics, or multiples, of the applied e.m.f.

X Q. 403. If the incoming signal or frequency is a low frequency telephone conversation, for example, do the harmonics and distortion referred to in your last answer, tend to interfere with, or make clearer, the telephone conversation?

A. It may do either; depending on the characteristics of the transformer and the receiver. For example, the transformers may pass rather poorly the higher frequency com- [fol. 1415] ponents of the voice, which failure may, in part, be compensated for by the production of the harmonics; on the other hand, if the transformers are well designed for this purpose, and the telephone receiver equally responsive over the whole ranges of voice-frequencies, then the presence of the harmonics may have a detrimental effect; this condition, however, is one which is realized only with great difficulty in practice.

X Q. 404. Assuming the drawing to represent a low-frequency amplifier, do you find in it any suggestion that either of the three tubes is to perform any rectifying function?

A. Yes, of course; the tubes are three-electrode vacuum tubes and the space between either the cold electrode tubes and the hot electrodes is a rectifier, and the whole action of the tubes hinges around this fact.

X Q. 405. To the extent that rectification occurs in any of these three tubes, still assuming it to be used as a low-frequency amplifier, for telephone currents, for example, does, or does not, the rectification tend to improve or impair the reception in the telephone?

A. That is a difficult question to answer, for the reason that the three-electrode device operates as it does, because inherently it is a rectifier, and the question of whether or not rectification improves, or injures, the transmission of speech, can only be answered by stating that it is present, regardless of whether the transmission is good or poor.

X Q. 406. Now refer to "Plaintiff's Exhibit No. 110", opposite printed page 227 of the record, and assume that high-frequency radio signals are received on the antenna A E. Do you agree that the first tube T will act to rectify the high frequency and create a low-frequency component in the plate circuit of the first tube?

A. I certainly agree that the first tube acts as a rectifier, but whether or not it creates a component of low frequency in the output, depends upon the nature of the applied electromotive force; consequently, I cannot agree with that part of the question, unless the input electromotive force is more completely defined.

X Q. 407. Assuming the incoming wave to be a modulated, continuous wave, how do you understand the first tube T will function?

A. It will function in several ways; first of all, it would repeat in the output circuit the incoming modulated electromotive force; it would give rise to harmonics of that electromotive force and also to frequencies corresponding to the frequencies of modulation.

X Q. 408. Now, do you agree that the object and purpose of the remaining two tubes is to pass on the modulated frequency with increased intensity?

A. That is a portion of their purpose, but their fundamental purpose is to make evident in the telephone receiver R, the presence and modulation of the high-frequency radio currents existing in the antenna, A, A', E; in other words, in combination with the first tube, they function to detect the presence of a high-frequency radio current.

X Q. 409. I am trying to find out if the word "detect", as used by you in your deposition, and particularly in your last answer, has any significance other than enabling sounds in the telephone R to be detected, and to that end, whether or not in the last answer, you mean anything more than that the first tube has acted to rectify the incoming signal, and the last two tubes to intensify the rectified signal in the form it exists in the grid circuit of the second tube?

[fol. 1416] A. I am using the word "detect" in the sense in which it has been employed for many years in radio, and in the sense in which it is used in the definition of the word detector, given at one time by the Standards Committee of Radio Engineers, and given in my direct deposition. Under this significance, the complete arrangement of "Plaintiff's Exhibit No. 110" constitutes a "detector", since its purpose is to make evident the presence of high-frequency radio oscillations by means of sound in the telephone receiver.

X Q. 410. I do not think that you answer my question and I will therefore try it in another way: Assume, for example, that there is applied to the input circuit, the grid circuit, of the last tube T^3, a low-frequency telephone current, but that the energy is not sufficient to enable a person to hear sound in the telephone receiver R. Under those circumstances do you understand that the device is acting as a detector?

A. Assuming that your question supplies the entire information necessary for its answer, it would then appear that the last tube was not performing *any* useful function; and I would not be able to say from this information alone, whether or not it was a detector.

X Q. 411. What is the significance of the reservation which you make in answering the last question?

A. The significance is that the information given in your question imputes an inoperative device, and it is not possible to apply a characterization.

X Q. 412. In what respect would such a device be inoperative, other than that the listener would not hear sound?

A. It would be inoperative because the purpose of the arrangement shown in "Plaintiff's Exhibit No. 110" is to produce a sound in the telephone, and if it fails to do this, it is not working.

X Q. 413. Now, assume that without any other change,

the energy of the received telephone conversation at the input of the tube is increased until a listener does hear sound in the telephone; under those circumstances is the device acting as a detector?

A. That will depend upon the source of the applied e.m.f. If it be derived from the decomposition of a radio frequency into audio components, then, under my understanding, it would be acting as a detector; in other words, it would be part of a mechanism by means of which a frequency so high as to be inaudible to the human ear were acted upon to produce frequencies which could be heard. On the other hand, if the applied e.m.f. is an audible one, and not derived from a radio frequency, I would say that while the device itself, viz., tube T^3 of Plaintiff's Exhibit No. 110" is a detector, under these circumstances it was not operating as a detector under my understanding of the term.

X Q. 414. Then, if the low-frequency telephone current applied to the input of the tube is derived from a telephone circuit, as I understand you, the tube is not operating as a detector; am I right?

A. That is correct; understanding, of course, that the tube itself is still a detector in its inherent capabilities.

X Q. 415. But the same tube, if deriving low frequency from a tube such as the first tube in "Plaintiff's Exhibit No. 110", which acts to create the low frequency from the incoming high frequency, is acting as a detector; is that correct?

A. Yes; that is to say, it is then part of the detecting mechanism, since it is assisting in the process of rendering the inaudible high-frequency radio oscillations audible.

[fol. 1417] X Q. 416. Now, assume, for example, that the antenna and the first tube of "Plaintiff's Exhibit No. 110" constitute a radio receiving station at New York, for example, receiving trans-atlantic wireless communications, and that in place of the second tube, T^2, and its grid and plate circuits, there is a telephone line receiving the signals as they exist in the plate circuit of the first tube and extending to another location, Chicago, for example, and that the telephone line is inductively connected to the third tube, T^3, at the distant location, Chicago, for example, under those circumstances is the tube T^3 acting as a detector, or not?

A. It would seem to me that it was still a part of the detecting system, serving the general purpose of making the radio-frequency wave satisfactorily audible.

X Q. 417. Please let me remind you that I did not ask you whether or not the tube would be part of a "detecting system", but that the question asks if, under these circumstances, the tube is acting as a detector within your definition.

A. I thought I had made clear my point of view, namely, that I considered the whole system to constitute the detector; that I considered the individual tube itself to be a detector, and functioning in the manner specified in your question, to be performing its portion of the detecting action.

X Q. 418. What portion of the detecting action do you understand that the tube T^3 is performing under these circumstances?

A. It is assisting in the process of making the original radio frequency oscillations audible.

X Q. 419. Can you not explain what particular part or function this tube performs in the process of making the original radio-frequency oscillations audible?

A. Certainly; it is increasing the audio-frequency applied to it and derived from the radio-frequency signals.

X Q. 420. In your answer to Q. 225 you say that practically the entire British Merchant Marine was equipped with the open-gap transmitter, and that it was employed on most of the Naval ships of the World, with the exception of the German Navy. Have you personal knowledge of these facts?

A. I presume I may say that I have personal knowledge of these facts, since, during the period when I was Chief Engineer of the Marconi Company, I possessed extensive sources of information relative to the use of radio in the world generally.

X Q. 421. But you do not pretend to have actually visited the entire British Merchant Marine or most of the Naval ships, do you?

A. No, certainly not.

X Q. 422. From such information as you had, do you understand that practically the entire British Merchant Marine was, during all of the period concerning which you have testified, equipped with apparatus made and sold by the British Marconi Company?

A. Yes, I understood that to be a fact.

X Q. 423. And that since in or about 1912, these same ships have, in increasing numbers, been provided with quenched-gap apparatus?

A. If that is a fact, I was not aware of it.

X Q. 424. Did you send, or attend, at either transmitting or receiving stations the alleged transmission of messages "some 6600 miles", referred to in your answer to Q. 225?

A. No, I did not.

X Q. 425. What, if any, personal knowledge have you of the alleged fact that war communication was maintained [fol. 1418] between England and Russia, as well as ships at sea at great distances from England, as stated in your answer to Q. 225?

A. I have first-hand personal information on that point, resulting from the fact that I personally listened to large numbers of such messages being transmitted.

X Q. 426. Where were you when you heard these messages?

A. At various places; for instance, Belmar, New Jersey, Lakewood, New Jersey, Miami, Florida.

X Q. 427. In your answer to Q. 225 you referred to a station of the United Fruit Company, at New Orleans. Do you recall that there was some trouble or complaint in connection with that station?

A. Yes, lots of trouble.

X Q. 428. To such an extent that the United Fruit Company refused to pay for it, did it not?

A. That I don't know.

X Q. 429. Do you make any question as to the fact that in the alleged demonstrations before Judge Mayer, such oscillations by the two-electrode vacuum tube as was demonstrated to Judge Mayer, was due to the presence of residual gas in the tube?

A. I don't know that I would say that the oscillations were due to the gas, but simply that the residual gas played a part in the action.

X Q. 430. Will you go so far as to say that the tubes would not have oscillated in the circuits as demonstrated before Judge Mayer, if the tubes had been high-vacuum tubes not containing residual gas?

A. I cannot say this as the result of actual experience, although I believe that it is probably true.

X Q. 431. You mentioned in your direct testimony, if I recall correctly, that the tests before Judge Mayer occupied about half an hour; am I correct in this?

A. I am not sure just what I stated in my testimony, but that corresponds with my recollection at the moment.

X Q. 432. For how long a period did the tube continue to oscillate without interruption during these tests?

A. I do not seem to recollect.

X Q. 433. In your answer to Q. 245, you state that in the demonstrations before Judge Mayer the essential thing was simply to demonstrate that the two-electrode tube had the capability of generating high-frequency oscillations, and that it was your understanding that this was in accordance with the wishes of the Court. Please state how your understanding of the wishes of the Court was acquired.

. . . . . .

Mr. Edwards: The complete sentence referring to this matter in the answer to Q. 245, is as follows:

"It was, furthermore, my understanding that this was in accordance with the wishes of the Court and that the question of reliability or otherwise, was not involved."

. . . . . .

A. My information, as I recollect it, was received from either Mr. Betts of the firm of Sheffield & Betts, or Mr. Waterman.

X Q. 434. You have no personal knowledge that the Court had any wish, of any kind, have you?

A. I received no direct personal information from the Court.

. . . . . .

[fol. 1419] X Q. 435. When you gave testimony in the Kilbourne & Clark case, did you bring to the attention of the Court where, in your testimony, the criticisms which you have set forth here against the Lodge Fig. 4 and the Telsa demonstrations which you set forth in your deposition in this case, particularly in your answers to Qs. 208 to 211, inclusive?

A. It is my recollection that I testified in the Kilbourne & Clark case relative to experiments performed with apparatus arranged in the manner of Fig. 4 of the Lodge patent, and also that I testified relative to experiments performed with the so-called Tesla coil. I did not, in that case, testify

as an expert, but as a fact witness, and do not recollect having given testimony relative to the Lodge and Tesla patents, and the disclosures therein.

X Q. 436. Do you mean that you did not, in the Kilbourne & Clark case, express your opinion as an Expert as to whether or not the Lodge Fig. 4 and Tesla apparatus demonstrated by Prof. Pickard, corresponded with the disclosure of the Lodge and Tesla patents respectively?

A. It is my recollection that I identified the apparatus demonstrated by Mr. Pickard with the Lodge Fig. 4, with the exception of the coil *k*, and that I pointed out that this particular coil had not been constructed by Mr. Pickard in accordance with my understanding of the instructions of the patent.

With respect to the so-called Tesla apparatus, I recollect that I pointed out that it had not been constructed in accordance with the instructions of the patent and was not being used in a manner corresponding to my understanding of the instructions of the patent.

X Q. 437. Have you made any criticisms of the Lodge Fig. 4, or the Tesla apparatus, in this case, which you, or Mr. [fol. 1420] Waterman did not point out to the Court in the Kilbourne & Clark case?

A. I do not recollect, so far as my own testimony is concerned, having pointed out relative to the actual tests of Fig. 4 of the Lodge patent made in the Kilbourne & Clark case, and the so-called Tesla apparatus demonstrated in the same case, which I did not point out in my testimony in the Kilbourne & Clark case. I have, of course, made many references and statements relative to these two arrangements in my present testimony, which I do not think were contained in my Kilbourne & Clark testimony. I do not recollect Mr. Waterman's testimony sufficiently well to be able to answer the question.

X Q. 438. Can you enumerate briefly the substance of each of the references, statements or criticisms which you have made in this case relative to the Lodge Fig. 4, or the Tesla patent, which you believe were not contained in the Kilbourne & Clark testimony?

A. No, I don't think that I could do that without a detailed comparison of my testimony in the two cases.

X Q. 439. As I understand your testimony, your principal criticism of the Lodge Fig. 4, as set forth in your

answer to Q. 208, is that if coil *k* were constructed in accordance with information to be found in the Lodge specification or drawings, it would short-circuit the condensers *j*, *j*, and, therefore, make the transmitter inoperative; am I correct in that understanding?

A. No, I don't think that you are, because while I have pointed out in my answer to Q. 208 that the coil *k* constructed in accordance with any information I can find in the patent, renders the device inoperative; as I read my answer to Q. 208, that is only a portion of my criticism of Fig. 4 and the balance of my reply brings out the facts which I consider equally important.

X Q. 440. The criticism that coil *k* would short-circuit the condensers is based upon your understanding that coil *k* should be a high-frequency coil of a very few turns, is it not?

A. My understanding of the construction of coil *k* is based on what the drawing Fig. 4 shows, since, as I recollect, there is no other information in the patent, except a statement to the effect that coil *k* should permit the thorough charging of the condensers, which statement implies that coil *k* should offer a negligible opposition to the flow of current from the induction coil *a* into the condensers *j*.

X Q. 441. I am not asking you as to the correctness of your belief; but, rather, whether it is not a fact that your criticism that coil *k* would short-circuit the condensers is based upon an understanding that coil *k* should be a high-frequency coil with very few turns?

A. The question contains an expression "high-frequency coil", which is somewhat indefinite in meaning, but I will state that it is my understanding that the patent directs that coil *k* should be constructed of relatively few turns.

X Q. 442. In your answer to Q. 209 you say that on substituting for the coil *k* as set up by Prof. Pickard, a coil made as nearly as possible like the disclosure of the patent, the device was found to be entirely inoperative. Will you describe what the coil which you considered to be "as nearly as possible like the disclosure of the patent", was like?

A. The answer to that question will probably be found in my testimony in the Kilbourne & Clark case. I do not, at the moment, recollect the exact details, except that it was a small coil with a few turns of fine wire.

[fol. 1421] X Q. 443. Was there any finding by the Court

that the device with this substituted coil was entirely inoperative?

* * * * * * *

A. I do not recollect the Court's opinion sufficiently well to answer the question.

X Q. 444. Who did find the device to be entirely inoperative?

A. The device was tested, as I recollect it, by Mr. Waterman and myself, in the presence of representatives of the defendant in the Kilbourne & Clark case, and also in the presence of expert engineers appointed by the Court and designated as "Assessors".

X Q. 445. Did the assessors find that the device with this substituted coil was entirely inoperative?

A. I do not recollect their report, but presume it is to be found in the Kilbourne & Clark record. I recollect most distinctly, that the arrangement was inoperative under these conditions, and this fact must have been evident to those present.

X Q. 446. In your answer to Q. 227, you refer to three types of transmitters involved in the Kilbourne & Clark case; will you state in each of these transmitters how many swings of current there were in the primary circuit between the time the spark-gap closed and the time it opened again?

A. No measurements were made upon which an exact answer to your question can be based. The Achilles set was of a type commonly and extensively used, and I can state that, based upon my experience with similar apparatus, I believe that about ten oscillations took place in the closed circuit for each spark. Oscillograms were made by Dr. Chaffee, and in his testimony, P. R., p. 2971 in the Kilbourne & Clark case, he states that these tests disclosed at least two and a half complete oscillations. From my knowledge of the method of making these tests, and also from the manner in which the Simpson transmitter tuned, I believe that there were two or three times as many swings as the oscillograph showed. No tests that I am aware of were made upon the Thompson transmitter, but I believe that the number of swings would be somewhere between five and ten.

X Q. 447. Referring to the Marconi patent No. 763,772, do you agree that if, in the system set forth in that patent, the spark-gap is a plain gap, a tight coupling between the

closed circuit and the antenna, it would result in the transmission of a double frequency from the antenna?

A. As I have already pointed out in my direct examination, the production of a complex wave-form involving two or more frequencies, is not determined by the coupling or spark-gap alone, but depends upon the resistance of the circuit as well.

If the antenna circuit is of low resistance, then there will be produced the double frequency form of wave; if the circuit is of high resistance, there will *not* be produced the two humps in the resonant curve. In this statement I am assuming that some particular close coupling is employed which is greater than the open spark-gap can be used with, and cut off at the end of the first series of oscillations in the closed circuit.

X Q. 448. Is the "resistance" to which you refer, ohmic resistance?

A. Yes.

X Q. 449. Does ohmic resistance in a tuned circuit act [fol. 1422] to vary the frequency of the current?

A. To a very slight extent, it does, although this amount is so small that it is usually neglected.

X Q. 450. The effect of ohmic resistance in the antenna, as referred to in your answer to XQ. 447, would be to change the form of the wave by flattening it out, rather than to change the frequency of the wave or waves, would it not?

A. The effect of the resistance in the antenna circuit is two-fold. It has the effect of broadening or flattening the resonance curve of the antenna circuit in the manner implied by your question, but its effect on the production of the double frequency with some particular degree of coupling, is due to a different action, viz., that the energy transferred from the closed circuit is consumed, thereby reducing the amplitude of the current in the antenna circuit and, coincidentally, the power of the antenna circuit to re-ignite the spark-gap by means of retransferring energy back to the closed circuit. This is the action which makes possible the employment of a closer coupling with a high-resistance antenna, when the antenna resistance is high, than is possible when the antenna resistance is low.

X Q. 451. The effect of resistance is to reduce the efficiency of the system, is it not?

A. That depends upon the particular sort of efficiency which is meant. If, by this term is meant the ratio of the

power input into the oscillating circuit containing the spark-gap to the energy radiated by the antenna, and if the resistance referred to is any resistance other than that of radiation resistance, then the efficiency is lowered. If, however, under these circumstances, the resistance is that kind of resistance known as "radiation" resistance, then the converse is true, and the greater the value of this resistance, up to some limiting point, of course, the more efficient the arrangement becomes. Of course, there are other standards of efficiency besides the one I have assumed in my answer; for instance, the common criterion of practical usefulness might be considered, and this is the radiation of the maximum amount of power from the antenna with a reasonable wave-form. Due to the quenching action of all types of spark-gaps, on this basis it may happen that the insertion of resistance into the antenna circuit resulting in a broad single-hump resonance curve, gives a result which is as good as that obtained with a lower resistance, and the necessity of employing looser coupling which results therefrom.

On this basis, therefore, the insertion of resistance in a antenna of a radio system similar to Fig. 1 of Marconi patent 763,772, may not result in a decrease of efficiency.

X Q. 452. Will you explain what you mean by "radiation resistance"?

A. By "radiation resistance" I mean the capability which an open antenna system such as that of Fig. 1 of Marconi patent 763,772 has of radiating energy out into space. This capability is an energy-consuming action and is, therefore, analogous to a resistance, and is commonly measured in the same electrical units as a resistance.

X Q. 453. To the extent that ohmic resistance is present in the antenna, it tends to make the antenna a poor radiator, does it not?

A. No, that is not correct. The presence of ohmic resistance, and by that I assume you mean any resistance except radiation resistance, has no effect whatever upon the radiating power of an antenna. It consumes energy, and for this reason makes it necessary to supply greater power to the antenna, in order to radiate a given power from the [fol. 1423] antenna, but it does not affect the antenna itself, in so far as this radiating capability is concerned.

X Q. 454. To put it another way: It does not vary the frequency to which the antenna is tuned; but does reduce

the energy delivered to the antenna and thereby reduce the energy sent out by the antenna, does it not?

A. The statements in your question are not quite technically correct. The insertion of resistance in the antenna circuit, assuming that we are not concerned with an associated circuit containing a spark-gap, does not materially affect what is commonly known as the natural frequency or period of the antenna circuit.

With respect to the power applied to the antenna, the presence or absence of resistance is not a controlling element, but it is a controlling element in determining the percentage of this power which can be usefully radiated.

X Q. 455. So that increasing the ohmic resistance in the antenna reduces the energy radiated, does it not?

A. That question is not answerable unless other conditions, such as the associated circuits from which the antenna derives its power, are specified.

X Q. 456. Other parts of the system remaining the same, is it not a fact that increasing the ohmic resistance reduces the amount of energy transmitted by the system?

A. Again I must point out that the question does not supply sufficient information to enable me to answer, for the simple reason that with one type of power supply to the antenna, the insertion of resistance under practical operating conditions would not necessarily, decrease the power radiated or the efficiency of the arrangement as a radio transmitter; whereas, with another type, it would decrease it.

X Q. 457. It is a fact, is it not, irrespective of the type of power supplied, ohmic resistance to the extent that it is present in the antenna, tends to dissipate energy?

A. Ohmic resistance in an antenna circuit will always consume or dissipate energy.

Re-direct examination.

By Mr. Vaill:

R. D. Q. 458. In view of opposing counsel's reference to one example of your testimony on which his objection was entered as not being competent, I will refer you to your answer to Q. 224 on direct examination (P. R., p. 1682), where you quoted from the testimony of Dr. Zenneck in the Kilbourne & Clark case, and will ask you whether or

not you personally heard Dr. Zenneck give the testimony which you quoted in said answer.

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[fol. 1424] A. I was present and heard Dr. Zenneck give the testimony referred to.

R. D. Q. 459. What other case did this testimony of Dr. Zenneck's relate to?

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A. This testimony was originally given in the suit of the *Marconi Wireless Telegraph Company of America* vs. *The Atlantic Communication Company.*

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[fol. 1425] R. D. Q. 462. In answer to X Q. 446 you stated that oscillograms were made by Dr. Chaffee and in his testimony in the Kilbourne & Clark case he states that these tests disclosed at least two and a half or three oscillations. Will you please state what connection you had with such tests and your personal knowledge of what took place as to methods of procedure and results?

• • • • • • •

A. I was present during these tests and familiarized myself with the apparatus and methods employed in the making of these tests.

R. D. Q. 463. In your last answer you apparently neglected to state your personal knowledge of the results of the tests conducted by Dr. Chaffee; will you please complete your answer?

A. I observed the results obtained by Dr. Chaffee in these tests and noted that they were the results referred to in his testimony, viz., that at least two and one-half oscillations were present in the closed circuit of the Simpson transmitter.

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Last question by the Notary: Do you know of any other matter relative to this claim?

Answer: No.

Deposition Closed

[fols. 1426-1427] *Deposition of Wilson Aull, Jr., for Claimant, taken at New York, N. Y., on the 9th day of June, A. D. 1927.*

Direct examination.

By Mr. Vaill:

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[fol. 1428] Q. 74. Dr. Miller, during his answering testimony for defendant, stated in answer to Q. 20 of his deposition (P. R., p. 801), referring to the method of reception by the use of the ultra-audion receiving circuit and the regenerative circuit with inductive coupling of "Plaintiff's Exhibits Nos. 109 and 114" respectively, as follows:

"It is apparent, therefore, that this important method of reception is made practically possible solely by reason of the oscillating property of the three-electrode vacuum tube."

Will you please state to what extent you can confirm Mr. Weagant's testimony in answer to Q. 309 (P. R., p. 1771), concerning the use of a two-electrode vacuum tube in the ultra-audion circuit similar to that of "Plaintiff's Exhibit No. 109"?

A. I have set up apparatus similar to that shown in the "Weagant Sketch No. 8," "Claimant's Exhibit No. 302," with which I used a two-element electron tube as shown at T. I also had a filament rheostat connected between the filament heating battery and the filament, so that I could regulate the temperature of filament F. Tube T was so placed that it was near the high potential end of the secondary tuning inductance *j*.

With this arrangement and with proper adjustment of the filament rheostat I had no difficulty in setting up oscillations and receiving C-W signals. I also received whistles caused by the beating of incoming broadcast signals with the locally generated oscillations by the well-known heterodyne action. The beat-note varied with the tuning of variable con-[fol. 1429] denser *h'*. When tuned to a broadcast station in varying the temperature of filament F by means of the rheostat, oscillations could be controlled or stopped altogether. Radio telephone signals were loudest when the circuit was adjusted so it was not quite oscillating; or, if continuous wave-signals were desired, they could readily be received by putting the circuit into the oscillating condition.

* * * * * * *

[fol. 1430] Q. 77. Dr. Miller, in his testimony on behalf of defendant, stated in answer to Q. 4 of his deposition on page 763 of the Printed Record, that:

"Crystals are incapable of generating oscillations, though a great number of crystal contacts have been and are being utilized as radio detectors."

Will you please state what experience you have had in connection with the reception of radio signals when the crystal detector has produced oscillations, and also as to the capabilities of the crystals to produce oscillations. In giving your answer will you refer to one or two publications which your experience may confirm?

A. It is well known in the art that crystal contacts having negative resistance characteristics may be used to generate oscillations in much the same manner that an electric arc is used for this purpose.

I have done some experimentaing with crystals used in circuits similar to those usually employed with the oscillating arc. Such methods have been pointed out in quite a number of publications, including Eccles' "Hand Book of Wireless Telegraphy and Telephony," 1918, page 259; "QST," March, 1920, page 44, and "Radio News," January, 1925, page 1166.

I have experimented with the circuits shown in "QST" and Fig. 3 of Dr. Pickard's article in "Radio News," and have obtained beat notes from a local broadcasting station, upon suitable adjustment of the crystal and potentiometer setting controlling the battery voltage. I obtained this result, using a galena crystal with a spring wire contact, and with a zincite crystal with a steel point.

These beat notes were, of course, due to the beating of local oscillations with the incoming telephone carrier wave. The correct adjustment of crystal and battery voltage is not easy to obtain and in my experience the adjustment did not hold long, but the intermittent beats set up, proved the existence of locally generated oscillations without doubt.

[fols. 1431-1432] Mr. Vaill: Counsel for claimant offers in evidence as one exhibit containing references to Dr. G. W. Pickard's work with Oscillating Crystals, photostat copies of page 44 of the publication "QST" for March, 1920, page 1166 and a portion of page 1270 of the "Radio News" for

January, 1925, and requests that the same be marked "Claimant's Exhibit No. 310."

(Said exhibit marked as requested.)

Mr. Vaill: Opportunity is extended to opposing counsel, for his own convenience and satisfaction, to attend and witness a repetition of the tests made by this witness and testified to in answer to Qs. 71 to 77, inclusive, of the direct examination.

Cross-examination.

By Mr. Edwards:

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[fols. 1433-1434] XQ. 93. Have you ever succeeded in generating oscillations with a crystal, other than one having negative resistance characteristics?

A. As far as I know, I have not. In generating the oscillations, it is almost impossible to tell just what the crystal characteristics are, except for one adjustment, the adjustment at which the characteristic curve is taken. It is theoretically impossible to obtain oscillations from a device such as a crystal or arc, unless it has a negative resistance or falling characteristic.

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Last Question by the Notary: Do you know of any other matter relative to this claim?

Answer: No.

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[fol. 1435] *Deposition of John V. L. Hogan, for Claimant, taken at New York, N. Y., on the 31st day of August, A. D. 1927.*

First Interrogatory by the Notary: State your name, your occupation, your age and your place of residence, whether you have any, and if any, what interest direct or indirect, in the claim which is the subject of inquiry; and whether, and in what degree, you are related to the claimant?

Answer: My name is John V. L. Hogan; age, 37; residence, Forest Hills, Long Island, New York; I have no

interest, direct or indirect, in the matters at issue and am not in any way related to the claimant.

Direct examination.

By Mr. Vaill:

Q. 1. What has been your training and experience in the art of Radio Engineering?

A. I have followed closely the literature and practical art of Radio Telegraphy and Radio Telephony continuously since I began as an amateur in 1904, or earlier, and I have carried on much experimental, research and engineering work in that field. I have designed, manipulated, constructed and investigated a great variety of apparatus for radio telegraphy and radio telephony.

I have directed and performed experimental investigation in the development of radio receivers in general, especially with regard to tuning and the prevention of interference, as well as of transmitting apparatus of various types, including numerous forms of spark and continuous-wave transmitters.

Work at my own stations, prior to 1906, brought me in touch with Dr. Lee DeForest, and for about six months in 1906 and 1907, I worked with him as his personal assistant at his laboratories in New York. In 1907 I continued my investigations in radio telegraphy and telephony, the tuning of receivers and transmitters, etc., both at the commercial radio station at Bridgeport, Connecticut, and at my own station. This work led to several patent applications of mine.

In January, 1908, I carried on an extensive series of tests of some special tuning devices for interference-prevention that I had devised, making use of the tower of the Times Building in New York, and receiving messages direct from Porto Rico, Cuba, the Canal Zone, etc. Beginning in the Fall of 1908, and continuing until 1909, I took courses in Electrical Engineering at the Sheffield Scientific School of Yale University, and was there awarded honors in Physics and Mathematics. During this period my experimental work was continued in the graduate research laboratories of the Scientific School and at my home station; data concerning the investigations then made have been published by me in my patent specifications and elsewhere. A considerable portion of my experimental work

at that time was directed toward the solution of tuning problems.

After an interview with Prof. Fessenden in December, [fol. 1436] 1909, I joined the staff of the National Electric Signaling Company and proceeded at once to its high-powered station at Brant Rock, Massachusetts. There I was put in charge of the long distance radio telegraphic tests made between that plant and the United States cruisers Birmingham and Salem. Until the Fall of 1921 I was continuously associated with the National Electric Signaling Company and its successor, the International Radio Telegraph Company, first as Telegraph Superintendent, then (in February, 1911), as Chief of the Operating, Erection and Inspection Department (from September, 1914), as Chief Research Engineer, Commercial Manager, and finally, as Manager. My work for the Company involved design, criticism, investigation, manipulation and manufacture of practically all forms of apparatus used in radio telegraphy and telephony.

In the Fall of 1921 I opened my own office as Consulting Engineer, and since that time have specialized in Radio. Throughout my contact with the field I have kept in close touch with the literature of the art, including the patents, as it has been published. Numerous technical papers and discussions written by me have been published in the Electrical World, the Electrician (of London), the Proceedings of the Institute of Radio Engineers, the Jahrbuch der Drahtlosen Telegraphie und Telephonie, etc.; and I have presented papers on radio subjects before meetings of the American Institute of Electrical Engineers, the Institute of Radio Engineers, the Society of Wireless Telegraph Engineers, the second Pan-American Scientific Congress (at Washington), at the Sheffield Scientific School and at Johns-Hopkins University, as well as before other organizations. A number of patents have been issued upon my inventions in Radio Telegraphy and Radio Telephony, both in the United States and abroad. I am a Fellow and Past President of the Institute of Radio Engineers, and served as Chairman of that body's Standardization Committee for a number of years. I am a member of the American Institute of Electrical Engineers, the American Association for the Advancement of Science, and other scientific and technical organizations. I have been called to Wash-

ington several times by Secretary Hoover, to serve in his Radio Advisory Conferences.

In general, I am familiar, by personal investigation and experience, with the design, manufacture and use of many types of radio transmitters and receivers. I am a practical radio operator and for some years held a Government license as such. I have written and had published by Little, Brown & Company, of Boston, a book on Radio, entitled "The Outline of Radio," which has gone into a second revised edition. Since 1908, I have made a close study of the patents in the art and science of radio-communication, and have been called upon to testify as a technical and practical expert in various litigations.

Q. 2. Have you read the Marconi tuning patent, No. 763,772 in suit, and do you understand the same, particularly with reference to the inventions recited in the transmitter claims thereof, numbers 1, 3, 6, 8, 11 and 12, the receiver claims thereof, numbers 13, 14, 16, 17, 18 and 19, and the combined transmitter and receiver claims hereof, numbers 10 and 20?

A. I have studied the patent, and believe that I understand it.

[fol. 1437] Q. 3. Briefly state the nature of the inventions referred to in the last question and the position such inventions occupied in the radio art at the date of Mr. Marconi's invention thereof which, for the purposes of this case, is that of the Marconi British patent No. 7,777, of April 26, 1900.

A. The inventions of the Marconi tuning patent relate particularly to the association of four tuned circuits in a wireless signaling system. Two of these tuned circuits are normally at the transmitter and two at the receiver. Certain of the claims of the patent (in particular Nos. 1, 3, 6, 8, 11 and 12) cover the transmitting station, certain others (Nos. 2, 13, 14, 16, 17, 18 and 19), the receiving station, and still others (Nos. 10 and 20), the entire system, including both stations.

Taking up the transmitter first, we find the arrangement typified by Fig. 1 of the patent, and clearly described in the specification. The chief elements of this transmitter are, first, the closed circuit comprising a spark-gap *c*, a condenser *e* and an inductance coil *d* (which in Fig. 1 constitutes the primary coil of a coupling or oscillation transformer) and, second, the open circuit comprising the an-

tenna *f* and A, the loading coil *g*, the secondary coil *d'* and the earth connection E. With reference to the closed circuit, the three important elements *c*, *d* and *e* may be of any type, there being no limiting statements or characterizations of them in the patent that would tend to limit their construction to any one of the usual designs. This circuit is described at page 2, line 9 as an "approximately closed circuit", as (line 10), "being a good conserver", and (line 15), "as persistent oscillator". The latter ("persistent oscillator") is carefully defined at page 2, lines 15 to 20 as "an electrical circuit of such a character that if electromotive force is suddenly applied to it and the current then cut off electrical oscillations are set up in the circuit which persist or are maintained for a long time". This means, technically, that the closed circuit may be tuned or be resonant to continuing trains of oscillations which are persistent except for the rate at which energy is transferred to the antenna or open circuit to be radiated. In the next part of this same sentence, beginning at page 2, line 1, such a closed or persistently oscillating circuit is contrasted against the antithetical type of circuit "which very quickly imparts the energy of electrical oscillations to the surrounding ether in the form of waves". Thus it is clear that this first circuit *c*, *d*, *e*, in the condenser of which the electrical energy of the transmitter is stored or conserved prior to its emission in space waves, must be one having low or negligible radiation power, so that, by itself, it will constitute "a persistent oscillator" or, in other words, a highly resonant circuit.

The elements of the transmitter open or antenna circuit of Fig. 1, comprising *f*, *A*, *g*, *d'* and E, have been referred to above. This circuit is defined at page 2, line 10 of the specification as an "open circuit", at lines 11 and 20 as "a good radiator" of wave energy and at line 21, as I have already quoted.

The Marconi invention of this patent presented an element found by Marconi to be essential (as has since been verified by many other investigators), viz., the tuning together of the two circuits, open and closed, at the transmitter. This tuning feature made a tremendous impression upon the art, and aided the radio worker of the day [fol. 1438] in overcoming his outstanding problems of increasing the distance of reliable transmission and increas-

ing the "localization" of signals or the selectivity of radio systems required to operate concurrently in the same general neighborhood. By following the law laid down by Marconi and stated at page 2, lines 118-129 of the patent, viz.:

"The capacity and self-induction of the four circuits—i. e., the primary and secondary circuits at the transmitting-station and the primary and secondary circuits at any one of the receiving stations in a communicating system—are each and all to be so independently adjusted as to make the product of the self-induction multiplied by the capacity the same in each case or multiples of each other—that is to say, the electrical time periods of the four circuits are to be the same or octaves of each other"

it was at once found that the transmitting station not only could be made more powerful than ever before (resulting in vastly greater transmission distances), but also that there was produced a radiator of purer waves better adapted for the "localization" of messages or syntonic interference—free operation.

Referring next to the receiving system, which is exemplified by Fig. 2 of the patent, we find the same two coupled circuits tuned together. The antenna-to-ground circuit *f'*, A, *g'*, *h*, *j'*, E is defined at page 1, line 51 of the specification as "a good absorber of electrical oscillations". This is the characteristic of an open circuit used for reception, just as "good radiation" is the characteristic of such a circuit used for transmission. The coupled secondary circuit which includes the secondary coils *j'*, the loading inductance coils *g'* and the tuning condenser *h'*, is shown as of the closed highly resonant or persistently oscillating (*i. e.*, substantially non-radiating and non-absorbing) type. The two circuits, open and closed, are tuned together as instructed at page 2, lines 118-129 of the specification quoted above. This tuning, and the arrangement of these circuits, enables the user to attain a high degree of accuracy in the tuning of the complete apparatus at a transmitting station and at one or more receiving stations.

As a practical matter, it has repeatedly and consistently been found that such tuning together of the open and closed circuit at a receiver permits the attainment of results which, in point of distance, selectivity and reliability of

reception, are vastly superior to any that could have been had by the use of any prior art apparatus.

Considering both the transmitting station and the receiving station as constituting a complete system, Marconi points out that the four tuned circuits (two at each end), are to be adjusted to the same frequency of resonance. The matter which I have already quoted from page 2, lines 118-129, and the following down to page 3, line 17 of the specification, covers this point. By such four-circuit tuning the advantages of distant-station selective intercommunication, which I have already covered in some detail as to the transmitter and receiver individually, are combined. The result was the production of a radio telegraph system far superior to anything that had previously existed, and marking so great and so nearly universally recognized an advance as to warrant the greatest respect for the invention of this patent.

Marconi himself, at page 1, lines 20 to 66, inclusive, of [fol. 1439] this specification, sets forth how the four-circuit tuning provides a system showing great improvement over the earlier Marconi re-issue patent No. 11,913 (which was the first to show a practical wireless telegraph system). In the re-issue patent only the single open radiating antenna circuit of the transmitter and the single open absorbing antenna circuit of the receiver were tuned together. This gave a relatively small degree of "localization" of the messages, that is to say, only a broad tuning of one station to another (in general not sufficient to meet the interference conditions of even twenty years ago), and also imposed very definite limits upon the transmission distance and reliability of the normal station. The four-tuned circuit system of the later patent 763,772, involving coupled tuned circuits, whether used completely at both stations or merely at either the transmitter or the receiver, resulted in the exceedingly substantial improvements that I have set forth. As to the transmitter, the improved system of the tuning patent not merely made possible the effective use of greater transmitting powers, but it avoided insulation difficulties that, in the system of the re-issue patent, often interfered with, or completely prevented effective transmission in wet or stormy weather. Further, the four-circuit tuning patent system had the important advantage over the "plain aerial" system of the re-issue patent that it removed the spark-gap from the res-

onant radiating circuit and thereby eliminated from that circuit a large part of the damping of the oscillations in the aerial. Thus a larger portion of the energy of the oscillating current is radiated efficiently, rather than being partly absorbed in the spark-gap resistance. In this way the aerial circuit is made a better radiator than that of the re-issue patent. As to the receiver, the provision of the coupled closed tuned circuit added greatly to the resonant selectivity of the system, thus not only minimizing interference, but increasing the signal response of a suitable detector and indicator apparatus.

Summarizing, the tuning system of the later patent 763,772 established in the art what has been generally recognized as a great practical advance over the plain aerial system of the re-issue patent, as well as over such other improvements as had been adopted by the practical workers in the field up to that time.

Q. 4. In your last answer you have referred to some of the advantages of the inventions of the Marconi tuning patent over Marconi's plain antenna or re-issue patent; please consider this subject further in connection with "Defendant's Exhibit K-6", being a reprint of the lecture by Marconi at the Royal Academy of Science, Stockholm, 1909, in which Marconi refers to his plain antenna and coupled tuned circuit inventions and their efficiency. Will you please state from your knowledge of the practical art, to what Mr. Marconi was referring in comparing the efficiency of the two systems, particularly beginning at page 24 of his lecture?

A. The portion of this paper at page 24, contains the following statement by Mr. Marconi:

"A remarkable fact, not generally known, in regard to transmitters is that none of the arrangements employing condensers exceed in efficiency the plain elevated aerial or vertical wire discharging to earth through a spark gap, as [fol. 1440] used in my first experiments—Figs. 2 and 3 (*ante*). I have recently been able to confirm the statement made by Professor Fleming in his book, 'The Principles of Electric Wave Telegraphy', 1906, page 555, that with a power of 8 watts in the aerial it is possible to communicate to distances of over 100 miles. I have also found that by this method it is possible to send signals 2,000 miles

across the Atlantic with a smaller expenditure of energy than by any other method known to myself.

"The only drawback to this arrangement is that unless very large aerials are used, the amount of energy which can be efficiently employed is limited by the potential, beyond which brush discharges and the resistances of the spark gap begin to have a deleterious effect."

Here Mr. Marconi emphasizes very clearly the power-limitation which is inherent to the original system of the Marconi re-issue patent 11,913. With ordinary antenna systems of the plain aerial type only a relatively small amount of power can be employed, and the signals will therefore travel only a relatively short distance in spite of the rather high electrical efficiency given to the system by its radiating qualities. On the other hand, when the coupled tuned system of Marconi patent 763,772 is used, even a small antenna can be made to send out powerful signals. Of course, if one has a very large antenna, its capacity may be sufficient so that even the old system will permit use of enough power to bridge quite long distances, such as the 2,000 miles cited by Marconi in that part of his lecture that I have quoted. But when the same large antenna is used with the coupled tuned system of the later patent, the useful power may be still farther and greatly increased, and then both the distance and the reliability of communication will be correspondingly multiplied. This is additional to the advantages of not requiring such perfect antenna insulation, of minimizing the heat-losses that occur because of the spark-gap resistance when there is a spark-gap directly in the antenna circuit, and of producing a sharper and better-tuned wave, all of which follow from the use of the Marconi tuning invention.

Q. 5. If you have read and understand the inventions of the Lodge patent No. 609,154, will you please briefly explain the construction and mode of operation of the invention of claims 1, 2 and 5 in issue herein of that patent and point out what, if any, bearing the disclosures of the invention of those claims has on the claims in issue of the Marconi patent in suit. Please give your reasons for any opinion you may express.

A. The Lodge invention of the claims referred to is the variably acting loading or inductance coil in the sending or receiving open antenna circuit for syntonizing or tuning

the transmitting antenna and the receiving antenna one with the other. This invention gave to the art, in addition to a way of increasing the persistence of oscillation of an open antenna system, a species of partial "localization" of messages by providing for the tuning together of the antenna systems at transmitter and receiver. In this connection it should be particularly noted that *only* the antenna circuits, and not any associated or coupled closed resonant or persistently oscillating circuits at either station were tuned together by Lodge. Marconi, in the tuning [fol. 1441] patent 763,772 not merely tuned the open circuits at both stations (as did Lodge), but provided the coupled closed circuits at each station and tuned them to the desired frequency or wave length. Thus Marconi tremendously improved the power radiation, the distance range, and the selectivity of the system. These improvements were so substantial that the Marconi four-tuned arrangement rapidly became almost universal in spark transmitting and receiving systems.

Q. 6. Will you please briefly explain the construction and mode of operation of the apparatus of the alleged "impulsive rush" invention of the Lodge patent, which has sometimes been referred to as "single chunk" excitation in this record, particularly such as is recited in claim 6 thereof, which is not in issue in this suit, and state to what extent such apparatus has been used?

A. The sixth claim of the Lodge patent, to which you refer, appears to be the only one that refers to this so-called "single chunk" method of exciting a transmitting antenna. Both in this claim and in the specification, at page 2, line 61, the apparatus is characterized as operating "by aerial disruption", thus indicating the idea of a sudden breakdown of the path between charging source and radiating antenna and the consequent "impulsive rush" of power to the antenna. Lodge's plan is exemplified by Figs. 3 and 4 of his patent, Fig. 4 being the more complete. Both of these figures illustrate a spark-gap (h^2, h^3), in series with the antenna, as in the Marconi re-issue patent. Lodge did not propose to take the spark-gap out of the transmitting antenna, but apparently thought that by the use of the additional supply-gaps h^6, h^7, he could effectively impress a sudden disturbing impulse upon the antenna, thereafter leaving it free to oscillate and to radiate waves. So far as I have been able to determine, this circuit has never been

adopted in the practical art; and I understand that when it was tested critically, it failed to operate as described by Lodge. The practical method of delivering energy to a radiating antenna system from a spark-gap system, as it has been adopted in the practice of wireless telegraphy, involves the production of a series of oscillations in a closed highly resonant circuit, and their transfer to a tuned antenna which contains no spark-gap, by means of a coupling oscillation transformer, as disclosed by the Marconi tuning patent 763,772.

Q. 7. Referring to Mr. Loftin's answer to Q. 21 relating to coupling (P. R., pp. 1023-1028), will you please state what is the character or degree of coupling between the primary and secondary circuits called for by the Marconi patent No. 763,772 and used in the construction and operation of transmitters and receivers made in accordance with the teaching of that patent?

A. Mr. Loftin says, near the middle of P. R. page 1027, that:

"The Marconi specification does not go directly into the matter of loose coupling between his circuits."

He appears to think, despite this, that, as he says near the bottom of the same page, the specification "implies a proper degree of loose coupling". He says further that Marconi's main object "is the localizing of the energy effort of his system" and that he (Loftin) has "shown that this cannot be accomplished in a coupled system without making the coupling loose". What Mr. Loftin considers would be a "loose coupling" and just how much "looseness" he [fol. 1442] thinks is imperative in his view of the Marconi invention, would appear, from his answer to X Q. 110 (P. R., p. 1166), to be a three per cent. or four per cent. coupling. I cannot agree either with his statement or his conclusion, for I find nothing in the Marconi specification, and I know of nothing in the practice of the Marconi invention in the art, that would tend to limit Marconi to the use of comolings looser than any definite maximum value. Looseness of coupling is a purely relative term. At a receiving station the operator will, following Marconi's construction, use whatever coupling he may find in practice, and under the particular conditions of the moment, will give him adequate selectiveness and responsiveness in his apparatus.

Similarly, at the transmitter, an operator will use whatever coupling gives adequate purity of wave, clarity of spark tone and efficiency. In general, and up to rather large limits, the higher the coupling the better will be the results from the energy viewpoint. On the other hand, too close a coupling will tend to destroy tuning accuracy under certain conditions. The closest couplings used in transmitter practice are about twenty per cent., and even this is relatively "loose" as compared to the theoretical maximum of one hundred per cent. coupling.

I understand that the apparatus specifically described in the Marconi patent, when it was re-constructed and measured by Mr. Waterman and Mr. Weagant, showed a wide range of variation in coupling coefficients. I see no reason why one should be limited in his choice of the best coupling for any particular purpose or condition by anything that is stated or implied in the Marconi tuning patent.

In my personal experience with spark transmitters, which includes the open-gap, rotary-gap and quenched-gap types), I have always found that the choice of coupling in the oscillation transformer was such as to produce the best radiation or largest antenna current, together with a good or clear spark and a satisfactory purity of wave. In any one of these cases resonance between the primary and secondary circuits was of the first importance though, secondarily, the coupling was adjusted or chosen so as to get the best energy and clarity in the radiated signal.

So far as I know, the use of coupled tuned closed and open circuits at radio transmitter and receiver began with Marconi's invention, and what we now know of the effects caused by variation of coupling has been learned from our study and uses of the Marconi tuned system.

Q. 8. Again referring to Mr. Loftin's answer to Q. 21, please state to what extent you may agree or disagree with his explanation of the relation between the primary and secondary circuits of the Marconi transmitter of patent 763,772, particularly as concerns the question of the decrement of the waves in the antenna circuit of such transmitter.

A. Mr. Loftin appears to take this matter up in the portion of his answer at P. R. pages 1042-1044. The first part of this testimony refers to the hypothetical transmitter adjustment represented by Figs. 4, 4*a* and 4*b* of Loftin Sketch H ("Defendant's Exhibit P-2"), opposite P. R. page 1043, and should require no discussion by me. This

is because, as Mr. Loftin says at the bottom of P. R. page 1042, he has "assumed for the purpose of discussion and illustration that the capacity and self-inductance of the antenna have such values as to give them a product differ- [fol. 1443] ent from the product of the inductance and capacity of the lateral circuit". In other words, Mr. Loftin has here assumed that the closed highly resonant circuit is *not* tuned to anything like the same frequency as the coupled open radiating circuit. Such an assumption is, of course, absolutely contrary to anything in the Marconi patent 763,772, which requires that the closed and the open circuits shall be tuned together. It is also contrary to the conditions used in practical operation. Consequently, I cannot see that its development by Mr. Loftin contributes anything to our understanding of the issues here, and it seems to me that a further discussion would be of no value.

The second part of his testimony, at P. R. pages 1044 and 1045, has to do with his Figs. 5, 5*a* and 5*b* in the same "Loftin Sketch H", and is an incomplete description of one transmitter condition or adjustment that *does* involve the Marconi tuning invention. Mr. Loftin shows that by tuning the closed and open circuits to the same frequency, and even under the limiting conditions which he assumes, waves of a single desired frequency are produced. He also points out at P. R. page 1044, by a comparison of Figs. 4*b* and 5*b*, that this tuning, as in the Marconi patent, will result in a greater strength of signal and, consequently, in better communication. Mr. Loftin does not give complete data for the case he illustrates and describes but, so far as the illustration goes, there is little to criticize in it as a showing of one exemplification of the Marconi invention. It must, however, be borne in mind that the conditions which he has assumed can represent only one such set of adjustments. Changes in frequency, in coupling, or in spark-gap characteristics would materially affect the curves drawn by Mr. Loftin. Nevertheless, so long as the two circuits at the transmitter remain effectively tuned to the same frequency, the Marconi invention would be utilized.

Mr. Loftin's testimony seems to imply that the conditions illustrated by his Figs. 5, 5*a* and 5*b* are the only conditions of operation utilizing the Marconi invention. I disagree flatly with any such conclusion, for I know from practical experience that the Marconi tuning invention is valuable, useful and utilized under many other practical conditions

or adjustments. I also disagree with certain of the conclusions that Mr. Loftin has stated at the top of P. R. page 1045, where he seems to insist that in the practical use of the Marconi invention the oscillations existing in the closed or "lateral" circuit must be long-drawn-out and prevented from feeding over into the antenna circuit at the rate that would be most effective.

I note that at P. R. page 1044, and again at P. R. page 1045, Mr. Loftin refers to the Lodge patent as stressing the tuning together of two circuits "for a good resonant transfer of energy" between them. He fails to point out that one of Lodge's circuits was at the transmitter and that the other was at the distant receiving station, so leaving the inference that Lodge had proposed the use of two coupled resonant circuits at either end of the system, similar to Marconi's, which is not the fact.

The Marconi tuning patent 763,772 gives practical directions for constructing both transmitters and receivers which have a wide range of coupling and wave-length adjustments. There is nothing in the patent that would limit the use of [fol. 1444] the tuning invention to any particular range of couplings, of spark-gap conditions or of wave decrements, and I know of nothing in the prior art that would enforce any such limitation. These several factors are interdependent to a considerable extent, one varying as any of the others is changed. The choice of any particular relation between them depends upon the practical conditions of operation. So long as the two characteristic circuits are tuned together, so as to enable effective resonant transfer of energy from the closed circuit to the radiating antenna circuit, the Marconi invention is used. This is the fact quite without regard to what particular values of the various adjustable factors may be selected by the operator to meet the conditions under which he may be working.

Q. 9. Will you please state what is your understanding of the use of the term "persistent oscillator" as used by Mr. Marconi in the specification of his patent No. 763,772, and state to what extent you may agree or disagree with Mr. Loftin's testimony concerning these terms, as given in his answer to Q. 21, P. R. 1033?

A. In the specification of the tuning patent Marconi uses the term "persistent oscillator" to define a type of circuit, viz., the closed highly-resonant primary circuit, in which electrical oscillations once set up will persist for a long

time, unless their energy is abstracted for radiation. The term is in contradistinction to the opposite term "good radiator", which defines the open or antenna circuit from which the energy of electrical oscillations is directly and effectively radiated, so that they cannot persist for a long time. At page 2, lines 15 to 20 of the specification, Marconi himself defines a "persistent oscillator" as

"*an electrical circuit* of such a character that if an electromotive force is suddenly applied to it and the current then cut off electrical oscillations are set up in the circuit which persist or are maintained for a long time."

Mr. Loftin, at the top of P. R. page 1033, in quoting this statement, disregards its punctuation and makes it appear that Marconi says oscillations were to be maintained in the primary circuit of his transmitter "for a long time". What Marconi did say was that best results are obtained when he uses a persistent oscillator in his primary circuit, the "persistent oscillator" type of circuit being defined as above by a parenthetical clause set off by dashes.

Mr. Loftin seems to gather that Marconi intended his primary circuit oscillations to persist for a long time, whereas there is nothing in the patent to suggest any such action. Mr. Loftin says, at P. R. page 1033, "there must not be permitted any too early unnecessary stopping or interference with the oscillations in the primary circuit", and with this I agree, since too early stopping of the oscillations would inhibit the resonant transfer of their energy from the closed circuit to the open circuit for radiation. Mr. Loftin does not point out the equally important opposite limit, however, that the primary oscillations must not be too long drawn-out. If the energy in the primary circuit is not transferred with reasonable rapidity to the antenna circuit from which it is to be radiated, it will be frittered [fol. 1445] away in lost heat and the transmitter will be inefficient. How rapidly the resonant transfer of energy may best be effected, will vary with different cases and different gap adjustments. In general, the efficiency of the system will be higher as the resonant transfer is made more rapid, for losses in the primary or spark-gap circuit will thus be avoided. Neither the specification nor the claims of the Marconi tuning patent limit the user to any one set of conditions. They leave his choice of adjustment

free, so that, by a selection of the proper values for his own particular condition, he may attain the maximum effectiveness that is characteristic of the Marconi invention.

Summarizing, I disagree with Mr. Loftin's implications or statements that by his use of the term "persistent oscillator" Marconi went beyond the definition of the type of circuit which he preferred to use as his transmitter primary, or that by any statement he limited the use of his invention to systems in which the oscillations of the primary circuit are somehow caused to persist in that circuit for an indefinitely "long time". Any such requirement or limitation would have been an unreasonable thing for Marconi to have made. It would necessarily have worked against the purpose of his transmitter invention, which was to obtain powerful and effective radiation of sharply-tuned radio waves. There is nothing in the Marconi patent, and I know of nothing in the prior art, that would enforce such a limitation upon him.

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Q. 10. Will you please state what are the actions of spark-gaps or means for producing radio-frequency oscillations that to one skilled in the art of radio telegraphy or telephony would come within the mode of operation and principles of action involved in the use of the transmitting system of Marconi patent No. 763,772?

A. At page 1, lines 43 to 45, Marconi describes, as an element of his transmitting station, "a producer of Hertzian oscillations or electric waves shown in the form of a spark-producer", and at page 1, lines 83 and 84, he refers to the connection in the secondary circuit of his induction coil or power transformer to "the spherical terminals or other contacts of a spark-producer". At page 2, lines 25 to 38, he describes the operation of the transmitting station, from which it is clear that the action of any type of spark-gap in a radio transmitter is fundamentally simple and easily understood. In Fig. 1 of this tuning patent, the closed highly-resonant circuit is shown as comprising the spark-gap *c*, the coil *d* and the condenser *e*. What is desired is to produce in this circuit Hertzian oscillations (or electrical waves or oscillations), by the charge and discharge of condenser *e*.

The coil or power transformer shown at the right of the gap *c* in Fig. 1 provides successive waves or surges of high

[fol. 1446] potential, which may recur at intervals of say 1 1000th second. If the gap *c* is "open" or non-conducting, as it should be at the beginning of such a high potential surge delivered from the transformer, the electrical energy will be applied to the condenser *e* by way of the direct-connection from the top of the power transformer of Fig. 1 and through coil *d* from the bottom thereof. Thus the condenser *e* will be electrically charged to a high voltage, and will, for the time, store or act as a reservoir for, the energy to be converted into electrical oscillations.

If, now, the separation of the electrodes or contacts of the gap *c* has been adjusted, as it should have been, so that a spark-discharge will pass across the gap when the condenser attains a potential slightly below the maximum that can be delivered by the power transformer, it is clear that the gap will "break down" or become conductive just before the peak of the charging surge is reached.

The electrical charge stored in the condenser-reservoir will then spill out across the spark-gap, and, with proper values of resistance in the closed persistently-oscillating circuit *e*, *d*, *c*, will swing back and forth around through the coil and gap. The rate of electrical oscillation in this closed circuit is very high, and is determined principally by the size of the coil *d* and the condenser *e*, that is to say, by the tuning of the circuit. A customary rate of oscillation in such a transmitter for Marine use is 500,000 complete oscillations per second. This corresponds to a radio wave length of 600 meters, and requires that each half oscillation or swing of the electric charge from one side of the condenser to the other be completed in the extraordinarily short time of one one-millionth part of a second. The oscillations of the stored energy would persist for an indefinitely long time, except as their energy was abstracted from the persistently-oscillating circuit for radiation as electromagnetic signal-waves from the antenna or to produce wasteful heat in the circuits or their elements. In a practical transmitter the energy will be withdrawn from the closed oscillating circuit in say from five to twenty complete oscillations, being for the most part delivered to the antenna to produce radiated waves. If, at the common Marine frequency corresponding to the 600-meter wave, the oscillations persist in the closed circuit for ten complete periods, they will last for the full time of twenty one-millionths of one second, which is, of course, a brief interval

as compared to the time between successive charges of the condenser by the power transformer.

When the oscillating energy in the closed circuit reaches a low or zero value (as, for instance, when it has been delivered to the antenna circuit by resonant transfer through the oscillation transformer coupling d, d'), the gap should automatically "open" or regain its non-conducting condition. This requires that the spark-gap should be designed to have a sufficient mass of metal or otherwise to be cooled adequately with respect to the amount of power being used, so that the function of "opening" will take place quite rapidly, and well before the generation of the next successive high potential surge from the power transformer. Otherwise, that is, if the gap has remained in conductive condition, the power transformer will be at least partially short-circuited and will be therefore unable to charge the condenser on the next potential-surge,—thus power would [fol. 1447] be wasted. Thus, for efficient operation, any heating of the spark-gap that would tend to maintain its conductivity too long or to cause the formation of an arc-discharge, must be avoided.

Assuming that the spark-gap has functioned correctly, i. e., that it is sufficiently well cooled to prevent arcing, the condenser is once more charged up to the break-down potential of the gap and the cycle of oscillation generation is repeated again and again, once for each high-potential surge from the transformer.

Many types of spark-gap, called by many names, have been devised before and since the date of the Marconi tuning invention. When used in a coupled tuned circuit wireless telegraph transmitter, all of them work in the general way I have described, and all are alike in the principle of operation. First, in the art came the "plain" gap between spherical electrodes, then various forms of flat-surfaced electrodes, then gaps operating in series, then gaps equipped with air-blasts for cooling (or operated in compressed air or in gases), then rotary gaps of various design, and, most recently, various forms of the so-called high-quenching or quenched gap. The improvements attained in the evolution of spark-gap design have been toward greater uniformity of operation, quicker recovery of the "open" condition upon completion of the series of oscillations in the closed circuit, and the ability to operate with

greater amounts of power with consequent increase of effective transmission distance.

In the use of any of these types of spark-gap, it is extremely desirable, and indeed, it is essential for high efficiency, to get the stored energy from the condenser into the form of oscillations and across to the antenna circuit to be radiated with as little loss of time and energy as may be possible. The resonant transfer from the closed to the open circuit is of tremendous assistance in obtaining this result, and it is probably the most important single feature of the Marconi invention of patent 763,772. It is utilized in all practical spark radio systems with which I am familiar, including those of the Government described in the testimony here, and it is both necessary and highly useful whether the spark-gap be of the open, rotary or quenched type.

There are no fundamental differences in the action of these gaps, the improved reliability and power-handling capacity of the quenched gap being due to its mechanical design, which involves large flat sparking surfaces, good cooling and the subdivision of the sparking space. In general, greater cooling results in a more definite cutting off of the closed circuit oscillations when the train or group of oscillations in the primary circuit first dies down toward or to zero energy, and thus improves the efficiency of operation.

Q. 11. Referring further to Mr. Loftin's answer to Q. 21, particularly at P. R. page 1034, will you please state to what extent, and for what reasons radio engineers have recognized the desirability of rapidly cooling spark-gaps?

A. I have, in my last answer, generally explained the action of the spark gap in a wireless telegraph transmitter using coupled tuned circuits. I disagree with Mr. Loftin's statements or implications at P. R., page 1034, as to the necessity of producing heat for the satisfactory operation of an open spark-gap, or of any radio spark-gap. Cooling, either by the choice of the size and shape of the electrodes, [fol. 1148] or by supplemental means such as air-blowers, has always been essential to avoid the production of large ionization; such as Mr. Loftin refers to, and thereby to avoid the harmful arcing which I have described. The literature of the art is full of references to this fact. Even when one is using only small power at a transmitting station, the gap must remain reasonably cool, and blowers and fans are often used in small stations when the mass or

shape of the gap electrode is inadequate to conduct the heat away with sufficient rapidity. Many materials have been used for spark-gap electrodes, and, in my experience, the choice between them has been determined by the character and effect of the oxides produced in the continuous use of the gap, rather than for the purpose of increasing metallic ionization, as suggested by Mr. Loftin. Sluggish ionization which would tend to hold over the spark discharge is distinctly harmful.

Q. 12. Please state in what respects you may agree or disagree with Mr. Loftin's statements as to the production of beats being the object of the quenched-gap transmitter employing so-called "tight coupling", as testified by him in his answer to Q. 29, particularly at pages 1103-4 of the Printed Record.

A. The conclusions of Mr. Loftin to which you refer seem to me to be based upon a misconception of the facts underlying transmitter operation, and I do not agree with them. In any Marconi coupled-circuit transmitter, whether it be of the quenched-gap or the open-gap variety, the several oscillations that occur in the primary circuit for each spark discharge represent electrical energy that must be transferred to the antenna circuit in order to be radiated. To effect this transfer of energy efficiently the two circuits must be tuned to substantially the same frequency. The closer the coupling between the circuits, if they are tuned together, the more rapidly and effectively the energy will be transferred to the antenna system. In any properly designed and operated Marconi transmitter the spark-gap will "open" as soon as the energy of the closed circuit has first been delivered to the antenna circuit, and no reaction of the antenna circuit upon the closed circuit can or will occur.

So-called "beats" in a coupled transmitter are produced by continued reaction between the closed and open circuits, and appear only in improperly adjusted apparatus where these reactions are allowed to occur. As to this, the conditions are identical, whether the transmitter uses an open gap or a quenched gap, and "beats" do not occur in either case when the transmitter is correctly used as in practice. "Beats" are an undesirable and undesired incident to the incorrect use of any form of coupled spark transmitter.

It should be noted that these so-called "beats", if they are allowed to appear, are not true beats of the heterodyne

type, and are not described by any proper or strict technical use of the term "beats". They are simply increases and decreases of power in the circuits, as the total energy is allowed to shift back-and-forth between the closed primary circuit and the open aerial or secondary circuit.

The adjustment of the time periods or tuning of the open and closed circuits approximately (or exactly), into accord with each other is for the purpose of providing efficient [fol. 1449] transfer of energy of one to the other, in both the open gap and the quenched gap transmitters. Good practice requires that once the power has been transferred to the aerial circuit it shall remain there to be radiated, and shall not be permitted to react back into the primary circuit with the consequent loss of efficiency and possible production of "beats".

Q. 13. In your last answer you have referred to "beats of the heterodyne type". Will you please explain how such beats are produced, and in what connection they are used; also please give the technical meaning in the radio art of the word "heterodyne".

A. Beats, strictly speaking, that is to say heterodyne beats, are variations in the intensity of a resultant radio frequency current produced by the interaction upon each other of two radio frequency currents derived from different sources and usually having somewhat different frequencies. The addition of the two continuous trains of oscillations, one from each source, results in a single combined train, the amplitude of which varies periodically and continuously from one extreme, measured by the difference of the two components, to the other extreme, measured by their sum. This beating is analogous to that which occurs in music when two organ pipes of slightly different pitch are blown at the same time, the combined tone then having a flutter or beat in its sound.

The heterodyne is a radio-receiving system invented by Fessenden and named by him from the two Greek words meaning "other" and "force". Its connotation is the combination of two separately produced forces, and in the practical use of the heterodyne receiver there are combined radio-frequency oscillations produced from two separate generators. This is evidently quite different from the production of what Mr. Loftin has termed "beats" in a radio spark transmitter, where the waning-and-waxing effect is

simply due to the transfer and re-transfer of energy between the two coupled circuits, and where there is only one source of radio-frequency power.

Q. 14. Do you find anything in the Marconi patent No. 763,772, or in the prior art bearing on that patent, or in the actual practice of the invention of the claims in issue, which requires the coupled tuned circuits of that patent, either at the transmitter or at the receiver, to be mathematically or exactly tuned to secure the beneficial result of the coupled tuned circuits of the patent? Please give your reasons for your answer.

A. I do not. When an engineer uses the term "exactly tuned" or "perfect tuning" he necessarily means that the tuning is to be exact within practical limits. So far as I know, there is nothing made or used that can be adjusted and maintained in adjustment with absolute or precise mathematical exactness. These comments apply not only to the Marconi patent and system, but also to any other part of the electrical or physical arts and sciences.

Marconi does not specify an exact mathematical precision of tuning. Like all other skilled engineers, he would necessarily recognize the impossibility of attaining any such condition. The point is, to my mind, that Marconi's patent discloses, for the first time, coupled closed and open circuits at radio transmitter and radio receiver, these circuits being tuned together with sufficient practical exactness to give the useful result of a good and efficient resonant trans-[fol. 1450] fer of energy from one circuit to the other. Neither now, nor at the time of Marconi's invention, could precise mathematical exactness of tuning be had and maintained. The practical apparatus which Marconi describes in the patent has the necessary variable elements to permit the attainment of good or practically exact resonance and to obtain its benefits over a considerable range of tuning adjustments, frequencies or wave-lengths, and couplings.

Q. 15. Do you find anything in the Marconi patent in suit, or in the prior state of the art relating thereto, that would require each of the coupled circuits at the transmitter or receiver to have variable or adjustable means to bring about the tuned or resonant condition of the circuits?

A. No, I do not. Prior to the application for the Marconi tuning patent, workers in the radio art were, I believe, familiar with both "fixed" and "variable" inductance coils,

and with both fixed and adjustable or variable condensers. However, these elements had never been used for tuning together the open and closed circuits of a radio transmitter or a radio receiver. Having shown to the art the desirability of such tuning, I see no reason why Marconi should have insisted upon the exclusive use of either fixed or variable tuning elements in any or all of his circuits, and I find nothing in the patent to suggest that he intended to do so. Anyone practicing the Marconi invention was left free to use, as he might choose, either a variable or a properly selected non-adjustable condenser or coil in any circuit,—the effective or working value of the particular unit, of course, being chosen so as to give the desired resonance between the circuits.

Q. 16. In your opinion, is there anything in the prior art, or in the Marconi patent No. 763,772, which would require that the invention of the transmitting claims in issue of that patent should be limited to a system in which oscillations of but one and the desired frequency are created in the primary circuit of the transmitter and that such oscillations are transferred at this one and desired frequency into the secondary or radiating circuit, without change of frequency? Give your reasons for any opinion you may express.

A. No, there is no such limitation either in the Marconi tuning patent or required by the prior art. The agreement in tuning between the primary and secondary circuits of the Marconi transmitter is to enable the oscillating current energy to be transferred resonantly, and therefore with the greatest efficiency from the primary to the secondary circuit. This is quite aside from, and has nothing to do with, the development of subordinate or parasitic frequencies of oscillation during the time the energy is being transferred, which may occur in any transmitter using coupled tuned circuits with any type of spark-gap. If very loose coupling is used, so that reaction of the antenna circuit is small or negligible, the radiation will be of practically one frequency. If relatively close coupling is used under good quenching conditions, *i. e.*, with the gap operating properly, the same will be true. If close coupling is used under bad quenching conditions, so that reaction between primary and secondary can occur, there will be at least two, and possibly three, oscillation frequencies developed in substantial or observable amounts. Which of these three conditions may at any time

[fol. 1451] exist in any particular transmitter has nothing whatever to do with the necessity of tuning the closed and open circuits together. This tuning is used to obtain the advantage of rapid resonant transfer of energy as set forth in the Marconi patent, and the Marconi tuning advantages are had in any of the three cases that I have described.

Q. 17. In Mr. Loftin's answer to Q. 27, P. R., page 1085, he states that:

"The idea that the primary circuit at the transmitting station should store a very large amount of energy, so much so that it would be impossible to immediately deliver it to the antenna circuit on account of the structure of that circuit preventing it from having sufficient capacity to take all of the energy it was possible to store in the primary circuit."

is indicated by the statement in the Marconi patent No. 763,772 (p. 2, lines 6-9), that

"The illustrated arrangement of parts at a transmitting-station enables much more energy to be imparted to the radiator *f*".

State whether or not you agree with Mr. Loftin that such an idea is conveyed by the language of the Marconi specification, giving your reasons for any opinion you may express.

A. I do not agree with Mr. Loftin's conclusion referred to in your question. The statement quoted from the Marconi specification simply indicates one of the main advantages of the Marconi invention, *i. e.*, to enable the antenna circuit to radiate more energy (and, therefore, to send signals to greater distances), than had before been possible with antenna circuits that included a spark-gap.

As a matter of technical fact the sentence quoted from the patent is directly contrary to Mr. Loftin's contention, for it requires "more energy to be *imparted* to the radiator" or antenna. Marconi's emphasis is, as it should be, upon the imparting of energy for radiation. This is entirely inconsistent with any idea that energy is to be *stored* in the primary circuit for a long time.

The fact is, as I have already explained, that Marconi first stores the energy in the primary condenser (not in the highly resonant circuit as a whole), then produces oscillations by the automatic discharge of the spark-gap, and then

transfers these oscillations resonantly, and as rapidly as possible, to the antenna circuit from which their energy is to be radiated in the form of signal-waves. As the patent makes clear, Marconi's invention is for the efficient and powerful radiation of energy, and not for its wasteful retention in a closed non-radiating circuit. I find nothing in the patent, and I know of nothing in the practical art, which would support such a distorted contention as that here made by Mr. Loftin.

Q. 18. Mr. Loftin, in his answer to Q. 23 (P. R., p. 1056) states that he does not consider that the "Waterman Sketch No. 2" entitled "Oscillations of Primary Circuit" and "Oscillations of Secondary Circuit" found opposite page 151 of Mr. Waterman's deposition, properly illustrates the oscillations of current in the two circuits of a transmitter adjusted as described in the specification of Marconi patent No. 763,772. Mr. Loftin also, in his answer to Q. 24 (P. R., [fol. 1452] p. 1058), states that there is no foundation for the sketch either in the Marconi specification or in the way the Marconi apparatus will function under any form of adjustment or association of circuits. Mr. Loftin further states in his answer to Q. 25 (P. R., p. 1060) that Mr. Waterman's sketch shows a quick dumping of energy from the primary to the secondary circuit, without the aid of resonance. Will you please consider Mr. Waterman's and Mr. Loftin's testimony on this subject, and state with which of them you agree, giving your reasons for your agreement.

A. I have read Mr. Loftin's answers to questions 23, 24 and 25, at P. R., pages 1056-1060, and believe that his criticisms of Mr. Waterman's "Sketch No. 2" are not justified; they appear to be based upon Mr. Loftin's own conception that the oscillations in the primary circuit of a Marconi transmitter must last for a long time, that the coupling between the closed and open circuits must be very loose, and that the spark-gap must be used in such condition that little or no cutting-off action could occur. These three assumptions of Mr. Loftin's are, I believe, contrary to fact.

Marconi describes his primary or closed circuit as a persistently oscillating closed circuit, as I have already described, and nowhere implies or requires that oscillations should remain in it for a long time. It is true that they must persist sufficiently long to make the resonant transfer of energy to the secondary circuit an advantageous action,

but this is true of the four or five oscillations indicated by Mr. Waterman's sketch. This is, of course, a "quick dumping" of energy as compared to a transfer that might last over the time of an entire wave-train, but it is a resonant transfer and extends over a long period of time as contrasted to the single impulse or "impulsive rush" method of excitation attributed to Lodge and stated by Mr. Loftin to be characteristic of the quenched-gap transmitter.

As to coupling, a wide range is shown in the Marconi tuning patent. I understand that the apparatus specifically described by Marconi in the specification, when reconstructed and carefully measured, included coupling coefficients of values as high as about twenty per cent.

As to the spark-gap, it is general recognized and well understood that any adequate type of gap shows some quenching action when in proper adjustment, and that the better the cooling or quenching, in general the better the efficiency of the system in which the gap is used.

In addition to the general criticism based upon the assumptions discussed above, Mr. Loftin falls into a grave technical error when, at the bottom of P. R., p. 1057, he says that "The total area covered by the oscillations illustrated by Mr. Waterman in the secondary circuit represents the total energy in that circuit" and proceeds to criticize the conditions represented by the sketch as one "which could not even be obtained with one hundred per cent coupling between the circuits." The horizontal axis of Mr. Loftin s and Mr. Waterman's sketches represents elapsed time and the vertical axis represents current, as Mr. Waterman clearly points out at P. R., p. 151. The area included by the wavy lines of the sketches therefore represent current multiplied by time, which is a very different thing from the "total energy" upon which Mr. Loftin bases his attack. In [fol. 1453] order to make his statements, Mr. Loftin has apparently assumed that the two axes represent respectively voltage and current, which two components, when multiplied together, give energy per unit of time, or power. The representation used by Mr. Waterman in his "Sketch No. 2" is technically correct and follows the methods of conventional drafting customarily used by authorities in the Radio art.

Summarizing, Mr. Waterman's "Sketch No. 2" indicates graphically the type of circuit action which occurs in a

well-adjusted modern spark transmitter using the Marconi invention. Mr. Loftin's criticisms seem to me to be based upon limiting assumptions which he himself has made, which do not appear in the Marconi patent and which are not observed in the practice of the Marconi invention.

Q. 19. Mr. Loftin, in his answer to Q. 26 (P. R., pp. 1062, 1063), referring to Mr. Waterman's "Sketch No. 3" inserted opposite page 155 of the Printed Record, states that the condenser j^3 of the Marconi Fig. 2, results in a certain defect in the representation of that figure, and that Mr. Waterman has removed the condenser from the position occupied in Fig. 2 of the Marconi tuning patent in suit without any justification in said Marconi patent for its removal. What have you to say on this subject?

A. With respect to Mr. Loftin's criticism of Mr. Waterman's "Sketch No. 3", given by Mr. Loftin in answer to Q. 26, I would first say that Mr. Waterman's sketch is exactly what it purports to be and what is labeled, *viz.*, "Marconi's Simplified Receiving Circuits". Mr. Loftin says at P. R., p. 1062, that Mr. Waterman has shown the condenser j^3 "in parallel with the variable condenser h'", but this is not the fact, as may be easily seen by looking at the drawing. He criticises Mr. Waterman for removing the condenser j^3 from the tuned circuit, in spite of the fact that Mr. Waterman accurately states that Marconi's showing of j^3 in the divided winding of coil j^2 "has no essential relation the mode of operation but is merely a refinement". Mr. Loftin should know that j^3 is simply a stopping or blocking condenser of relatively large size and that it has no substantial effect in tuning the closed circuit of the Marconi receiver, whether placed in the center of the divided coil, as in Fig. 2 of the patent, or whether shown as in Mr. Waterman's Simplified "Sketch No. 3". To my mind, Mr. Waterman is amply justified by the Marconi patent in the presentation of his "Sketch No. 3", for the elements there shown perform the useful functions assigned to them by the Marconi tuning patent. The rearrangement of the simplified sketch, which Mr. Waterman carefully explained, simply serves to make these functions all the more clear.

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[fol. 1454] Q. 20. Please consider the Tesla patents No. 645,576, dated March 20, 1900 ("Defendant's Exhibit

X-2"), No. 649,621, dated May 15, 1900 ("Defendant's Exhibit L-6"), the Tesla British Patent No. 20,981, of 1896 (Defendant's Exhibit Y-2") and the Martin-Tesla Book ("Defendant's Exhibit B-4"), in connection with Mr. Loftin's testimony relating thereto and state what bearing such patents and publication have upon the inventions of the Marconi tuning patent No. 763,772, and particularly as to the combination of elements and their mode of operation as included in the claims thereof which are in issue herein. Please give your reasons for your opinions.

A. I have studied the Tesla patents cited, the Martin Book and a number of other publications dealing with Tesla's work. Some of Tesla's publications, his patents 645,576, 649,621 (and a number of others), and the Martin Book, were set up by Defendant and considered as anticipations of Fessenden's continuous-wave radio patent, reissue No. 12,168 in the suit of Kintner *et al. v.* Atlantic Communications Company, before Judge Mayer in the U. S. District Court for the Southern District of New York, which was reported at 249 Fed. 73. In that suit, where I testified on behalf of plaintiff, I made a thorough survey of Tesla's work in high-frequency electricity. Telsa was not working in the radio telegraph art, and his devices have no more than a certain remote resemblance to some elements of radio apparatus.

Mr. Loftin attempts to excuse Tesla's definite statements as to his invention and its uses, by terming them "ambitious", and to avoid the fact that Telsa was working on a plan of high voltage electric *conduction* (not wave radiation), by considering references to that fact as "theory" on Tesla's part. Such excuses cannot avoid Tesla's own statement of his invention, as at page 2, lines 114-121 of his patent No. 645,576, as follows:

"Expressed briefly, my present invention, based upon these discoveries, consists then in producing at one point an electrical pressure of such character and magnitude as to cause thereby a *current* to traverse elevated strata of the air between the point of generation and a distant point at which the energy is to be received and utilized."

Tesla proposed to set up enormous voltages (millions of volts), far in excess of those used in radio signaling, which would *force* electric *current* (not radio waves), through the

rarefied air high above the earth. This current he proposed to use to operate lamps, electric motors, etc. As Mr. Loftin points out, he makes an incidental suggestion of the transmission of intelligible messages (at page 5, line 31), but this is not wireless telegraphy as Marconi knew it and as we have known it since Marconi's first work. That is to say, it is not Hertzian or *radio* telegraphy operating by means of radiated electro-magnetic waves. It is simply a suggestion of a peculiar type of current-conduction telegra- [fol. 1455] phy in which the air's conductivity to high voltage electric discharges was to be utilized just as the wire's conductivity for low voltage electricity is used in ordinary Morse wire telegraphy.

Mr. Loftin also says in effect that the explanation of Tesla's transformer coil design (as given in his patent), shows Tesla to have had the Marconi tuning invention. Such a contention seems to me to do violence to the facts set forth by Tesla, who disregards entirely the destructive effect that his proposed elevated conductors would necessarily have had upon the "synchronizing" of his transformer coils when they were connected thereto. Tesla's explicit directions are to adjust the transformer secondary coil to produce a maximum voltage at its central terminal, and then to apply that exceedingly high veltage to the elevated conductor through the wire B (of his patent 645,576). By following these instructions one would obtain splendid results for the lighting of vacuum lamps, the production of spark displays and the other types of demonstration characteristic of Tesla's work, as described by Martin and others, but the apparatus would be utterly useless for the generation of radio waves from the elevated conductor. To make the Marconi invention Tesla would have had to tune his entire secondary circuit *with the elevated conductor attached* (not merely the secondary coil alone), and this he does not describe and evidently did not do. Moreover, there is no reason why he should have done so, for, if he had, upon removing the elevated conductor he would have found his famous "Tesla coil" an inert thing, incapable of producing the forty-foot sparks and the other striking demonstrations upon which he placed so much emphasis.

The second patent, No. 649,621, is a division of that already considered and adds nothing to its disclosure. However, this second patent makes even more clear the

distinctions between Tesla's projected plan and the Marconi tuning invention, for Tesla says at page 2, lines 73-82, the following:

"It is to be noted that the phenomenon here involved in the transmission of electrical energy is one of true conduction and is not to be confounded with the phenomena of electrical radiation which have heretofore been observed and which from the very nature and mode of propagation would render practically impossible the transmission of any appreciable amount of energy to such distance as are of practical importance."

The British patent No. 20,981 shows a subordinate device and might be used in connection with the high voltage conduction apparatus of the U. S. patents. The Martin Book, to which Mr Loftin refers at P. R., pp. 956-958 and 1155, is on matters entirely apart from radio signaling, is purely speculative as to power transmission and is considerably less definite than even the patents here referred to. None of these patents, nor any publication concerning Tesla's work that I have found (including the Martin Book), shows any realization of radio telegraphy, of the problem in radio that Marconi solved by his tuning invention, nor of Marconi's solution of that problem.

More specifically, none of Tesla's disclosure show or describe Marconi's apparatus or its operation, nor could any-[fol. 1456] thing shown or described in Telsa's disclosures be used to produce Marconi's results, without substantial changes or additions. In fact, the Tesla disclosures do not describe a radio system or any system having an open or radiating circuit coupled to a closed circuit, including a spark-gap or detector, the two circuits being tuned together, or in resonance when in operation. Finally, so far as I am aware, none of these disclosures of Tesla was ever put into practical use.

The "Loftin Sketch A", purporting to represent a Tesla transmitter, which appears opposite page 957 of the Printed Record, shows an organization which cannot be found in any of the Tesla publications. Part of the sketch seems to be based upon part of Fig. 165 of the Martin Book, which illustrates several circuits for converting electric currents. Another part of the drawing is stated by Mr. Loftin to be based upon Fig. 185 of the Martin Book, which figure has nothing whatever to do with radio telegraphic transmission

or reception. The primary and secondary coils P and S_1 of Mr. Loftin's sketch may have been taken by him from one of the Tesla patents, though they are not there shown in association with the other apparatus of "Loftin Sketch A". This sketch is evidently a composite drawing made up of various elements shewn by Tesla and Martin at various different parts of their publications and, so far as is shown, never combined by Tesla in the way indicated.

Q. 21. What, if any, bearing has the receiving apparatus described in the Lodge patent in suit No. 609,154, and illustrated in Figs 12 and 13 thereof, upon the inventions of the receiving claims Nos. 2, 13, 14, 16, 17, 18 and 19 of the Marconi tuning patent No. 763,772, and also of the combined transmitter and receiver claims Nos. 10 and 20 of that patent?

A. It seems to me to have no bearing upon the tuning invention.

Mr. Loftin says, at P. R., page 1109, that Lodge shows a secondary circuit that "is impliedly tuned" to resonance with the antenna circuit. He says at P. R. page 1111, that two of Marconi's receiving station claims, Nos. 2 and 13, "do not in any way refer to the matter of resonance between the two circuits" and hence are met by Lodge's Figs. 12 and 13. He also says, at P. R. page 1120, that Fig. 13 of the Lodge patent shows:

"an open absorbing circuit associated with a closed secondary circuit with means provided for adjusting the two circuits to be in tune with the incoming frequency of the radio signals."

I do not understand upon what basis Mr. Loftin thinks that the secondary circuit *e, f, g, u* of Lodge's Fig. 13, or the approximately corresponding circuit of Fig. 12, is "impliedly" tuned, for I find nothing in the Lodge patent to suggest such tuning and the coherer circuits shown are of a nature not susceptible of tuning. Neither figure of the Lodge patent, nor the descriptions thereof, meets Marconi's invention, nor do they meet, even in terms, the Marconi claims that specify the tuning of two circuits at the receiver (*i. e.*, claims 14, 16 and 17), or the tuning of four circuits at transmitter and receiver (*i. e.*, claims 10 and 20). Neither figure nor description meets the spirit of the other claims, as taken in the light of Marconi's specified

tuning relation, nor do they even meet the terms of those [fol. 1457] claims. Marconi's claims 2, 13 and 19 recite a condenser in circuit with the wave-responsive device or detector, and his claims 18 and 19 require a variable inductance coil in the detector circuit. Lodge shows neither of these tuning elements, and the suggestion of a condenser as alternative to the resistor shown at W in Lodge's Fig. 12 has nothing whatever to do with tuning. In the Lodge receiver there is no pair of coupled tuned circuits, as described and claimed by Marconi, nor is there any resonant transfer of energy from one to the other of such circuits.

Q. 22. Please consider the Marconi patents Nos. 627,650, 647,007, 647,008, 647,009 and 668,315 in connection with the testimony of Mr. Loftin bearing thereon, the first of which was referred to by Mr. Loftin at pages 1071, 1160, and 1167 of the Printed Record, and the latter four patents at pages 1021, etc., of the Printed Record and state what, if anything, you find in them bearing upon the claims in issue of the Marconi patent No. 763,772 in suit.

A. I have studied the five patents to which you refer, and find nothing in any of them that bears upon the tuning of two coupled circuits, as disclosed and claimed in the Marconi tuning patent 763,772.

Of the patents which you enumerate, the four latest to issue, show various forms of transformer coils for radio receivers, and teach nothing of tuning the closed circuit of a receiver. The first patent to issue, No. 627,650, shows an inductively-coupled receiver in which the coils are chosen of a fixed value, which has no tuning condenser, and which has no closed tuned circuit. I note that at P. R., page 1072, Mr. Loftin suggests that the stopping condenser k' is to be varied for the tuning of the detector circuit, but to make this statement, he must have overlooked its position in the circuit. The condenser k' is simply a blocking or stopping condenser shown in the first circuit of this patent to prevent the coil j^2 from short-circuiting the battery current around the coherer. Like any stopping condenser, it may be changed in size, to some slight advantage, as the wave-length used is changed; but it is in no sense a tuning element and it is neither suggested nor described as such in the patent. Because of the small capacity and the high resistance of the coherer T, a condenser so connected will not tune the circuit of coil j^2. Consequently this patent,

Mr. Loftin to the contrary notwithstanding, shows nothing of the tuning invention of Marconi's patent 763,772.

Q. 23. Please consider: (1) the apparatus and its mode of operation as described and illustrated in the Stone-Baker letters and the depositions of Joseph B. Baker, John Stone Stone and Walter C. Dean, stipulated in this case, and also Mr. Loftin's testimony relating to such apparatus (P. R., pp. 1076-1082, and 1086); (2) the apparatus and its mode of operation disclosed in the Stone application as originally filed and on which patent No. 714,756, issued on December 2, 1902, and Mr. Loftin's testimony relating to such patent (P. R., pp. 1082-1087); and state whether or not, in your opinion, any of such apparatus and its mode of operation discloses the devices or combination of elements and mode of operation of any of the inventions of the Marconi tuning patent No. 763,772, as recited in the claims thereof which are in issue herein; give the reasons for any opinion you may express.

A. I have carefully read the Stone-Baker letters bearing [fol. 1458] dates of "June 30, 1899" and "July 15, 1899", as well as the depositions referred to in your question. Certain apparatus is illustrated by a wiring diagram on the third page of the earlier Stone-Baker letter, "Defendant's Exhibit F 3". However, no wiring diagram can show whether or not the various circuits illustrated are tuned to the same or to different frequencies; and for information on that important matter we must turn to the next descriptive of the figures.

In the Stone-Baker letters Mr. Stone points out:

(1) That he wishes to produce oscillations "of a frequency corresponding to the fundamental of the *wire*" (June 30, page 2);

(2) That certain of the circuits illustrated are to be tuned "one to another and all to the same frequency" (June 30, page 4);

(3) That simple oscillation of a vertical wire does not produce a pure wave (July 15, page 3);

(4) That in his arrangement "the vibratory current developed in the vertical wire is not due to the oscillatory discharge of the wire" (July 15, page 4);

(5) That the current is a *forced* oscillation depending as to frequency only upon the impressing force and "not

upon the electro-magnetic constants of the circuit in which they are developed" (July 15, page 5);

(6) That the period of the impressed forces may "be the same as that of the fundamental or the *vertical wire*" (July 15, page 5);

(7) That, at the receiver, "the circuit *in which the coherer is located* is practically opaque to" currents produced by off-frequency waves (July 15, page 6); and

(8) That there is no difference in principle between the two species of circuits shown in the June 30th letter (July 15, page 8).

All of these items support the view that Stone did not want and, in fact, would not tolerate an antenna system which was tuned to the frequency of the associated closed circuit, since he conceived that the free oscillations thus produced would not be "simple harmonic" or pure as to frequency. He did propose to improve selectivity by inter-station tuning of closed circuits. He even gave the option of making the closed circuit frequency the same as the fundamental of the aerial *wire* used, but he nowhere suggested that it could be the same as the natural or tuned frequency of the aerial system or circuit, *including both vertical wire and transformer coil*. The suggested "tuning of these circuits one to another" might, in the absence of Stone's more detailed and extensive instructions to the contrary, be thought to indicate a tuning of the antenna system. With his full disclosure before one, however, and considering his repeated injunction to use forced oscillations only, to make the wave-frequency independent of the antenna constants, etc., it is perfectly clear that the only circuits Stone proposed to tune "one to another" were the closed circuits illustrated. His letters to Baker thus lacked any disclosure of the important tuning together of closed and open circuits at transmitter or receiver, or both, which tuning is the essence of the Marconi invention and is stated or implicit in all the Marconi claims.

[fol. 1459] In the above quotations, as elsewhere in my deposition, the italics have been inserted by me.

I have also studied carefully the Stone patent 714,756, to which you refer, and its file history. As originally filed, the specification follows closely along the lines of the Stone-Baker letters, and appears to have been drawn from a similar disclosure. The original application at page 4,

lines 18 to 22, points out that the antenna is to be made a source of waves "of any desired frequency independent of its length and other geometrical constants". At page 10, lines 19 to 26, Stone emphasizes his intention of using *forced* oscillations in the antenna "in lieu of producing natural vibrations". At page 13, he points out the tuning together of the *closed* circuits at transmitter and receiver. At page 15, lines 23 to 25, he states that the forced oscillations in the transmitting antenna are "practically independent, as regards their frequency, of the constants of the second circuit in which they are induced". From the beginning to the end of the original specification there is no suggestion of tuning together closed and open circuits at either transmitter or receiver, and the Stone invention is clearly shown as ignoring any antenna resonance. In some of the transmitters which he illustrates, there are several closed circuits tuned to the same frequency, but no tuned open circuit. Similarly, in some of his receivers, there are several closed circuits which may be tuned together, but no tuned open or absorbing circuit. Stone's theory was evidently that forced oscillations, not utilizing any antenna tuning, were essential for selectivity; and he at his filing date, apparently did not appreciate the tremendous increase in efficiency obtainable by the Marconi invention of using in combination, either at transmitter or receiver, or both, closed and open circuits tuned alike.

However, in the amendment dated April 8, 1902 (Paper No. 7), Stone inserted into the specification a statement that:

"The vertical wire may with advantage be so constructed as to be highly resonant to a particular frequency and the harmonic vibrations impressed thereon may with advantage be of that frequency."

This insertion appears in the issued patent at page 6, lines 62-66, and may be taken as a recognition in 1902 that Marconi's tuning of the aerial circuit was a desirable thing. On page 6 of the long amendment dated June 7, 1902 (Paper No. 12), Stone's attorney refers to "the important cases when the elevated conductor of a wireless telegraph system has a fundamental which is of the same frequency as the forced vibration impressed upon it", when he says, "the natural vibrations excited will not interfere with the wave

form". This is true when "aerial conductor" and "vertical wire" are taken to mean the entire radiating circuit, or antenna plus coils and ground connection, but it is not true when the vertical wire alone is meant. The modification of the specification shows Stone's adoption in 1902 (even though simply as "important" cases), of Marconi's tuning of the antenna circuit to the closed circuit. The application as filed on February 8, 1900, and as prosecuted up to April, 1902, shows no such conception of the Marconi invention.

* * * * * * *

[fol. 1460] Q. 24. Please consider the Stone patent No. 638,152, granted November 28, 1899, and Mr. Loftin's testimony relating thereto (P. R., pp. 1065-1067) and state what, if any, bearing that patent has upon any of the inventions disclosed in the Marconi tuning patent No. 763,772, particularly as recited in any of the claims thereof at issue herein, giving your reasons for such opinion as you may express.

A. This Stone patent 638,152 is suggested by Mr. Loftin at P. R., page 1065, as stating the fundamentals for both radio communication and what is now known as "wired radio". The contrary is the fact, for the Stone patent omits the important and essential element, *viz.*, the wave or oscillation detector. This is a patent on a wire telephone system of doubtful operability, and contains no antenna at either transmitter or receiver, no second tuned circuit at either transmitter or receiver, involves no radio or radiated waves, and has no wave-responsive device. It contains no suggestion of the Marconi invention and meets neither the terms nor the spirit of any of the Marconi claims.

Mr. Loftin seems to treat this patent in much greater detail than its disclosures would warrant, and makes a number of interpretations of its wording with which I cannot agree. For instance, with reference to the clause "closed secondary reactions generally should be avoided or minimized", Mr. Loftin finds Stone directing the user to use "loose coupling". This clause has nothing to do with loose coupling or any other working coupling, but is an instruction to avoid what is generally known in the art as the effects of "short-circuited secondaries", *viz.*, a reaction

which tends to increase losses and reduce the effective inductance of any coil in which it is allowed to appear.

Q. 25. Defendant has introduced in evidence (P. R., p. 961), the Stone patents No. 577,214, granted February 16, 1897; No. 714,831, granted December 2, 1902 (Filed January 23, 1901, as a division of patent No. 714,756), and the File Contents thereof; No. 726,368, Filed April 4, 1894, granted April 28, 1903, and the File Contents thereof; No. 726,476, granted April 28, 1903 (Filed March 12, 1903, as a Division of Patent No. 726,368). Will you please briefly consider these patents in connection with the said File Contents thereof, and state what, if any, bearing the disclosures thereof prior to April 26, 1900 (the date of Marconi's inventions of patent No. 763,772), have upon that patent, and particularly the inventions of the claims in issue in patey' No. 763,772. Please state your reasons for such opinion as you may express.

A. Of the four patents which you enumerate in your question, only two were filed prior to April 26, 1900. Of these two the first one to issue is No. 577,214, which was filed on September 10, 1896. It is simply for a special type of single resonant circuit in a wire net-work, and has no suggestion of even a wireless use,—much less any disclosure of the Marconi tuning invention. Therefore, I do not see that its disclosures have any bearing upon the Marconi [fol. 1461] patent No. 763,772 or its claims. The other of the two Stone patents is No. 726,368, which was filed on April 4, 1894. This shows a wire telegraph system using low frequencies. The only specific frequencies stated are 250, 500 and 1,000 cycles per second, which are far below the radio frequencies used in the wireless art from the time of Marconi to the present. This patent of Stone neither shows nor suggests antennae, wave detectors, nor plural tuned circuits, and discloses nothing anticipatory of the Marconi invention. This patent did not issue until April 28, 1903, but even in the years after Marconi's invention I find nothing in the File history to suggest that this invention of Stone's had anything in common with Marconi's. For these reasons I see no bearing of either of these Stone patents upon the Marconi invention or the claims of Marconi patent No. 763,772.

Of the other patents cited by you, No. 726,476 was filed on March 12, 1903, as a division of the wire telegraph patent 726,368, just discussed. It issued with the parent case

on April 28, 1903, and its specification is substantially the same, if not identical. The same comments apply to this patent, and I cannot see that it has anything to do with the Marconi tuning invention.

The remaining Stone patent is No. 714,831, which was filed on January 23, 1901 as a division of patent 714,756, which I have already discussed in my answer to Q. 23. The specification as filed in 1901 showed no recognition of tuning the antenna or radiating circuit to the same frequency as the closed circuit, but on April 14, 1902, the case was amended to include this feature,—just as the parent case was amended on April 8, 1902, in the way I have previously explained.

Q. 26. Please consider the Hutin & Leblanc patent No. 838,545 and the Pupin patents Nos. 519,347, granted May 28, 1894, and No. 640,516, granted January 2, 1900, also Mr. Loftin's testimony relating thereto, and state what, if any, bearing they have on the inventions of the Marconi tuning patent No. 763,772 and recited in any of the claims of said patent in issue in this suit, giving your reasons for such opinion as you may express.

A. The Hutin & Leblanc 838,545 is for "multiple telegraphy and telephony" over wire lines. It has no reference to radio or to any other form of wireless signaling. For its wire transmission purposes it proposes the use of a group of circuits associated with the wire line and each tuned to a *different* frequency. The highest current-frequencies suggested are far below those used in radio at Marconi's time, and those proposed for telegraphy are within the audible range never used for radio. The disclosure has no antenna, no spark-gap, no coupled open and closed circuits, no detector,—in fact, it is utterly remote from radio and from the Marconi tuning invention. It represents a pioneer and probably important invention in line wire communication, but evidently taught nothing to the radio art. The principle of single-circuit resonance had already been brought into radio by Lodge, before Marconi's four-circuit tuning invention.

The Pupin patents Nos. 519,347 and 640,516 show respectively a transformer and a wire line signaling system. Such extremely low audible current-frequencies as 150 and 250 cycles per second are suggested in the system patent (as at page 2, lines 70-74), and similar low frequencies are evidently contemplated for use with the transformer, al-

[fol. 1462] though no numerical values of frequency appear to be given in patent 519,347. Like the Hutin & Leblanc invention, these appear to be remote from radio, and include neither antennae, spark-gaps, coupled open and closed circuits, nor detectors. The ideas of resonance set forth by Hutin & Leblanc and Pupin were well known fundamentals of electrical engineering training by the time of the Marconi invention, and had been applied to inter-station tuning by Lodge. Their existence or statement in these patents, or in the text-books, seems to me to take nothing from the beauty, originality, or utility of the Marconi four-circuit tuning invention.

Q. 27. Please consider the Braun British Patents No. 1,862 of 1899 and No. 12,420, of 1899, also Mr. Loftin's testimony relating thereto, and state what bearing, if any, such patents have on any of the inventions of the Marconi tuning patent No. 763,772, as recited in any of the claims of said patent in issue in this suit.

A. I have read the two British patents to Braun, and Mr. Loftin's comment upon them at P. R., p. 1076, and I believe that these patents have no bearing upon the Marconi tuning invention. I note that Mr. Loftin makes no contention that primary and secondary circuits of the transmitter of 1862/1899 and primary and secondary circuits of the receiver of 12,420/1899 are tuned together or in pairs. This is in line with the disclosures of the patents themselves, for they contain no word or hint of tuning together the circuits at either the transmitter or the receiver. Thus that fundamental and extremely important feature of the Marconi tuning invention is missing from the Braun British patents. In addition, the disclosures of both patents are quite vague and indefinite. They give no impression that Braun had, or intended to have, any circuit tuning such as Marconi's.

Q. 28. Please consider "Defendant's Exhibits M-6 and N-6" which are the Braun U. S. Patents Nos. 797,169 and 797,544, applied for April 6, 1899 and May 18, 1903, respectively, both of which were granted October 15, 1905, together with the File Wrappers and Contents thereof, copies of which File Contents are herewith submitted to you, and state what the two applications for the Braun United States patents disclosed prior to the date of the Marconi invention (April 26, 1900), and also what relation such disclosures have to the disclosures of the Braun British pat-

ents you have just discussed in your answer to the previous question, pointing out what significant statements you find in the United States patents which were not included in the British patents, noting the date or dates when such statements were inserted in the applications for the United States patents to Braun.

A. The two U. S. patents to Braun, together show the figures of British 1862 1899. Those of the first U. S. Patent 797,169 correspond to Figs. 1 and 3 of the British patent, in which an "air-wire" or "transmitting wire" is directly connected to a Leyden jar. The drawings of the second or Divisional U. S. patent 797,544, correspond to Figs. 2 and 4 of the British patent, in which an elevated wire is connected inductively, or both inductively and directly, to the spark-gap. The specification of 797,169 is generally similar to that of the British patent, although it is considerably revised and contains a good deal of added material. The specification of U. S. patent 797,544 com-[fol. 1463] prises almost entirely the additional text which is not found in the British patent.

The original U. S. application, as it was filed on February 6, 1899, has its specification practically identical with that of the British patent. It shows no appreciation of the function of the antenna or radiating circuit, it does not show or mention a ground connection, and it has only an incidental showing of a transmitter having two circuits,—even as to this, the specification contains no suggestion of tuning. The entire original specification was cancelled and a new specification substituted by Paper No. 9 on July 22, 1902. Even this new specification contains no disclosure of the Marconi tuning invention. In the argument accompanying the new specification, Braun's attorneys pointed out that the waves from his transmitting wire were "not of its own frequency but of the frequency of the oscillation circuit", and thus different from Lodge. A further substitute specification was filed as Paper No. 11 on June 1, 1903, and here for the first time appears any suggestion that the invention comprised a closed reservoir circuit in combination with an open radiating circuit. I cannot find any statement that these two circuits should be tuned together, either in this final substitute specification or in the patent as issued.

The Divisional U. S. application, which resulted in patent 797,544, was filed on May 19, 1903, just before the third specification was filed in the parent case. It suggests that "by dimensioning properly the Leyden jars, the transformers, the coils, etc., the most favorable results will be obtained", and that the secondary coil "may be earthed", neither of which thoughts appeared in the original specification. On June 3, 1903, a substitute specification was filed in the divisional case, containing the same suggestion. The Examiner required cancellation of the provision that the transmitting wire or secondary might be "earthed", but evidently did not object to the "dimensioning properly" statement. This latter, which made its appearance in 1903, is the only hint of tuning that I have been able to find in either case. There is nothing in the least anticipatory of the Marconi tuning invention.

Q. 29. Are you familiar with the construction and mode of operation of the wireless or radio apparatus, including the quenched gap transmitters, used by the defendant herein, such as the wireless apparatus manufactured by the Navy, Wireless Specialty Apparatus Company, Telefunken Company, National Electric Supply Company, Wireless Improvement Company, Foote-Pierson Company, Simon, Loewenstein and Kilbourne & Clarke Company, as the same are described and illustrated by the proofs herein? If so, please state, as a question of fact, whether in the operation of such quenched gap transmitters there is any action which can properly be termed an "impulsive rush" or "single chunk" excitation which obviates the necessity of tuning the primary and secondary circuits of such quenched gap transmitters to syntony or resonance.

A. I am generally familiar with the apparatus to which you refer and believe that I have used or seen transmitters manufactured by most, if not all, of the organizations listed in your question.

The action of these quenched gap transmitters, not only in my own experience with them, but also as I under- [fol. 1464] stand the work of others, depends upon the resonant transfer of a series of oscillations, in the spark-gap circuit, to a tuned antenna circuit. The gradual transfer of energy in such a system extends over the time of from say five to ten or more complete oscillations, and is in no sense a "single chunk" or "impulsive rush"

transfer. Its character is such that efficient operation can be had only by careful tuning of the closed and open circuits, as set forth in the Marconi tuning patent.

Q. 30. In Mr. Loftin's answer to Q. 29 of his deposition, he discusses the United States patent to Seibt, No. 1,216,615, and on page 1192 of the Printed Record he makes the following statement:

"The foregoing clearly brings out that the quenched gap system is based upon the fundamental principles laid down by Lodge which I have previously quoted, namely, quickly dumping amount of energy into the radiating circuit, and as soon as this accomplished to electrically remove the dumping source from a maintained connection with the radiating circuit in order that the radiating circuit may be free to form this energy into a long drawn out train of very powerful one frequency oscillations."

State whether or not you agree with Mr. Loftin in making the above statement, giving your reasons for your answer.

A. I have read Mr. Loftin's answer to Q. 29, which is summarized in the portion of his testimony quoted by you, and disagree completely with several of his conclusions.

The system of the Seibt patent 1,216,615, which Mr. Loftin says is descriptive of the Wireless Specialty Apparatus type of quenched gap transmitter, depends fundamentally upon resonance between the primary or closed persistently oscillating circuit and the open or radiating circuit, as is characteristic of the Marconi patent 763,772. In Seibt's patent, at page 1, lines 64 to 66, he points out the basic requirement or assumption that the natural periods of these two circuits are to be the same and at page 2, lines 24 to 31, he states that if they are not in resonance with each other, only a part of the energy is transferred. Thus the delivery of power from the closed circuit to the open circuit depends entirely upon the resonance or tuning of Marconi, and takes place over a series of oscillations, as is further shown by Seibt's Figs. 2 and 4, which illustrate five complete oscillations before the so-called "quenching" is to take place. When Mr. Loftin says (at P. R., pp. 1096, 1097) that this system is "fundamentally" "based on the system disclosed by Lodge in his patent 609,154 of 1898, particularly the transmitter illustrated in Figure 4", if

he means to imply the presence of any "impulsive rush" action that might obviate the need of tuning primary and secondary to the same frequency in order to obtain efficient transfer of energy. Mr. Loftin is wrong. The Marconi invention and the disclosure of the tuning patent are not limited to any particular time of transferring energy from the closed circuit to the antenna circuit. Whether the energy is transferred "quickly" or "slowly", if resonance between the circuits is utilized to aid the passage of oscillating energy through the coupling system, then the Marconi invention is used.

Mr. Loftin's testimony seems to be based upon certain assumptions that are contrary to fact. Among these is his [fol. 1465] view that in the Wireless Specialty quenched gap transmitter there is some mysterious time relation between the circuits which, as he says at P. R., p. 1098, "is for a purpose having nothing whatever to do with a resonant transfer of energy". Further, he seems to think that the antenna alone determines the wave period. Mr. Loftin also builds up an elaborate theory of the co-existence in the circuits of a number of currents having multiple frequencies, which is not supported by any facts that have come within my experience or to my knowledge. He has attempted to put the operation of a quenched gap in the Marconi transmitter circuit into a class which he says is different from that of the Marconi patent, and which he contends is exemplified by an impracticable suggestion of Lodge, be[illegible] purely artificial differentiation. The facts are that the Lodge Figure 4 transmitter has been found to be of little, if any, value, that the Marconi transmitter is widely recognized to be of the greatest practical importance, that the quenched gap system does not operate by any "impulsive rush" or "sudden dumping" or "single chunk" of energy from closed circuit to antenna, and that the quenched gap system utilizes Marconi's circuit and his resonant transfer of energy from the closed to the open circuit. Consequently, I disagree flatly with Mr. Loftin's conclusion quoted by you.

Mr. Vaill: Counsel for claimant offers in evidence certified copies of the File Wrappers and Contents of the two United States patents to Ferdinand Braun, Nos. 797,169 and 797,544, and requests that the same be marked respectively "Claimant's Exhibit No. 311, File and Contents of Braun U. S. Patent No. 797,169" and "Claimant's

Exhibit No. 312, File and Contents of Braun U. S. Patent No. 797,544".

(The Notary marks said exhibits as requested.)

* * * * * * *

Q. 31. In answer to Q. 12 of his deposition, Major Mauborgne testified (P. R., p. 1220), during his consideration of the quenched spark transmitter, that the last adjustment of the circuit thereof:

"may cause the primary and the secondary to be slightly out of tune with each other, as can be demonstrated by a measurement of the primary if the antenna and ground be disconnected."

Please state in what respects you may agree or disagree with this statement, giving your reasons therefor.

A. Major Mauborgne describes correctly one method of adjusting any spark transmitter for the maximum effectiveness of radiation, but appears to be in error in his final [fol. 1466] statement that the "last adjustment may cause the primary and the secondary to be slightly out of tune with each other." In my experience this adjustment is most likely, if not certain, to bring the two circuits practically exactly in tune with each other so as to give the best resonant transfer of energy from the closed primary circuit to the open antenna circuit.

The demonstration that Major Mauborgne suggests, *viz.*, measurement *after* the antenna and ground have been disconnected, is obviously incorrect, for any such disconnection will necessarily remove from the system the substantial tuning elements contributed by the effective inductance and capacity of the antenna and ground. The mere act of disconnecting the antenna is bound to change the tuning relations in the system. No measurement made after such disconnection could possibly show the relative tuning conditions that had existed in normal operation, when the antenna and ground are always connected.

Q. 32. Please consider and compare the evidence relating to the transmitters used by the defendant herein as represented by the following exhibits:

Telefunken Type, "Plaintiff's Exhibit No. 79" (opposite P. R., p. 180);

National Electric Supply Co., Field Radio Pack Set, "Plaintiff's Exhibit No. 80" (opposite P. R., p. 192);

Wireless Specialty Apparatus Type, "Plaintiff's Exhibit No. 87 (P. R., p. 164);

Wireless Improvement Co. Type, "Plaintiff's Exhibit No. 88" (opposite P. R., p. 188);

Simon Type, "Plaintiff's Exhibit No. 89" (opposite P. R., p. 189);

Type manufactured by Navy, "Plaintiff's Exhibit No. 93" (opposite P. R., p. 187);

Kilbourne & Clark Type, "Plaintiff's Exhibit No. 95" (opposite P. R., p. 183);

which Mr. Weagant testified to be the apparatus installed on the S. S. Achilles;

Lowenstein Transmitter, "Plaintiff's Exhibit No. 101" (opposite P. R., p. 190);

Foote-Piersen Pack Set, "Plaintiff's Exhibit No. 102" (opposite P. R., p. 196);

and state whether, in view of Mr. Loftin's answers to Qs. 29, 30, 31 and 32 (P. R., pp. 1096-1124), of his deposition they are, in your opinion, substantially the same in construction, mode of operation and the results produced as the apparatus involving the inventions of the Marconi tuning patent No. 763,772, particularly as recited in the transmitter claims of said patent Nos. 1, 3, 6, 8, 11 and 12 and the transmitter apparatus included in claims 19 and 20, or any one or more of said claims, giving your reasons for such opinion as you may express.

A. I have considered the evidence and made the comparisons called for in your question. In my opinion, the several types of transmitters that you specify are substantially the same in their combination and arrangement of elements, their mode of operation and the results produced when in use, as the transmitters described in the Marconi [fol. 1467] tuning patent, and as set forth in the claims enumerated in the question, as follows:

The Wireless Specialty Apparatus transmitter shown in "Plaintiff's Exhibit No. 87" (opposite P. R., p. 164) contains the induction coil or power transformer of claims 1, 3, 11, 12 and 20, as shown at *c*. It has the condenser in the secondary circuit of that coil, shown at *e*, as called

for in claims 1, 3, 6, 11 and 12. The spark-gap G is the automatic means for producing oscillations, of claims 1, 3, 6, 8, 11, 12 and 20. The open circuit of claims 1, 3, 6, 8, 10 and 20 is shown as comprising the antenna *f*, A, the variable inductance *g*, the oscillation-transformer secondary coil *d'* and the ground or earth E. This open circuit is electrically connected with the spark-gap G by means of the oscillation-transformer *d*, *d'*, as required by claims 1, 3, 8 and 10. There is also a variable inductance in the open circuit, provided by the coil *g* with its tap 1, and coil *d'* with its tap 2, as called for in claims 1, 3 and 8. The generator in the primary circuit of the induction coil or power transformer, stated in claim 3, is shown at *a*. The "means for varying the primary circuit", also called for by claim 3, is the sending-key *b*, which is specified more closely as a "signaling instrument" in claims 11 and 12. The oscillation-transformer of claims 6, 8, 10, 11, 12 and 20 has already been referred to as comprising coils *d*, *d'*. This has its secondary coil, *d'*, connected in the open or antenna circuit, as in claims 6, 8 and 11. One end of the secondary *d'* is connected (through the coil *g*), to the antenna or radiating conductor A, *f*, as required by claims 6, 8 and 20; and the other end is connected to the capacity of the earth at E, as called for by claims 6, 8, 11, 12 and 20. There are provided, in the variable coils *d*, *d'* and *g*, the requisite means for adjusting the two circuits (closed and open), to accord or resonance, as explicitly stated in claims 6, 10 and 20, and as implied in the other claims by the specification. The primary *d* of the oscillation-transformer and the condenser *c* are in an electric circuit, and the condenser discharges its energy through the coil *d* and the spark-gap G, as in claims 11, 12 and 20. The antenna loading inductance coil *g* is connected to the end of the secondary *d'* opposite to the end that is connected to earth capacity, and the aerial conductor A, *f*, is connected to the inductance coil *g*, as called for in claims 11 and 12. Thus all the elements of claims 1, 3, 6, 8, 11 and 12, and all the transmitter elements of claims 10 and 20, in the specific combinations of each claim and operating as called for by the claims, are found in this Wireless Specialty Apparatus type of transmitter.

The Telefunken type of transmitter is shown in "Plaintiff's Exhibit No. 79" (opposite P. R., p. 180), and is very similar to the Wireless Specialty Apparatus type described

in detail above. The only differences seem to be that the induction coil or transformer C is connected across the terminals of the spark-gap G, instead of across the condenser *c*, that a one-coil or auto oscillation-transformer *d*, *d'*, is used instead of the two-coil variety and that an antenna condenser H, with shunting switch S is provided. None of these variations affect the operation of the apparatus with respect to the claims of the Marconi patent cited, and all the elements of all the claims, in the stated combinations, are present just as in the Wireless Specialty Apparatus type of transmitter.

[fol. 1468] The Kilbourne & Clark type shown by "Plaintiff's Exhibit No. 95" (opposite P. R., p. 183) is identical with the Wireless Specialty Apparatus type, except for the interchanged position of spark-gap G and condenser *c* (as in the Telefunken transmitter), and the addition of another means for adjusting the tuning of the closed circuit, *i. e.*, the variable inductance *d'*. The elements of all the claims appear, in the combinations of the claims, and the apparatus operates in accordance with the specification and claims of the Marconi tuning patent, as I have already explained. It may be noted that this "Kilbourne & Clark type" of quenched gap transmitter is the so-called "Navy Standard" made by Kilbourne & Clark to meet U. S. Navy specifications, and is quite different in its provision of tuning means, omission of the mercury-arc rectifier tube, etc., from the Kilbourne & Clark apparatus referred to by Mr. Loftin in his answer to Q. 37 (P. R., p. 1139).

The transmitter of the type manufactured by the Navy, shown by "Plaintiff's Exhibit No. 93" (opposite P. R., p. 187) is identical with the Wireless Specialty Apparatus Co. transmitter, discussed above, in all respects pertinent to the Marconi tuning patent. It meets the elements and combinations of the claims, and operates as specified in the claims, in the same way.

The same is true of the Wireless Improvement Co. type of transmitter shown by "Plaintiff's Exhibit No. 88" (opposite P. R., p. 188).

The Simon type of "Plaintiff's Exhibit No. 89", also opposite P. R., p. 188, is identical, except for the interchanged position of spark-gap G and condenser *c*, which affects neither the operation of the transmitter nor the appearance in it of the claimed combinations.

The Lowenstein transmitter of "Plaintiff's Exhibit No. 101" (opposite P. R., p. 190) is identical with the Telefunken type discussed above, except for the relative positions of spark-gap and condenser, and the omission of the antenna condenser H. These variations are immaterial with respect to utilization of the Marconi tuning invention, and my previous comments apply to this transmitter also.

The National Electric Supply Company type of field radio pack set, shown in "Plaintiff's Exhibit No. 80" (opposite P. R., p. 192), is identical with the Wireless Specialty transmitter, except that the antenna-circuit inductance coil *g* of claims 11 and 12 is functionally and in substance included in the inductance coil comprising the oscillation-transformer secondary *d'*. As explained in connection with the other transmitters, it thus involves the elements, combinations and operation of the transmitting apparatus of claims 1, 3, 6, 8, 10, 11, 12 and 20.

The Foote-Pierson pack set shown in "Plaintiff's Exhibit No. 102" (opposite P. R., p. 196), is like the National Electric Supply set just described, except for the use of a one-coil oscillation-transformer *d, d'*. The same comments and conclusions apply.

Mr. Loftin, in his discussion of infringement in answer to Q. 29, at P. R., pp. 1110 and 1111, states that if the inventions of the claims in issue are applicable to defendant's types of quenched gap transmitters, then the claims are also applicable to the disclosures of Lodge, Tesla and Stone. In my opinion, for the reasons already stated in my previous answers, the disclosures of Lodge, Tesla and Stone, in construction, arrangement of elements or mode of operation, are not anticipatory of any of the transmitter claims in issue.

[fol. 1469] Q. 33. Referring further to Mr. Loftin's testimony mentioned in the last question, will you please compare the receivers used by the defendant herein and represented by the following exhibits:

Type manufactured by the Navy, "Plaintiff's Exhibit No. 93" (opposite P. R., p. 187);

Wireless Specialty Apparatus Type, "Plaintiff's Exhibit No. 87" (opposite P. R., p. 164);

Telefunken Type, "Plaintiff's Exhibit No. 79" (opposite P. R., p. 180);

Kilbourne & Clark Type, "Plaintiff's Exhibit No. 95" (opposite P. R., p. 183);

Lowenstein Type, "Plaintiff's Exhibit No. 96" (opposite P. R., p. 191);

National Electric Supply Co., "Plaintiff's Exhibit No. 80" (opposite P. R., p. 192);

Foote-Pierson Pack Set, "Plaintiff's Exhibit No. 102" (opposite P. R., p. 196);

Fig. 89 of "Plaintiff's Exhibit No. 78," Federal Co. Receiver (opposite P. R., p. 212);

and state whether or not, in your opinion, the receiving apparatus therein illustrated and described in the testimony are substantially the same in construction, mode of operation and the results produced, as the apparatus involving the inventions of the Marconi tuning patent 763,772, as recited in claims 2, 13, 14, 16, 17, 18 and 19 of that patent, and the receiving apparatus recited in claims 10 and 20, or any one or more of said claims, giving your reasons for such opinion as you may express.

A. I have studied the testimony to which you refer and have made the comparisons requested. In my opinion, the several types of receivers to which the question refers are substantially the same in construction, in operation and in the results obtained when in operation, as the receivers described in the Marconi tuning patent and particularly claimed as the invention of the claims enumerated in the question, as follows:

The Wireless Specialty Apparatus Company type "1 P 76" receiver is illustrated in "Plaintiff's Exhibit No. 87" (opposite P. R., p. 164). I have used receivers of this type in practical radio work, and am familiar with their design and operation. The receiver is designed for use with an antenna shown at A, *f*, of "Plaintiff's Exhibit No. 87," and this is the "oscillation receiving conductor" or "aerial conductor" of claims 2, 10, 13, 14, 16, 17, 18, 19 and 20. The variable inductance coil *g* and the variable primary coil *f'*, constitute the variable inductance in series with the antenna, as called for by claims 2, 13, 18 and 19. The detector T in the exhibit is the electrically connected wave-responding device of claims 2, 13, 14, 16, 17, 18, 19 and 20, the electrical connection being by way of the oscillation-transformer *f'*, *f²*. The tuning condenser *h'* connected to, or in circuit with, the wave-responsive device or detector, is the condenser of claims 2, 13 and 19. The pri-

mary and secondary coils j' and j^2 constitute the oscillation-transformer of claims 10, 13, 14, 16, 17, 18, 19 and 20. The aerial conductor A, f, is connected with one coil (j'), of the [fol. 1470] oscillation-transformer, as required by claims 13, 14, 16, 17, 18 and 19, and there is a capacity at the other end of the primary coil j' provided by the earth E, as called for in claims 13, 14, 16, 17, 18, 19 and 20. The variable tuning condenser h', and the variable tuning inductances g, j' and j^2 are the means for adjusting the primary and secondary circuits to resonance, of claims 10, 14, 15, 17 and 20 (specifically), and implicitly required by the other receiver claims in view of the specification. The variable inductance j^2 is in the circuit of the wave-responsive device, as called for by claims 18 and 19; and the battery B and telephone R constitute respectively the battery and "receiving instrument" specified by claims 19 and 20 as in the detector circuit. The only other elements of the claims considered, that bear upon the receiver, are the "closed circuit" connected through the oscillation-transformer secondary j^2 (in claim 10), which is provided by the tuning condenser h', and the shunt condenser connected in the antenna circuit and around the primary coil of the oscillation-transformer, as called for by claim 16. This condenser is added in practice, when the operator desires to receive long waves by use of a relatively small receiving aerial, in order to tune the primary circuit effectively by making up for the insufficient capacity of the small antenna itself. I have thus indicated all the receiving elements of claims 2, 10, 13, 14, 16, 17, 18, 19 and 20, in the combinations of those claims, as they appear in the Wireless Specialty Apparatus Type 1 P 76 receiver. Further, I know, from my use of these receivers, and of others similar to them, that their normal operation and the results obtained, are in accordance with the Marconi tuning patent.

The Telefunken type of receiving apparatus is shown at the right of "Plaintiff's Exhibit No. 79" (opposite P. R., p. 180). I have also used apparatus of this type and am generally familiar with it. It is used with the antenna or elevated conductor f, A, and comprises the variable antenna-circuit inductance j', the electrically-connected wave-responsive device or detector T, the condenser in circuit therewith h', the oscillation-transformer j', j^2 with the aerial connected to one end of one coil (j'), and the capacity or earth E connected to the other end, the means for ad-

justing the two circuits to resonance (comprising variable tuning condensers h and h', and variable coils f' and f^2), the variable inductance in the wave-responsive device circuit f^2, the receiving instrument or telephone R in the detector circuit, and the closed circuit connected to the oscillation-transformer coil f^2. I have already identified all of these elements with the claims in which they appear, in my comparison with the Wireless Specialty Apparatus Company receiver above. In this Telefunken receiver all the elements of claims 2, 10, 13, 14, 16, 17, 18 and 20 are founds in the combinations of those claims, and the operation of the receiver (and its results), are, in my experience, those of the Marconi tuning patent. The Telefunken receiver does not include the battery which is specifically recited as an element of claim 19, although this battery may obviously be added to the circuit in the usual way whenever a detector is used that requires or favors the use of such an additional source of electric potential. The modification of the Telefunken receiver shown on the exhibit chart E^4 does not contain the tuning condenser h' and, therefore, depends upon the variable inductance f^2 (in con-[fol. 1471] junction with the effective capacity of the rest of the closed circuit), for tuning,—otherwise, it is like the E^3 receiver which includes the condenser h'.

The Kilbourne & Clark receiver is shown in "Plaintiff's Exhibit No. 95" (opposite P. R., p. 183). This receiver is quite similar to the Telefunken and Wireless Specialty types just described, and contains all the elements recited as to both those receivers. The battery of claim 19 is shown at B, and the adjustable condenser of claim 16 appears at h. Thus this receiver embodies all the elements of claims 2, 10, 13, 14, 16, 17, 18, 19 and 20, in the combinations of these claims, and its operation and results are those of the Marconi tuning patent.

The Navy receiver of "Plaintiff's Exhibit No. 93" (opposite P. R., p. 187) contains the elements of all the claims, in the combinations of the claims, except the shunting primary condenser of claim 16 and the battery of claim 19, either or both of which may be added in practice, as indicated above.

The same is true of the Lowenstein receiver shown in "Plaintiff's Exhibit No. 96" (opposite P. R., p. 191), and of the National Electric Supply Company, "Field Radio

Pack Set" receiver, shown in "Plaintiff's Exhibit No. 80" (opposite P. R., p. 192).

The Foote-Pierson Pack Set receiver illustrated by "Plaintiff's Exhibit No. 102" (opposite P. R., p. 196) shows the battery of claim 19 and substitutes a one-coil or oscillation auto-transformer for the two-coil oscillation-transformer more commonly used in modern radio apparatus; the general functions of the two types of oscillation-transformer are, however, the same.

Thus, in all of these receivers there are provided the variable or tuning means of the Marconi tuning invention. The normal, intended and best mode of operation of all these receivers is that of the Marconi tuning invention. I have personally used receivers of all these types, either as made by the manufacturers named, or in substantially identical form, and I know that their operation does, in fact, utilize the tuning invention of the Marconi patent.

I find that I have omitted consideration of the Federal Co. receiver shown in "Plaintiff's Exhibit No. 78" (reproduced opposite P. R., p. 213). This receiver embodies all the elements of all the claims, in the combinations of those claims, with the exception of the adjustable condenser in shunt to the primary coil and the battery in the circuit of the wave-responsive device or detector, either or both of which may be added, as I have above described. The diagram does not indicate that the secondary coil of the oscillation-transformer is of variable inductance, but I know from my experience with these receivers that the coil must be made variable, as provided in claims 18 and 19, unless operation over a relatively smaller range of wave lengths is sufficient. In this case the variability of tuning provided by the adjustable condenser in the closed circuit may be adequate.

* * * * * * *

[fol. 1472] Q. 34. Mr. Loftin, in his answer to Q. 32 (P. R., p. 1119), and in his answer to Q. 33 (P. R., p. 1124), states that Mr. Waterman's sketch "Plaintiff's Exhibit No. 102", which is a diagram of the Foote-Pierson pack set, is incorrect in showing two windings in the oscillation-transformer and submits a sketch which, Mr. Loftin states, correctly illustrates the Foote-Pierson pack set, and also the Telefunken and Lowenstein sets. What have you to say on this subject?

A. Mr. Loftin has apparently misinterpreted Mr. Waterman's sketches of the Telefunken, Lowenstein and Foote-Pierson apparatus. He should have noted that the red and black coil indications in each of these circuits are printed one over the other, to indicate conventionally the presence of two circuits or current paths in a single coil or "auto" oscillation-transformer. This is clear from the printed reproductions of the exhibits, but is even more striking in the originals, as, for instance, that of "Plaintiff's Exhibit No. 102", showing the Foote-Pierson pack set, in which the red and black convolutions indicating the two current paths are exactly superimposed. There is no room for confusion on this point, for where the apparatus involved a two-coil oscillation-transformer (as in the Wireless Specialty Apparatus Company's transmitter and receiver of "Plaintiff's Exhibit No. 87", reproduced opposite P. R., p. 164) the two coils have been shown separated and side by side, and not superimposed in the drawings. To my mind, Mr. Loftin's criticism of this point is not warranted. Mr. Waterman has adopted a customary conventional method of representing the two circuits which co-exist in a single coil of a one-coil oscillation-transformer. As is well known, and as I believe Mr. Loftin would agree, the one-coil oscillation-transformer and the two-coil transformer, are alike as to their general functions. "Close coupling" or "loose coupling", as and when desired for the particular conditions of use, can be had with the auto-transformer, just as with the two-coil transformer.

Q. 35. Referring to Mr. Loftin's answers to Qs. 29, 30 and 32 of his deposition, wherein he compares the apparatus of the Marconi tuning patent No. 763,772 with the wireless apparatus of the Wireless Specialty Apparatus type, illustrated in Plaintiff's Exhibit No. 87" and other wireless apparatus used by the defendant, which the claimant considers to be infringements, and state wherein you may agree or disagree with Mr. Loftin's answers, particularly as concerns the conclusions reached as to the operation of said apparatus used by the defendant.

A. Mr. Loftin's long answer to Q. 29 (at P. R., pp. 1096-1109) sets forth a complicated theoretical argument attempting to distinguish between the Marconi patented apparatus and the Wireless Specialty Apparatus Company types of sending and receiving stations. I have also read his an-

swers to Qs. 30 and 32, in which he discusses the relations of the Marconi claims to the Wireless Specialty Company's [fol. 1473] apparatus and to other types used by the defendant. So far as I can determine, he does not deny that both or either transmitter or receiver embody the elements of the Marconi claims in the combinations of those claims. I understand, therefore, that in the application of the technical terms of the claims to the individual parts of the apparatus, as I have stated it in my preceding answers, there is no difference of opinion between us.

However, Mr. Loftin apparently does contend that the elements and combinations of the Marconi tuning claims are found in the prior art and specifically in Tesla, Lodge, Marconi's 1899 patent and Stone. I disagree flatly with this view, and have already set forth, in some detail, my reasons for this disagreement.

Mr. Loftin also appears to urge that (even though I assume that the technical meaning of the terms of the Marconi tuning patent claims is agreed to be descriptive of the Wireless Specialty Apparatus Co. and other instruments), there are certain fundamental differences in the mode of operation of the quenched gap transmitters that take them outside of the spirit of the Marconi tuning invention. I find no such contention as to the receivers I have referred to, and consequently will discuss them no further.

At pages P. R., pp. 1107 and 1108, Mr. Loftin has summarized what he contends to be the differences between the quenched gap transmitters of the Wireless Specialty Apparatus type of "Plaintiff's Exhibit No. 87" and what he calls the "open gap type" of transmitter of Marconi patent 763,772. These points may be briefly stated as follows:

Mr. Loftin seems to think that because the Wireless Specialty Apparatus transmitter (*a*) uses a quenched gap, (*b*) operates with relatively close coupling, and (*c*) follows the Seibt patent 1,216,615 in some respects, he is justified in concluding (1) that it has no persistently oscillating circuit, (2) that there is no resonant transfer of energy from closed to open circuit, (3) that the tuning adjustments required and provided, are not for the purpose of tuning, (4) that the transmitter operates with its two circuits deliberately de-tuned one from the other, (5) that the wave-frequency is "determined" by the antenna circuit and not by the closed circuit, and (6) consequently, that the apparatus

is a "single-circuit transmitter" like that of Lodge's Fig. 4 and not within the Marconi tuning patent.

These conclusions of Mr. Loftin seem to be based upon his statements in various prior answers which relate to his conception of the action of the quenched gap transmitter as compared to that of an open gap transmitter, to some of which I have already referred. His statements are apparently based upon incorrect assumptions of technical fact, which I do not find to be substantiated either by the literature of the art, or by my personal experience in the operation of transmitters using quenched and other types (including the so-called "open") *types* of gap.

Taking up Mr. Loftin's conclusions in order, I have already explained that the persistently oscillating circuit of the Marconi tuning patent is simply a circuit free from radiation loss of energy and, consequently, one that will oscillate for a relatively long time if its energy is not withdrawn for radiation or otherwise. The primary circuit energy in the Wireless Specialty Apparatus Company [fols. 1474] transmitter swings back and forth through from five to ten complete oscillations before being completely transferred to the antenna circuit (just as in the case of the National Electric Signaling Company transmitter which was previously enjoined under this Marconi tuning patent), and would oscillate for a much longer time were it not withdrawn by the antenna circuit to be radiated. The closed circuit comprising the condenser *c*, spark-gap G and primary coil *d* in the Wireless Specialty Apparatus Company transmitter of "Plaintiff's Exhibit No. 87" (reproduced opposite P. R., p. 164), is the same in elements, function and result as the similar closed circuit of the Marconi specification and claims.

Mr. Loftin's first contention is equivalent to saying that the quenched gap transmitter is based upon the principle of quickly dumping the energy of the primary circuit into the radiating circuit, as compared with the open gap system in which the energy is maintained for a long time in the primary circuit.

I do not agree with this first conclusion of Mr. Loftin as given in his summary, because, as a matter of fact, as I have previously pointed out, the action of a quenched gap transmitter is not based upon the principle of quickly dumping the energy of the primary circuit into the radiat-

ing circuit in a "single chunk". Mr. Loftin states that the action of the quenched gap transmitter is like that which he attributes to the transmitter of Fig. 4 of the Lodge patent, but, as I have previously stated, the quenched gap transmitter does not operate in that way. In its usual operation there are six or eight complete oscillations of the primary circuit before the gap is opened by the quenching action, and during this entire period the energy is being transferred from the primary circuit to the antenna or radiating circuit.

Mr. Loftin's second conclusion, that there is no resonant transfer of energy, is similarly not justified by the facts. The Seibt patent itself points out the necessary condition of resonance, or the agreement of circuit time periods, and both theory and practice show that in order to transfer energy quickly and effectively from closed to open circuits (as is done in the defendant's quenched gap transmitters), the resonant adjustment of the two circuits is essential. In my own personal experience with quenched gap transmitters it has always been my custom, with approximately correct coupling, to tune the primary and secondary circuits as nearly to resonance as possible, and then to adjust the coupling of the oscillation-transformer so that the maximum current in the antenna is obtained consistent with a clear note of the transmitter signal. This second conclusion of Mr. Loftin's is really a corollary to the statement given in his first conclusion, for if it were true that there was a quick dumping, impulsive rush, or single chunk transfer of energy from the primary circuit into the radiating circuit, then, of course, resonance between the circuits would be neither necessary nor desirable. But where the transfer is continued through a number of successive oscillations, as it is in the quenched gap transmitter, syntony must be obtained between the two circuits in order that there will be any efficient transfer at all.

Mr. Loftin's third conclusion, that the adjustable coils are provided in order to depart from resonance, rather than to attain it, is hardly to be taken seriously. If absence of resonance were the thing desired, it would be sufficient to leave the primary circuit adjustment fixed at a point out [fol. 1475] of resonance, and utterly unnecessary to readjust the primary coil when the wave-length was changed. But this is not what is done. The adjustments are provided

and used to attain the tuning adjustment that gives rapid and efficient resonant transfer of energy, as set forth by Marconi. Mr. Loftin in effect says that the arrangements for the adjustments of the two circuits of the two systems are for entirely different purposes, in the quenched gap system the adjustment being for the purpose of controlling the point of production of a "beat" of no energy in the primary circuit. To my mind he is entirely wrong in this third conclusion that he gives as a basis for establishing a difference between two types of transmitters. In the quenched gap arrangement the adjustment is not for the purpose of controlling the point of production of a "beat", but it is for the purpose of obtaining syntony or resonance between the two circuits with the proper degree of coupling to give the desired clear note. This signal note or spark tone depends upon the number of spark discharges per second and not upon any "beat" produced in the transmitter. As a matter of fact, the adjustments with the open gap transmitter and the quenched gap transmitter, in the practical use of either apparatus, are made in an identical manner and for the same purpose, *i. e.*, to get the maximum radiation of a substantially pure wave from the antenna circuit, together with a clear spark tone or note having the pitch of the spark-discharge frequency.

Mr. Loftin's fourth conclusion, that the circuits are deliberately operated "out of tune" with each other, is simply contrary to fact, as I understand the testimony in this case shows. My own experience in quenching gap operation agrees with the Seibt patent, and with general theoretical considerations, that operation with the circuits *in tune* is essential to the best results. Mr. Loftin contends that the quenched gap apparatus depends upon a tight coupling that will produce two frequencies sufficiently widely separated to obtain an "early beat", while the open gap apparatus depends upon a coupling relation between the two circuits so loose that the two frequencies will be merged into one. This is an incorrect statement of the fundamental reason for using a somewhat tighter coupling with the quenched gap than with the open gap. The main object of tighter coupling in quenched gap apparatus is to produce a greater transfer of energy from the primary circuit to the open or radiating circuit, and this is made possible by reason of the fact that the cooling action of the quenched gap quenches or causes the spark to "go out" before the energy of the

secondary or radiating circuit can be transferred back to the primary circuit. In other words, the group of oscillations in the secondary circuit is produced by a resonant transfer of energy from the primary circuit to the secondary circuit in a somewhat shorter time than is ordinarily possible with the open gap used at moderate or high powers. It is, therefore, merely a question of degree which relates only to the length of time or number of oscillations which take place while the energy is being transferred from one circuit to the other. This question of time varies and is entirely in accordance with the amount of quenching produced by the various types of gap with the particular amount of power and degree of coupling being used, from the open gap to the quenched gap, including the various forms of rotary gaps and those quenched by the use of blowers, as I have already pointed out.

[fol. 1476] The fifth conclusion, that the antenna circuit "determines" the wave-frequency, is merely a matter of words. If a wave-frequency of 500,000 per second is desired, the antenna will assuredly be tuned to the 500,000-cycle frequency, and so may be said to "determine" the frequency. But in order to obtain adequate resonant transfer of energy, the closed circuit will also be tuned to that frequency of 500,000 per second, and hence it may equally be said to be the determining element. Lodge had no closed circuit so tuned, and therein lies an essential difference between Lodge on the one hand, and Marconi, Seibt and the defendant's transmitters on the other. Thus, Mr. Loftin's fifth conclusion also seems to me to be unsupported by fact.

Mr. Loftin's sixth conclusion or contention, that the quenched gap transmitter is a "single circuit" apparatus and, therefore, results in a three-circuit tuned system when used with a two-circuit receiver, the frequency of the oscillations being determined by the radiating circuit with the primary entirely out of consideration, is a corollary to the second conclusion above mentioned. The second conclusion given by Mr. Loftin (that there is no resonant transfer of energy), is incorrect and it necessarily follows that his sixth contention is also incorrect. There is a resonant transfer of energy between the primary and secondary circuits of the quenched gap transmitter, since these circuits are in syntony with each other. The quenched gap transmitter is thus obviously a two-circuit apparatus, and results

in a four-circuit tuned system when used with a two-circuit receiver.

The six contentions advanced by Mr. Loftin may, as a matter of simple analysis, be reduced to one, *viz.*, that he contends that on account of a closer coupling between the primary and secondary circuits of the quenched gap transmitter a "beat" is produced by de-tuning, thereby preventing a resonant transfer of energy. On the other hand, the actual operation of the quenched gap transmitter, both theoretically, as well as practically considered, involves actual resonance between the primary and secondary circuits. This causes a resonant transfer of energy and permits a quenching of the spark in the primary circuit, so that when the voltage is reduced to a value below that necessary to maintain the spark, the spark "goes out" and the spark-gap "opens". The quenched gap transmitter is an improvement over the original open gap transmitter simply because at higher powers and with higher spark-frequencies, a closer coupling may be employed and, therefore, a greater amount of energy transferred more rapidly and more efficiently without destroying the purity of the signal transmitted. This is merely a matter of degree, and not a difference of substance, between transmitters using the two types of gap.

My theoretical knowledge of, and practical work in the art, and particularly with spark transmitters of all types, convinces me that (Mr. Loftin's statements notwithstanding), the quenched gap transmitter of the Wireless Specialty Apparatus Company, as illustrated in "Plaintiff's Exhibit No. 87", is fully within the spirit and substance of the invention of the Marconi tuning patent and involves the same principle and mode of operation. My detailed discussion of Mr. Loftin's comments upon the Wireless Specialty Apparatus Company transmitter, as given in this answer, is also fully applicable to the other quenched gap transmitters of the defendant.

[fol. 1477] Q. 36. Assuming that in some particular design of quenched gap transmitter, or that in some particular use of a quenched gap transmitter such as those used by the defendant herein, which the claimant considers to infringe the Marconi tuning patent 763,772, it had been found desirable to de-tune the antenna circuit so that its natural frequency differed from that of the closed primary circuit

to the extent of, say, two per cent, and that thereby the quenching action had been improved under the particular conditions then involved; how would the use of such adjustments affect the matter of utilizing the resonant transfer of energy from the primary to the secondary circuit of such transmitter by tuning, as disclosed in the Marconi patent?

A. Assuming the slight de-tuning of the antenna circuit stated by you (although I cannot see how this could improve the operation of any quenched gap transmitter), a transmitting set so adjusted would still utilize, and practically just as effectively as before, the resonant transfer of energy that I have already described. Unless the quenched gap transmitter were completely re-designed and re-organized in a way that (so far as I know), has never been done in the art, so as to cause it to produce a "single chunk", "impulsive rush" or sudden-blow excitation of the antenna, the oscillations in the closed circuit would swing through their normal five or ten complete cycles before transferring the bulk of their energy to the antenna circuit. In order to get this energy through the oscillation-transformer and into the antenna, it is necessary to use a sufficiently close identity or agreement of tuning of the two circuits to give the benefit of resonant transfer. Otherwise the energy will remain too long in the closed oscillation circuit, will not be transferred effectively to the antenna circuit, and will prevent the desired quenching action.

Q. 37. Assuming that, in the use of the transmitter portion of the inventions of the Marconi patent, and using an open gap, a reaction between the primary and secondary circuits was produced, resulting in a so-called "impure wave", but when a quenched gap was used such reaction did not take place and did not produce such a wave; would there be any difference in the mode of operation as to the tuned or resonant transfer of energy from the closed to the open circuit?

A. No, there would be no difference in this respect. The substitution of the quenched gap for the open gap would simply give the advantage of a more rapid cut-off of energy in the primary circuit, so preventing (under the assumptions made in your question), reaction from the antenna circuit upon the closed circuit. This would result in the radiation of a purer wave, probably of greater intensity and with a clear spark tone. There would be an improvement of efficiency in the transmitter, but the open and closed

circuits would still have to be tuned to the same frequency, so as to give the essential rapid resonant transfer of energy to the antenna circuit.

The matter of the purity of wave, to which your question refers, depends largely upon the degree of coupling between the circuits and upon the amount of quenching action developed by the gap, which latter is again dependent upon the amount of power used, as well as upon the tendency of the antenna circuit to react upon the closed circuit. No matter what particular adjustment or value of each of these various factors may be chosen for the conditions of opera- [fol. 1478] tion, it will, nevertheless, be necessary to tune the closed and open circuits to substantially the same frequency, in order to transfer the energy effectively. Moreover, no matter what conditions of adjustment are selected for practical use, there will inevitably be a certain, at least mathematical, and probably practical, impurity of the wave radiated. That is to say, the radiated waves can never be precisely and mathematically of a single frequency for the entire period of their radiation. If poor quenching and moderately close couplings are used, the wave radiated will have the so-called "double hump" or will radiate for part of the time at each of two predominant frequencies. How closely these frequencies of radiation coincide, and the relative effective intensity of the radiation at each frequency, will depend upon the adjustments of the transmitter. If maximum quenching, as attained in the practical quenched gap apparatus, is used, together with the appropriate coupling, the greater part of the radiated energy will be at a single frequency, but there will, nevertheless, be present two parasitic frequencies of somewhat different value for at least a portion of the total time of radiation. With the best quenched gap apparatus available, if the adjustment is such that the primary circuit is not "opened" upon the first resonant transfer of the energy to the antenna circuit (and thus, if power reaction between the circuits is allowed to appear), these extraneous or parasitic frequencies of radiation may become quite prominent and amply sufficient in intensity to produce harmful interference effects. No matter what type of gap is used, the best adjustment requires the maximum suppression of parasitic radiation frequencies and the maximum localization of the transmitted energy in the desired wave. This is true of the quenched gap, and was true of the apparatus used by Marconi at the

time of his invention. It is simply the proper method of using the resonant transfer of the Marconi patent.

Q. 39. Have you any personal knowledge of the construction and operation of the transmitters and receivers of the National Electric Signaling Company, such as is illustrated in "Plaintiff's Exhibit No. 105" (opposite P. R., p. 217), and described in Mr. Waterman's answer to Q. 30 of his deposition, beginning on page 215 of the Printed Record? If so, will you please state how you acquired such knowledge?

Q. Yes, I am familiar with the design, manufacture and use of these transmitters and receivers. I was employed by the National Electric Signaling Company for a number of years, and during that time my duties included the supervision and use of apparatus of this character.

Q. 40. Will you please state how the construction and mode of operation of the apparatus of the National Electric Signaling Company, referred to in the last question, compares with the construction and operation of any of the apparatus used by the defendant herein, and concerning which you have testified.

A. The National Electric Signaling Company transmitter of "Plaintiff's Exhibit No. 105" is substantially identical with the Simon transmitter of "Plaintiff's Exhibit No. 89" and (except for the interchanged position of the spark-gap G and condenser *c*), with the Wireless Specialty Apparatus transmitter of "Plaintiff's Exhibit No. 87". The National Electric Signaling Company transmitters used both [fol. 1479] quenched and rotary spark-gaps and, for emergency, plain spark-gaps, without other substantial change in the apparatus.

In my answer to Q. 32 I have compared the transmitter claims of the Marconi tuning patent with these other transmitters of defendant, and, in view of the substantial identity of the apparatus, the same comments and conclusions apply to the National Electric Signaling Company transmitter.

The National Electric Signaling Company receiver of "Plaintiff's Exhibit No. 105" is almost identical with the Wireless Specialty Apparatus Company receiver of "Plaintiff's Exhibit No. 87", discussed in my answer to Q. 33. In the National Electric receiver there are added the antenna tuning condenser shown immediately over the coil *a'*, its disconnecting (or short-circuiting), switch and the switch for the secondary tuning condenser *h'*. These variations do

not affect the functions or operation of the various corresponding parts, which are like those of the Wireless Specialty receiver. I may note that the National Electric operators frequently connected an antenna shunt tuning condenser across the primary coil *f'* of the receiver as indicated in the Telefunken and Kilbourne & Clark receivers of "Plaintiff's Exhibits Nos. 79 and 95". The comments and conclusions as to the relation between the receiving claims of the Marconi tuning patent and the construction and operation of these several receivers, as given in my answer to Q. 33, apply also to this National Electric Signaling Company receiver.

Q. 41. In your opinion, what significance is to be attached to the comparison between the action of pendulums and the coupled tuned circuits of the wireless apparatus of the Marconi tuning patent 763,772 as made by Mr. Loftin in his answer to Q. 21 (P. R., pp. 1023-1027)?

A. No significance should be given to the analogies as set forth and explained by Mr. Loftin, nor to the conclusions he has drawn from them, since his analogies are exceedingly imperfect and utterly insufficient to give even approximately a true picture of what occurs in the complicated electrical system of the Marconi tuning patent.

In the first place, mechanical analogies of electrical phenomena are notoriously dangerous, and must be used only with the greatest caution, if one is not to be led astray at the points where the analogue necessarily departs from the true conditions of the actual apparatus being studied. Carefully used, some analogies are helpful in analyzing even fairly complicated electrical effects, but before proceeding with them, one must be sure that his premises are sound.

One of the evident errors in Mr. Loftin's testimony appears at the bottom of P. R., p. 1023, where he says that it is well known that in transferring alternating current energy from one circuit to another through any form of coupling, there results a conversion of the one frequency into alternations into two frequencies. This, which he states as a general proposition, is true only of special cases. It is generally known, for instance, that the frequency of the alternating current of a power system remains unchanged regardless of the number of transformer interlinkages, and this fact is made use of in the operation of electrically-driven clocks which, for the accuracy of their

time-keeping, depend essentially upon a uniformity of frequency. Again, at P. R., p. 1024, Mr. Loftin refers to the effect of throwing a load upon a generator driven by a turbine or engine as analogous to coupled-circuit effects. [fol. 1480] The analogue is extremely far-fetched, for in systems of the type cited there are no resonant elements, and the well-known "hunting" or swinging in speed is caused by simple mechanical or load reactions. Still further, at P. R., p. 1025, Mr. Loftin says that if two pendulums are not of the same size, that is, if one is large and the other small "so that they do not have the same natural frequency of vibration", certain effects upon the rate of transfer of energy will be had. He should know that in a simple pendulum the natural frequency of vibration depends only upon the length of the pendulum and the acceleration of gravity, and that it has nothing whatever to do with the size of the pendulum-bob, although this latter is, of course, of the greatest importance in considering the way in which energy will be transferred from one pendulum to another. Again, at P. R., p. 1026, his pendulum system utterly fails to reproduce conditions approximating the Marconi circuits, for Mr. Loftin has completely disregarded both the difference in persistence of the closed and open circuits and has failed to introduce any element corresponding in its action to the all-important spark-gap. Of his entire discussion the only statement that I find which I would care to endorse appears at P. R., p. 1027, where he says:

"If the second pendulum is made to have exactly the same natural period as that of the first, then these two energies are brought together to a common purpose, that of creating swings of one frequency, with the result that the extent or amplitude of swing is substantially increased."

This statement, although made in connection with limiting conditions which cannot be accepted as having any bearing on the operation of the Marconi system, is, nevertheless, an indication that Mr. Loftin realizes the fact that when one has an agreement between the natural frequency of the two elements of a coupled system, he will gain the benefits of resonant transfer of energy from one to the other and thereby get improved results.

I have myself used free and coupled pendulums for the study of some of the conditions in oscillatory electric cir-

cuits, but never in the way explained by Mr. Loftin in his answer to Q. 21. With proper precautions, such mechanical experiments show the advantages to be had by tuning the closed and open circuits of spark transmitters of any type, including those using the quenched gap. The particular points thus capable of demonstration are the rapid and efficient transfer of energy made possible by tuning the circuits together, the fact that each circuit can vibrate with only one frequency at a time (and never at two frequencies, as suggested by Mr. Loftin), and that quenching is materially assisted in a system using any type of gap by establishing resonance between the circuits since (as is also pointed out in the Seibt patent), *all* of the energy is thus transferred from one circuit to the other and the gap is permitted to "open" automatically without interference from a residuum of energy in the primary circuit.

There is one additional point, not commented upon by Mr. Loftin, which I might mention in connection with this discussion of pendulum experiments, *viz.*, that consideration of two pendulums hanging side by side and coupled together through an elastic band, or otherwise, can give one at least a partial understanding of why "single chunk" [fol. 1481] or impulsive rush transfer of energy from primary to secondary circuits has never been attained in radio practice. If we set one pendulum into oscillation by drawing it back and releasing it, it can obviously drive the secondary pendulum into full motion only by a gradual transfer of its energy through the elastic coupling link. To get a "single chunk" effect it would be necessary to strike the second pendulum a single violent blow, and it is perfectly clear that nothing of this sort can be accomplished through any elastic coupling that would permit freedom of vibration of the second pendulum. Being forced to transfer the energy over the time of at least five or ten complete swings, radio engineers have, since the time of Marconi, invariably taken advantage of the increase in effectiveness produced by resonant transfer. To approximate the "single chunk" excitation it would be necessary to devise an electrical system that would produce effects somewhat analogous to the striking of a single heavy pendulum with a powerful mallet, and thereafter immediately removing the mallet so as to prevent its interference with the swinging of the pendulum. Such a system would depend upon brute force, rather than sympathetic vibration to

produce its effects, and, so far as I know, has never been successfully approximated in the radio art.

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Cross-examination.

By Mr. Edwards:

X Q. 42. What specific object do you understand to be sought for in the Marconi patent No. 763,772?

A. That which Marconi states at page 1, lines 13 to 19 of the specification, viz.:

"to increase the efficiency of the system and to provide new and simple means whereby oscillations or electric waves from a transmitting-station may be localized when desired at any one selected receiving-station or stations out of a group of several receiving-stations".

X Q. 43. Can you translate this into non-technical language and tell us in a word what that object is?

A. Probably as good a brief statement as I can make is that the object is to improve the distance and effectiveness of radio transmission by providing a system that is more powerful, more reliable and more selective than the radio systems that had preceded it.

X Q. 44. When he speaks of increasing the efficiency of the system, does that indicate that he desires a more powerful system, *i. e.*, which, for a given in-put of energy would transmit to a gréater distance?

A. I believe the reference to increased efficiency of the [fol. 1482] system is made broadly, that is, that Marconi there refers to improved performance and, therefore, a better practical efficiency throughout, as well as at various points of the system. One factor that would contribute to greater system-efficiency is the use of a more powerful transmitter and another would be the use of a transmitter having a high power-efficiency.

X Q. 45. But in a word, is not the specific result of increased efficiency the obtainance of greater distance of transmission?

A. That will depend upon what kind of efficiency you mean. If you refer to transmitter power efficiency, an increase may be accompanied by variations in other factors that would decrease effective transmission distance. If

you refer to over-all operating efficiency, your statement is correct. I might add that increased operating efficiency sometimes shows up as permitting greater reliability of transmission of messages, rather than greater distance alone.

X Q. 46. Well, do you agree that the statement of the object of the invention is "to increase the efficiency of the system" suggests that at least one object is to transmit to a greater distance?

A. Yes, the reliability of transmission and other factors being assumed constant.

X Q. 47. When the part of the specification which you have quoted refers to localizing the transmitted waves at one selected receiving-station, does that refer to selectivity?

A. Yes, selectivity of the receiver, as well as definiteness of radiation from the transmitter, is involved.

X Q. 48. That is to say, the means to insure the transmission of one selected frequency from the transmitter and the reception of that selected frequency at one or more selected receiving-stations?

A. Yes, in so far as the practical limitations of the apparatus permit.

X Q. 49. Do you understand that the attainment of selectivity is necessarily accomplished by the attainment of increased efficiency of the system?

A. I believe that an increase in selectivity is an important part of increased system efficiency, though the extent to which it is essential will necessarily depend upon the conditions of interference under which the particular system is operating at the particular time considered.

X Q. 50. Referring to the transmitting apparatus shown in Fig. 1, do you agree that the tighter the coupling between *d* and d^1, other conditions remaining the same, the greater would be the transference of energy from the closed circuit to the antenna?

A. Yes, that is generally true, though it would be more accurate to say that the tighter the coupling, the more rapid would be the transfer of energy. It should be noted that the question is hypothetical, because in practice other conditions in the transmitter will not remain the same when the coupling is changed.

X Q. 51. Do you agree that in this Fig. 1, other conditions remaining the same, that the tighter the coupling

between d and d^1, the more pronounced will be the double-wave transmitted from the antenna?

A. No, I cannot agree with the statement as you make it. The appearance of a double-wave depends upon too many factors other than the coupling. It is a fact that if conditions are such that a double wave can be observed during any part of the transmission time, the two frequencies will, in general, become more widely separated as the coupling between closed and open circuits is increased.

[fol. 1483] X Q. 52. Assuming in Fig. 1 that the LC of the antenna circuit is independently adjusted to be the same as or a multiple of the LC in the closed circuit, do you consider that a resonant transfer of energy will occur, irrespective of the degree of coupling?

A. Such an adjustment, if it takes into account the effective values of inductance and capacity of the frequency used, always gives, in my experience, a sufficiently close agreement of the electrical time-period of the circuits to permit a good resonant transfer of energy from one to the other. In some transmitters the effec ive inductance of either circuit is affected slightly as the coupling is varied, and where this is the case, a re-adjustment may further improve the resonant transfer. Such re-adjustments are, however, always very slight and often entirely unnecessary.

X Q. 53. Is my question X Q. 52 susceptible of a categorical answer Yes, or No?

A. Yes. I think the first part of my answer was, in effect, an affirmative answer, though I thought that the precautions which I understood to be implied by your question should be made clear.

X Q. 54. Do you agree that every circuit that is resonant has an electrical time-period of its own?

A. It has, if you mean that it has a frequency of oscillation for which it exhibits the least impedance. Some circuits containing inductance, capacity and resistance, are called "resonant", even though the resistance is so great that they will not oscillate freely if disturbed electrically and then left alone.

X Q. 55. Then do you agree that this time-period of the circuit is determined by the adjustment of the inductance and capacity of the circuit?

A. Yes, the inductance and capacity are the controlling factors, though in some cases the effective resistance may have a small effect upon the time-period.

X Q. 56. Now, if the time period of the closed circuit is independently adjusted and that of the antenna is independently adjusted, the product of the capacity multiplied by the self-induction of the respective circuits being the same, and the circuits be coupled together, will there be a resonant transfer of energy, no matter how tight the coupling?

A. There will, provided that the act of coupling the circuits together has not, in the particular apparatus under consideration, too greatly modified the effective values of the inductance or resistance in the two circuits.

X Q. 57. Do you place any limitation on the words "effective" and "too greatly" in your last answer?

A. No, I am using the phrase "effective inductance" in its normal engineering sense, which means simply the net amount of inductance that is effective in the circuit under consideration. As to "too greatly", I cannot assign any general numerical limits, but simply wish to make it clear that there may occur mathematically or precisely determinable variations that are of no consequence in practice.

X Q. 58. Do you understand that the Marconi patent teaches that the inductance and capacity of the several circuits are to be adjusted independently, as distinguished from adjusted by first coupling and then tuning experimently? [fol. 1484] A. No. The instruction that the capacity and self-induction of the circuits are each and all to be so independently adjusted, which appears near the end of page 2 of the specification, refers to the adjustment of each element with respect to the others, and does not make the distinction excluding coupling and experimental tuning, which you state in the last part of your question. At page 3, beginning at line 12, Marconi points out that the adjustment "may be made in any convenient manner and employing various arrangements of apparatus, those shown and described herein being preferred". The apparatus shown in Figs. 1 and 2 is provided with coupled circuits and means for experimental tuning adjustments.

X Q. 59. Do you understand that it is following the instructions of the Marconi patent if the tuning be made without predetermined adjustment of the LC in each of the circuits, but by first coupling them and then adjusting the adjustable tuning elements q at the transmitter and q^1, q^2 at the receiver?

A. Yes, that mode of adjustment would be within those taught by the Marconi patent.

X Q. 60. You do not consider it essential that the two circuits be independently adjusted to a given time-period by calculation?

A. No.

X Q. 61. From your point of view it is quite sufficient to couple the circuits and by varying the adjustable elements, arrive at the tuning by trial?

A. Yes, though, of course, a preliminary calculation or experiment might be helpful.

X Q. 62. When you arrive at the tuning in this manner by trial, how do you know when the two circuits are properly adjusted?

A. From the fact that (considering the transmitter), the greatest antenna current, the purest wave and the best spark tone are had when the circuits are in tune; and (considering the receiver), by the fact that the greatest signal-response is had when the circuits are together tuned to the arriving wave-frequency.

X Q. 63. When you get the greatest response in this manner, how do you know what is the exact value of the LC in either of the two circuits?

A. You do not know it numerically, and you do not care for the numerical values as a practical operating matter. If you wish to determine them for design or other purposes, they may then be measured.

X Q. 64. How do you know, under those circumstances, how the value of the LC in one circuit compares with that of the value of the LC in the other circuit?

A. As a result of observation, a study of the work of others, or by direct measurement, you find that under those circumstances the electrical periods of the two circuits are the same for all practical purposes. This fundamental physical fact is continually used for the measurement of capacity and inductance.

X Q. 65. From your last answer do you mean the same, or do you mean substantially the same?

A. I mean either, that is to say, I cannot exclude either. Generally speaking, the electrical periods will be substantially the same, usually they will be the same within the limits of accuracy of practical measurements and in some

[fol. 1485] cases they will be even mathematically the same, so far as any laboratory method permits us to determine.

X Q. 66. In arriving at the tuning by trial in the manner referred to, you might, or might not, vary the degree of coupling; am I right?

A. It is not necessary to vary the degree of coupling in order to tune the circuits together, but in the practical operation of an apparatus provided with means for coupling variations, one might take advantage of that additional adjustable feature.

X Q. 67. If one did take advantage of that adjusting and varied the degree of coupling, would not that tend to unbalance the periodicity of the respective circuits to some extent?

A. Whether or not it would tend to do so, will depend upon the particular design of the apparatus in use. If the instruments are such that a variation of coupling inherently causes a change in the effective inductance of either or both circuits, as is sometimes the case in practical radio apparatus, there will be such a tendency.

X Q. 68. If an unbalancing does, in fact, result, do you consider that the respective circuits are still resonant with each other?

A. If the result of a change in coupling were to produce a divergence of period so great that the advantage of resonant transfer of energy were no longer had (and this is a limiting case which I have never experienced), it would not be accurate to say that the circuits remain in resonance with each other. On the other hand, if the change produced a variation that was determinable in the mathematical sense, or even measurable, but the circuits were left with such substantial agreement of their natural periods that the condition of resonance aided in the transfer of energy from one to the other, it would be correct to say that they were in resonance to that practical extent.

X Q. 69. In giving your testimony in this case have you had before you any figures as to the actual values of LC in any of the circuits in any of the types of Defendant's apparatus concerning which you have testified?

A. No, I have had no such data here before me. I have used, and measured the values of inductance and capacity in certain of the apparatus referred to, and I have made many measurements on equivalent circuits corresponding to others of the instruments.

X Q. 70. Which of the circuits of which apparatus of the Defendant have you measured?

A. I have used an measured the elements of the Wireless Specialty Apparatus Company receiver, and, to the best of my recollection, I have had measurement data on the Telefunken receivers, and on the Navy receivers illustrated by "Plaintiff's Exhibit No. 93". I have also used and measured circuits corresponding to those of the pack set receivers. I have used and have had measurement data on the circuit elements of the transmitters of the type manufactured by the Navy ("Plaintiff's Exhibit No. 93") and the Wireless Improvement Company type ("Plaintiff's Exhibit No. 88"). I have also used and measured and worked from measurement data on transmitting circuits corresponding to the detailed variations shown as the Wireless Specialty, Simon and Lowenstein types, though I do not believe I have ever personally experimented with apparatus made by these three manufacturers.

X Q. 71. When did you make the measurements referred to in your last answer?

[fol. 1486] A. In the period within which I was employed by the National Electric Signaling Company and its successor, International Radio Telegraph Company; that is to say from about 1912 to about 1919.

X Q. 72. You did not have any of this data before you at the time of giving your deposition in this case, did you?

A. That is correct, I did not.

X Q. 73. And it is a fact, is it not, in giving your deposition you assumed from the various diagrams that if the circuits were adjusted to give best results, for example, transmission of a single frequency and reception of that frequency at a receiving-station, that then the various antenna and closed circuits would be such that the LC would be approximately the same in each of the circuits, did you not?

A. No, I am afraid that is hardly a fair statement. I have based my testimony only partially upon the diagrams to which you refer, and have relied mainly upon my experience with the apparatus itself.

X Q. 74. But you have assumed throughout, have you not, that the precise value of LC in any of the circuits is unimportant, and that it is sufficient if these values are approximate?

A. No, I do not think I have made any such assumption. The precise values of inductance and capacity in any of the circuits may be extremely important. I have assumed that in using any of the apparatus referred to in the case, the operator would follow the best tuning practice of the art, in order to get the best results of which the apparatus is capable. Such adjustment will, in my experience, invariably result in either a precise or a substantially close agreement of the electrical periods of the coupled circuits.

X Q. 75. If the coupling is made very tight, would the effect be negligible?

A. I am afraid I do not understand your question.

X Q. 76. You may assume the question to refer to the transmitter and that the other adjustments of the circuits remain the same?

A. No, increasing the coupling in a practical transmitter would be likely to increase the rate at which energy was transferred to the antenna circuit, and to increase the tendency of the antenna circuit to re-act upon the closed circuit. These effects would certainly not be negligible from either the theoretical or practical viewpoints. Depending upon the particular transmitter design, and the secondary effects of these two direct results of a change in coupling, there might, or might not, be additional practical variations produced to such an extent as would make them not negligible.

X Q. 77. Assume that the spark-gap of Fig. 1 of the Marconi patent No. 763,772 is a plain gap, then does it not follow that as the tightness of the coupling d, d' is increased you would increase the tendency to send out two waves?

A. The tendency to send out two waves, if I understand you correctly, would be increased as the coupling was made closer, without regard to what type of spark-gap was used. This is because in any given apparatus the tendency of the antenna power to react upon the closed circuit would be likely to increase with increase of coupling. Whether or not the tendency would result in the emission of parasitic waves would depend upon the antenna resistance, the gap condition, the spark-frequency and the amount of power used in the transmitter.

[fol. 1487] X Q. 78. The effect of the plain gap used with the tight coupling would be to prolong the effect of the two waves, would it not?

A. That would depend upon the gap condition and the amount of power being used, among other things. For each set of conditions there is usually some maximum coupling that can be used without causing "re-ignition" of the gap and consequent continued radiation of parasitic waves. If the coupling and power-relation are such that re-ignition occurs (which is not a desirable condition in practice), further increase of coupling or further increase of power may cause a greater proportion of the radiated energy to appear in the parasitic waves and this effect is, I presume, that to which you refer in your question.

X Q. 79. Well, do you not agree that, other conditions remaining the same, the effect of the plain gap as distinguished from the quenched gap, is to cause the "re-ignition" to continue for a longer time?

A. I would put it, if you do not mind, that with the quenched gap one can ordinarily use higher power, higher spark-frequencies and closer coupling than with the plain gap, still preventing "re-ignition" and the consequent substantial radiation of parasitic waves.

X Q. 80. Kindly answer my question as it is put.

A. I should have to disagree with it as it is stated, because of the impossibility of holding all conditions the same when one type of gap is substituted for another, and because the effect of "re-ignition" in producing parasitic waves depends more upon the number of times it occurs than upon the absolute time over which it continues.

X Q. 81. Do you not agree that, other conditions remaining the same, the effect of substituting a plain gap for a quenched gap would have the effect of causing the "re-ignition" to occur a greater number of times for each time the circuit is charged sufficiently to break down the spark-gap?

A. No, that is not an invariable rule such as could be accepted as a general statement covering all cases. That result would be had if the coupling and power conditions were such as to cause it, but otherwise not. I do not see how I can improve, as a general statement, my answer to X Q. 79.

X Q. 82. Do you agree that in Fig. 1, assuming the use of a plain gap, that in general the effect of a tight coupling is to send out two waves?

A. No. Whether or not reaction occurs that would produce the so-called "double hump" effect, will depend upon a number of factors you have not specified, including antenna-resistance, spark-gap condition, spark-frequency and power.

X Q. 83. What is the effect of the antenna-resistance?

A. An increase in antenna-resistance will reduce the power available to react upon the closed circuit, if there is a tendency for such reaction.

X Q. 84. Does the presence of resistance in a circuit change the time-period of the circuit?

A. It has a slight effect, as I think I have said, but in most radio apparatus the effect is so small that it is ordinarily neglected.

X Q. 85. The effect of the resistance is, in short, to cause loss of energy, is it not?

A. Resistance of a conductor causes conversion of the electrical energy passing into heat. Whether or not this [fol. 1488] is loss, depends upon the system being considered. In an antenna, for instance, an important component of the total resistance is the so-called "resistance equivalent of radiation" or, for short, "radiation-resistance". An increase of this component represents, in general, a gain in the transmitter efficiency, though it will produce the effect stated in my answer to X Q. 83, just as would any other increase in resistance.

X Q. 86. In answering X Q. 83 did you have in mind the ohmic resistance or the radiation resistance referred to in your last answer?

A. Both; I was referring to the total antenna resistance, which is what I thought was inquired about.

X Q. 87. In order to make your answer to X Q. 83 complete, would it not be proper to add that an increase in antenna-resistance would also reduce the power available to send out waves from the antenna?

A. No, for that would not be the fact. If the increase in total resistance were in the component represented by conductor-resistance, the antenna system as a whole would have a smaller radiation efficiency. On the other hand, if the increase in total antenna-resistance were in the component of radiation-resistance, the antenna system would have a greater radiation efficiency.

X Q. 88. In so far as the resistance comprises what you term "conductor-resistance", its effect is merely to cause

loss of energy both for transmission purposes and for reaction upon the closed circuit and is evidenced only by a flattened or broadened wave-form, is it not?

A. That is correct, unless by "merely" and "only" you mean to exclude other effects and evidences, such as the generation of heat. I assume that by "broadened wave-form" you mean a broadened resonance curve for the antenna system alone.

X Q. 89. What is the spark-gap condition to which you refer in your answer to X Q. 82?

A. That refers to the conditions which are affected by the size and shape of the spark-gap, the condition of the surfaces, its temperature, its ventilation, etc., that is to say, it is a generic term covering the design and operating conditions of the gap itself.

X Q. 90. Will you explain in what manner each of the factors which you enumerate in answer to X Q. 89 affect the matter of whether or not two waves are sent out?

A. Speaking generally, the smaller the electrodes, the smaller the flat areas in opposition, the less the mass of the electrodes, the rougher or dirtier the surfaces, the higher the gap temperature and the poorer its ventilation, the greater will be the tendency for re-ignition under conditions where re-ignition can take place.

X Q. 91. Assuming that you have a given spark-gap and other conditions remaining substantially the same, is it not true that the effect of loosening the coupling is, on the one hand, to tend to cause the double wave to disappear and only one wave to be transmitted and, on the other hand, to reduce the power of the set, *i. e.*, to cause loss of energy in the coupling?

A. The first part of your question is substantially correct, for I understand it to assume the existence of a substantial "double wave" under the initial conditions. With any spark-gap so operated as to show substantial parasitic waves, a loosening of the coupling will cause the frequencies of the two waves to approach each other, up [fol. 1489] to the point where the coupling is not too tight to prevent re-ignition. At that point the coupling-waves, so called, will substantially disappear and further loosening of the coupling will have little, if any, effect upon them. Change of coupling from too close a position, which I understand is the initial adjustment assumed by your question, to a looser value may either increase or decrease the

power radiated by the transmitter,—which way the power changes will depend upon the other factors I have referred to, including the type of gap, its ability to handle the power applied, etc.

X Q. 92. If in Fig. 1 of the Marconi patent the closed circuit is tuned independently to one periodicity and the antenna is independently tuned to the same periodicity and the two circuits are tightly coupled together, will the radiateded wave have the same periodicity?

A. Yes, unless the action of coupling some particular apparatus has the effect of changing the effective time-periods of the circuits. I am, of course, assuming that the power relations and the gap conditions are correct.

X Q. 93. In the case I have stated would not the period of the radiated wave differ from the period of the two circuits by a certain percentage?

A. No, not unless in the particular apparatus considered the circuit periods were changed by the coupling. As I have indicated, if the power and gap conditions were not proper, there might occur re-ignition which would result in at least some radiation of off-frequency waves.

X Q. 94. Have you any reason to suppose that the coupling would change the time-periods, as suggested by you in your answers to the last two questions?

A. Yes, that does occur in some cases. I have seen apparatus in which the placing of a secondary coil into coupling relation with a primary reduced the effective inductance of the primary, and consequently the period of the primary circuit, to a determinable extent.

X Q. 95. In my questions XQs. 92 and 93 I asked you to assume a tight coupling in Fig. 1 of the Marconi patent. With that understanding do you understand that the radiated-wave would have the same periodicity as that of the two circuits, or do you understand that the radiated-wave would differ from that of the two circuits by a certain percentage?

A. The radiated-wave, under the conditions I stated in answer to those two questions, would have the same periodicity as to the circuits. Any wave radiated from any antenna must have the frequency of the currents or oscillations flowing in that antenna.

X Q. 96. Do you consider that with the receiver of the Marconi patent No. 763,772 the tuning would be as good

if the closed circuit was tightly coupled to the antenna as it would be if it were loosely coupled?

A. No, for in general the selectivity of such a coupled receiving system increases as the coupling between the circuits is decreased, within practical limits.

X Q. 97. Referring to your answer to Q. 36, I understand you to say that in that instance de-tuning the antenna to the extent of say two per cent., would still utilize practically and just as effectively as before, the resonant transfer of energy; is this understanding correct?

[fol. 1490] A. Yes. My statement was "practically just as effectively as before" and applies to the hypothetical conditions set up in the question.

X Q. 98. If now, in this case, the closed primary circuit is tuned to a wave-length of 600 meters, would the radiated-wave be exactly the 600-meter wave, the antenna being de-tuned two per cent.?

A. I would expect the first part of each radiated-wave train to contain some energy at the frequency corresponding to 600 meters, some energy at some frequency depending upon the coupling and, perhaps, some energy at a frequency two per cent. different from that corresponding to 600 meters. In the latter part of each wave-train I would expect the radiation to be at a frequency some two per cent. different from that corresponding to 600 meters, for the conditions assumed were that "quenching action had been improved". This is a somewhat complicated case which, so far as I know, has not come within my practical experience, but general considerations of transmitter action point to the conclusion that the radiation would not be entirely of a single frequency. Nevertheless, the tuning of the two transmitter circuits together is sufficiently close, so that resonance would be of substantial assistance in transferring energy from one to the other. As I said in answer in Q. 36, I cannot understand how such de-tuning could improve the operation of the transmitter. My experience on this point agrees with the statement in the Seibt patent, to the effect that resonance between the circuits is essential for a rapid and complete transfer of energy and for good quenching.

X Q. 99. Would your answer to Q. 36 be the same if the antenna circuit were de-tuned say five per cent.?

A. It is impossible to state generally a numerical limit at which the benefit of resonant transfer is no longer had, for circumstances alter cases. I think it likely that at least in some transmitters a substantial advantage of resonant transfer would be had with the circuits de-tuned as much as five per cent., though it is difficult to say, because it is not a practical case and the operation of the transmitter would, in my experience, be tremendously improved, both as to quenching and radiated power, if the circuits were tuned more closely together. I would expect the radiation with a five per cent. de-tuning to be quite complex, if the apparatus were of the customary design.

X Q. 100. Are we to understand, however, that in any apparatus employing designs such as indicated in the various defendant's exhibits that de-tuning at two per cent. does not result in any diminution of the effective resonant transfer of energy?

A. No, I do not think that would be the fact in the practical apparatus. I believe that a two per cent. de-tuning would permit a fair resonant transfer, but that enough energy would be left in the closed circuit when reaction of the antenna commenced, to interfere with the proper quenching and, consequently, that the practical effect would be a spoiled spark-tone and probably a reduction of antenna power. If conditions could be had under which the two per cent. de-tuning resulted in improved quenching action (which is a condition quite outside my experience), I believe the operation would be practically as effective as before and that adequate resonant transfer of energy from primary to secondary would necessarily be had.

X Q. 101. Will you explain how the energy left in the [fol. 1491] closed circuit when reaction of the antenna commenced would, or could, interfere with the proper quenching?

A. One important function of any spark-gap is to "open" quickly, so as to prevent antenna energy from feeding back into the closed circuit. It is difficult, if not impossible, to design a spark-gap which, under service conditions, will retain its ability so to "open" unless the energy passing through it remains at a low or substantially zero value for a longer time than occurs during the powerful oscillatory swings of the charge immediately after the gap breaks down.

As Seibt shows, if the two circuits were tuned together, practically all of the primary circuit energy will be transferred to the antenna, and the gap will thus have adequate opportunity to "quench" or "open". If the circuits are not tuned to substantially the same frequency, the antenna power will start to react upon the closed circuit while the gap is still carrying the last few oscillations resulting from the first charge of the condenser. Thus, the time of zero or substantially zero power will not be sufficient to permit good quenching action.

* * * * * * *

X Q. 102. In your answer to Q. 6 you referred to "this so-called 'single chunk' method" in referring to the Lodge patent. I note that you quote the words "single chunk". From what source did you obtain this quotation?

A. From the question, *i. e.*, Q. 6. I don't know where the term originated.

X Q. 103. Do you find any such quotation in the Lodge patent?

A. No, as I recall the patent, that phrase does not appear. The phrases used by Lodge are in his claim 6, and I think in his specification, and are by "aerial disruption" and "impulsive rush". Looking at the Lodge patent I find the portion at page 2, lines 72 to 95, inclusive, bearing on this matter and specifying that the electric charge is to be supplied to the antenna "in as sudden a manner as possible."

X Q. 104. Do you find anything in the Lodge patent which states that after the gap h^{10}, h^{11} breaks down there will not be more than one swing of the current before the gap opens?

A. The specification does not go into detail as to the action of what is called (at page 2, line 48), the "starting-gap" h^{10}, h^{11}, but the tenor of the description beginning at page 2, line 72, is to the effect that the antenna is to be charged "with an impulsive rush" and "in as sudden a manner as possible". The only function stated for the starting-gap h^{10} seems to be that its spark "precipitates a discharge at the supply gaps h^6 h^7 and suddenly supplies the capacity h h' with electric charges, which then surge through the [fol. 1492] connecting coil h^4 (divided into two parts in this figure) and spark into each other at the discharge-gap between the knobs h^2 h^3." This states fairly definitely that the action of the supply-gap, initiated by the starting-gap,

is to place a single impulsive charge upon the antenna, which charge thereafter oscillates in the antenna or capacity area system to radiate waves. Thus the specification does not cover the point as to which you inquire with reference to the spark across the starting-gap h^{10} h^{11}, but is definite as to the single impulsive rush which charges the antenna system through the supply gaps h^6 h^7.

X Q. 105. Do you find anything in the Lodge specification indicating that upon the occurrence of this impulsive charging of the antenna there cannot be a few swings of the current in the charging circuit?

A. The patent does not state what happens in the circuit comprising k, j, j, h^{10} and h^{11}, so that if this is what you call the "charging circuit", my answer would be in the negative. On the other hand, if you mean to include the whole circuit which charges the antenna system through the supply-gaps h^6, h^7, I think it is quite clear that Lodge intended the capacity areas to receive their positive and negative charges in a sudden manner, rather than by metallic conduction from the induction coil secondary, as in the Marconi re-issued patent. This idea excludes oscillations in the supply circuit including the gaps h^6, h^7. It is referred to at page 2, lines 18, *et seq.*, in addition to the portions to which I referred above.

X Q. 106. You say in your answer to Q. 6 that Lodge did not propose to take the spark-gap out of the transmitting antenna. Do you not think that that statement is too broad, in view of the statement on page 2, line 87 that, "it is permissible in the arrangement of Figs. 3 and 4 to close this last gap when desired, etc.", the statement referring to the "knobs h^2, h^3"?

A. Perhaps so, though I have regarded that particular suggestion as of a fugitive type that would certainly be exceedingly difficult of realization. The Lodge transmitters, as the art knows them, invariably have a series antenna spark-gap.

X Q. 107. You refer to the Stone patent 714,831 and refer particularly to Figs. 5 to 7, inclusive. What specific element or elements of the Marconi claims do you find to be absent from these figures?

A. Without attempting to refer in detail to each of the Marconi claims, I can say that the drawings taken by themselves do not establish the vital difference between Stone's arrangement and Marconi's tuning invention. Stone did

not tune his closed and open circuits together to secure resonant transfer of energy from one to the other, nor to utilize the selectivity of the four circuits, two open and two closed. This fundamental distinction does not appear from a simple wiring diagram, unless it be implied by the showing of variable tuning elements (which do not appear in the Stone drawings). I would not consider the showing of adjustable tuning elements to be essential in all cases where tuned circuits are intended, however, and consequently think that the distinction between Stone and Marconi should not necessarily be made on that basis. Your question, I believe, limits me to the Stone drawings, and I have answered accordingly. In my direct examination I have attempted to make clear my reasons for believing that Stone patents, as filed, and up to a time after the date of the [fol. 1493] Marconi tuning invention, did not include Marconi's four-circuit tuning.

X Q. 108. I think you do not question that Stone, in his Figs 5 and 6, discloses that the transmitting and receiving stations, with substantially the same circuits, and assembled in the same way as in the Marconi tuning patent, save with respect to the manner of tuning those circuits. Is that substantially correct?

A. The circuits are not dissimilar in their fundamental components and their mechanical arrangement, but their electrical functions and performance are substantially different, by reason of the tuning feature introduced by Marconi and the detailed changes which that would require.

X Q. 109. Are not Stone's circuits substantially identical with that of Marconi, except in the matter of tuning and such results as may flow therefrom?

A. Yes, if by "substantially", you exclude such differences as the antenna loading coil of Marconi's Figs. 1 and 2, the shunt primary condenser of Fig. 2, etc. I am referring, as before, to Figs. 5 and 6 of Stone patent No. 714,831.

X Q. 110. In short, if Stone had tuned the antenna of his transmitting circuit, with or without an adjustable loading coil, to be resonant with his circuit S, I_1, L C, and had likewise made the antenna at his receiving station resonant with the circuit I_2, C', C L, his system would then have functioned, according to your understanding of the Marconi system; is that correct?

A. That is correct, as a brief statement, if by "antenna" at transmitter and at receiver, you mean the entire antenna circuit. It would do no good simply to use an antenna whose natural period, taken alone, agreed with the natural period of the associated closed circuit, and then to insert an inductance coil such as L_2 for associating the newly-formed antenna system with the closed circuit.

X Q. 111. But if he had included the coil L_2 in his antenna and then had adjusted the antenna as a whole, so that it would be resonant to the circuit C, S, L_1, L, then the system would have functioned as does the Marconi system?

A. Yes, if the tuned antenna system included the vertical wire V, the coil L_2 and the connection to the earth E, at transmitter and receiver, I believe the Marconi resonant transfer and tuning selectivity would have been had.

X Q. 112. You make no question, do you, but that Stone's circuit C, S, L_1, L, was a tuned circuit?

A. That is correct, that is to say, this was a circuit having a definite natural frequency which would be followed by free oscillations occurring in it.

X Q. 113. What governed the frequency of that circuit, or rather, what governed the selection of the frequency to which the circuit was tuned?

A. The frequency of natural oscillation in the circuit is determined primarily by the amount of inductance and capacity effective under the conditions of use, possibly modified to a small extent by the resistance of the circuit.

X Q. 114. Stone proposed to adjust the inductance L and capacity C of the circuit C, S, L_1, L so that the frequency of [fol. 1494] that circuit could be the frequency at which he desired the waves transmitted from the antenna to oscillate, did he not?

A. Yes, taking the inductance L to be the symbolic representation of the total inductance in the circuit (including the effect contributed by the coil L_1), and not merely the inductance of the coil marked L in Fig. 5 of Stone's patent, No. 714,831.

X Q. 115. There is on question in your mind, is there, but that Stone expected the waves which would be transmitted from the antenna to have the same frequency as the frequency to which the Circuit C, S, L_1, L was tuned?

A. That is correct. He proposed to force oscillations of this frequency upon the antenna system, and thereby to cause radiation of waves of the same frequency, uncompli-

cated by any tuning or natural oscillation of the antenna system.

X Q. 116. It is there, is it not, that you draw the distinction between Stone and Marconi; *i. e.*, that Stone proposed to force the oscillations from the circuit C, S, I_1, L upon the antenna, whereas Marconi would not force the oscillations from his corresponding circuit upon the antenna?

A. That is not quite a correct statement. The point is that the oscillations developed in the antenna by Stone's transmitter were to be forced without the benefit of resonant transfer and without utilizing the natural tendency of a tuned antenna system to oscillate sympathetically at the driving frequency, whereas Marconi's transmitter made practical use of this phenomenon of sympathetic resonance.

X Q. 117. Well do you say that Marconi did not intend to *force* the oscillations from the lateral or charging circuit upon the antenna?

A. That is correct, understanding the customary usage of that phrase as applied to the development of forced oscillations, *i. e.*, to working without the benefit of resonant transfer.

X Q. 118. Is it not fair to say that the substance of your last two answers is, in short, that in Stone the oscillations in the antenna are *forced* to the extent that the antenna is not tuned to the lateral or charging circuit, whereas in Marconi the antenna is tuned to the lateral circuit and to that extent the oscillations in the antenna coincide with the natural period of the antenna, and so are not *forced?*

A. Yes, that is a fair statement within practical limits, unless you are importing some special significance to the word "forced" which I don't understand.

X Q. 119. And if Stone's antenna were, in fact, tuned to the same frequency as his lateral or charging circuit, then the oscillations in his antenna would not be *forced?*

A. That is correct, speaking of the antenna system as a whole, and using "forced" in the customary sense. Of course, you realize that it has been proposed to analyze the oscillations resulting in any tuned circuit from the application of a practically synchronous driving force, into a "forced" component that rapidly dies away and a "free" component that builds-up and represents the final effective oscillation.

X Q. 120. I note that I have been referring to the Figs. 5 to 8 in Stone's patent 714,831. There is no question between us, is there, but that these figures are the same as the corresponding figures in Stone's patent 714,756?

A. I believe the four correspondingly numbered figures [fol. 1495] in the two patents are substantially, if not identically, the same. In the preceding questions, however, we have concentrated rather upon Figs. 5 and 6, and have not discussed Figs. 7 and 8.

X Q. 121. Now, still concentrating on Figs. 5 and 6, and referring more particularly to the receiving station, Fig. 6, may I assume that if Stone had, in fact, tuned his antenna system to the same frequency as that of the lateral circuit L_1, C', C, L, that then his receiving system would have functioned in the same manner as the receiver set forth in the Marconi patent?

A. That is substantially correct.

X Q. 122. May I assume that you make no question but that the lateral circuit L_1, C', C, L, was tuned to the same frequency as that of the wave which was to be received?

A. You may.

X Q. 123. And that frequency was the same as the frequency to which circuit C, S, L^1, L at the transmitting station was tuned?

A. That is my understanding.

X Q. 124. Is it your understanding that Stone deliberately detuned the antenna system at the receiving station, so that it would not be in tune with the wave which he expected to receive?

A. Yes, in line with his understanding that the simple or natural oscillation of the antenna system was not pure, and was therefore to be avoided in favor of forced oscillations for a highly selective system.

X Q. 125. To what extent do you understand he intended to detune the antenna at the receiving station?

A. To whatever extent was necessary, in order to avoid the effects he feared, and in general, even to the extent of providing a so-called "aperiodic" or untunable antenna system.

X Q. 126. Do you find in the Stone patent any direct statement to the effect that the antenna system is to be detuned, or the extent to which it shall be de-tuned?

A. Referring to patent 714,831, at page 2, beginning at line 15, Stone says:

"It is further the object of the present invention to enable the vertical or elevated conductor in such a system to be made the source of simple harmonic electromagnetic waves of any desired frequency independent of its length and other geometrical constants."

Noting that the matter which follows was added to the specification in 1902, I would point out that the emphasis upon the independence of the antenna constants is an instruction contrary to tuning of the antenna.

At page 3, beginning at line 6, Stone points out that in general the coupling together of tuned circuits results in a complex oscillation, which, on his premises, must be avoided in a selective system of the sort he proposes.

At page 3, beginning at line 33, he discusses natural vibrations of electrical systems as contrasted with "forced vibrations" which are "independent of the electromagnetic constants of the circuit" (lines 58 and 59), and goes on to show that the natural or tuned vibrations of an antenna system are "necessarily of a complex character" (page 3, [fol. 1496] line 81). He points out at line 91 a similar complexity of frequency in the natural oscillations of a receiving antenna system, which he points out introduce a defect in selectivity. He refers to the use of an aperiodic elevated conductor "adapted to receive or transmit *all* frequencies" in the text at page 3, lines 122 to 130, inclusive, which was inserted by amendment in 1902.

At page 4, beginning at line 42, he points out that for his selective system he causes the electric vibrations to be of a simple harmonic character "by producing what are substantially forced electric vibrations in the vertical conductor in lieu of producing natural vibrations" and thereafter he points out that he attains selectivity by interposing between the receiving antenna and the detector "a resonant circuit or circuits attuned to the particular frequency of the electromagnetic waves which it is desired to operate the translating devices."

Thus the broad instructions specifically direct the user to avoid natural or tuned oscillations in the antenna system, excepting in so far as that thought was introduced as an alternative by the matter inserted in 1902, to which I have already referred.

In his references to the figures at page 4, he points out that two frequencies may be transmitted from the same antenna

by the arrangement of Fig. 15, according to his system, and that waves of two frequencies may be received on a single antenna by the arrangement of Fig. 14. Alternative arrangements for this double use of the antenna system are shown in Figs. 15, 16 and 17, and obviously for proper results at frequencies which can be selected by the associated closed circuits, the antenna system must be detuned from both. At page 5, in describing the operation of the transmitter of Fig. 5, he points out that simple harmonic waves are produced by the forced vibrations in the antenna, and beginning at line 31 of page 5, he emphasizes the tuning effects of the closed circuit for selectivity.

In sum, the whole emphasis is upon the use of either a detuned or an aperiodic antenna system to avoid complex effects of multiple frequencies which Stone apparently conceived would interfere with the type of selectivity he sought. As I have pointed out, he later realized that "the vertical wire may with advantage be so constructed as to be highly resonant", and inserted such a statement in 1902, but the original disclosure is perfectly clear as to his intent to avoid any antenna tuning.

X Q. 127. Do you dispute the correctness of the matter stated in lines 6 to 32, inclusive, on page 3 of Stone patent 714,831?

A. This is a very general statement and, generally applied to some associations of simple circuits containing no spark-gap (such as shown in Stone's Fig. 1), the first part of it may be true. The specific numerical examples given refer to two conditions of coupling, by some unknown amount, of two circuits which initially had radically different natural periods. I know of no case in practical radio that corresponds to this complex situation. Whether or not Mr. Stone's figures are correct, would depend upon a number of conditions that he has not defined, though I have little doubt that it would be possible to assume some set of conditions which would lead, at least mathematically, to the figures which he gives. I disagree with his last statement, if it be read to imply the contemporaneous existence [fol. 1497] in any one circuit of more than one resultant current, though, of course, it is recognized that a complex current which is changing as to frequency or otherwise may, over a period of time, be analyzed into several com-

ponents which are not co-existent during briefer intervals, and if this is the interpretation to be given that passage, I can accept it. The general statement "the presence of each simple circuit modifies the natural period of each of the other circuits with which it is associated" is too broad to be true of all cases, for it depends upon many factors, including the way in which the circuits are coupled, whether or not either of them includes a spark-gap or other damping element, their relative resistances, etc. As an illustrative or explanatory comment applying theoretically to the association of simple circuits such as those shown in Fig. 1 of the Stone patent, and without complicating factors, it can be accepted as at least instructive, though necessarily not complete.

X Q. 128. Well, do you disagree with the general proposition in that part of the specification just referred to, that if two simple circuits, each like the circuit shown in Fig. 1, be tuned to have a natural period of its own when isolated, that when these circuits are inductively coupled, as indicated in Fig. 3, there will be an increase or decrease of the natural period of the two circuits?

A. Yes, I cannot accept that as a completely general proposition. For example, you will note that in the instance used by Mr. Stone to explain his theory, circuits with two different natural periods "when isolated" are given, and it is stated, beginning at line 25, that the inductive association of the circuits together has increased the natural period of the high-period circuit and decreased the natural period of the low-period circuit. It should be clear that such a teaching cannot be applied to a practical radio case in which the isolated or initial periods of the two circuits are the same, for there is then no "high-period circuit" to have its period increased, and no "low-period circuit" to have its period decreased. Both start alike, and the opposing tendencies discussed by Mr. Stone should result in no change, unless some other complicating factor were introduced. I have already pointed out, in answer to your earlier question, that if the coupling of two circuits having initially the same period resulted in a change of the effective self-inductance of either circuit, a corresponding change in period might be expected. This is, however, outside the case which Mr. Stone appears to be considering at this portion of his specification.

X Q. 129. In the case you mention, that is, where the initial frequencies of the two circuits are the same, then the coupling would, by reason of the reactive effect of one circuit upon the other, tend to give the wave-form a double hump, would it not?

A. I think you are referring to an effect upon the resonance-curve that may be drawn to illustrate the currents in two simple coupled circuits under some conditions, which will show a "double hump" or double frequency effect. If two simple circuits are coupled as in Fig. 3 of the Stone patent, and if the coupling is sufficiently close, a disturbance of one circuit may result in a natural oscillation of that circuit, part of the energy of which may be transferred resonantly through the inductive coupling to the second similarly tuned circuit. Under some conditions, the current in the driving circuit will be slightly reduced in frequency, while that in the driven circuit will be slightly [fol. 1498] increased, until the energy has substantially passed from circuit 1 to circuit 2. Then, still assuming the simple conditions of Fig. 3, the second circuit becomes the driving circuit and its oscillations may be correspondingly slowed down while it is retransferring the energy through the coupling back to the first circuit. During this interval, the first circuit, being one that is driven, may oscillate slightly faster than its normal frequency. Thus both circuits are the seat of alternately recurring currents whose frequency gradually shifts by a slight amount above and below the natural oscillating frequency, and some of the time they will oscillate at one value and some at the other. There is an intermediary condition in which they will both oscillate at the natural frequency. In such a simple case, uncomplicated by resistance effects, etc., the divergence between the driving and driven frequencies will ordinarily be negligible at moderately loose coupling but will become increasingly great up to the point where the two frequencies may be separately measured, as the coupling is increased.

X Q. 130. Do you agree with the correctness of the statement in the Stone patent 714,831 on page 5, beginning line 90, and ending in line 104?

A. That is an incomplete statement of part of the proposition which I set forth in my last answer, and in so far as it applies to the same conditions and re-states the same

matter in different words, I agree with it. You should note that in this specification, written a good many years ago, Mr. Stone has not drawn the limiting conditions as closely as I did in my preceding answer, nor as I believe he would draw them today.

X Q. 131. Do you agree that the addition of the inductance coils L, L in Figs. 5 and 6, as set forth on page 6, lines 46 to 61, is the same thing as saying that the antenna and lateral circuits at the transmitting and receiving stations are loosely coupled?

A. Yes, generally speaking that is correct. The effect of inserting a loading coil not coupled to the antenna is twofold, in that in general the time-period of the circuit is increased and the coupling to the associated circuit is decreased. Quantitatively the effects will vary with the constants of the particular case, but as a rule the effect will be to "loosen" the coupling of the circuits, even if not to make the coupling "loose" in any attempted absolute sense of that word.

X Q. 132. I take it that your view is that when Stone on page 6, lines 68 to 72, says that "the vertical wire may with advantage be so constructed as to be highly resonant to a particular frequency, and the harmonic vibrations impressed thereon be of that frequency" that he here means that only the wire and not the coil I_2 is to be of that frequency. Is that your view?

A. I think I pointed out the ambiguity of that particular statement by Mr. Stone near the end of my answer to Q. 23. The statement is a true statement as of 1902, when "vertical wire" is taken to refer to the entire radiating circuit, including the coupling coil and ground connection. It is not a true statement if taken to mean the wire alone. My view is that by 1902, Mr. Stone appreciated these facts and inserted the statement into his specification, to be read as an instruction that the entire antenna system might be tuned with advantage, this then being well known.

X Q. 133. That is, you understand the quotation which [fol. 1499] I have just made from the patent 714,831 to mean that the entire antenna system may with advantage be made resonant with the lateral circuit?

A. You are adding another element not here mentioned by Mr. Stone, namely, the "lateral circuit." My view is that the statement in the patent is ambiguous, but that if

read on the entire antenna circuit, is true, and by 1902 was known to be true; whereas, if read on the vertical wire alone, is not true, and by 1902 was known not to be true.

X Q. 134. And is it your view that prior to 1902, it would not have been known to be untrue unless it referred to the entire antenna system?

A. I am not sure that I understand your question, but my view is that prior to the date of Marconi's invention (some time prior to 1902), it was not recognized that an antenna system might, with advantage, be so constructed as to be highly resonant to a particular frequency and made part of a system in which that particular resonant frequency was impressed upon the antenna system (in a transmitter), or withdrawn from the antenna system (in a receiver) by resonance system. I doubt that anyone, either prior to 1902, or since, would seriously have pressed any advantage supposed to be attained by making a vertical wire, by itself, highly resonant, though, as Stone suggested, he might, in some cases, have wished to radiate waves having a frequency corresponding to the fundamental of the particular Marconi vertical wire antenna which some one of his transmitters was intended to replace.

X Q. 135. Is it your view that one reading the Stone letters of June 30, and July 15, 1899, would understand that his reference to making the fundamental of the wire at the receiving station to be the same as that of the wire of the transmitting station and his reference to the period of the impressed force being the same as that of the fundamental of the vertical wire, are intended to draw a distinction between the fundamental of the wire itself and that of the coil connected in circuit with the wire?

A. It is not a matter of a distinction between the fundamental of the wire itself and that of the coil connected in circuit with the wire, but rather a distinction between the fundamental of the wire itself as it would have been used according to the Marconi re-issue patent and the natural or tuned period of vibration of the entire antenna system, including the vertical wire, the coupling coil and the connection to the ground. My view is that the conclusion of an unprejudiced scientific reader would be that these two statements (referred to by you in the question), are not entirely clear when taken by themselves, but that the balance of the description contained in the two Stone letters

makes them clear and sets up the distinction that I have specified at the beginning of this answer.

X Q. 136. The Stone antenna system was composed of nothing but a wire and an interposed coil, was it not?

A. So far as one can judge from the diagrams in the letter dated June 30, 1899, the antenna system comprised a vertical wire, a serially-connected coil and a ground connection.

X Q. 137. The ground connection was a wire connecting the coils to ground, was it not?

A. That is correct, though, of course, sometimes copper strip or other conductors are used. I mention it simply [fol. 1500] because its constants must be considered in addition to those of the vertical or aerial wire, in tuning the antenna system as a whole.

X Q. 138. And the coil itself was a wire, was it not?

A. Yes, ordinarily, though strip conductors are also used frequently in coil design.

X Q. 139. So that the entire antenna consisted of a wire, and nothing but a wire, did it not?

A. Yes, as a matter of words, though the statement of the question contains an unsound implication.

X Q. 140. And your view that Stone did not intend to tune the antenna system to the lateral circuit is based upon your view that his reference to tuning the wire of the antenna, or making the fundamental of the antenna wire the same as that of the lateral circuit, meant that he only made the fundamental of that part of the wire outside of the coil to be the same as that of the lateral circuit. Is not that substantially correct?

A. No. I have tried to point out that the reference to the fundamental of the wire, taken as a matter of words by itself, is not clear. My conclusion that it refers to the vertical wire, and not to the antenna system as a whole, is based on the additional statements in the Stone letters, which emphasize the tuning of the closed circuit, that the simple oscillation of a vertical wire does not produce a pure wave, that in his arrangement the current developed in the wire is not due to the oscillatory discharge of the wire, and that the current is a forced oscillation, depending as to frequency only upon the impressing force, and not upon the electromagnetic constants of the circuit in which the currents are finally developed.

X Q. 141. I do not think that you quite apprehend my question. I am not asking you as to why you think Stone

did not tune his antenna system as a whole to the lateral circuit, but I am asking you if it is not a fact that your view that Stone did not intend to tune the antenna system to the lateral circuit is based on your understanding that Stone's reference to the fundamental of the antenna wire indicated only that part of the wire outside of the coil?

A. I think that those are both conclusions which are based upon the other statements in the Stone letters, and that neither conclusion is based upon the other.

X Q. 142. Well, I take it you will agree with me that if the reference in Stone's letters meant that he would make the fundamental of the antenna system as a whole the same as that of the lateral circuit, then he described a system such as you understand the Marconi system to be; will you agree with me that far?

A. Yes; based on your assumption, though I consider it inconsistent with the Stone letters.

X Q. 143. Well, will you go further, and agree with me that your view that Stone did not intend to tune the antenna system as a whole to the lateral circuit, is based upon your view that his reference to making the fundamental of the antenna wire the same as that of the frequency impressed upon it, meant only that he would make that part of the wire outside of the coil the same frequency as the frequency impressed upon it?

A. No, I have tried to say that I considered both to be conclusions and both based upon the balance of the Stone [fol. 1501] disclosure. It is true that they are co-ordinate conclusions, so to speak, and that they are consistent conclusions, but I think they support each other only to that extent. Both are based upon the emphasis on freedom from dependence of frequency upon antenna constants, etc., which I have already outlined.

Last Question by the Notary: Do you know of any other matter relative to this claim?

Answer: No, nothing occurs to me that would be pertinent.

Mr. Vaill: Counsel for claimant offers in evidence the following photographs of apparatus used by Mr. Wilson Aull, Jr., during his deposition, as included in his testimony given

in answer to questions 71 to 77, inclusive, and it is requested that said exhibits be marked respectively as follows:

* * * * * * *

"Claimant's Exhibit No. 315 (Ultra Audion Circuit and Two-Electrode Tube of Aull Question 74)":

* * * * * * *

"Claimant's Exhibit No. 317 (Crystal Acting as Oscillator of Aull Question 77)."

(Said exhibits so marked by Notary.)

It is stipulated and agreed by and between counsel for the respective parties that the above-mentioned "Claimant's Exhibits Nos. 313 to 317," inclusive, are photographs of the apparatus used by Mr. Wilson Aull, Jr., in his demonstrations referred to in answer to questions 71 to 77, inclusive, of his deposition, and correctly represent the arrangements of said apparatus; that said photographs were taken under his direction shortly after the making of said tests and demonstrations and that if said Wilson Aull, Jr., were recalled as a witness, he would so testify.

Edward W. Vaill, Of Counsel for Claimant; C. V. Edwards, Special Assistant to the Attorney-General.

[fol. 1502] *Deposition of Frank N. Waterman, recalled as a witness on behalf of the claimant in rebuttal, taken in New York, N. Y., on the 23rd day of December, A. D. 1927.*

First Interrogatory by the Notary: State your name, your occupation, your age and your place of residence; whether you have any, and if any, what interest direct or indirect, in the claim which is the subject of inquiry; and whether, and in what degree, your are related to the claimant.

Answer: My name is Frank N. Waterman; age, 62 years; residence, Summit, New Jersey; occupation, Consulting Engineer; I have no interest, direct or indirect, in the claim which is the subject of inquiry, and am not related in any way to the claimant.

Direct Examination.

By Mr. Vaill:

Q. 1 Are you the same Frank N. Waterman who has heretofore given a deposition on behalf of the claimant during its *prima facie* case?

A. I am.

Q. 2. Do you find that the specification of the Marconi tuning patent No. 763,772 provides or requires that the oscillations in the primary circuit of the Marconi transmitter be long-drawn-out or persistent for a long time, and that the specification includes "loose coupling" instead of "tight coupling"? Also please state whether or not you find that Mr. Marconi considered that his system required "loose coupling" in view of his address before the New York Electrical Society of April 17, 1912, as reported in the Transactions of the Society of November 15, 1912, pages 4 to 29, inclusive ("Defendant's Exhibit J-6"). In connection with your answer, please consider Mr. Loftin's testimony in answer to Q. 21, beginning at page 1017 of the Printed Record, his answer to Q. 22, beginning at page 1052 and his answer to Q. 27, as found on page 1068 of the Printed Record.

A. I do not. The facts are to the contrary.

I have read the testimony referred to and will give my reasons for disagreeing with the opinions expressed.

Mr. Marconi founded a wholly new art. The patent in suit constituted the second great step and so complete was it that the organization disclosed in the patent has been used in substantially all spark transmitters and been the basis of the receiving apparatus employed with such transmitters down to date.

There was no established language or terminology for this art; the patentee had to be his own lexicographer.

To understand the extraordinary novelty of the subject matter dealt with in the patent, it is necessary to bear in mind the fact that Marconi in his patent, which is re-issue 11,913, had disclosed a new phenomenon in the electric arts in general. In the ordinary practice of the electrical art a path for an electric current had to be closed. Current did not flow in an open circuit.

[fol. 1503] Marconi hung a vertical wire in the air, as disclosed in this earlier patent, and caused high-frequency currents to flow between the top of this wire and the earth.

In order to accomplish this, he interposed a spark-gap in the wire and put a charge on the upper insulated part of it, which surging across the spark-gap when the charge became great enough to break down the insulating quality of the gap, caused high-frequency oscillating currents to surge back and forth between the earth and the top of the wire.

This was an amazing phenomenon, and, still more amazing, he found that this wire caused electric waves to be radiated like invisible light from a lighthouse, which followed the surface of the earth.

To designate this circuit by reference to its electrical character, he called it a "radiating circuit" or a good radiator.

This arrangement established the art of wireless telegraphy, or, as we say today, radio. The receiving arrangement consisted of a similar vertical wire in which there was interposed a suitable detector. This wire converted the received waves into high-frequency electric currents. Because of their high frequency, an indicating instrument could not directly respond to them and the detector was employed to bring about a useful response to these received waves in a suitable indicating instrument.

While the invention of this earlier patent was of extreme utility, it had very marked limitations, and efforts were made to overcome or minimize these limitations. It was found that the presence of the spark-gap in the transmitting antenna and of the detector in the receiving antenna, were chief or important factors in causing the limitations. Efforts were accordingly made to get rid of these elements in the transmitting and receiving antennae.

Marconi solved the problem in the patent 763,772, inquired about. In doing so, Marconi recognized that he must avoid at the transmitting station, using two circuits, both of which were capable of radiation and at the receiving station he must avoid two circuits, both of which were capable of directly "picking up" the received waves.

Lodge, in his patent No. 609,154, which otherwise made a great contribution to the art, made the mistake in his Fig. 4, of getting a combination which afforded two radiating circuits. The arrangement was useless, therefore, and has never been employed.

Marconi, in the patent in suit, took the spark-gap out of the antenna and put it into a circuit which could oscil-

late, but could not radiate. He also took the detector out of the receiving antenna and put it into a local circuit which could oscillate, but could not directly "pick up" the received waves effectively.

To distinguish the local circuit into which he put the spark-gap from the radiating circuit which had the power of quickly giving up all its charge in the form of radiated waves, he called it a "persistent oscillator" and described it as being "a good conserver" in distinction from the elevated conductor which he described as being "a good radiator of wave energy."

Mr. Loftin has ignored this manifest meaning of the terms used, and by giving to the expression "persistent oscillator" a meaning out of harmony with all the language and purport of the patent, has built up a deposition which, according to my view, is without meaning or significance, and wholly out of harmony with all of the facts.

[fol. 1504] The distinction between Marconi's "good radiator" and his "persistent oscillator" is simple, intelligible and non-technical. The first gets rid of its energy by radiating it; the energy leaves the system completely and never comes back. The "persistent oscillator" if operating by itself, cannot get rid of its energy by radiating, but the charge imparted to the condenser must oscillate back and forth through the circuit until its energy frittered away in heat, due to the resistance in the circuit, much of which is in the spark-gap. In other words, by itself this circuit is a totally useless thing.

Marconi made the two circuits into a single structure of amazing utility, by "coupling" the two together so that the energy which was first stored in the local "persistent oscillator" circuit could be imparted to the antenna or "good radiator" circuit and he enabled the energy to be transferred from the first to the second circuit quickly and effectively by tuning the two circuits to the same wave-length, by making the product of the self-induction multiplied by the capacity, the same in each of the two circuits. Only by the tuning of the two circuits together in this manner can the energy be transferred quickly and efficiently from one circuit to the other.

The concept, which is fundamental to this invention, is that the local circuit can have a large condenser capacity for a given wave-length, as compared to that of the antenna which is relatively small. The amount of electrical energy,

that is, the size of the charge, that can be put into a given capacity, depends upon the electrical pressure or voltage that can be used to force the charge into it. This electrical pressure, however, has to be appropriate to the spark-gap. Because the capacity of the antenna of Marconi's prior arrangement of re-issue patent 11,913 was necessarily small for a given wave-length, the charge that the suitable spark-gap pressure could impart to it was small. By putting the spark-gap into a local circuit which could have a relatively large capacity included in it, the same spark-gap voltage or pressure was able to impart to the local circuit a correspondingly larger charge.

In other words, the local circuit being a good conserver, having a large capacity, was made by Marconi's arrangement to act as a reservoir for the energy which was to be subsequently radiated, and also it could contain such energy as was necessarily, that is, unavoidably, to be lost in the spark-gap and other unavoidable circuit-resistances.

In the art of transmitting power by wire, when two circuits were linked or coupled together for the purpose of transferring energy from one to the other, it was found necessary to have iron core transformers with the coils as intimately associated as possible, so that the coupling between them was the closest attainable and, in general, higher than ninety-nine per cent. The transformer, for example, whose coupling was as low as eighty-five per cent, would have been quite useless, except for very special purposes.

At the time of the Marconi patent in suit, the technique of this art was not developed to a high state. There were available few methods of measurement. In order to disclose his invention, Marconi was compelled to resort to practical examples of it and through these practical examples, he discloses the fact that he can efficiently transfer energy from one circuit to another by his method, with couplings between the two circuits of only twenty per cent, or less, [fol. 1505] and at the same time get efficient energy transfer, thus enabling the antenna to effectively receive and radiate the energy stored in the local circuit.

When these two circuits—the "persistent oscillator" and the "good radiator" circuits were tuned to the same wave-length, *i. e.*, product of inductance and capacity, and associated as disclosed in the Marconi patent in suit, the "good radiator" preserves its capacity of radiating, but in a

greatly improved form, due to the absence of the spark-gap; while the local "persistent oscillator" becomes endowed with the ability to quickly transfer its energy to the antenna.

Because the antenna no longer contains a spark-gap, it can be charged to a much higher voltage than the spark-gap could tolerate; because the energy is first accumulated in the local circuit, the energy can be handed over to the antenna circuit in a number of parcels, so to speak, by a number of current surges through the local circuit and thus the voltage of pressure in the antenna need not be too great for its insulation to withstand, even though the antenna radiates a total charge which, if imparted directly to it, would have made the voltage impracticably high.

In other words, such an elevated conductor as was disclosed in the early Marconi patent above referred to, had two limitations to the charge which could be imparted to it. One was due to the spark-gap, which could not have a very high voltage; the other was due to the insulation of the antenna and the insulating capacity of the air in which it was suspended and it, therefore, could not have too high a voltage, even if the spark-gap could have tolerated it.

Marconi solved both of these problems. The spark-gap problem he solved by putting the spark-gap in the local circuit, to which he gave a large capacity, so that it could store a large quantity of energy; the problem of getting sufficient energy into the antenna to produce a signal which would carry for a long distance, he solved by associating the local circuit with the antenna in tuned relation, so that the energy could be transferred in more than one swing or oscillation, and by using several oscillations to transfer it, it could pass to the antenna while the latter was radiating and thus the building up of an excessive voltage could be avoided.

As I have stated, the effectiveness of this method was so great that it came into substantially universal use, and has remained in use to this day, for substantially all spark-gap transmitters. I have read the testimony of Mr. Weagant and Mr. Hogan on this subject and agree fully therewith.

Mr. Loftin has based his entire deposition on this patent upon the assumption that the expression "a persistent oscillator" which the patent uses at page 1, line 38 and again at page 2, line 14, is to be understood with the signi-

ficance which he himself imposes, and entirely apart from the definitive significance of the patent itself, where it is obviously merely a term of contrast. What the patent clearly sets forth is that the open or antenna circuit is endowed with the unique property of radiating capability. In contrast to this the local circuit, by itself, is endowed only with the oscillating capacity.

It follows from this, of course, that each circuit necessarily oscillates—again considering each by itself—until its energy has disappeared. How long this will be, depends upon what electrical characteristics each circuit has, that is, upon the relations existing between the capacity of the circuit to receive a charge and its inertia and resistance [fol. 1506] elements, known respectively as the "inductance" and the "resistance." The resistance in the case of the antenna includes what is known as its "radiation resistance," this being a way of numerically expressing its capacity to get rid of energy in the form of electric waves.

How long the closed circuit would keep on oscillating until the charge got too small to continue to pass across the spark-gap, would depend, therefore, not upon any particular emphasis placed on the words of the patent, as Mr. Loftin seems to think, but upon the electrical characteristics of the circuit—still considering it by itself.

Aside from the description of function which the patent contains, and which is very clear, the patentee describes how to build a number of different arrangements to realize the invention. Mr. Marconi is evidently a very thorough and a very practical man, and the instructions which he gives show careful working out of the actual apparatus. From these instructions I was able, many years ago, to reconstruct and test the apparatus described, and did so for a number of the arrangements tabulated on page 4 of the patent, and I found them to work as described. To give an approximate idea of the behavior of the local circuits of these arrangements with respect to the number of oscillations, I have calculated the number of oscillations that might reasonably be expected in these circuits, that is to say, in the primary circuits of tunes 1 to 4 on page 4 of the patent, using the figures given in the table and my own actual measurements of the wave-lengths radiated. To do this it is necessary to know the equivalent resistance of the spark-gap, by which I mean that resistance which

would dissipate the same energy in the same number of oscillations.

Marconi, in the patent in suit, shows spark-electrodes in the form of spheres. Referring to page 185 of the work entitled "Principles of Electric Wave Telegraphy and Telephony," by J. A. Fleming, 1906 Edition, I find curves giving the resistance of spark-gaps between ball electrodes of iron, zinc or brass, and I have taken the data for zinc or brass as giving the lowest resistance and, hence, the largest number of oscillations. Using the length of spark-gap given by Marconi on page 4 of his patent, I find that the number of oscillations which these primary circuits would have, when not connected to the antenna, and assuming that the spark-gap would cut off the oscillations at ten per cent. (an arbitrary assumption commonly made), would be as follows: For tune 1, 12 oscillations; for tune 2, 5 oscillations; for tune 3, 15 oscillations; for tune 4, 5 oscillations. I produce a chart illustrating these oscillations. (Claimants Ex. 319.) These figures, of course, are only illustrative and they will vary with the nature of the spark-gap and the efficiency of the condensers and coils. I have assumed that all of the resistance is in the spark-gap (I may say that the same data regarding spark-gaps, just above referred to, is found on page 185 of the Edition of 1906).

When the two circuits are in operative relation to one another, then the energy from this closed or local circuit is not permitted to exhaust itself in the resistance of the circuit, and the energy is rapidly transferred to the antenna circuit, except in so far as some of it is consumed in the resistance of the primary circuit. It follows that since the spark-gap resistance remains the same the energy will have been imparted to the antenna in fewer oscillations than would occur in the primary circuit oscillating by itself. This is a universally recognized fact and I find that it is [fol. 1507] agreed to by Mr. Loftin in his testimony in this case.

We may find out how many oscillations would be required to transfer the energy of the primary circuit to the secondary, radiating circuit, by a formula which I find given by Prof. Morecroft on page 247 ("Claimant's Exhibit No. 321") of the work entitled "Principles of Radio Communication," published by John Wiley & Sons, Copyright 1921, provided that we know the couplings. While I have

actually measured these couplings, it was many years ago, and I am not now able to find the note-book in which the records were made. I have, however, a definite independent recollection of the first and the third tunes. The first was between ten and eleven per cent. and the third was between nineteen and twenty per cent. Adopting these figures, and using Prof. Morecroft's formula, just referred to, I find that the numbers of oscillations required to transfer all of the energy from the primary to the secondary circuit in tune 1 is five, and for tune 3, two and a half.

It will be seen, therefore, according to the Marconi patent in suit, the number of oscillations is not some indefinitely large number, as seems to be fancied by Mr. Loftin. It is a definite number, determinable from a knowledge of the coupling.

I have a definite recollection that in these tunes the range of coupling was from five to twenty per cent., substantially. It follows that the range of the number of oscillations in the Marconi patent as given by the numerical illustration, is from ten down to two and a half. This is not a matter of opinion, therefore, as to which Mr. Loftin may have one view, and I may have another; it is a matter of fact. So far as the illustrations of the patent go, the persistently-oscillating circuit referred to in the patent is one which, in association with its antenna, has from two and a half to ten oscillations, and in tunes three and one has respectively two and a half and five.

* * * * * * *

In the foregoing I have not referred to transmitter tunes 5 and 6, nor can I, because I have not the data. As to tune 5, it is possible to draw reliable inferences from the data given in the table on page 4 of the patent; noting that tune 5 uses the same transformer as tune 3, it is possible to roughly infer the wave-length from the capacities and to infer the coupling from the transformer. By this process of inference and by extending the curve of spark-gap resistance in the Fleming book above referred to, it appears that the number of oscillations in the closed circuit when not coupled to the antenna is of the order of five. Assuming that the coupling is of the same order as that of tune 3, [fol. 1508] then it appears that the number of oscillations in the primary circuit when coupled to the antenna is of the order of two and a half. With respect to tune 6, I note

that the transformer employed is transformer No. 3, described beginning at line 41, page 3. This transformer has ten turns in each of its two coils and they are wound one over the other. The coupling is therefore close, since there is no added inductance in the antenna, and all the inductance of the primary circuit is coupled to the antenna. I have no recollection of what this coupling was, as a matter of fact, but judging as a matter of experience, it is certainly closer than ten per cent. The number of oscillations in the primary circuit before the energy was all transferred to the antenna would be five or less.

From the foregoing it appears that Mr. Loftin's attempt to make the term "persistent oscillator" mean a circuit which, when coupled to the antenna, has very many oscillations in it, is unwarranted. It is unwarranted in view of the language of the patent. It is unwarranted in view of the descriptive contrast which Marconi was drawing between the two circuits which he proposed to associate, and it is explicitly excluded by the illustrative examples which Marconi gives of embodiments of his system.

Marconi discloses in the patent in suit an arrangement by which he associates a radiating circuit with a non-radiating circuit and he obtained an efficient transfer of energy from the non-radiating circuit to the radiating circuit by tuning the two circuits to resonance. Only by so tuning them could this quick transfer of energy be obtained. The mathematical demonstration by which Prof. Morecroft discusses the operation of the circuit includes the resonance of the two circuits, and by resonance he means the thing defined as such in the Marconi patent in the passage beginning at line 118, page 2, viz., that the product of the self-induction by the capacity is the same in each circuit. In stating the formula which I have above referred to, and which determines the number of oscillations required to transfer the energy, he says:

"If the two circuits are properly tuned all of the energy will have been transferred to circuit 2 in $\frac{1}{2}k$. cycles;"

Marconi, of course, was entitled to make the association of the two tuned circuits anything that he pleased. If the two circuits were respectively a closed circuit having little or no radiating capacity, and an open circuit having a radiating capacity, and if the two were tuned together, so that the product of inductance by capacity in one, was the same

as that in the other, and the spark-gap was in the closed circuit, then the arrangement would seem to be that disclosed by the patent, without regard to the coupling. The word "coupling" in this connection was not known at the date when the patent in suit was written. To disclose constructions such as he had in mind at the time he resorted to examples of operative arrangements, which he described in detail.

It is a remarkable fact that the range of coupling covered by these examples is, in fact, the range which continued commercial use of the apparatus since the date of the patent, has proven to be most desirable.

The matter of coupling is wholly a matter of degree; it expresses the extent to which the local reservoir circuit [fol. 1509] is loaded by its association with the antenna. In an absolute sense all coupling used in a radio circuit is loose coupling. It rarely exceeds the twenty per cent. which is the tightest or least loose coupling employed in the illustrations given by Marconi. The expressions "loose coupling" or "tight coupling" merely refer, when applied to radio circuits, to which half of this range given by Marconi, the coupling is in. If it is less than ten, it will often be found to be referred to as "loose"; if it is more than ten, it is sometimes referred to as "tight." But whether it is called "tight" or "loose" as applied to radio circuits, it is always extremely loose by comparison with what is used in circuits for wire-transmission of electricity, such as power and light circuits.

What particular coupling will be used in any given transmitter is a matter of choice with the constructor. If what he wants is efficient radiation of energy he will so choose his apparatus that when the energy has once been transferred to the antenna it will remain there to be radiated, and will not be transferred back to the local circuit to be wasted in the spark-gap and other circuit-resistances. Whether this will happen for given coupling and circuit proportions, depends upon the amount of energy to be radiated and the particular construction of the spark-gap. One cannot successfully send a boy to do a man's work in radio, any more than in any other line of endeavor. That is to say, a spark-gap which might successfully handle a given energy-charge, cannot be expected to handle equally successfully ten or twenty times that charge.

At the date of the Marconi patent in suit, the ordinary source of energy for charging the condenser c in the local circuit was a large spark-coil. The energy which it could supply was small. For that purpose the ball type of spark-gap could be used with considerable satisfaction, but in his earlier patent, re-issue 11,913 at page 2, line 7, Marconi pointed out that:

"If a very powerful source of electricity giving a very long spark be employed, it is preferable to divide the spark-gap between the central balls of the smaller oscillator into several smaller gaps in series."

As the art has developed, larger and larger quantities of power have been demanded and constant effort in devising spark gaps able to handle larger quantities of energy have been exerted. In these constructions cooling is of paramount importance and if a gap is properly cooled, the energy, when once transferred to the antenna, is not returned to the local circuit, and the phenomena that occur are such as are illustrated in my sketch called "Waterman Sketch No. 2" found opposite page 151 of the printed record. No form of spark-gap that I am acquainted with will give this most desirable type of operation if it is over-loaded by using too much power on the circuit or coupling it too tight to the antenna. The ball type shown in the Marconi patent, the series of balls referred to in the re-issue patent, as just above noted, the rotating gap and the parallel plate type of gap in the form of the so-called quenched gap, or otherwise, will all give this type of operation of my "Sketch No. 2", when operated within their proper loads.

Mr. Loftin's testimony differs from mine on this subject, because he insists on imposing on the Marconi patent [fol. 1510] conditions which do not exist, save in his own imagination, and because of a number of misconceptions on his part.

Mr. Loftin imposes upon the Marconi patent a condition which he calls "cumulative resonance"; I refer, for example, to page 1023 of his deposition in the printed record. Because he insists on defining resonance in a way in which it is not defined in the patent, he draws numerous unwarranted conclusions and inferences. He states, for example, that if the two circuits of the patent are so coupled that they re-act on one another, then they do not have this cumulative resonance and, hence, are not within the Marconi

patent, as he interprets it. He forgets that in order to transfer energy from one to the other effectively, as pointed out in the patent, they must re-act on one another. Marconi has definitely arranged them to transfer energy rapidly and efficiently.

Marconi has stated in explicit terms what he means by having the circuits in resonance. He means that the product of inductance by capacity shall be the same for the two circuits (page 2, line 118). There is no warrant in the patent for Mr. Loftin's restrictive limitation to what he calls "cumulative resonance".

Another restriction which he insists on placing upon the patent is that the lateral circuit must produce oscillations which are transferred "without change in characteristics" to the antenna. This is an entirely meaningless expression which is not contained in the Marconi patent. Mr. Loftin's idea seems to be that Marconi made the radiated oscillations more persistent by the use of what Mr. Loftin calls a persistently oscillating circuit. He seems to think that the persistency which he imagines for this circuit is in some way imparted to the antenna. Of course, everyone familiar with the art knows that nothing of the sort happens. Marconi obtained greater persistence of oscillations from the antenna by taking the spark-gap out of the antenna and by the use of the Lodge loading coil. The art has followed in his footsteps and done the same thing.

Mr. Loftin appears to be of the impression that because the circuits are in resonance, therefore the energy cannot be transferred quickly from one circuit to the other. This is exactly the reverse of truth. It is because they are in resonance that the energy can be, and is, transferred extremely quickly, as, for example, in from two and a half to ten oscillations in the illustrative examples given in the patent. In this connection I call attention to the fact that the number of oscillations which might occur in the local circuit by itself has very little to do with the number that will occur before the entire energy has been transferred to the antenna when the two are coupled together. For example, in tune 3, the local or persistent oscillator circuit has fifteen oscillations as shown in my diagram produced in this answer. When coupled to the antenna, however, in the manner described, and as found by test, there are only two and a half oscillations before all the energy has been transferred to the antenna. The coupling was shown by test to

be about twenty per cent., and this means, as I have pointed out, that two and one-half oscillations are all that are required for the transfer of the energy.

The question refers to "Defendant's Exhibit J-6", referred to by Mr. Loftin beginning at P. R., page 1068. Mr. Loftin prefaces his reference to this address by Mr. Marconi with the statement that "there can be no resonance without a coupling condition that will permit of but one [fol. 1511] frequency to which the circuits can be resonated". He then continues with a reference to the Marconi lecture and states that his views are confirmed by a quotation which he makes from that address. The statement made by Mr. Loftin strikes me as nonsense, but whatever he meant by it, it is not warranted by the patent, nor by Mr. Marconi's address, and certainly not by the statement which he quotes from the latter. This statement is as follows:

"These two circuits are tuned so as to have approximately the same natural period of electrical oscillation. They then—like tuning forks—have been adjusted in syntony. It is well known that when using an ordinary spark discharge in the primary circuit, unless weak coupling is employed, the oscillations set up in one circuit create oscillations of two frequencies in both circuits. This has the disadvantage that the radiated energy becomes divided between two waves of different length, and if the receiver is tuned to only one of these wave lengths, it will utilize or absorb only part of the energy reaching the receiver—the energy of the other wave being lost."

This quotation in no way confirms Mr. Loftin's statement above quoted, nor does it in any way affect the meaning of the patent in suit nor limit it to Mr. Loftin's special definition of "cumulative resonance". Mr. Loftin's conclusions, found on P. R., page 1068, following the quotation which he makes, are both erroneous and unwarranted. In the quoted passage Marconi was briefly recounting the characteristics of coupled tuned circuits, electrically speaking, preparatory to discussing improvements in spark-gaps, and in the very next sentence he points out that he had developed a spark-gap which was capable of opening the circuit of the persistent oscillator and preventing any retransfer of energy, even with the enormous powers required for his long distance or trans-oceanic transmitters. He also

refers to the Wien spark-gap or so-called quenched spark gap, but this very gap operates with couplings within the range of the examples given in the patent in suit. Mr. Marconi did not state that the circuits were not in resonance if the spark-gap did not prevent the re-transfer of energy, as Mr. Loftin assumes. On the contrary, he stated that they were in resonance. His statement merely says that if the spark is not extinguished when all the energy has been transferred to the antenna, the most desirable conditions for reception are not attained. On what basis of reasoning Mr. Loftin can argue that this statement constitutes a limitation of the meaning of the patent in suit, I am unable to see. It has nothing whatever to do with the meaning of the patent. Clearly, if the circuits are in resonance, and of the character described in the patent, the arrangement is within the patent, whether the spark gap behaves in the best possible manner or not. There is no spark-gap which will not operate badly if over-loaded, so far as I know, and neither the spark-balls of the patent nor any of the improvements thereon, will operate in the most desirable manner if improperly loaded. It has been found in practice that in general, the better the cooling, the less loose the limiting coupling for effective operation can be, but substantially all of the coupiings used in practice, so far as I know, have been substantially those indicated by the illustrative examples in the Marconi patent in suit. The patent is re-[fol. 1512] markable in that it discloses substantially the arrangement which years of subsequent practice have shown to be best suited to the purpose. The only improvements which have been made in this transmitter, aside from mere details of convenience, have been in spark-gaps capable of opening the local circuit at the end of the energy-transfer period with increasingly greater quantities of energy. In other words, by improvements in spark-gaps, larger and larger transmitters were made possible.

Mr. Vaill: Counsel for claimant offers in evidence the drawing produced by the witness in connection with his last answer, and requests that the same be marked "Claimant's Exhibit No. 319".

(The Notary marks said exhibit as requested.)

Q. 3. Will you please consider your answer to Q. 7 of your *prima facie* deposition, as found on page 147 of the

Printed Record, regarding the number of oscillations represented in the table on page 4 of the Marconi patent No. 763,772, and state in what respect, if any, you may desire to explain your testimony, in view of Mr. Loftin's criticism thereof, as found in his answer to Q. 22 (P. R., pp. 1054-5).

A. The next to the last paragraph on P. R., p. 147, is certainly not correct. It states that "the circuit if oscillating by itself, would have three complete oscillations—if the current continues to oscillate until it fell 1 per cent. of its original value." It would not require three oscillations to cause a fall of one per cent. There is clearly a typographical error in this paragraph and possibly, also an error of calculation.

The words "until it fell 1 per cent of its original value" should have read "until it fell to ten per cent. of its original value". I do not make this statement as a matter of recollection, because I do not remember, after the long interval which has elapsed, just what I did say, but I make it because I do know that my custom at that time and since, in dealing with spark-gap circuits, was, and has been to consider ten per cent. as the limit to which the oscillations might be considered as falling in a spark-gap circuit. Understanding this correction to be made, the statement that three complete oscillations would be required, is an incorrect statement. The word "three" should be changed to "twelve" The clause would then read as follows:

"I find that assuming the resistance of the spark-gap to be 1 ohm, the circuit if oscillating by itself, would have twelve complete oscillations—if the current continued to oscillate until it fell to ten per cent. of its original value."

As I pointed out in my last answer, and as is admitted by Mr. Loftin, this is not the number of oscillations which would occur when the circuit is coupled to the antenna. When so coupled, the number of oscillations will be less, because the circuit is then loaded by its association with the radiating antenna.

As noted in my last answer, it will be five oscillations under the conditions of construction specified for tune 1 in the Marconi patent in suit.

* * * * * * *

[fol. 1513] I note that Mr. Loftin criticizes the value of the spark gap resistance which I used in this calculation.

I disagree with his criticism and think that a value of one ohm for the resistance of the entire circuit was low, rather than high. I took my value from the curves published by J. A. Fleming, found, for example, on page 185 of the 1906 Edition, using the value for the spark-gap length given in the table on page 4 of the patent in suit.

I note that Mr. Loftin refers to the Zenneck book translated by Selig, entitled "Wireless Telegraphy," and particularly to Figure 21 on page 19 thereof. Mr. Loftin probably overlooked the fact that this set of curves is only given by Zenneck to show the unreliability of the method of measurement used, hence, it can hardly be entitled to great weight.

I note that the formula given by Prof. Morecroft for the number of oscillations required to transfer the entire energy from the persistent oscillator to the good radiator does not depend upon spark-gap resistance. This number, which is five complete oscillations for tune 1 under consideration is, therefore, not subject to any uncertainty, such as Mr. Loftin thinks exists in the choice of spark-gap resistance, when the circuit is not associated with the antenna.

Q. 4. Will you please consider "Loftin Sketch K" (P. R., p. 1057), and his testimony relative thereto in answer to Q. 23 of his deposition (P. R., p. 1056), particularly his alleged correction of your "Sketch No. 2" which is included in Mr. Loftin's "Sketch K"; and also Mr. Loftin's answer to Q. 24 of his deposition (P. R., pp. 1058-60), in which he further criticizes your testimony as relates to your "Sketch No. 2," and particularly as concerns the question of coupling referred to in your *prima facie* deposition (P. R., pp. 152-3), and state whether or not Mr. Loftin's treatment of your sketch and your testimony relative thereto has changed your opinion regarding the same, giving your reasons therefore?

A. It has not. As to most of the statement referred to, the fact is simply that Mr. Loftin is wrong, while as to the second matter referred to in the question, his answer is based on a misquotation.

In considering his "Sketch K," the upper portion of which is my "Sketch No. 2" and the lower one of which is Mr. Loftin's supposed correction thereof, Mr. Loftin makes a number of errors. For example, he seems to assume that such sketches are quantitative and in addition to this error he has failed to note that in my sketch I illus-

trated the charge as determined by the voltage across the condenser, whereas he illustrates the current flow.

Mr. Loftin's first criticism is that my "Sketch No. 2" shows "far too few" oscillations to represent the interpretation which he has chosen to put on the closed or persistent oscillator circuit of the Marconi patent in suit. What Mr. Loftin ignores, and apparently does not know, is the fact that what will happen in the circuits that Mr. [fol. 1514] Marconi put together is determined by the laws of nature, and not by Mr. Loftin's opinion as to the meaning of the language of the patent. The language of the patent, in my opinion, is not open to any such interpretation as Mr. Loftin puts upon it, but is entirely in harmony with the laws of nature which apply.

Having tested the apparatus disclosed in the patent, I know that the laws of nature determine definitely that in those illustrative examples the number of oscillations required to transfer the energy to the antenna, as shown in my "Sketch No. 2," varies from two and a half to ten. My "Sketch No. 2"—which was entirely illustrative, and not intended to represent a particular case, shows four oscillations in the primary circuit, which is certainly well within the range of the illustrations given by Marconi. Mr. Loftin's amendment to the sketch shows about fourteen oscillations in the primary circuit, which is outside the range of the illustrations contained in the patent.

In my opinion, this matter has nothing to do with the presence or absence of the Marconi invention. An arrangement giving either result would be within the patent. An arrangement would also be within the patent which gave fewer primary oscillations, and it would also be within the patent if it gave more oscillations in the primary circuit. The whole matter is immaterial. It is of no consequence one way or the other.

In my opinion, it is also immaterial whether or not the spark gap cuts off when the energy has been transferred, or whether it fails to cut off and permits some re-transfer. The latter is certainly not ordinarily desirable, although it may be in special cases. I am unable to see that the precise performance of the spark-gap, in other words, has anything whatever to do with the presence or absence of the Marconi invention.

The figures which I have given, based on Prof. Morecroft's equation, represent the maximum number of oscil-

lations required to transfer the energy. If the spark-gap works effectively, the number actually occurring may be less; in this case not all of the energy will be transferred. Mr. Loftin makes the mistake of thinking that resonance between the primary and secondary circuits requires slow transfer. Exactly the reverse is the case. It permits enormously rapid transfer; a rapidity which can be obtained in no other way. Mr. Loftin has apparently confused the action of a resonant receiving system gradually building up energy received from a far-distant transmitter. But resonance has no such limitation; it is the means by which the quickest possible transfer can be obtained.

Mr. Loftin labors under the erroneous impression that in the Marconi arrangement the primary persistent oscillator, or non-radiating circuit, must be the means which determines the duration of oscillation emitted by the antenna. He is entirely mistaken; the primary circuit has nothing whatver to do with the number of oscillations emitted by the antenna; this number is determined by the construction of the antenna and by the magnitude of the coil *a* inserted in it.

Mr. Loftin's next mistake is the assumption that "Sketch No. 2" was intended to be quantitative. He is mistaken. I used the conventional form of illustration which, so far as I know, is never quantitative.

Mr. Loftin says that the oscillations marked (*b*) are much too great in height and that such a result could not be obtained, even with one hundred per cent. coupling. He [fol. 1515] is mistaken. My sketch illustrates oscillating charges as measured by the voltage. If the sketch had intended to be quantitative it should illustrate antenna voltage, and be very much larger than I have shown it and not smaller, as Mr. Loftin assumed. This is easy to see from the following fact: if the same charge were imparted to the antenna by some imaginary extraneous means as is imparted to the condenser of the primary circuit, the voltages produced would be in the ratio of the capacity. The capacity of the antenna might be say .0002; the capacity given for the primary circuit is approximately .007. The voltage on the antenna would then be thirty-five times that on the primary circuit and to illustrate such a condition my curve (*b*) should be thirty-five times the height of my curve (a). This condition, of course, would not exist for two reasons, first, because all the time that the energy is

being transferred from Marconi's closed circuit to his antenna circuit; the antenna is radiating energy and, second, because some of the original charge put into the primary circuit is lost in the spark-gap. To represent the facts quantitatively, however, it is clear that my sketch (*b*), which Mr. Loftin criticizes, should be much higher; that is, should show much higher oscillations than it does and not much less, as Mr. Loftin asserts.

Instead of illustrating a coupling of the order of one hundred per cent., as Mr. Loftin alleges, my sketch illustrates a coupling of the order of eight or ten per cent. To assert the contrary, as Mr. Loftin does, displays either sheer ignorance or a disregard of the facts. The coupling can be directly obtained by taking the reciprocal of twice the number of complete oscillations in which the energy falls to zero in the primary circuit.

Mr. Loftin next accuses me of suppressing the alleged fact that with the very tight coupling which he erroneously imagines will exist, two oscillations would exist. He is wrong again. Mr. Loftin seems to have the erroneous impression that the current in a circuit can be going in two directions at once. Mr. Weagant has clearly pointed out Mr. Loftin's error in this regard, as found in Loftin Sketches G and H, "Defendant's Exhibits O-2 and P-2."

With a coupling of eight to ten per cent. there are not necessarily two frequencies, and my "Sketch No. 2" should not necessarily have shown any waxing or waning of the curves to illustrate that condition. So far from suppressing anything, I fully and clearly pointed out, as, for example, on P. R., p. 152 of my former deposition, that for best results the coupling must not be tighter than will permit the spark-gap to open the primary circuit when the energy has been transferred to the antenna.

From the point of view of the Marconi invention, however, I fail to see that it is of any consequence whether there is, or is not, a coupling somewhat tighter than that required to give best results or, indeed, somewhat looser. The Marconi patent is not a patent for a particular degree of coupling, it is a patent disclosing the association of a non-radiating circuit with a radiating circuit, and the transfer of energy from the first to the second by the principle of resonance. It is capable under the condition illustrated in my "Sketch No. 2" of giving the result there illustrated and I fail to see that it is of the slightest consequence

whether someone uses it with a spark-gap which will give a less efficient result.

[fol. 1516] Mr. Loftin further criticizes the sketch because he says it is typical of that usually found "illustrative of the action of the quenched-gap type of transmitter." I fail to see that this is a basis of criticism. If I understand what Mr. Loftin refers to, it is simply one well-known form of the Marconi invention. Substituting one particular construction of spark-gap for another certainly does not take the construction outside of the description of the Marconi patent, particularly when it does not alter the mode of operation, but simply realizes the result with greater reliability. Indeed, it is going too far to say that it does realize the result with greater reliability than does the rotary gap, for instance. According to my understanding, improving the spark-gap so that it will carry greater energy or attain the desired result with less attention, is only the normal and expected result of extensive use and experience with the invention.

Regarding the second reference in the question, viz., that to Q. 24 of Mr. Loftin's deposition, the fact is simply that the answer misquotes what I said, and it may be that he was misled. He does not put the statement in quotation marks, but represents me as saying "that the coupling cannot be too close if the results indicated in the Sketch No. 2 are to be attained." What I said was "the association, or as it is called at the present time the coupling of the two circuits, must not be too close if the best results and the precise results indicated in Waterman Sketch No. 2 are to be obtained."

Mr. Loftin proceeds to state that I have not shown what he calls "loose coupling" but rather what he calls "tight coupling."

I have already pointed out that these terms have no absolute meaning, since all couplings used in radio transmitters of this type are loose. As a matter of fact, Mr. Loftin himself has defined a loose coupling on P. R., p. 1024, as folllows:

"It is common to say that if the two circuits are so loosely interlinked as to create no apparent two frequencies from a practical point of view, that the circuits are 'loosely coupled'."

My "Sketch No. 2" shows only one frequency, because there are no undulations of strength of the waves and, therefore, it shows loose coupling according to Mr. Loftin's own definition. Furthermore, the coupling which is deducible directly from it seems to be eight to ten per cent., which is "loose" according to any definition that I find in Mr. Loftin's testimony. A quenched spark-gap transmitter, such as he frequently refers to, also gives but one frequency and hence, by his own definition, is also "loosely coupled." Mr. Loftin seems to think that if any transmitter does show undulations in the radiated wave-strength, then it is not within the Marconi invention. Any type of gap will give this result if the circuits are too closely coupled, for the particular construction of the gap, whether the gap be what he calls a quenched-gap, or not. My own opinion would be that such a transmitter, without regard to the gap construction, simply did not illustrate the Marconi invention in the best form; whereas, my "Sketch No. 2" does illustrate it in its best form, without regard to the type of gap. What may, or may not, be within the patent in a legal sense, I, of course, do not undertake to say, as I understand that is a matter for the Court alone.

I note that on page 1059 of the Printed Record, Md. Loftin says:

[fol. 1517] "As a matter of fact, the cessation of oscillations in the primary circuit is not determined by the association of the two circuits, but upon spark-gap conditions. * * *"

This is misleading. The maximum number of oscillations in which the energy will be transferred from the primary to the secondary circuit is determined solely "by the association of the two circuits," if they are in tune with one another, as described by the Marconi patent. If they are not in tune, a greater number will be required. All that the spark-gap can do, so long as there is no re-transfer of energy, is to make the number of oscillations less than that determined by the association of the circuits. For instance, in my "Sketch No. 2," as described in my deposition, the spark-gap is illustrated as requiring a voltage indicated by the dotted line x at the time when the oscillations have fallen as indicated in (a). The spark-gap, therefore, is shown as having opened the circuit just before all the energy is transferred.

Mr. Loftin is wrong when he states that no open or plain gap will give the result indicated in "Sketch No. 2." It will, as I know from experience. It is also true, as I have stated, that it will require much more care in the construction and operation of the gap to attain that result than would be the case with a quenched gap, so-called.

Further on in his answer to Q. 24, Mr. Loftin states that: "The quick transfer of energy and early cut off illustrated by Mr. Waterman takes away from the primary circuit all ability to create oscillatins of the desired frequency." This is an incorect statement from several points of view. It is based, like many other statements which he makes, upon an assumption on his part, that the words "a means which automatically causes oscillations of the desired frequency," refers to the primary circuit as a whole. I find no warrant in the patent for any such view. On the contrary, the condenser c in the primary circuit is said to discharge through this means and this precludes any such meaning. Furthermore, the specification definitely defines what it means at page 1, line 43, where it says "a producer of Hertzian oscillations or electric waves shown in the form of a spark-producer."

The local or primary circuit has nothing whatever to do, except to store energy until the spark-gap goes into operation. The instant this occurs oscillations are produced, and energy is transferred to the antenna circuit. Since the two circuits are in tune of resonance, as described in the patent in suit, the oscillations which the spark-gap sets up will be of the desired frequency, and energy will be rapidly and efficiently transferred to the antenna circuit, at which time the spark-gap will go out of action and the energy accumulated in the antenna will continue to be radiated. An effective gap, that is to say, a spark-gap working in the most desirable fashion, will cut off by or before the time when all the energy has been transferred to the antenna. The antenna begins to radiate as soon as the spark starts and it continues not only till the spark ends, but until long afterwards. Just how long afterwards depends upon the construction of the antenna and the localized inductance which it contains. The spark-gap thus acts to set up or cause oscillations of the desired frequency, and the language of the patent is quite correct. Also, my "Sketch No. 2" is not in conflict with this or any other statement of the patent,

but was intended to be, and is, entirely in harmony therewith.

[fol. 1518] Mr. Vaill: Counsel for claimant offers in evidence a photostat copy of page 185 of Fleming book entitled "The Principles of Electric Wave Telegraphy," 1906 Edition, and requests that the same be marked "Claimant's Exhibit No. 320."

Also a photostat copy of page 247 of a book by J. H. Morecroft, entitled "Principles of Radio Communication," 1921 Edition, and requests that the same be marked "Claimant's Exhibit No. 321."

(The Notary marks said exhibits as requested.)

Q. 5. Please consider the paragraph quoted by Mr. Loftin from printed page 153 of your prior deposition, and found on page 1060 of Mr. Loftin's deposition and state whether or not Mr. Loftin's comments on your testimony has tended to change your views with respect to precise tuning or adjustment of the circuits under the Marconi tuning patent 763,772, giving your reasons for your answer.

A. What Mr. Loftin says in no way alters my opinion, for what he says is substantially wholly erroneous; and, furthermore, it apparently is not consistent with itself. Of course, it would be a mere commonplace to point out that nothing can be precise in a rigid sense. Everyone knows that. Mr. Loftin, in fact, does not seem to insist upon it, yet the reasons which he thinks afford a basis for his differing opinion would require absolute precision.

Mr. Weagant has correctly stated the facts in this regard. They are, briefly, that a spark-gap circuit tunes broadly; that is to say, it is impossible to tell with any approach to absolute precision when it is in mathematically perfect resonance. A considerable variation, as, for example, one or two per cent either way, makes no detectable difference in the result, and ordinarily cannot be detected. Mr. Loftin is laboring under an erroneous impression in his reference to forced and natural oscillations. As Mr. Weagant has pointed out, Mr. Loftin's testimony, and some of his diagrams, as for example, Figs. 2 and 2*a*, of Sketch G, and Fig. 4*a* of Sketch H, are based upon a curious notion wholly erroneous, that current can flow simultaneously in two directions in the same circuit. No such operation is possible, and all of the numerous statements which Mr. Loftin

has based on that concept, are incorrect. As I know, from my own use of the apparatus of the Marconi patent and many tests thereon, it is exactly correct to say as I did, that "No mathematically exact or precise equality between the circuits is realizable in practice" and also it is correct to say as I also did, that "it is important to the efficient transfer of energy that this equality should be approximately or substantially attained." I agree with Mr. Loftin that the apparatus illustrated by Mr. Marconi is "capable of the desired precision of adjustment," but no absolutely precise adjustment is desired. It is neither necessary nor attainable, nor would it add to the practical utility.

Q. 6. Please refer to Mr. Loftin's answer to Q. 26 of his deposition (P. R., p. 1062), wherein he criticizes your "Sketch No. 3," opposite page 155 of the printed record, on which page you refer to a sketch in your prior deposition, and state whether, in your opinion Mr. Loftin's criticisms are justified by the specification or drawings of the Marconi patent in suit, No. 763,772.

A. Mr. Loftin's criticisms are not justified. I was referring to, and in my sketch "Plaintiff's Exhibit 99" (opposite [fol. 1519] P. R., p. 157), I showed the connections described in the Marconi patent by reference to Fig. 2, and the particular embodiments thereof in the table on page 4 of Marconi patent in suit. As I stated, and as is, in fact, stated on the sketch itself, my "Sketch No. 3" is a mere simplification of Fig. 2 of the patent. Functionally the apparatus of the patent is not altered in any way.

All of the testimony which I gave was based upon the drawings of the patent, of which "Sketch No. 3" was a mere simplified illustration. Mr. Loftin states that I changed the position of the condenser j^3, which I also stated. He says there is no justification in the Marconi figure or specification for this change. If he means that there is no instruction in the patent to make the change he is, of course, correct; but if he means that it makes any practical difference, he is wrong. He states that in the position shown the condenser j^3 "has its share in affecting the product of inductance and capacity of the circuit," whereas he says that my "Sketch No. 3" is effectively removed from the circuit. To show how trivial a matter this would be, I refer to tune 2 on page 4 of the patent, where the condenser h' is given as .00004. The value for the condenser j^3 is not

given, because it is quite immaterial. .004 is commonly used and sometimes .002. Taking the latter figure as being most unfavorable to my sketch, the tuning effect of condenser j^3 in tune 2, is to change the effective capacity of h' to .0000392, or about two per cent. Since the condenser h', however, is adjustable, this amounts to a mere trifling change of adjustment.

The operation in any case is precisely the same, and I have no desire to alter the figure of the patent in any respect. I merely introduced my "Sketch No. 3" because it is, in fact, operatively identical, and I thought it might be easier to understand. The other comments which Mr. Loftin makes have no foundation in fact, and merely indicate that he has not used the circuits and is not familiar with their operation.

I have used the arrangement exactly as shown in Fig. 2 of the patent in suit and as shown in my diagram, "Sketch No. 3," and I know that the operation is the same.

Q. 7. Will you please state whether or not you agree with the statement of alleged facts, opinions or views expressed by Mr. Loftin in his answers to questions 29, 30, 31, 32 and 33, which are found beginning at page 1096 of the printed record and continuing through page 1146 thereof, in respect to defendant's quenched-gap transmitters, particularly criticisms made by Mr. Loftin of parts of your previous deposition relating to such transmitters, giving your reasons for your answer?

A. I do not agree with Mr. Loftin's testimony referred to; I am compelled to infer from the testimony which he gave that he has never used the transmitters such as he was discussing, and knows little about them. At any rate his statements are so far from the facts as to leave room for no other conclusion.

These answers deal with what he calls, and what has been called in the trade, the quenched spark-transmitter. Mr. Loftin states that it is "beyond all doubt" that these transmitters are of the type described in United States Patent No. 1,216,615, to Seibt. He proceeds to discuss these transmitters on that basis.

The Seibt patent refered to, is "Defendant's Exhibit C 3." I am familiar with the patent. This patent shows [fol. 1520] a transmitter comprising an open antenna circuit constituting a good radiator and a local circuit constituting a good conserver or pesistent oscillator, which cannot

radiate. These two circuits are tuned, as described in the Marconi patent, to have the same natural period, and they are associated so that energy can be supplied to the persistent oscillator and transferred by it to the antenna circuit, all as disclosed in the Marconi patent.

The Seibt antenna or good radiator circuit comprises an elevated conductor connected through an inductance coil and oscillation-transformer to earth (a measuring instrument is also shown which, of course, does not affect the operation in any way). The local or persistent oscillator circuit comprises a reservoir condenser C, the primary S' of an oscillation transformer and a spark-gap F.

As Mr. Weagant has discussed this patent and its File Wrapper, and has pointed out the several disclosures of Seibt, to the effect that these two circuits are in resonance with one another, with which testimony I agree, I will not repeat.

It is clear, then, that the Seibt patent, which Mr. Loftin says discloses the quenched spark-gap transmitter employed by the Navy, shows exactly such an arrangement as is disclosed in the Marconi patent in suit. The sole difference is, that whereas the Marconi patent refers to the spark-gap as "spherical terminals or other contacts of a spark-producer or other electric-wave or oscillation producer" (p. 1, line 83), Seibt describes a particular type of spark-gap of the sort set forth in the prior Marconi patent, re-issue 11,913, which is characterized by a succession of gaps in series. The Seibt arrangement is particularly suitable for powerful transmitters, and Marconi says, at page 2, line 7 of his prior patent:

"If a very powerful source of electricity giving a very long spark be employed, it is preferable to divide the spark-gap between the central balls of the oscillator into several smaller gaps in series."

This is what Seibt has done and he shows, in Figs. 10, 11, 13 and 14, arrangements of this character. It is constructions of the type shown in Figs. 13 and 14 that have been commonly employed. In short, the sole difference between what Seibt shows and what is disclosed in the Marconi patent in suit is that Seibt has chosen, and improved upon, the particular type of spark-gap referred to in the above quotation from the early Marconi patent. This,

of course, is in compliance with the instruction of the Marconi patent No. 763,772, that any suitable gap may be employed.

The operation of the two arrangements is the same. Both are subject to the same difficulties and have the same advantages. If in either one a certain coupling is used, a certain number of oscillations will be required to transfer the energy from the closed circuit to the open circuit. Thus, if the coupling is ten per cent., five oscillations will be required in either case; if the coupling is twenty per cent., two and a half oscillations will be required in either case; there is no difference whatever between the structure disclosed by Marconi and that of the Seibt patent, in this regard. If, in either case, the association of the two circuits is too close, in view of the amount of energy to be [fol. 1521] transferred and hence the amount of heat to be dissipated in the gap, reaction will occur between the two circuits and the waves transmitted will pulsate and exhibit two frequencies; sometimes three frequencies. There is no difference between them in this regard. The difference between them is that the Seibt form of Marconi's multiple gap cools admirably and will handle a relatively large amount of energy very reliably and is therefore better than a succession of spheres. It is easier to get a gap of this Seibt type into operation in the most desirable manner, as illustrated in my "Sketch No. 2", than it is in a gap in which the sparking surfaces are open freely to the atmosphere and the gap remains in good operating condition much longer.

* * * * * * *

The apparatus constituting the transmitter of the Wireless Specialty Apparatus type which Mr. Loftin was talking about in his answer to Q. 29, and which he says is beyond all doubt that of the Seibt patent, is thus seen to be identically the apparatus of the Marconi patent in suit, it has the same circuits, they are tuned together in the same way, and the spark-gap is such a "spark-producer or other electric-wave or oscillation producer" as is referred to in the Marconi patent.

The two circuits are in resonance in the sense defined in the Marconi patent, viz., their natural frequencies are made alike by making the product of capacity by self-induction in the two circuits the same. Mr. Loftin, how-

ever, says that they are not in resonance in his use of the term. Mr. Loftin has, throughout his deposition, made use of a special definition of resonance. The fact that the two circuits are "so independently adjusted as to make the product of the self-induction multiplied by the capacity the same in each case", which is all that is required by the Marconi patent (page 2, line 123), is not enough. According to Mr. Loftin, if the circuits are so related that one reacts on the other, then resonance does not exist, even if the circuits have been independently adjusted, as required by the patent in suit. He ignores the fact that if the circuits did not react on one another, they could not act on one another, and the apparatus would be practically inoperative.

Mr. Loftin does not allege that the apparatus of the Marconi patent is inoperative or useless; on the contrary, he seems to recognize its great utility. He merely seems to seek to limit it by imposing definitions of words which the patent does not contain, and by disregarding the explicit instructions which the patent does contain. The Marconi patent specifies that "the electrical time periods" of the non-radiating persistent oscillator circuit and of the radiat-[fol. 1522] ing antenna circuit shall be made the same by adjusting the products of the inductances and capacities of the two circuits to be the same. He does not appear to deny that Seibt has the same adjustment, but he says that "the adjusting of the time period of the two circuits is for a purpose having nothing whatever to do with a resonant transfer of energy between circuits as was necessary to the success of the Marconi system". I have not found that he gave any proof of this statement and it is wholly incorrect. It is only necessary to read the Seibt patent to see that it is incorrect. Figs. 2 to 5, which show different degrees of promptness of response of the spark-gap in opening the primary circuit, which are the basis of the disclosure of the Seibt patent, are all based upon the assumption that the same resonant transfer of energy exists as disclosed in the Marconi patent, and Fig. 6 is said to be "the resonance curve of the coupled system where the spark snaps off rapidly" (Seibt patent, p. 3, line 3). It is exactly the "resonance curve" of the arrangement of the Marconi patent where the spark snaps off as it should. Seibt merely discloses a reliable form of spark-gap for obtaining this desired action with large powers.

Since Mr. Loftin has had so much to say about coupling, that is to say, the closeness or looseness of association of the closed and open circuits of the transmitter for energy-transfer purposes, it is interesting to note that the coupling indicated by the figures of the Seibt patent is about ten per cent., while the range indicated by the illustrative examples of the Marconi patent is from five to twenty per cent. In my experience with quenched spark-gaps I have found that the use of such a gap in the Marconi transmitter as shown by Seibt, enables effective operation as shown in my "Sketch No. 2" to be realized with couplings ranging from ten to twenty per cent.

Another allegation which Mr. Loftin makes is that the Seibt arrangement "is based on the system disclosed by Lodge in his patent 609,154"; it is not. This statement ignores the actual structure of Lodge and is based upon the restrictive definitions which Mr. Loftin has devised, such as the limitation to what he calls "cumulative resonance" and to the entirely impossible restriction which he undertakes to place on the term "persistent oscillator", by which he thinks is meant a circuit which performs in contravention to the laws of nature and keeps on oscillating for a long time, whether it is coupled to the antenna or not. As I have pointed out, the number of oscillations before a non-radiating circuit has transferred all its energy to the antenna is determined by the coupling and is from two and a half to ten in the illustrations given by Marconi.

Lodge made the mistake in his Fig. 4, to which Mr. Loftin refers, of proposing an arrangement having two radiating circuits. Looking at Fig. 4 of the Lodge patent No. 609,154, it will be seen that there is absolutely no more reason for regarding the circuit h, h^4, h^2, h^3, h^4, h', as the radiating circuit, than there is for regarding the circuit h, h^8, h^9, k, h^5, h^7, h' or of the circuit h, h^6, h^5, j, h^{10}, h^{11}, j, h^5, h^7, h'. As a matter of fact, these are radiating circuits.

Lodge made the mistake of associating a charging circuit which was a radiating circuit, with other radiating circuits, and thus produced a useless arrangement which has never been used.

The Seibt transmitter as illustrated either in the patent or in the Wireless Specialty Apparatus Company trans- [fol. 1523] mitter, has the Marconi arrangement, wherein there is one circuit which is a persistent oscillator, and cannot radiate appreciably, associated with a second circuit

which is stretched widely open, with one end in the air, and the other connected to earth and hence, is a radiating circuit.

Quenched spark transmitters of this Seibt type therefore, in no way resemble the Lodge arrangement, but have exactly the Marconi arrangement, viz., a non-radiating circuit containing a spark-gap associated with a radiating circuit, which has no spark-gap, the two having the same "electrical time periods" as required by the Marconi patent. There is no possible basis in fact for Mr. Loftin's contention that the Seibt arrangement is based upon that of Lodge, unless he wants to go so far as to say that the Marconi patent in suit is also based upon Lodge's Fig. 4, which he does not assert. Lodge has a plurality of radiating circuits; the idea which is fundamental to Marconi is that the spark-gap shall be in a non-radiating circuit, which he calls a persistent oscillator, because of its non-radiating capacity. There is no such circuit associated with a radiating circuit in the Lodge patent, nor is there the idea of a resonant transfer of energy from the non-radiating circuit to the radiating circuit, by making the electrical time periods the same.

The sole basis for Mr. Loftin's contention that there is not a resonant transfer of energy in this Sebt arrangement having the so-called quenched-gap, is that the primary or local circuit would, in the best operation, cease to oscillate when all of its energy had been transferred and that this may take place in a number of oscillations, relatively small as compared to the number of oscillations from the antenna circuit. That this idea is without foundation is shown by the fact that the number of oscillations in which the energy is transferred to the antenna, as shown by Seibt, falls definitely in the range definitely disclosed by Marconi, as pointed out in my preceding answers. It is because of the resonant transfer that the energy can be handed over in so few oscillations. What happens is as follows: The spark-gap, discharging, sets up oscillations of the desired frequency in the non-radiating circuit. Associated with this circuit is the open circuit which can, theoretically, be set into oscillation at any frequency, but because its electrical time period has been made the same as that of the spark-gap circuit, it offers the lowest possible resistance to being set into oscillation at this frequency to

which it is tuned. It therefore greedily absorbs energy from the local circuit, which thus acts as a reservoir into which the energy was preliminarily introduced. While it is thus absorbing energy, it also is radiating, and it is thus able to radiate much more energy for a given permissible electrical pressure developed than it could if the energy had to be imparted to it directly.

It is this feature of the rapid resonant transfer of energy from the non-radiating to the radiating circuit which accounts for the enormous utility of the Marconi invention, and it is fundamentally quite immaterial whether the spark-gap employed takes one form or another.

In his answer to Q. 29, referred to in the present interrogatory, Mr. Loftin refers to his sketch G, wherein he says he has shown in red and green the two frequencies which exist when the spark-gap does not function to open the local circuit after its energy has been all transferred. I have pointed out that the Figs. 2 and 2*a* on this sketch (the ones he is here talking about) represent a totally impossible [fol. 1524] state of affairs and show nothing but Mr. Loftin's ignorance of electrical science; but, overlooking this, the use which he makes of his figures on P. R., p. 1098, appears to me to assert that such operation is not possible with the Seibt apparatus. If Mr. Loftin entertains this view, he is mistaken. It is just as easy to cause the Seibt apparatus to operate in the manner which Mr. Loftin apparently intended to illustrate, as it is when some other form of spark-gap is used. All that is necessary in either case is to omit to sufficiently loosen the coupling. Whatever form the spark-gap may take, it will fail to open the circuit at the moment when the energy has been all transferred to the antenna, unless the coupling is made loose enough. It is, of course, true that a gap having ample provision for cooling, does not require the coupling to be loosened as much as one whose cooling is less adequate. This, however, is a mere matter of degree, and has no bearing on the presence or absence of the combination and mode of operation described in the Marconi patent.

Mr. Loftin also seems to suggest that the Seibt patent implies that with other forms of spark-gap the operation will always be that which Mr. Loftin sought to illustrate by his sketch G. I do not so understand the Seibt patent. In fact, I understand it to state quite the opposite.

(A to Q. 7 continued): On page 2 of the Seibt patent, after explaining by reference to Fig. 2, the possible effect of reaction between two circuits, Seibt says at line 32:

"In the foregoing consideration it is assumed that the spark gap acts as an ordinary conductor and retains its conductivity until the energy at the discharge has been entirely dissipated."

"Dissipated" in this quotation, does not mean "transferred"; it means converted into heat, because Seibt is talking about Fig. 1, wherein there is no radiation. The spark-gap, however, does not act as an ordinary conductor, but, as Mr. Weagant has explained, its resistance rapidly increases as the energy in the oscillating charge decreases. Hence, it tends to be extinguished when the energy has all been transferred, and will do so if the spark-gap is properly cooled. In his Fig. 7, Seibt shows a simple way of effecting such cooling by using hollow spark electrodes filled with water. Seibt then goes on to say that the condition of retained conductivity is approximated the more as there is more vaporization of the metal of the electrodes, or as the load on the gap is increased by increase of current; also, this condition, he says tends to exist the more as the heat conductivity of the electrodes becomes smaller.

He then states:

"In practice these characteristics and conditions of the spark gap are never fully attained * * *."

This means that it would take a very bad spark-gap condition, or a very insufficiently loosened coupling, to bring about the results shown in his Fig. 2, which I assume is what Mr. Loftin intends to show in his sketch G.

Seibt then continues at line 51 of page 2:

"Consequently, in practice, after a discharge of the condenser through the spark gap, such a condition of high [fol. 1525] resistance is created at the spark gap as to destroy its conductivity and its capacity to act as a conductor for the current before the discharge energy has been entirely dissipated, thereby, in effect, snapping off the further flow of current across the spark gap when the current intensity falls below a certain value."

He then proceeds to point out in further discussion of what happens in practice, that this condition of high-re-

sistance in the gap may occur at any one of the instants shown in Fig. 2, when the energy has all been transferred to the antenna. I understand that his Fig. 4 shows what happens when the spark-gap resistance becomes high enough to prevent further oscillation as soon as the energy has all been transferred to the antenna. Fig. 4 (which corresponds to curve (*b*) of my "Sketch No. 2") shows what happens in the antenna. Fig. 5 of the Seibt patent shows what happens in the secondary circuit when the opening of the primary circuit does not occur when the energy has first been transferred to the antenna, but does occur when it has been transferred a second time.

This description of the Seibt patent corresponds to my understanding of the fact. No matter what spark-gap is used, if it is not sufficiently cooled for the energy which it is called upon the handle, or if the association with the antenna has not been made sufficiently loose, the spark-gap resistance may not prevent transfer of energy back to the primary circuit immediately after all the energy has been passed to the antenna. This desired termination of the action of the spark-gap may, therefore, occur the first time that the energy is transferred, or the second time, or the third time. The more re-transfers of energy there are, the less desirable for most purposes, is the operative efficiency. It has, therefore, been the endeavor from the outset, that is, from the first introduction of the apparatus of the Marconi patent, to provide better and better cooling for the spark-gap, and to pay more careful attention to its operating condition, where the highest usefulness of the result has been desired.

I have operated the apparatus of the Marconi patent extensively and have used spark-gaps of a variety of kinds, and I have always found that resonant transfer of energy was essential, and that with proper care all forms of spark-gap give the same result. The operative range of coupling is that covered by the examples given in the Marconi patent. All of them give reaction effects, unless the coupling is loosened down to the neighborhood of twenty per cent. Sometimes it must be loosened still further. This is a matter of degree, depending upon the clearness of the spark-terminals, their heat dissipation and the load imposed on them. I have adjusted quenched spark transmitters hundreds of times, and have always found that they behaved in the same way as Marconi transmitters having other

forms of spark-gap; a resonant transfer of energy is essential, and resonance has, in a transmitter with a quenched-gap, exactly the same functions and importance as with other forms of gap.

On printed record page 1099 of his deposition, Mr. Loftin quotes from the Seibt patent, page 2, lines 74 to 87, and he seems to intimate that Seibt is there talking about the operation of an apparatus containing the quenched-gap. Examination of the patent will show that he is not; he is talking about the characteristics exhibited by prior circuits, and [fol. 1526] he says that they may act in any of the ways shown in his Figs. 2 to 5, inclusive. The passage which Mr. Loftin quotes, therefore, directly contradicts Mr. Loftin's whole theory of operation of what he calls the "Marconi type apparatus."

It is not until page 3, line 6, that Seibt says:

"From the foregoing considerations it will be seen that in practical operation it is desirable that the spark snaps off, or is quenched, or, in another expression of the idea, that the primary circuit is opened, at the instant when the current amplitude first reaches zero value in the primary circuit, or at the spark gap, and that the duration of the spark be as short as possible, that is, that the coupling between the circuits shall be sufficiently strong or close and adjusted to secure a rapid decrease of the oscillations in the primary circuit with corresponding reduction of the energy in the primary circuit to substantially zero value as indicated by the diagrams, in which case the maximum of efficiency is attained in the transformation of energy from the primary to the secondary circuit."

All of the specification up to this point is devoted to showing the various degrees of operative effectiveness exhibited by prior structures typified by Fig. 1. In the passage just quoted, Seibt points out that it is preferable that the spark should be extinguished when the energy in the primary circuit first falls to zero. The specification then proceeds to explain the construction by which Seibt expected to obtain this result with greater certainty.

Seibt made an improvement if he is, in fact, the original inventor of Figs. 13 and 14 of his patent, in that he accomplished the Marconi result with a degree of reliability which previously had required a rotating gap, and he did it without moving parts. This form of gap came largely into

use, although it never entirely displaced other forms, and my understanding is that the United States Navy, in many of its contracts, required that where the Seibt form of gap was furnished, a rotary form of gap should also be supplied, to be interchangeable with the quenched-gap, so that the rotary gap could be employed when the quenched-gap became dirty, or otherwise out of order, and failed, therefore, to operate as shown in my "Sketch No. 2," and began to operate in the manner which I assume Mr. Loftin intended to illustrate in Figs. 2 and 2ª of his Sketch G. In other words, when the operation changed from that of Fig. 4 of the Seibt patent to that of Fig. 2 of the same patent. Mr. Loftin's quotation from the Seibt patent, therefore, quite completely contradicts his own argument when read in its context.

On page 1103 and following of the Printed Record, Mr. Loftin seems to express the opinion that even though the circuits are adjusted as required by the Marconi patent and have the same electrical time periods, the Marconi invention is not employed if this adjustment is made for some other purpose than what he calls the "resonant transfer of energy" in a manner corresponding to his "cumulative resonance" theory.

I disagree with this opinion. The Marconi patent calls for the association in a transmitter, of a radiating and non-radiating circuit, whose electrical time periods are equal; he does not undertake to give all the reasons why they should be so adjusted, but he clearly and definitely states [fol. 1527] what should be done. These instructions of the Marconi patent in suit are faithfully embodied in the quenched spark-gap transmitters employed by the Navy, and it would seem to be entirely immaterial whether the Marconi patent does, or does not, set forth all of these advantages, or reasons for so doing, which Mr. Loftin finds apply to these transmitters.

With respect to Mr. Loftin's answer to Q. 30, in which he deals with the claims of the Marconi patent, my understanding is that these are proper subjects for interpretation only by the Court. I have explained my understanding of the invention and my reasons for stating that Mr. Loftin interprets the terms of the patent in an erroneous manner, not warranted by the patent, but, in fact, inconsistent therewith. It would seem to serve no useful purpose to

follow him into a detailed discussion of the claims, wherein he applies his erroneous definitions to their terms.

In his answer to Q. 31, Mr. Loftin endeavors to explain away the very definite instructions given by the various Government publications and the like, to the effect that the circuits of the Wireless Specialty Apparatus type of transmitter should be tuned to resonance, or equal time periods. The substance of his contention appears to be that although they are manifestly intended to be accurate, they are merely loose and careless statements, which should not be taken seriously.

Having shown that Mr. Loftin is mistaken in most of his ideas as to what the facts are, it would seem that the statements of the Government publications are entitled to full weight. I will therefore not discuss this matter in detail.

In his answer to Q. 32, Mr. Loftin gives many other forms of apparatus. It does not seem to me to be necessary to follow him through this long list of apparatus. In so far as it refers to quenched-gap transmitter apparatus, what I have already said applies, and I believe Mr. Loftin to be as completely mistaken as to each of these as I have shown him to be with respect to the Wireless Specialty Apparatus Company's transmitter, which he says is beyond a doubt that of the Seibt patent.

In so far as this answer deals with receiving apparatus, it seems to me only necessary to point out that the instructions of the Marconi patent No. 763,772, so far as concerns the adjustment of the electrical time periods, is made to explicitly apply to the receiving circuits.

Marconi's receiving apparatus is, in a sense, an inversion or reversal of his transmitting apparatus. Just as an elevated conductor connected through an oscillation transformer to earth is an efficient radiator of energy passed over to it from a non-radiating local circuit, so a similar elevated conductor at the receiving station is an efficient absorber of the energy of electric waves which it intercepts. Associated with this open antenna circuit Marconi shows and describes a tuned local circuit which has little or no absorbing capacity of itself. By the electrical association of the two circuits, the energy which the elevated conductor absorbs from the ether is handed on to the closed circuit, where it is utilized in any suitable form of detector, as explained at page 2, lines 57 to 77 of this Marconi patent.

The instructions of the patent are that the electrical time periods of these two receiving circuits shall be the same as those of the two transmitting circuits.

[fol. 1528] On page 4 of the specification Marconi illustrates by examples, various forms which the receiving apparatus may take. In Fig. 2 of the drawing, he shows the complete receiver incoporating all of the various devices which he describes. In the examples on page 4, he designates what form each element takes, and he shows that the elements of the complete system of Fig. 2 need not all be used at one time, but that they may be used in various combinations, all embodying the fundamental feature of two circuits whose time periods are equal to one another, and to those of the transmitter.

In "Plaintiff's Exhibit No. 99," found opposite P. R., p. 157, I have illustrated, diagrammatically, the arrangements of these several receivers of the table. I do not find that Mr. Loftin anywhere challenges the accuracy of this showing. He merely seems to assert that receivers used by the Navy, which are of the types corresponding to tunes 1, 3, 5 and 6, are "outside of the showing" of the Marconi patent (P. R., p. 1117). It is a little difficult to know what he means by this, since they are certainly not outside of the showing, but happen to be within it. He calls attention to the fact that the Lodge patent, in Fig. 13 thereof, shows no tuning means in connection with the coil *u*, which is connected to the connector *c* and indicator *q*, and he makes the statement that "Fig. 13 is a tunable circuit." This is decidedly misleading. Lodge gives no instructions that the time period of his circuit is to be made the same as that of the antenna, or as that of the transmitter. Hence, his disclosure is not the same as that of the Marconi patent, and Mr. Loftin has no right to make the quoted statement.

If, on the other hand, Mr. Loftin means to say Lodge's detector circuit is adjustable, then he is also wrong, as it is neither shown nor described as adjustable.

My understanding is that the illustrative examples of the Marconi patent all are intended to have time periods between circuits alike, and equal to those of the transmitter. I constructed these circuits and found this to be the fact. I also understand it to be the fact that circuits used by the Government and referred to in Mr. Loftin's answer to Q. 32, were in fact adjusted to have the time periods of the two circuits alike and equal to those of the transmitters.

from which they were designed to receive signals. I therefore understand that they are such circuits and such receivers as are referred to in the Marconi patent, and I find nothing in Mr. Loftin's testimony to change that view.

In Mr. Loftin's answer to Q. 33, he criticises "Plaintiff's Exhibit No. 102" on the ground that it shows two coil-transformers, instead of what are known as auto-transformers having only a single coil.

In making this criticism, Mr. Loftin evidently looked at the lithographic reproduction, and not at the original exhibit. In the original exhibit the red and black lines are in register, as near as it is possible to get them, while in the reproduction they are very much out of register.

Furthermore, as Mr. Loftin should know, the diagram illustrates current paths, the black showing the path of the antenna current, and the red that of the local circuit current. I find on P. R., pp. 196 and 197, that I explicitly stated that "the Foote-Pierson apparatus of specification No. 410 has both the transmitting and receiving oscillation transformer of the direct coupled or auto-transformer type." I went on to say:

"As I have already explained, this change in the form [fol. 1529] of the oscillation transformer does not in any way alter the operative relation of the two circuits nor change the mode of operation of the apparatus."

I note that Mr. Loftin does not appear to challenge the accuracy of this statement; he merely alleges that the drawing "Plaintiff's Exhibit No. 102," is erroneous. If he had looked at the original exhibit, I think he would not have made even this criticism.

Q. 8. Although you may have, in substance, stated your understanding of the facts, in your previous answers, I will ask you to refer to Mr. Loftin's statement beginning at the bottom of page 1139 of the Printed Record, to the effect that defendant's transmitters of the quenched-gap type "are based on the fundamental principle of the Lodge impulse excitation set forth in Lodge's 1898 patent; that is, the principle of quickly delivering the energy from the primary circuit into the antenna circuit non-resonantly and separating in effect the primary circuit from the secondary circuit once the delivery is complete, leaving the energy in the secondary circuit free to oscillate at the

natural period of the secondary circuit, uninfluenced by any maintained connection to the primary circuit." Please state whether or not the above statement accords with your understanding of the operation of defendant's quenched-gap transmitters.

A. I does not. I have already pointed out that the defendant's quenched-gap transmitters are not based upon, and do not embody, what Mr. Loftin has called the Lodge impulse excitation principle. Lodges does not have in his transmitter a local circuit of the non-radiating type; he does not have such a circuit associated with an open radiating circuit. Furthermore, Lodge does not have two circuits of any kind whose electrical time periods are equal to one another, as required by the Marconi patent.

The defendant's quenched-gap types have all of these things, and they do not have Lodge's multiplicity of spark gaps, nor his multiplicity of radiating circuits. They are, in fact, in every respect like the apparatus of the Marconi patent, and they have the Marconi mode of operation; they are not at all like the apparatus of Fig. 4 of the Lodge patent, and they do not have any such mode of operation as Lodge aimed at, but failed to realize.

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Q. 9. Please refer specifically to Mr. Loftin's answer to Q. 31 of his deposition (P. R., p. 1113), and state to what extent, if any, Mr. Loftin may be justified in criticising your previous testimony (P. R., p. 171), in which you quote from "Plaintiff's Exhibit No. 78," Navy Manual 1913, and "Plaintiff's Exhibit No. 91," Signal Corps book entitled "Radiotelegraphy," on the subject of resonance or equal [fol. 1530] time periods in quenched-gap transmitters.

A. Mr. Loftin does not meet the issues raised in his question 31, he merely avoids them.

Wherever the question of resonance arises, Mr. Loftin similarly avoids the issue by setting up his own special definition of resonance, which is not an accepted definition, but something for which the has coined the name "cumulative resonance," devised to meet the exigencies of his testimony.

The word "resonance," as applied to the Marconi patent, and as used in the art, means equality of electrical time period (Patent 763, 772, p. 2, l. 127).

Furthermore, Mr. Loftin, in this answer, does not refer at all to some of the matters raised by my *prima facie* testimony, to which the question referred him.

I will consider the references *seriatim*. The Navy Manual of 1913, "Plaintiff's Exhibit No. 78," page 57, was quoted by me as follows:

"89. In fig. 29a, A B and C D have been given some turns in common, forming an air core-autotransformer, but, whether directly or indirectly connected, these two circuits —the *closed* and *open* circuits—must have equal natural periods in order to produce and radiate electric waves efficiently."

This statement immediately follows the discussion of the quenched-gap transmitter, of which, however, no circuit diagram is given. The reference to "Fig. 29a" is for the purpose of explaining that although there is but a single coil in some transmitters, there are, nevertheless, two circuits "the *closed* and *open* circuits" and the statement is that the two circuits of a transmitter "must have equal natural periods," which means that their "electrical time periods" must be the same.

It is evident from the entire context that this statement is perfectly general and applies to transmitters having closed and open circuits, without regard to the form of the spark gap.

On page 162 of the same publication, Mr. Loftin repeats my former quotation as follows:

"ADJUSTMENTS.

"224. This includes *calibration* and *tuning*. *A station is tuned when both sending and receiving circuits are correctly calibrated, coupled and adjusted to the standard damping and standard wave lengths.*" (Italics in the original.)

Mr. Loftin avoids this by saying that it is a very general statement and might apply to a system having but one circuit at each station. If he had read the rest of the paragraph, which expressly includes the closed circuit, as well as an open circuit at each station, he would have seen that his statement was incorrect. This above-quoted statement is in the chapter entitled "Installation, Adjustments and Measurements," and immediately follows the specific de-

scription of transmitting and receiving apparatus, the immediately preceding page to this chapter being a diagram of a quenched-gap transmitter.

Continuing under the same heading on the same page and referring broadly to any "spark sending set," I find the following also quoted by Mr. Loftin:

"The closed sending circuit should be in resonance with [fol. 1531] the open circuit and coupling and decrement of the open circuit such as to afford the necessary selectivity to the receiving circuits with the best efficiency of radiation."

In order to avoid the effect of this quotation, Mr. Loftin actually misinterprets it and attempts to make it a mere nonsensical statement without meaning. There is no excuse for such a distortion; the meaning is perfectly clear; it says, first, that the sending circuit should be in resonance with the open circuit and, second, that the coupling and decrement of the open circuit should be such as to afford the necessary selectivity in reception, together with best efficiency of radiation.

The meaning is conclusive that the writer definitely intended to say the circuits of the transmitter should be in resonance, without regard to the kind of spark-gap used. It is interesting to note that the sense in which this writer uses the term "resonance" is identically that of the Marconi patent, as will be seen by reference to page 43, where I find the following:

"63. Two circuits having the same electrical length are said to oscillate in *resonance;* their periods are equal, though the inductance and capacity may not be the same in each."

This means that the circuits have the same time period, electrically speaking, and the products of their inductance and capacity are alike.

On page 163, Mr. Loftin quotes the next sentence following the last quotation on page 162, as follows:

"Receiving circuits to receive from such a sender should be in resonance with each other and with the sending circuits and should have the same coupling as the sending circuits. The telephone diaphragm should be in resonance with

the wave train (alternator) frequency and with the operator's ear."

Mr. Loftin says that this quotation is important, because it shows that the previous quotation as to the sending circuit refers to the open-gap type, rather than the quenched-gap type. It does not. Mr. Loftin is mistaken, because he bases this statement on his own peculiar and limited definition of "resonance," which is not the definition of the Marconi patent, nor is it a definition having any application in this case, or any warrant that I know of, outside of Mr. Loftin's own mind.

The important thing is this statement, together with the preceding quotation from page 162, used terms as defined by the writer of the book (Navy Manual, "Plaintiff's Exhibit No. 28"), and it will be noted that these two statements toge' r exactly correspond to the instructions of the Marconi patent in suit, page 2 lines 118 to 128, where Marconi also says that all four circuits of the sending and receiving systems should be in tune.

Mr. Loftin also alleges that this quotation "is also a very loose technical statement," and says in effect that there is no sense in having the circuits of the receiver in tune with the circuits of the transmitter. This, however, is merely another attempt to enforce his peculiar definition of "resonance" and has no foundation in fact.

The two quotations are accurate technical statements and describe the necessary conditions for the operation of the [fol. 1532] apparatus of the Marconi patent, whether the transmitter employed one form of spark-gap—as, for instance, the so-called quenched spark gap—or some other, such as the ball-gap shown in the Marconi patent.

In my former answer, as found on P. R., p. 171, I quoted portions of a resume statement from page 163 of "Plaintiff's Exhibit No. 78," which manifestly and necessarily includes the quenched-gap form of spark-gap, as well as the open-gap. Mr. Loftin has neglected to refer to this at all. The portion which I quoted in my previous deposition reads as follows:

"Resonance is thus seen to be a vital quality in wireless telegraph circuits. * * * (3) Resonance of closed oscillating circuit with open radiating circuit. (4) Resonance

of coupled receiving circuits with each other and with coupled sending circuits."

Since this a resume and clearly includes all of the apparatus previously described by the author and uses the term "resonance" with the author's meaning, and *not* with Mr. Loftin's meaning, it is important. It seems strange that Mr. Loftin should have omitted to refer to it.

It is a succinct statement that the condition laid down by the Marconi patent 763,772 is recognized by the author as the proper condition and "a vital quality" without regard to the type of spark-gap employed.

Mr. Loftin next quotes from the Signal Corps book, "Radiotelegraphy," "Plaintiff's Exhibit No. 91," page 67 (the reference "page 57n" P. R., p. 1115, is a typographical error; the correct reference is given P. R., p. 171). The quotation reads as follows:

"When the adjustments of a quenched spark transmitter have been correctly made—that is, the circuits are in resonance, the coupling is right, etc.—a simple experiment will show that the primary current is a *minimum;* that is, the spark has been quenched and the primary current has been stopped quickly, as at the point Q. of figure 53, and that at the same time the secondary current is a *maximum;* that is, it persists for a long time, as shown in figure 56." (Italics in the original.)

Mr. Loftin admits that this quotation definitely refers to the quenched-gap type. He says, however, that the statement is incorrect; that the use of the word "resonance" is incorrect. This, as I have repeatedly pointed out, means merely that it does not agree with Mr. Loftin's use of the term.

The author of this Signal Corps book, "Plaintiff's Exhibit No. 91," defines the sense in which he uses the term as meaning that the two associated circuits have "the *same frequency*" and he continues: "that is, the two circuits are *syntonized*, or *tuned*, or are *in resonance*." (Italics by the author.)

Two circuits which have the same frequency, have the same electrical time period. The usage by this author of the Signal Corps book is, therefore, in accord with that of the Marconi patent, in the passage above noted.

The statement in this book is entirely correct, as I know by the very large number of tests which I have personally made. It is only Mr. Loftin's definition of "resonance," for which he is the sole authority, that is wrong.

It is interesting to note that Figure 56, to which this quo- [fol. 1533] tation refers, shows three oscillations in the primary circuit, and that applying Prof. Morecroft's rule, to which I have already referred, this means a coupling of about sixteeen per cent., which is within the range of the illustrative examples given by Marconi. It is interesting to note, also that the same statement is true of the illustration on page 56 of "Plaintiff's Exhibit No. 78," Navy Manual. These authorities, therefore, are in all respects in accord, and in total disagreement with Mr. Loftin. They are also in accord with my testimony in my former deposition. and in this deposition.

In my former deposition (P. R., p. 171), I quoted from this same book (Signal Corps Manual, "Plaintiff's Exhibit No. 91"), the following statement from page 107, as follows:

"The tuning of the closed and open circuits to resonance, and the determination of the correct coupling between them are the two most important adjustments in a quenched spark transmitter."

Mr. Loftin neglects to refer to this quotation, although it is a flat contradiction of his entire testimony on this subject and, as I have just noted, the coupling referred to as illustrated by the author on page 67, is within the range of coupling of the apparatus by which Marconi illustrates his invention. Remembering that the author's use of the word "resonance" is exactly in accord with that of the Marconi patent, and that it is used specifically with refereince to a "quenched spark transmitter," it will be seen that the denial of the correctness of Mr. Loftin's position could not be more complete. It is strange that Mr. Loftin should have overlooked this quotation.

Q. 10. In answer to Q. 2 of your present deposition you referred to the limitations of the apparatus involved in the invention of Marconi's plain antenna patent (re-issue No. 11,913), and the problems Marconi had to solve, and how he solved them by the invention comprised in his tuning patent No. 763,772, thereby producing the result of selectivity and long-distance signaling. Were these results due wholly to

the improved mechanism of the invention of the tuning patent, and not to a mere increase in energy or power applied to such mechanism? If so, what is the technical explanation of Mr. Marconi's comparison of these two systems, particularly referred to on page 24 of "Defendant's Exhibit K-6," Marconi's lecture of 1909 before the Stockholm Royal Academy of Science. Please give your reasons for any opinion you may express in your answer.

A. Considering the two structures on a comparable basis, the improved results of Marconi patent No. 763,772 are wholly the result of the improved mechanism of this tuning patent. The subject is an involved one, and it is doubtful, perhaps, whether Mr. Marconi himself would today make the same statement, because we now know so much more about the vagaries of transmitting conditions, that we are well aware that the comparison of efficiencies on a basis of distance attained at different times, is wholly without meaning. It is well known that for little-understood reasons a given transmitter will often make a record for distance that could not normally and regularly be made, except by a transmitter of many times the power.

The only basis upon which such a comparison could be made would be to have two transmitters having the same size of antenna, emitting the same wave-length, and applying the same power, and operating successively one immediately after the other, for repeated trials, the signals being received [fol. 1534] in both cases, with the same receiver, in the same state of adjustment. Of course, this would mean that the transmitter of the tuning patent would be operating way below its normal power-input, or else that the plain antenna transmitter of patent re-issue 11,913 would be operating with an excessive voltage and, hence, in excess of the high-resistance spark-gap. If any such test has ever been made, I am not acquainted with it.

The practical test would be to arrange a given antenna and ground connection, so that they could be alternately switched from a transmitter of the type of patent 11,913 to a transmitter of the tuning patent, each being adjusted for its best performance with the same charging voltage. This test I have made. Naturally, I could not be at both the transmitting and receiving ends, but judging from the readings of the antenna ammeter, the comparison was extremely unfavorable to the plain antenna transmitter.

As Mr. Marconi himself points out in the exhibit referred to, either an enormous antenna has to be used to radiate a comparable amount of energy from the plain antenna, or else brush-discharge losses and spark-gap losses become so large that there is no gain in trying to increase the energy.

The comparison is easily seen by taking the illustration used in one of my former answers, where I pointed out that assuming the antenna of tune 1, page 4 of patent 763,772, to have a capacity of about 200 micro-microfarads and taking the capacity of the primary circuit as given for that tune to be approximately 7,000 micro-microfarads, the ratio is one to thirty-five. Assuming the same spark-gap and spark-gap potentials and the same antenna, it is thus seen that the energy delivered to the two transmitters (of patent 11,913 and patent 763,772 respectively), would be in this ratio of one to thirty-five. If the signals were received by the same receiver and comparisons made of the signal strengths, it would be found that the effectiveness of the transmitter was of this order, if not considerably greater. The reason it might be expected to be greater, is that the transmitter of patent 11,913 would not give as well-sustained a train-of-wave, because of the resistance of the spark-gap in the antenna.

This last condition means that the signal from the plain antenna could not be as selectively received. It would interfere with other receivers tuned to a widely different frequency. Comparable results in this regard could not be attained with the plain antenna, using the same antenna in both cases, which is the only basis on which the comparison would be instructive.

These greatly-improved results of the arrangement of the tuning patent are due wholly to its construction; that is, to the mechanical differences between it and the transmitter of the plain antenna patent. I, of course, use the word "mechanical" broadly to refer to the different elements, and association of elements which go to make up the two transmitters and not as distinguishing between what might be called mechanical and electrical elements.

This answer also holds good, whether the spark-gap employed has one form or another, always assuming that the structure of the tuning patent is arranged in conformity with the patent, and that the spark gap is properly proportioned to its load, and in good operating condition.

Even if the arrangement of the tuning patent made no [fol. 1535] gain in power and distance, as determined by the strength of field created at the receiving point (which is the true measure of effectiveness, because it measures the energy at the receiver) the apparatus of the tuning patent would, nevertheless, be used to the exclusion of that of the open antenna patent, because of the greatly reduced interference which it would cause and the better effective reception. In other words, two transmitters, one of each type, which created the same field strength at the receiving point, would not be equally effective. The one might be intolerable, because of the interference which it created, or give an impracticably weak signal, because incapable of sharp tuning, while the other would be effective and would not cause a comparable amount of interference. Thus the effective range of the transmitter of the tuning patent would be greater, and its interference less, and these qualities are wholly the result of an enormous improvement in the combination constituting the transmitter invention of the tuning patent.

Q. 11. Please refer to Mr. Loftin's answer to Q. 37 (P. R., p. 1139), in which he refers to "Plaintiff's Exhibit No. 105," produced during your former deposition as illustrating the apparatus of the National Electric Signaling Company, including plain, rotary and quenched-gap transmitters, and which was before the Court in the suit against that company, for the infringement of the Marconi tuning patent, and particularly where Mr. Loftin statse that he failed to find

"any evidence in the opinion of Judge Veeder having considered anything but the plain or open-gap type, this being at page 849 of the report, where he states:

"'While in the defendant's apparatus the loose coupling emits only one wave and admits of electric resonance.'

"This conclusively shows that defendant's apparatus in that case which was considered in Judge Veeder's opinion was of the Stone or Marconi plain-gap type, depending upon loose coupling."

Does this quotation from Judge Veeder's opinion show that he considered in that opinion only the plain-gap type of transmitter used by the National Electric Signaling Company, and from your knowledge of that case did the defendant claim that its quenched-gap apparatus did not infringe the tuning patent?

A. It does not. To understand the opinion one should understand that the defendant in that case did not contend, as does Mr. Loftin, that the Marconi patent was limited to some excessively loose coupling. On the contrary, it contended that it was limited to what Mr. Loftin calls a "tight coupling." It contended that the Marconi patent was limited to an operation in which the four circuits all stayed in operation all the time, and that the defendant's transmitter, when used with that particular gap, called the quenched spark-gap, was so loosely coupled with respect to the capacities of the gap that the gap ceased to operate after the energy had been transferred to the antenna.

I was a witness in that case and testified to the same effect as I have here testified, viz., that the transmitter of the Marconi patent was not altered by changing the type of gap, that all three forms of gap illustrated in "Plaintiff's Exhibit No. 105," were equally within the disclosure of that patent, and that except as to questions of degree, they operated in the same way.

[fol. 1536] The defendant, through its expert witness, Dr. Kennelly, contended specifically that the transmitter with the quenched spark-gap was not within the disclosure of the patent, and that the patent did not disclose loosely coupled circuits.

Judge Veeder, therefore, not only had before him all three forms of spark-gap, viz., the ball-gap, the quenched-gap and the rotary-gap (Plaintiff's Exhibit No. 105" in this case), but he had testimony at length regarding the transmitter with the quenched-gap specifically.

There is, therefore, not the slightest reason for any supposition that Judge Veeder was not referring collectively to all of the forms of the National Electric Signaling Company apparatus. I have, of course, no way of knowing what was in Judge Veeder's mind, but I was present throughout the trial and know that he listened to the testimony attentively, and that he appeared to understand it. I would therefore assume that had he intended to base his decision on part of the apparatus only, and exclude the rest, the fact would have been made clear in his opinion.

The quotation from Mr. Loftin's testimony contained in the question, indicates to me that Mr. Loftin was again merely hiding behind his own unwarranted restriction on the meaning of the word "resonance." Certainly there is no other possible basis for his deduction from Judge

Veeder's opinion, that I can think of. It seems clear to me that Judge Veeder accepted the views of the Marconi invention, and its application to the defendant's apparatus, presented by the plaintiff in that case, and rejected the views presented by the defendant.

. . . . . .

[fol. 1537] Q. 12. Please refer to the synchronous rotary gap transmitter used by the Navy and purchased from the NESCO around the year 1910, according to the testimony of Mr. George Clark (P. R., p. 231); also the non-synchronous rotary gaps purchased and used by the Navy in 1911 [fol. 1538] and 1912, and continuing up until 1919, according to the testimony of Mr. Clark, and as illustrated in Mr. Clark's drawing "Plaintiff's Exhibit No. 112" (opposite P. R., p. 241), and compare the same with the construction and mode of operation of the rotary gaps involved in the suit of Marconi *vs.* National Electric Signaling Company, and with the inventions of the transmitter claims in issue of Marconi tuning patent No. 763,772, pointing out any similarities and differences which, in your opinion, exist between the rotary gaps referred to by Mr. Clark and that involved in the suit against the National Electric Signaling Company and the inventions of the said claims of the Marconi tuning patent.

A. Mr. Weagant, in his answer to Q. 197, beginning at P. R., p. 1608, has clearly and briefly outlined the development of spark-gap construction, and I am in entire agreement with his testimony.

As I have pointed out, the apparatus constituting the transmitter of the Marconi patent 763,772 in suit at once established its enormous superiority over everything that had gone before, and the progress of the art from that time on the transmitters consisted largely in the production of improved details, of which the spark gap was one. The effort was to produce spark-gaps which, by reason of better cooling required less care to obtain perfect results and would permit larger powers to be employed. One form that this development took was the production of so-called "rotary" gaps. As Mr. Clark's diagram indicates, these commonly consisted of two fixed electrodes, between which rotated a wheel having numerous electrodes so mounted as to come into line with the fixed electrode. Sometimes this arrangement was reversed, and there were a large

number of fixed electrodes circularly arranged, while a pair of electrodes were mounted to rotate with relation to them. The principle is the same. By this means excellent cooling was obtained and, so far as I know, the largest amounts of power that were ever transmitted with damped oscillations have been transmitted by the arrangement of this Marconi patent in suit, employing rotary-gap transmitters.

The synchronous gap of the National Electric Signaling Company, referred to in the question, and the nonsynchronous gaps referred to in the question, are illustrations of this rotary gap construction. The designation "synchronous gap" merely means that the rotary element is driven by the generator which furnishes the energy to the transmitter, while the designation "non-synchronous" means that the rotary element is not driven by the generator and, consequently, does not have a speed of rotation definitely related to that of the generator.

As is the case with the multiple gap transmitter of the particular construction which has been called the "quenched-gap," these rotary gaps merely replace the ball electrodes shown in the Marconi patent and the system functions in the same way in all cases, when properly adjusted. These gaps, in other words, constitute the "spark producer or other electric wave or oscillation producer" referred to by Marconi at page 1, lines 83 to 85, of patent 763,772.

As with the quenched-gap, the ball-gap, and all other forms of gaps, the effectiveness of the rotary gap in permitting the rapid transfer of energy to the antenna made possible by the resonant adjustment of the circuits depends upon the condition and construction of the particular gap in use. For a number of years I operated a transmitter provided with three forms of spark-gap, either of which could be used at will. One was an open gap, having [fol. 1539] cylindrical electrodes, with hemispherical terminals, one was a non-synchronous rotary gap, and the third was a quenched-gap. I found that the resonant adjustment of the circuit was always the same, no matter what wavelength was used within the range of the transmitter for best results, but that the coupling necessary for proper quenching to give the operation illustrated in my "Sketch No. 2" (opposite P. R., p. 151), differed, being very loose in all cases, as compared to the possible maximum of 100 per

cent., being slightly looser for the rotating gap than for the "quenched" gap, and still looser for the plain open gap. In the testing of many other transmitters I found it to be generally the case that the operation is the same, without regard to the character of the gap, the sole difference being a matter of degree in the association or coupling of the circuits.

The rotary gaps referred to by Mr. Clark correspond in all respects to the rotary gaps involved in the suit of Marconi vs. The National Electric Signaling Company, in which I was a witness, and the transmitter claims in issue apply to them in the same way as to transmitter having the open gap or the quenched gap, in my opinion. As I understand these transmitter claims, which are 1, 3, 6, 8, 11 and 12, they are in no way restricted by their description to any particular sort of spark-gap construction. Claims 1, 3, 6 and 8 refer to the spark-gap as "a means which automatically causes oscillations of the desired frequency." Claims 11 and 12 refer to it as "a producer of electric waves of high frequency." These expressions correspond to the description of the specification, which refers to what is now called the spark-gap as "a spark-producer or other electric wave or oscillation producer." It is, therefore, immaterial what the precise construction of the spark-gap is, in my opinion, and the rotary gaps referred to in the question are such as I understand are referred to in these claims, just as are the so-called quenched-gap and the so-called plain gap. The transmitters being otherwise in accordance with the description of the claims, it is immaterial, so far as the correspondence of the transmitter to the description of the claims is concerned, whether one of these constructions of spark-gap is used, or another.

Q. 13. Will you please consider the paragraphs quoted by Mr. Loftin in connection with the construction and mode of operation of the apparatus described in the Stone-Baker letters purporting to be dated June 30, July 18 and July 22, 1899, and referred to in the depositions of Messrs. Stone, Baker and Dean herein (P. R., pp. 863-952), and referred to by Mr. Loftin in his testimony relating to such apparatus (P. R., pp. 1076-1082, 1086, 1091), and state what, if any, bearing said letters have on the apparatus and the mode of operation of the Marconi tuning patent in suit, and particularly the apparatus recited in the claims thereof, in

issue herein, giving your reasons for any opinion you may express.

A. I have read the testimony referred to, and I have also read Mr. Weagant's testimony beginning at P. R., p. 1650. I disagree entirely with Mr. Loftin's opinions as expressed in his testimony, and I agree with the statements and opinions of Mr. Weagant.

Mr. Loftin, in my opinion, entirely overlooks or ignores the point of view of the art and the meaning of terms. What the art then knew as a wireless telegraph system comprised an elevated wire hung in the air, and one terminal connected to earth; there was one such wire at the [fol. 1540] transmitter and the other at the receiver. This was the original Marconi arrangement disclosed, for example, in his re-issue patent No. 11,913.

As disclosed in that patent, these two wires,—one constituting the transmitter, and the other the receiver,—had the same fundamental wave-length, which meant that the transmitting wire sent a signal whose fundamental wave-length was determined by the wire, and because the receiving wire had the same wave length, it readily picked up the signals so sent; that is, it readily responded to that wave-length.

By means of a spark-gap in the transmitting wire, this wire was charged, as, for example, by an induction coil, and its discharge gave rise to the waves which, however, due to the rapid radiation, the high resistance of the spark-gap and the small initial charge, rapidly died out and became insensible.

As Stone points out, the wave-trains which were emitted were of an extremely complicated nature, expressable mathematically by a long mathematical expression, which is worth quoting because these Stone-Baker letters are mathematical in character and show that what Stone was engaged in was a mere excursion into mathematical realms. The expression is:

$$\text{"}A_1 \sin pt + A_2 \sin 2\,pt + A_3 \sin 3\,pt + \&c$$
$$B_0 + B_1 \cos 2\,pt + B_3 \cos 3\,pt + \&c\text{"}$$

Stone undertook to provide a means of simplifying the radiation, which he thought he could do by avoiding the shock of discharge and producing what he calls "forced

current vibrations in the wire" and he reasoned that he would accomplish his object because, as he says:

"forced vibrations as is well known depend for their period and form only upon the period and form of the impressed forces and not upon the electro-magnetic constants of the circuit in which they are developed as is the case with *free* or *natural* vibrations of a system."

Stone proposed to retain the transmitting wire, with its fundamental frequency of oscillation or wave-length, and the receiving wire of the same fundamental wave-length, and he proposed to force thereon "oscillations from an oscillator, which oscillations shall be of a frequency corresponding to the fundamental of the wire." To accomplish this result Stone associated his oscillator with the antenna or vertical wire by means of a transformer, one coil of which was connected between the wire and earth. In this manner he forced upon the wire, according to his first letter, oscillations of the same frequency as the fundamental of the wire, and he expected thereby to realize simple oscillations which he thought he had mathematically proven to be represented by the simpler mathematical expression

$$"A_n \sin pt."$$

Stone's idea was a very natural one. Forced oscillations were well known and, according to Stone's mathematics, expressed in the second Baker letter, he should be able to force oscillations on the wire of his mathematically simple form, without regard to the fundamental frequency or wave-length of the wire.

Furthermore, Stone's idea was perfectly sound; he could force oscillations on the wire, but the trouble was, and is, that they are of no use, because of their excessive feebleness. Stone's mathematics was defective because of its [fol. 1541] incompleteness. Nature does not work that way, and the scheme proposed by Stone is utterly worthless because of its extreme ineffectiveness and the feeble character of the oscillations produced.

Stone followed the thought of the art. Marconi, in the patent 763,772 in suit, entirely disregarded it; that is, he entirely disregarded the teachings of his own former work and obtained a true grasp on the processes of nature. He entirely ignored the fundamental frequency of the wire

as it had existed, and directs that a radiating *circuit* should be constructed, having such a wire that when combined with the coil of his oscillation transformer and, if desired, also with an additional coil *g* (Fig. 1 of patent 763,772), the whole combination circuit should have the same fundamental frequency as that of the non-radiating circuit in which the oscillations were generated.

This is a wholly different concept from that of Stone; Stone's instructions were to erect a wire having a given fundamental wave-length, to construct an oscillator that would generate oscillations of that same wave-length and to force these oscillations upon the wire. He thus entirely missed Marconi's concept and failed to produce anything useful. Of course, he also did not attain the simple oscillations that he expected. Indeed, such oscillations as he could have produced would have been of still more complex form, which could still have been represented by the very complex formula quoted above by adding more terms, which are indicated in the formula given by Stone by the character "&c."

It does not seem to me to be profitable to consider in detail Mr. Loftin's long dissertation on these letters; he reaches his conclusion by disregarding what Stone says and credits him with saying something which he does not say. Stone throughout deals solely with the existing concepts of the art and undertakes to produce forced oscillations of the frequency of the wire itself. The idea of forced oscillations was a familiar one to the art, and has been well explained by Mr. Weagant.

Mr. Loftin credits Stone with the disclosure of a circuit comprising the wire and the coil, which are together so proportioned as to have the fundamental frequency of the oscillator. No such idea is stated or suggested by Stone, either in words, or in mathematical symbols, nor is it in any way implied by his diagram. I regard it as a wholly gratuitous assumption on Mr. Loftin's part, not having any foundation in the Stone-Baker letters.

I call attention to the fact that the second of his letters makes it clear, both mathematically and in terms, that Stone regarded it quite immaterial, so far as attaining his result of simple oscillations is concerned, or apparently any other result, whether the oscillator was made to have the frequency of the wire or not.

In my opinion, the Stone-Baker letters do not disclose structures such as set forth in the Marconi patent or referred to by the claims thereof in issue.

Q. 14. Will you please state the fundamentals of construction, function and mode of operation of the two-electrode vacuum tube, and also of the three-electrode vacuum tube, as a result of your personal knowledge and use of such tubes, and state in what respects they are similar or dissimilar. In this connection I will ask you to please consider the testimony of defendant's witnesses as comprised in the answers of Dr. John H. Miller to Q. 6, beginning on page 764 of the Printed Record, to Q. 17 (P. R., p. 786) and Q. 21, (P. R., p. 805), where he states what [fol. 1542] he considers to be essential differences, and the answer of Dr. Robert A. Millikan to Q. 12, beginning on page 845 of the Printed Record, pointing out in what respects, if any, you may agree or disagree with the statements made by these witnesses and the conclusions expressed by them, as bearing upon the technical facts, inquired about in this question?

A. In answering the question and in considering the testimony referred to therein, it is important to bear in mind that Fleming's patent was applied for in 1905, De Forest's patent was applied for in 1907 (I refer to the so-called grid patent, "Defendant's Exhibit K." No. 879,532), while Dr. Miller and Dr. Millikan testified in 1923, when their minds were so filled by the enormous mass of information acquired subsequent to 1907, that they were entirely unable to get back to the fundamental basis on which these structures rest.

Only the most trifling part of the knowledge with which these gentlemen testified could have been known to Fleming and to DeForest, when they were working their two and three-electrode vacuum tubes. I shall endeavor to get back to the fundamentals involved which constituted the great disclosure of Fleming, on which the whole radio art of vacuum tube devices rests.

These two and three-element vacuum tubes are, in substance, small incandescent lamps, within the bulbs of which there is, in addition to the filament, a cold plate with a terminal wire sealed through the glass in the same manner that the filament wires are sealed, so that electrical connections can be made with them without disturbing the vacuum existing in the bulb. In the three-element bulb,

there is an additional cold element, which most commonly takes the form of a sort of wire screen, usually interposed between the filament and the first-mentioned cold plate; this grid-like element also has a lead wire sealed into the glass for purposes of external connection.

When the filament is not lighted, the space between the elements inside the bulb is non-conducting for ordinary voltages or electrical pressures such as are used with these bulbs in practice. When, however, the filament is heated, the vacuous space becomes conducting and this fact had been known and intensively studied for very many years prior to Fleming's application for his patent 803,684, in suit. It was a very extraordinary phenomenon which ultimately came to be explained as the result of the emission by the filament, due to its high temperature, of minute charges of negative electricity derived from the atoms of the filament material.

After studying this strange phenomenon for many years and publishing results of many experiments on it in various technical publications, Fleming at length discovered that these minute charges of electricity given off by the hot filament could be utilized to give highly useful results in wireless or, as we now call it, radio telegraphy, and he disclosed in his patent, and in publications of about the same date, how to so use such a device, and some of the fundamental ways in which it acted.

The most fundamental fact involved in such vacuum tubes is that the electrons given off by the heated filament can be controlled by electrical voltages connected exteriorly between the cold plate element and the filament, even when these voltages oscillate at the enormous frequencies employed in radio work. When there is no voltage applied between the cold element and the filament, the electrons [fol. 1543] which are emitted have, so to speak, nowhere to go, and in general return to the filament. If, however, the cold element is made positive with respect to the filament, then some of the emitted electrons follow the electrostatic field so created and pass from the filament to the plate, so that a negative current flows from the filament to the plate as long as the latter is maintained positive and the filament is kept lighted.

Fleming discovered that if such a tube were so associated with a receiving antenna, or other source of wireless or high-frequency currents, so that the plate element was al-

ternately made positive and negative with respect to the filament, electricity flowed between the plate and the filament when the plate was positive, but did not flow when the plate was negative. This, at any rate, was his theory and it is the theory still entertained today by those skilled in the art.

By putting a receiving instrument either in the same or in another circuit between the plate and the filament, an indication was obtained showing or detecting what was happening in the bulb and, therefore, in the antenna connected to it; if waves were received indicating a dot or a dash, the indicating instrument responded with a visible or audible signal corresponding to a dot or a dash. In the same way, if a current carrying the voice or music, is received, a telephone connected with the bulb responds by reproducing the voice or music. This result is due to a variation of potential between a cold element in the bulb and the lighted filament therein.

If a battery or other constant source of voltage is applied, so as to make the cold element positive with respect to the filament, a steady current flows between the plate and filament (negative in the direction filament-to-plate), if, while this battery is still applied, radio-frequency signals are also impressed between the plate and the filament, this steady current is correspondingly varied up-and-down and, by properly adjusting the battery voltage, very loud signals may be obtained.

DeForest improved the Fleming two-element vacuum tube by putting into it the third or grid element. That it was an improvement, no one would deny, but he did not thereby take away from the device any of its former properties. If the filament is not lighted, the space is non-conductive. If the filament is lighted, but no voltage is impressed between either of the cold elements and the filament, nothing happens. If a voltage is impressed between either of the cold elements and the filament, or both connected together, and the filament, the same results happen as in the case of Fleming's two-element bulb. If the voltage so impressed is a radio-frequency voltage, the same effects happen as already described. If a battery or a battery and a radio-frequency signal are impressed, the results are as in the simple two-element structure.

As in the case of the two-element bulb, the battery and the radio signal do not have to be applied by the same ex

ternal connections, the signal may be applied by one external connection or circuit, and the battery by another, and the external indicating device may be in the circuit of the battery.

A well constructed two-element bulb used as a detector has a sensitiveness when a tungsten filament is employed, about equal to, or slightly superior to, that of the best crystal detector (Dr. Miller says it is only one-fourth or one-fifth as sensitive, but this only shows that he never used, or never properly used, a good two element tube). When there are three elements in the tube, as shown in the DeForest patent 879,532, it is possible to connect the cir- [fol. 1544] cuit containing the radio signal between the filament and one of the cold elements, while the battery and indicating device are connected between the filament and the other one of the cold elements. In other words, the two functions, viz., that of receiving signals and of carrying the steady current and indicating the response, are divided between the two cold elements, and when this is done, an improvement in sensitiveness is attained, which Dr. Miller rates at about fifty per cent., as compared to the crystal.

What it is that happens under these circumstances is fundamentally the same as before. If a signal is applied to either of the cold elements, the potential of that element with respect to the filament changes; when it is made positive, electrons pass from the filament to the element; when it is negative, they do not, unless a battery is also connected from the positive terminal to the element, in which case the number of electrons passing changes, that is, the current waxes and wanes. If the signal is applied, say, to the grid element, which is not otherwise polarized, while the plate element is polarized by a battery, then when the grid element is made positive by a signal, electrons flow to the grid, and when it is negative, electrons do not flow to the grid. When electrons flow to the grid as the result of a positive potential, if a measuring instrument were inserted and a positive potential maintained, a certain current would be found to flow between the grid and the filament. Assume that the same voltage were now transferred to the plate element (assuming no polarizing battery present), a current would similarly flow between the filament and the plate. In other words, the two elements considered

separately, act in the same way. When a positive voltage is applied to the grid while there is also a battery connected to the plate, not only does a current flow between the grid and the filament, but an increase of current occurs between the plate and the filament. The same result would occur if the signal were also applied to the plate. The three-element bulb, however, has the advantage that when the signal is applied to the grid or a positive voltage is so applied, the increase of current between the plate and the filament will be greater than it would have been if the same positive voltage had been applied directly to the plate. In other words, while the effects are the same in kind, the three-element construction is an improvement. It enables a more effective control of the electrons emitted by the filament to be had; and, further, because there are three elements to be utilized, instead of only two, the device is obviously susceptible of more different modes of connection. For example, one of the cold elements may have one polarizing battery connected to it, and the other may have another and different battery connected to it, and these may be even opposite in polarity. In this way, a great widening in the possible range of control of the electrons emitted by the filament may be had. In all cases, however, the operation is the same, and consists in the control of the movement of the electrons which are emitted by the heated filament.

Referring to the answer of Dr. Miller, mentioned in the question, Dr. Miller admits that "the operation of both the Edison two-element valve, which is Fig. 1 of my drawing A, and the three-element DeForest device, which is Fig. 2 of that drawing, depend upon the peculiar property of a heated filament of emitting what are called electrons or thermions."

Although I do not find that Dr. Millikan makes any simi- [fol. 1545] lar explicit statement, he does not deny the facts stated by Dr. Miller. I assume, therefore, that it may be taken as admitted that these two devices, the two-element and the three-element vacuum tubes operate, in view of this fundamental fact.

Dr. Miller then proceeds (P. R., p. 765) to state briefly with respect to the two-element bulb, some of the controlling effects which exist when the cold element is polarized with respect to the filament and subjected to oscillating currents. When, however, he passes to the consideration of the three-

electrode vacuum tube, he fails to point out that exactly the same sort of control occurs. He passes at once to the statement that "the three-electrode device of DeForest, which is Fig. 2 of drawing A, is an amplifying relay or amplifier."

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Dr. Miller thus entirely omits any fundamental consideration of the three-element tube and passes at once to the uses of it, for which he has laid no foundation by a description of its fundamental properties, other than the admission which I have quoted, that it depends "upon the peculiar property of the heated filament of emitting what are called electrons or thermions." He does not state that like the two-element valve, it depends upon the fundamental fact disclosed by Fleming, that when these electrons are subjected to electrostatic field effects produced by high-frequency radio currents, they are able to respond thereto and that the utility of the device depends upon this ability. If he had pointed out this fact, the fundamental identity of the devices would have been at once apparent.

He did not point out that the mere emission of the electrons by the filament is of no more consequence in the three-element device, than it is in the two-element. He did not explain that the operation of the device depended upon the same fact as the two-element device, viz., that by an additional electrode and an external circuit connected thereto, and to the filament, electrostatic field effects are produced in the same manner as in the two-element valve, which control the response of the emitted electrons and their flow in the external circuit. Elsewhere, of course, he has at various times substantially admitted this, but not in a context which brings out the fundamental identity.

In the diagram which he produces in answer to Q. 6, and which is marked "Miller Drawing B" and is found opposite P. R., p. 765, he does not illustrate the two devices under at all similar conditions, and, therefore, his diagram is highly misleading.

I produce a diagram, "Waterman Drawing No. 5" Claimant's Exhibit No. 322), in which I have illustrated the two devices under the conditions of Dr. Miller's Fig. 1 of "Miller Drawing B". Fig. 1 of this drawing is the same as Fig. 1 [fol. 1546] of "Miller Drawing B"; Fig. 2 is the same as Fig. 1, except that the bulb shown is a three-element bulb, with the grid element connected to the filament through an

indicating instrument I and the source of oscillations; Fig. 3 is the same except that the plate element is connected to the filament through the same indicator and oscillator elements. The results are indicated by the diagrams below the individual figures. They are identical.

I produce a second diagram, "Waterman Drawing No. 6" (Claimant's Exhibit No. 323), in which I show the three-element and the two-element tubes employed with a battery, after the manner of Fig. 2 of "Miller Drawing B". Fig. 1 of this drawing is like Fig. 1 of "Miller Drawing B", except that it has the battery marked B, in Dr. Miller's Fig. 2. Fig. 2 of this sketch is the same as Fig. 2 of "Miller Drawing B". Fig. 3 of this drawing shows a two-element valve, arranged with two external circuits, after the manner of "Miller Drawing B", Fig. 2, the condenser C acting as a break between the two circuits, fulfilling in this regard the function of the space in the tube between the plate and grid elements. The diagrams below each of the figures show the effect produced, which is the same effect as shown by Dr. Miller's Fig. 2.

Thus it appears, and is the fact, that in their fundamental mode of operation these devices are the same. Both the two-electrode tube and the three-electrode tube take advantage of, and utilize, by causing the received signal to produce a varying electrostatic field, the extraordinary sensitiveness of the emitted electrons from the filament to the effects of such a field. No matter how they are utilized in radio work, including all of the uses which Mr. Miller mentions, it is this responsiveness of the emitted electrons to electrostatic control, even at the highest frequencies employed in radio, and which Fleming discovered and disclosed, that is the cause and means of the operation. Whether the three-element device is acting as what Dr. Miller calls a rectifier, or an amplifier, or an oscillator, it is always responding to and exemplifying that control of the electron stream which is produced by introducing an auxiliary electrode into the tube in proximity to the filament, and introducing by an external circuit, fluctuating voltages between these elements, as Fleming taught.

What DeForest did when he introduced the grid element was to extend this control. The idea of controlling an electrostatic field by the screening action of a grid, was not a new phenomenon in the art. Dr. Miller admits (P. R., p. 767) that it had been recognized and mathematically investigated by Maxwell many years prior. That the introduction

of this screen or grid into the tube greatly increased its utility nobody, I assume, would deny. Certainly, I have never denied it. But in adding this device, DeForest did not abandon anything which Fleming had, nor anything which affected the fundamental mode of operation, by electrostatically controlling the emitted electrons. On the contrary, what he did was to perfect and extend this control.

Fleming, in his Royal Society paper read February 9th, 1905, showed several forms in which his device could be constructed, and gave extensive experimental data illustrated by curves. This showed how the device responded with varying potential differences applied between the cold element and the filament, and how the current, that is, the electron flow between the filament and cold element varied, when this potential difference varied. In this case a battery was employed in the external circuit. Where DeForest's [fol. 1547] grid element was employed, it was found that the same effects occurred, but that the electron flow, that is, the passage of the electrons from the heated element to the plate element when the battery is present, may be altered either by applying oscillations to the plate, as in Figs. 1 and 3 of "Waterman Drawing No. 6", or it may be effected by applying the oscillations to the grid element, as in Fig. 2 of my "Drawing No. 6."

It is found, however, and this is the particular advantage of the arrangement, that a given oscillating electromotive force has a greater effect when applied to the grid, than it does when applied to the plate. For example, in the early DeForest tube which I used, a voltage of one volt applied to the grid was from one and a half to two and half times as effective as the same voltage applied to the plate, other things being the same. At the present time, greater ratios are commonly employed, which have become possible as knowledge of such devices has increased. This ratio is sometimes spoken of as the "amplification ratio" or "constant" of the tube.

Obviously, this is an advantage, as it gives a device of definite amplifying capabilities, but it does it by virtue of the same principle and mode of operation as in the case of the Fleming device, and the device is the same, with simply the addition of the screening element.

It must not be imagined that because the three-element tube shows this ratio of effectiveness of one to one and a half, or one to two and a half, or more, that, therefore, it

always amplifies in that ratio; it does not, and it was many years before much of anything was understood about it or, perhaps, even its existence was known. In the early years after the production of the three-element tube this property existed rather as a dormant capability than as anything to which real effect was given.

The sole basis of Dr. Miller's differentiation and comparisons, to a considerable extent also, Dr. Millikan's, is that when they talk about the three-element tube, they have in mind, as indicated by their statements, the present-day highly-developed bulb, with filaments which represent years of investigation and structural arrangement representing still more years, and endowed with all of the capacities which have resulted from the labors of many workers in the development of circuits while, when they refer to the Fleming device, they refer to the necessarily crude first attempts and insist that it must be considered only in the precise circuit arrangement that Fleming shows. It is like comparing the highly-developed locomotives, stationary engines or turbines of today, with the first crude steam engine of Watt, wherein the piston moved in one direction by taking steam through its full stroke, and in the other by squirting cold water into the cylinder, and allowing the steam to condense. Nobody doubts, however, that the present-day highly-developed steam engines are simply improvements upon Watt's device. There is not, of course, any such difference between a two-element device constructed with modern knowledge and a three-element device constructed with the same knowledge.

Dr. Miller, for example, has stated that the three-element device as a detector or frequency converter, gives results about fifty per cent. better than a good crystal, and about five times as good as a two-element valve. On a proper basis of comparison, that statement is not true. I have made an immense number of such comparisons, and a good Fleming valve is equal to, or a little superior to, the best; that is, the most sensitive crystal, when used in place of a crystal in a [fol. 1548] radio circuit and when constructed with a modern high vacuum. It is, of course, true that some of the Fleming valves that were produced in the early days were less sensitive than the crystal, and it is also true that some of the early DeForest three-element valves or audions, were less sensitive than the crystal, when used to replace it in a radio circuit.

In point of fact, uniformity or the possibility of uniformity in either two or three-element tubes is strictly a modern achievement, resulting from a vast amount of investigation and labor, in the standardization of materials, the standardization of dimensions and great exactness of construction to the dimensions, together with cleanliness in construction and perfection and standardization in evacuation processes. The early Fleming two-element tubes and the early DeForest three-element tubes did not have the benefit of any of these improvements, with the result that individual tubes, whether two-element or three-element, differed greatly among themselves.

It is manifestly misleading, and only obscures the true facts, to compare the highly-developed device of one form with the undeveloped device of the other form. It tends to still greater confusion, when the properties which grow out of the development of modern circuits are ascribed to the device itself.

In his answer to Q. 17, beginning P. R., p. 786, Dr. Miller discusses the Fleming two-element device in the arrangement of Fig. 1 of the Fleming patent and the three-element device in the arrangement known as the PN circuit. These two circuits were not new to the art, they are the two circuits of Marconi's prior patent 627,650. Fig. 1 of the Fleming patent corresponds to Fig. 2 of the Marconi patent 627,650 ("Defendant's Exhibit B-6"), while the PN circuit corresponds to Fig. 1 of the same patent. The two circuits differ in that in Fig. 2 of "Defendant's Exhibit B-6" the signal is put into the connected device and the result thereof indicated in a single circuit; whereas, in Fig. 1, to which the PN circuit corresponds, the signal is put into the connected device by one circuit, and the result thereof is indicated in a second circuit. DeForest, in his so-called PN circuit, connects one of these circuits, viz., that which impresses the signal on the tube, between the grid and the filament, while the other of the two circuits, viz., the indicating circuit, he connects between the plate and the filament.

* * * * * * *

It will be seen that in Fig. 1 of this patent 627,650 ("Defendant's Exhibit P-5") the functions of receiving the signal and impressing it on the device T are assigned to one of the two circuits, namely, that containing the receiving coil f^2, [fol. 1549] while the function of indicating what happens

is assigned to the second circuit containing the indicator R.

The condenser *k'* in the input circuit is primarily for the purpose of confining the current from the battery B to its own circuit including the device T. This device T is indicated as a glass tube, containing terminals, known as a coherer, which was a form of detector used at that time, and which required the battery B to be applied to it.

DeForest applied the condenser which is shown at C of Fig. 1 of his three-electrode patent 879,532 ("Defendant's Exhibit K"), for the same purpose, as stated at page 1, line 95, where he says:

"In order to close each of said circuits to the passage of direct current from the aforesaid battery [B] there-through or to prevent the development of a difference of potential between the members *a* and *b*, or between *a'* and *b*, or to prevent the members *a* or *a'* from receiving an electric charge from said battery, I insert the condenser C" in said otherwise mechanically closed circuit and find that the presence of said condenser produces a great increase in the sensitiveness of the oscillation detector" * * *

DeForest connected his input circuit between the grid and the filament, to impress the signal on the device, and he connected the output circuit between the plate-element and the filament to indicate what happened as a result of impressing the signal. He thus chose the one of the two old Marconi circuits which was appropriate to his three-electrode tube. Fleming having a two-electrode tube, chose Fig. 2 of this Marconi patent 627,650.

Of course, we now know that DeForest did not need the condenser *k'* (C" in the DeForest patent) for the purpose which he specified, but DeForest did not know it at the date of his patent. Dr. DeForest did not have the large amount of subsequently-acquired knowledge with which Dr. Miller has testified.

To show the similarity of the fundamental action of the Fleming two-electrode and the DeForest three-electrode devices, I produce a drawing, which I have marked "Waterman Drawing No. 7" (Claimant's Exhibit No. 32-). Fig. 1 shows the two-electrode tube in the circuit of the Fleming patent, and Fig. 2 the three-electrode in the circuit of the DeForest patent, except in each case I have omitted the antenna. Assuming continuous oscillations are being received, the electron-control by the electrostatic fields pro-

duced within the tube of Fig. 1, would produce an electron flow from the filament to the cold electrode during each portion of each oscillation, when the cold electrode was positive, and the flow would be suppressed during every interval when the cold element was negative. This I have indicated by the semi-sinusoid marked "Electron Flow".

In Fig. 2 the same condition exists in the grid circuit. Since there is a condenser in this circuit, this action could not continue indefinitely in the way that I have indicated it, unless there were some leakage path by which the charge in the condenser would be kept from increasing to too great an extent.

In the tubes as DeForest built them, the tube itself was leaky enough to accomplish this result. With the improved tube of today, it is customary to provide a definite leakage for the condenser by putting a very high resistance around it.

[fol. 1550] It will be seen that the control of the electron flow by the electrostatic field produced by the signals is the same. In the lower lines of Figs. 1 and 2 I have shown the current in the telephones indicated by I in the drawing. This would be a steady current, which would be indicated in a galvanometer by a steady deflection in Fig. 1, while in Fig. 2 it would be a similar steady current, which would be evidenced in the galvanometer by an alteration in the deflection which would be produced by the battery B, in the absence of a signal. Of course, in neither case would a sound be produced in the telephone, other than a "click" when the signal began, and in order that a signal might be produced in the telephones, the continuous oscillations supposed to be received would have to be "modulated", — either by suitably breaking them up in sending dots and dashes,—in which case telegraph signals would be received, or varying them to correspond to the voice or music, in which case the voice or the music transmitted would be audible in the telephones.

The purpose of the diagram is to show that in each case, that is, with the two-electrode and the three-electrode tubes, we are dealing with the same fundamental electrostatic control produced by the radio-frequency oscillations, in accordance with Fleming's discovery. Dr. Miller has pointed out the fact that the mass of the electrons is only one two-thousandth part of the mass of the atom of hydrogen for the speeds at which the electron moves in the tube, and that

this is the reason why it is supposed that the electrons can respond at radio frequencies. But the fact that it could so respond was discovered by Fleming and disclosed by him, in his patent in suit, and it is this fact that is fundamental to the operation of the tube, whether it has two electrodes or three.

The two and three-element tubes may be used to detect oscillations by responding to their electrostatic control in another slightly different arrangement, wherein a polarizing or biasing battery is employed. In "Waterman Drawing No. 8" (Claimant's Exhibit No. 325), I have indicated this battery by C, and it will be noticed that they are oppositely poled, because in the two-element tube the single plate-element has to perform both of the functions of receiving and indicating; whereas, in the three-electrode tube they are separated. In this instance, therefore, it is the electron flow to the plate-element which is to be compared, since the grid-element is so biased as to leave it to perform solely the function of electrostatic control, while the plate circuit does the indicating. In the two-element tube in this single circuit, the single circuit has to perform both functions.

It will be seen that in each case in the absence of a signal, a certain current would flow, which is indicated by the dotted line in the middle diagram of each figure. The polarization in each case is assumed to be such as will result in an unsymmetrical effect, which Dr. Miller has called a "distortion", to occur when oscillations are received. The result is that the normally flowing direct current is varied more in one direction than the other, with the result that the current in the indicator I is altered, as in the lower sketch of each figure.

Here, again, we have illustrated the same fundamental electrostatic control exerted by the impressed oscillations.

Of course, these diagrams are not intended to be quantitative. As I have already said, the control which is effected when the grid-element is present is greatly improved. The grid-element is enabled to control the current of a battery [fol. 1551] in the output circuit, viz., the battery B. As a result of this improved control, the three-element tube has improved capabilities, but these improved results should not be allowed to obscure the fundamental fact that both act in response to the same primary causes, viz., the emission of electrons in a heated filament in a vacuum and their con-

trol by electrostatic fields produced by cold elements introduced for the purpose, when signals are introduced between the cold element and the filament in each case.

Mr. Vaill: Counsel for claimant offers in evidence the four drawings referred to by Mr. Waterman in his last answer, as Waterman Drawings Nos. 5, 6, 7 and 8, and requests that the same be marked respectively "Claimant's Exhibits Nos. 322, 323, 324 and 325".

(Said exhibits marked as requested.)

Q. 15. Dr. Miller, in his answer to Q. 17 (P. R., p. 786), compares the operation of the Fleming valve in the circuit of the patent in suit with that of the DeForest PN audion used by the Navy as illustrated in "Plaintiff's Exhibit No. 83". Will you consider this answer of Dr. Miller regarding the PN circuit, and state whether or not you agree with his conclusions, or whether he has advanced any reasons which affect your opinion on this subject, as stated in your previous deposition? (P. R., 222-3.)

A. I have considered the testimony of Dr. Miller referred to, and it does not alter, but rather confirms the opinions which I expressed in my former deposition. With Dr. Miller's technical explanation of the operation of the three-element bulb in the PN circuit, I have no quarrel; it is, as I understand it, the usual present-day method of explanation which assumes the fundamental facts of electrostatic control. I differ radically, however, as to the statements of differences and implied differences between the two-electrode and the three-electrode tubes. I also differ with his statement that his explanation "stresses the most essential features of the action of the tube in this circuit". It does not; on the contrary, he omits to point out that the fundamental action is the control of the emitted electrons by the electrostatic fields produced, which control is the same as that in the two-electrode tube of Fleming.

The PN circuit is the circuit of Fig. 1 of the Marconi patent 627,650, reproduced in my preceding answer and in Fig. 2 of my drawing 7 ("Claimant's Exhibit No. 324"). Fig. 2 of my drawing 8 ("Claimant's Exhibit No. 325") differs in that the biasing battery is substituted for the condenser in the input circuit. I will here confine my answer to the form of circuit shown in Fig. 2 of drawing 7.

As pointed out in my last answer, the operation of this arrangement is fundamentally the same as that of the two-electrode tube. It is commonly referred to at the present time as the "grid-rectification" circuit. Dr. Miller, on P. R., p. 788, admits that the action which I have indicated occurs in this PN circuit:

"Received oscillations, modulated at audio-frequency, produce rectified current pulses in the grid circuit of the tube when the amplitude of the oscillations is increasing, and thus, by reason of the grid condenser, cause the average grid potential to become more negative."

[fol. 1552] Again on page 787, he says:

"When the first of these alternations are applied to the tube they produce rectified current pulses between the grid and filament of the tube, the action being similar in this respect to that of the two-electrode rectifier".

He then explains that, owing to the presence of the condenser, in order that this action may continue, the condenser must be able to discharge through some leakage path, and that current will continue to flow in rectified pulses to compensate for this leakage.

Dr. Miller, in other words, admits that the controlling action in the three-electrode tube in this PN circuit, is exactly the electrostatic control of the Fleming two-element bulb, and he points out that the effect of this rectification is to cause the current in the plate-circuit to change, and thereby indicate in the output circuit the result of the receipt of the oscillations exactly as indicated in my drawing No. 7.

In view of this admission, the only differentiation between the two and the three electrode tubes is that in the specific circuit shown in the Fleming patent the impressing of the oscillations and the indication of what happens, is done in one circuit. He says (P. R., p. 790):

"The two-electrode device in the Fleming circuit constitutes essentially a rectifying device in a single circuit in which the received oscillations are rectified and themselves flow through and are indicated by the indicator. On the other hand, the three-electrode device in the PN circuit as well as in the regenerative circuit constitutes essentially a different type of vacuum tube connected to two separate

circuits neither of which performs the functions of the Fleming circuit."

Unless this is a mere quibble, it is wholly untrue. I pointed out in my former deposition that in the circuit as shown in the Fleming patent, two functions are performed, one being to impress the signal on the tube, and the other being the indication of the current or current-change which results, and I pointed out that in the PN circuit there are two parts, viz., that which is commonly called the input circuit, which performs the function of impressing a signal on the tube, thereby setting up the electrostatic field, and the other, viz., the output circuit, which performs the function of indicating the result. The only basis for Dr. Miller's statement that I can conceive of is that he means that neither of the two parts into which the PN circuit is divided (as taught by Marconi), as compared to the single circuit shown in the Fleming patent, performs *both* of these functions. The input circuit, of course, does not indicate because there is no indicator in it, but if Dr. Miller means to suggest that it would not indicate if an indicator were put in it, he is wholly mistaken, and his statement is entirely incorrect. If, for example, a telephone is put into the input circuit of the PN circuit, as for example, adjacent the filament, in the same relative position as the indicator I of Fig. 1 of my drawing No. 7, the signal will be heard. Exactly the same thing is true of the modified arrangement of my drawing No. 8. From every point of view that I am able to think of, therefore, Dr. Miller's statement that neither of the two parts of the PN circuit "performs the functions of the Fleming circuit" is wholly incorrect and misleading. The fact is that because the input path of [fol. 1553] the PN circuit performs the functions of the Fleming circuit, the three-electrode tube is able, through the more effective use of the electrostatic control, to perform the additional function of influencing the flow of the battery B in the PN circuit, as though a stronger signal had been applied to the plate of that circuit.

* * * * * * *

On P. R., p. 790, Dr. Miller says, in continuation of the last quotation:

"In the PN and regenerative circuits, while the received oscillations are increasing in amplitude, they produce

rectified current pulses which charge the condenser, which charges leak away when the received oscillations are decreasing in amplitude or are not being received."

This is a correct statement, and is an admission of the same electrostatic control action upon the electrons, as found in the two-electrode tube. His immediately following statements, however, are wholly incorrect. He says:

"Such rectification as occurs is not indicated in either circuit. Even if it were possible to observe this rectification it would not reproduce the audio-frequencies which the detector is intended to indicate."

These statements are incorrect. Dr. Miller himself, in fact, goes on to say that it is this rectification which is the cause of the variation of voltage between the grid and filament which, in turn, by the same sort of electrostatic control, causes the indicator and the plate circuit to show what has happened by responding to the signal. His statement that "even if it were possible to observe this rectification it would not reproduce the audio frequencies" is absurdly incorrect, as anyone can prove for himself who has a radio set, the wiring of which is accessible enough to permit the introduction of a telephone in the position corresponding to that of the indicator I, Fig. 1 of my "Drawing No. 7" ("Claimant's Exhibit No. 324"): that is, into the input circuit of the PN or regenerative detector. Whatever the detector is responding to, whether it be telegraph signal, speech or music, will be heard just as faithfully reproduced as though the telephone were in the output circuit. Of course, it will not be quite as loud because, as I have stated, the three-element tube has the advantage that a given signal applied to the grid is equivalent to a somewhat greater signal applied to the plate, this being one of the improvements that DeForest made when he inserted the grid. But to say that the audio frequencies which the detector is intended to indicate, cannot [fol. 1554] be observed in this circuit, is highly absurd and untrue, and merely shows that Dr. Miller never tried it, and has an incorrect understanding of the operation of the device.

None of the statements which I have made in this answer, or in my preceding answer, are in any way dependent upon the degree of exhaustion or vacuum in the tube. I have

tried the experiment with both so-called "hard" tubes and with so-called "soft" tubes, and the result is the same.

This statement of Dr. Miller's is so astonishingly in conflict with the facts as ordinarily understood, that to make perfectly sure of the matter I repeated the test within the present week, although I have done it many times before. I found the facts to be exactly as I have stated them, and entirely in conflict with Dr. Miller's statement. It is clear that Dr. Miller was simply not informed as to the facts.

The action of the three-electrode tube in the PN circuit is exactly the same sort of action as occurs in the two-electrode tube.

Q. 16. In Dr. Miller's answer to Q. 18 (P. R., p. 791), he compares the operation of the Fleming valve with the three-electrode audion when a local battery is employed. In his answer to Q. 21 (P. R., pp. 808-10), and in his answer to Q. 23 (P. R., p. 814), he comments on, and criticises your previous testimony relating to the use of a local battery with the Fleming valve and audion, and says that your testimony conveys a wrong impression in respect to such use, and that you are incorrect in stating that the Fleming valve may be used to amplify when a local battery is employed. Dr. Millikan also states that a hard Fleming valve with or without a battery is incapable of amplification (P. R., pp. 847-8). Will you please make such comment upon defendant's testimony above referred to on these subjects, as may seem necessary, and also briefly point out why users of the Fleming valve are entitled to employ a local or B battery therewith, giving your reasons for any opinion you may express?

A. Referring first to the latter part of the present question, I may say that the use of a local or B battery with detectors of many sorts, was exceedingly well known, both as a matter of disclosure in patents and publications and as a matter of actual use in connection with detectors of many different forms, long prior to either the Fleming or the DeForest patents for the two-electrode and three-electrode tubes respectively. Since Mr. Weagant, in his answer to Q. 260 (P. R., p. 1719), and to Q. 304 (P. R., p. 1766), has given references to a number of instances of this prior knowledge, I will not repeat. I have read his testimony and find that it correctly states the facts as known to me.

Dr. Miller's statement of the physical basis of his comparison is found in his answer to Q. 21 (P. R., p. 805), as follows:

"The Fleming valve as shown in the Fleming patent is identical in structure with the device shown in the Edison patent No. 307,031 of October 21, 1884, and illustrated in my Figure 1 of drawing A. Both structures consist of an incandescent filament and cold plate insulated from each other within an evacuated inclosure and both devices utilize the emission of electrons from such an incandescent filament and the flow of these electrons through the space between the filament and the plate. The shape and location of the cold plate is somewhat different in the two cases. Edison shows a plane plate located between the two legs of the filament while Fleming shows a cylindrical plate [fol. 1555] surrounding the filament. This, however, is an immaterial difference which does not change the principle of operation.

"The three electrode vacuum tube has a third electrode called the grid which is utilized as a sensitive control member over the electron flow between the hot filament and the cold plate."

I have no quarrel with this statement, so far as it goes. It simply does not go far enough. After the Edison tube had been known for very many years, and had received a large amount of study by eminent scientists, Fleming discovered that the electrostatic forces that could be produced by high-frequency radio signals could control the electron emission from the heated filament for the purposes of radio work. This was an epoch-making discovery in the history of radio, and I agree with Dr. Miller also, that the three electrode tube, by virtue of its grid electrode, exercises this function of electrostatic control over the electron stream in a very sensitive way.

The statements of Dr. Miller confirm me in the view which I previously expressed, that what DeForest did when he put in this third electrode, was to divide the cold element into two, so that the two functions performed in the two-element bulb can be divided, the function of impressing the signal being assigned to one cold element, while the function of indicating the result is assigned to the other. I disagree entirely with Dr. Miller's view that such a statement is misleading. I think, on the contrary, that it is Dr. Miller's

statements that are misleading. I believe that stating the matter in this way states the exact fact in readily comprehendable terms.

Dr. Miller is apparently loath to admit that the two-electrode tube of Fleming can be used in the PN circuit, viz., in the circuit of Fig. 1 of the Marconi patent 627,650, reproduced in my second preceding answer. A glance at the figure shows that it is only necessary to substitute the two-electrode tube for the device T, in order to connect it in that circuit, and it is only necessary to try it to find that it works. Mr. Weagant testifies to having so used it, and I can confirm that testimony, because, on a considerable number of occasions I have seen him use it, and have participated in the observations. I have also so used it myself hundreds of times. On many of these occasions I simply inserted this two-element tube into the socket of a DeForest PN detector box connecting both circuits to the plate element, as in the Marconi patent, and used it without other change, save, of course, of a proper adjustment of the battery. It will be seen that if the electrode of the device T in Fig. 1 of Marconi patent No. 627,650 is regarded as split into two parts, each of which has a lead wire brought out, no alternation is effected except that one of these parts receives the signal from the branch f^2, k', while the other branch containing the battery B and the indicator R connected to the other portion, indicates what happens. What is more, the device T of the Marconi patent could have its left-hand electrode split longitudinally and connected in the manner just described, and it would continue to function just as before. Furthermore, this device T of the Marconi figure being, as I understand it, a coherer, is, as Mr. Weagant has pointed out, also an amplifier. Since, however, it has no such refined and graduated electron control as that discovered by Fleming, it is not capable of corresponding usefulness.

One reason why Dr. Miller says that he does not regard it as proper to consider that the plate element of Fleming [fol. 1556] is split into two parts, is because the ordinary three-electrode tube has its additional cold element in the form of a grid. Dr. Miller should know, however, that this is not an essential. It is not the thing which DeForest did in his original three-element amplifier patent. In that patent (841,387) ("Claimant's Exhibit No. 270"), De-

Forest literally divided the cold element into two parts, to one of which he assigned the function of impressing the signal to control the electron flow, and to the other of which he assigned the function of indicating what happened and so giving the amplified signal, using a battery, of course, in this circuit, because, as Dr. Miller says, such a battery is required by the fundamental law of the conservation of energy.

Looking at Fig. 4 (part of Claimant's Ex. 270) of this patent, for example, it will be seen that the cold element is divided into two plates, D, D', to one of which, D', is assigned the function of impressing the signal, while to the other, D, is assigned the function of indicating what happens. It will be noted that this is the PN circuit, and that it is identical with the circuit of Fig. 1 of the Marconi patent 627,650, with one electrode of the device T split into two parts. It is, of course, immaterial which is split in the case of the device T, but it is the cold element that must be split in the case of the vacuum tube, because it is the cold element which exercises the electrostatic control of the electrons emitted by the filament. DeForest, in turn, got this split element from Fleming, as will be seen by comparing the DeForest patent 841,387, "Claimant's Exhibit No. 270", with the Fleming paper, "Claimant's Exhibit No. 269". This has been referred to and explained by Mr. Weagant in his answer to Q. 263 (P. R., p. 1723). I may say that I have a number of tubes in which the two cold elements are both plates, although not in the precise form shown in the DeForest patent, and they all perform all of the functions of the three-electrode tube in which the third electrode has the form of a grid.

The construction of the third element in the form of a grid was an improvement patented by DeForest in his patent 879,532 ("Defendant's Exhibit K").

In view of the foregoing facts, I am unable to see any possible basis for Dr. Miller's criticism. It is his statements, and not mine, that are misleading.

In connection with his answer to Q. 21, Dr. Miller, in effect, admits the substantial identity, but undertakes to distinguish by saying that the functions are different. Here, again, however, he omits to refer to the fundamental similarity of operation, and to the obvious fact that the two functions are in both cases divided so that the input func-

tion is served by one branch, and the output by the other branch, of the PN circuit.

In "Miller Drawing L" he has produced as Figs. 3 and 4, illustrations of the two-electrode and three-electrode tube in this form of circuit. He attempts to disguise the similarity by putting in the tuning condenser in Fig. 4, and leaving it out of Fig. 3, and putting in the coil L in Fig. 3 and leaving it out of Fig. 4. Of course, neither is essential in either figure. Certainly, if the tuning condenser was used in one case, it would be in the other.

Dr. Miller then proceeds to illustrate in Fig. 3*a* a different arrangement of the elements, but, for some unexplained [fol. 1557] reason, fails to point out that an identical rearrangement can be made for Fig. 4 of his drawing L.

I produce a drawing, marked "Waterman Drawing No. 9" (Claimant's Exhibit No. 326), in which I have made this re-arrangement.

Under the heading "2-Electrode Tube" I show the parallel arrangement of Dr. Miller's Fig. 3*a* and underneath it the ordinary diagram of the PN circuit, in which I have included a tuning condenser indicated by the arrow. Under the heading "3-Electrode Tube" I show this parallel arrangement of the circuits after the manner of Dr. Miller's Fig. 3*a*, and underneath it I show the same PN circuit in the ordinary method of illustration. It will be seen that whether illustrated in the parallel arrangement of drawing of Dr. Miller's Fig. 3*a* or in the usual form of Fig. 1 of the Marconi patent 627,650, they are identical, save that the three-electrode tube has two cold elements, while the two-electrode tube has but one.

With respect to the use of a local battery, I have no essential disagreement with Dr. Miller as to the use of a biasing battery in connection with crystal rectifiers, as found in his answer to Q. 18, beginning (P. R., p. 791), nor have I any disagreement with his statement that "the use of a battery with an amplifier is indispensible by reason of the law of conservation of energy." What I object to is again what he omits to say. Dr. Miller fails to point out that an exactly similar use of a biasing battery is made with the three-electrode tube, as I have shown in Fig. 2 of my drawing No. 8, in my second preceding answer.

Dr. Miller also omits to point out that just as the biasing battery when used with the crystal and with the Fleming

two-element bulb when employed as a simple detector, is adjusted to take advantage of a bend in the characteristic curve, so also in the three-element tube in a precisely similar manner, the biasing battery, shown at C, Fig. 2 of my "Drawing No. 8", is adjusted to take advantage of the bend in the characteristic curve of the three-element tube. Had Dr. Miller pointed out these facts, the precise parallelism between the two-electrode and the three-electrode devices in this regard also, would have been apparent.

As a matter of fact, in the practical use of the three-electrode tube, as in that of the two-electrode tube, sometimes the tube is used in the PN circuit with the condenser, and sometimes it is used with the biasing battery. The first shown in my "Drawing No. 7", Fig. 2, is commonly known in the art as grid rectification; whereas, that with the biasing battery shown in Fig. 2 of my "Drawing No. 8", is commonly known as "plate rectification." Both forms of detection are common, and both are rectification, if that term has any appropriateness in either case. Of course, when either the two-element or three-element bulb is used as an amplifier, or to generate oscillations, then, of course, energy must be supplied by a local source, and this is drawn from a local battery, whether the tube has two electrodes or three. Of course, the two-electrode tube having only two electrodes, naturally has only one battery, while the three-electrode tube, having two cold electrodes, may employ two batteries, and one of these may be utilized to take advantage of the shape of the characteristic curve only, while the other is used to furnish the energy for amplification and maintain an electron flow to its cold element. When the two-electrode tube is used to amplify or generate oscillations, one battery serves both functions.

I note that Fleming, in his Royal Society Paper of 1905, which is "Claimant's Exhibit No. 269", shows fully the [fol. 1558] effect of a battery with different filament temperatures and different values of the battery in the two-electrode tube.

Mr. Vaill: Counsel for claimant offers in evidence the drawing referred to by Mr. Waterman in his last answer as "Drawing No. 9", and requests that the same be marked "Claimant's Exhibit No. 326".

(Said exhibit marked as requested).

Q. 17. Will you briefly state what is meant when it is said that a two or three-electrode tube will "generate oscillations", and also explain the relation of the so-called negative resistance and falling or rising characteristic curves, as used in connection with the subject of such oscillations, and also please state the relation of these functions to the amplifying action of vacuum tubes, particularly regarding the regenerative circuits of "Plaintiff's Exhibit No. 114, Vacuum Tube Receiver Arranged for both Oscillations and Regeneration", considered by you in your previous deposition, and referred to by Dr. Miller in his answer to Q. 17 (P. R., p. 786).

A As Mr. Weagant has pointed out, it is a misnomer to say that a tube "oscillates", regardless of the number of electrodes. What happens is, that the whole circuit combination, whatever the circuit arrangement may be, together with the tube, generates oscillations by an amplification process. A tube alone can neither amplify, nor produce oscillations; but in connection with appropriate circuits, either the three-element tube or the two-element tube, whether the vacuum be high or low, can amplify, and can produce oscillations, in various specific ways. Both the two-electrode and the three-electrode tubes, when so amplifying or producing oscillations by means of appropriate circuits, do so in virtue of electrostatic control of the electrons, emitted by the filament, of the same sort as disclosed by Fleming, and this is true for both forms, whether the vacuum is of the so-called "soft" order, so that, according to present-day theories, ionized air or gas particles take part in the action, or whether the vacuum is high, or of the so-called "hard" order, so that all of the electron control is produced directly by circuit elements.

* * * * * * *

Of course, the oscillating circuit, in any case, must be provided with a battery or other source of electrical energy, and what happens is that the combination of circuit and tube is able to draw energy from the battery in pulsating fashion, the energy being represented by an electric current which alternates in direction, so far as its alternating-current component is concerned. Of course, as Dr. Miller has himself several times stated, the law of conservation of [fol. 1559] energy makes a battery or other source of energy indispensable in an oscillatory arrangement, whether the

oscillator be a crystal, an arc or a two or three-electrode tube. See, for example, Dr. Miller's testimony at the top of page 768 of the Printed Record, and again at the top of page 793. In contending that the two-element bulb must not be used with a battery, Dr. Miller's position amounts merely to the contention that the two-element bulb must violate the law of the conservation of energy.

Fundamentally, all so-called oscillators are merely devices which, when associated with the appropriate circuit, enable energy to be drawn in pulses from a local source of current. The device in question may be a crystal, or an arc, or any one of a considerable variety of tubes in which the electrons emitted by a heated filament, are controlled. In general, devices which are able to produce a negative resistance effect in a circuit connected to a local source of current, can be made to "generate oscillations" in this sense which I have just defined. When such a condition exists, the phenomena that occur are, of course, exceedingly complex, but in general it may be said of all of them, that what happens is that increase of current gives rise to a decrease of the effective resistance offered to its flow. As Dr. Miller has himself said, this would naturally give rise to a further increase of current, which would go on forever, if not stopped. It is usually stopped by an increase of the losses, and as soon as the current begins to decrease, that decrease is accompanied by increase of effective resistance, and a continued decrease follows until the losses are so far reduced that the reverse effect again occurs. Thus the device draws pulses of current from the battery, the precise nature of which is determined by the circuit as a whole.

In the vacuum tube, whether of two or of three electrodes, the whole operation depends upon the control of the electron emission, through the instrumentality of one or more cold electrodes by means of suitable associated circuits, and depends upon the ability of these electrons to respond to such control at radio-frequency, as first discovered and applied by Fleming.

It is clear that in this process of generating oscillations, the tube or other device must enable the circuit to draw momentarily from the battery more energy than it is consuming. This, of course, is simply another way of saying that the circuit combination is amplifying and, in general, any device which is capable of so amplifying at radio-frequencies, is capable of oscillating. Conversely, if it is

capable of oscillating, it thereby demonstrates its ability to amplify.

In order that either tube may amplify, it is necessary to so control the electron flow that the internal resistance of the tube or, perhaps, what might better be called the effective internal resistance, varies by an amount sufficient to produce a greater current change than would result from applying the input voltage alone, directly between the plate and filament element.

In either the two-electrode or the three-electrode tube, this effect may be brought about in various ways. If, for example, a sufficiently high battery voltage be applied between the plate and the filament—whether there is, or is not, a grid element present—the remnant gas which is in the tube, seems to play a part in the operation and may act to give the tube what is called in the present question "a [fol. 1560] falling characteristic", in virtue of which the circuit behaves as though a negative resistance were introduced into it.

When the electrons are emitted by the heated filament they create around it what is sometimes referred to as a "space charge". The electrons, in other words, carry negative charges and are said to negatively charge the space they occupy. Fleming discovered—although he did not phrase it that way—that by impressing radio-frequency voltages on the space between the cold and hot elements, the "space charge" was controlled and varied to produce the effects illustrated in my several drawings 5, 6, 7 and 8. When the remnant gas which remains after evacuation is sufficiently affected by the electron flow, the impression of radio-frequency signals on the space, causes this gas to aid in the variation of the "space charge" and very great amplification may be attained thereby by either a two or a three-element tube. I have many times obtained signals in this manner with a two-element tube that were enormously louder than could be obtained with a crystal, or with a two-element or three-element tube operating with an adjustment that did not bring this element into play.

Either a two-electrode or a three-electrode tube when so amplifying, may, by suitable adjustment, be made to "generate oscillations". This means, as I have above pointed out, not that the tube generates oscillations, but that the combination of the tube and circuit is able to draw pulses of current from the local battery.

If either the two or the three-electrode tube is so circumstanced with reference to the connected circuit that the electron stream is influenced in some other way, so that sufficiently great changes in its apparent internal resistance are produced by the input circuit, then, also, we have a combination which will amplify and may produce oscillations.

Mr. Weagant has shown, and I have myself many times made the same use of the two-element bulb, that amplification and oscillation may be produced if the input circuit acts electrostatically on the space surrounding the filament, without connection to the plate. When the circuit in which the received oscillations exist is connected to the plate of the two-electrode tube, it acts electrostatically, as I have explained, to control the electron emission. This, as I have just stated, may be expressed as a control of the "space charge". If the input coil of the condenser is so placed that it acts directly on the space surrounding the filament, then the electron flow is controlled so that the battery connected to the plate furnishes current by way of the electron flow, which varies more greatly than would have been the case had the input circuit been directly connected to the plate. In other words, it behaves as though a larger signal had been applied to the plate. In other words, the tube amplifies. By impressing this amplified output upon the input in any suitable manner, the arrangement generates high-frequency currents. I have done this both with tubes having an ordinary incandescent lamp vacuum exhausted exactly in accordance with the knowledge of the art at the date of the Fleming patent, including all of the precautions mentioned by Fleming, and also with tubes exhausted with more modern means, so that an even higher vacuum was obtained, and I have done it many hundreds of times.

What DeForest did when he put in the third electrode, was to give a convenient way of applying this electrostatic [fol. 1561] control of the electron flow, and the grid structure of DeForest's second patent 879,532 is a particularly useful way of accomplishing the result.

In either the two or the three electrode device, producing oscillations in its associated circuits by the control of the "space charge" around the filament, the tube behaves as though its resistance was changed by a greater amount than would be due to the application of the input oscillations directly to the plate-element. In other words, the circuit

behaves as though a negative resistance had been inserted. Fundamentally, therefore, the operation of either of the two or three-electrode tube in all methods of functioning depends upon that control of the electron emission or, if it is preferred, variation of "space charge", which Fleming discovered and taught in his patent in suit, and while various specific theories may be applied, depending upon the circuit used, they are all fundamentally based on the same principles, viz., this electrostatic control of the electron stream.

If one studies the mathematical theories that have been evolved to express the conditions of oscillation of the three-electrode tube, for example, he will find that there is a different specific theory for each specific circuit. The same, of course, is true for the two-electrode tube; in each case the results will be expressed in terms of the electrical characteristics of the circuit and of the tube, but, so far as the tube is concerned, they all rest upon the emission of electrons and the electrostatic control of that emission. To insist on specific theories, and overlook the fundamental substratum of fact, as Dr. Miller has done, merely obscures the issues, and does not elucidate them. It is certain that neither Fleming, when he applied for his patent in suit 803,684, on April 19, 1905, nor DeForest, when he applied for his patent 879,532, on January 29, 1907, knew anything about the ability of the devices which they disclosed to produce oscillations. This was only realized subsequently.

It was shown in the case of *Marconi* vs. *DeForest*, before Judge Mayer, in which case I was a witness, that DeForest worked directly on the disclosures of Fleming, and he improved Fleming's device without, however, altering its fundamental mode of operation. Subsequent use of these devices has developed the fact that the same fundamental control has the added capacity of generating oscillations.

The regenerative circuit of "Plaintiff's Exhibit No. 114", referred to in the question, is a means whereby the oscillations produced in the output circuit may be impressed upon the input circuit, so that they again affect the electron stream or, as I have expressed it, are again detected, whereby further amplification is secured. The same circuit arrangement is applicable to the two-electrode tube, as shown, for example, in "Weagant Sketch No. 7", found opposite P. R., p. 1770 ("Claimant's Exhibit No. 301"). I have used this arrangement very many times, both with

two-electrode and three-electrode tubes. In the three-electrode tube the effect which the high potential end of the oscillatory circuit of "Weagant Sketch No. 7" has upon the space charge around the filament, is similarly exerted through the instrumentality of the grid-electrode.

* * * * * * *

[fol. 1562] This regenerative circuit is simply one of a variety of circuit arrangements in which the capability of these tubes of producing the so-called negative resistance effects may be utilized to produce amplification and oscillation. Another circuit, which is referred to in the record as the ultra-audion circuit, as, for example, "Plaintiff's Exhibit No. 109, Waterman Diagram Defendant's Ultra-Audion", although specifically different in appearance, is equally a regenerative circuit. The regenerative circuit is a convenient one to employ when the tube is called upon to detect and amplify or oscillate at the same time.

Mr. Weagant has dealt at length with the matter of the falling characteristic in high vacuum two and three-electrode tubes as, for example, in his answer to Q. 50, beginning P. R., p. 1706, and as I fully agree with the statements that he has made and the authorities which he has produced and referred to, I will not repeat. The whole matter of the so-called falling characteristic or negative resistance is somewhat esoteric in nature, but it refers to the fact that under some conditions various devices, including the two and the three-electrode tubes, may so operate that when the current increases, the apparent driving voltage decreases, and *vice versa*. If the circuits are properly disposed and adjusted, either the two-electrode or the three-electrode tube will exhibit this property—in co-operation, of course, with its circuits—whether the vacuum be of the so-called "hard" or the so-called "soft" order. Both may, when exhibiting this property, show effects indicating that the residual gas is playing some part in the operation if the tubes are "soft", and both may exhibit it without any trace of residual gas action through direct electrostatic control of the electron flow by the electromotive forces developed in the circuits.

In all the various uses the tube, whether of two electrodes or three, is operating in virtue of that unilateral conductivity described by Fleming, which results from the control of the electrons, emitted by the hot filament, by electrical

potentials applied from without. Through the instrumentality of external circuits connected to one or more internal cold elements in various forms of circuit arrangements, all of the various effects which have been discussed in this record are produced.

Q. 18. Defendant's Expert, Dr. Miller, in his answer to questions 4, 9, 11, 12 and 13 (P. R., pp. 758-784), refers to the demonstration before Judge Mayer during the supplemental trial (see "Claimant's Exhibit No. 171," P. R., pp. 1543, et seq.), in the case of the present claimant against the DeForest Radio Telephone and Telegraph Company, which demonstration related to the capability of the tube of the Fleming patent in suit to oscillate, and he comments on, and criticises, some of your evidence in that case in respect to such demonstration, stating that the demonstration was a "trick", that essential facts were withheld, and that evidence was given which was not in accordance with the facts. Will you please consider the above-mentioned testimony of Dr. Miller, stating what demonstration was [fol. 1563] required by Judge Mayer, the facts of what occurred during such demonstration and whether or not the demonstration was a "trick", or whether any essential facts were withheld or any evidence given that was not in accordance with the facts. If necessary, you may refer to "Claimant's Exhibit No. 171", which contains the record of evidence before Judge Mayer during the supplemental trial in the DeForest case.

A. Dr. Miller was, of course, entirely unwarranted by the facts in using any such language as that referred to in the question. Dr. Miller was not present at the tests before Judge Mayer, and had no knowledge of the facts. Dr. Miller has, throughout his deposition, used strong adjectives and characterizations. It has seemed to me, however, that it is unnecessary to pay attention to them.

It is, of course, not true that the demonstration before Judge Mayer was a trick, or that any essential facts were withheld, or that evidence was given which was not in accordance with the facts. It is true, on the contrary, that no part of the apparatus or its connections, was concealed from view, that everything that was done was done openly in the presence of both sides, and that there were men present quite as competent to detect a trick or deception as Dr. Miller, and that they examined the apparatus with the greatest particularity and that, in fact, some of the modes

of procedure were mutually agreed upon by plaintiff's and defendant's representatives respectively. The testimony was, to the best of my knowledge and belief, in accordance with the facts as understood by the witnesses; certainly that was the fact so far as I am personally concerned.

By reference to "Claimant's Exhibit No. 171" I note that I explained to the Court that the wiring was clearly traceable upon the board containing the apparatus and that I also produced a diagram of it marked in that case as "Plaintiff's Exhibit No. 2". It is my recollection that this diagram was examined and checked by the representatives of the defendant. I note that it appears, also, that the defendant requested, and was given, permission to operate the apparatus. My recollection is that Dr. Stone, one of the representatives of the defendant, did operate it.

The circuit that was thus used was the PN circuit and the oscillating two-electrode tube was used as a transmitter to furnish a signal with an ordinary operator's telegraph key. This was received by heterodyne reception with a three-element tube.

Later, according to my recollection, other tubes were used, because it was pointed out that the first one employed had shown some evidence of ionization in the form of a "blue glow" around the edges of the plate element. In subsequent tests, a bulb or bulbs which showed no trace of "blue glow" under the most critical examination, was employed. The circuit was also changed to the form of circuit shown in the Fleming patent, first with a shunted condenser, as shown in the sketch on page 89 of "Claimant's Exhibit No. 171", and later with this condenser removed. Also, the view was expressed by someone representing defendant that the oscillations of the two-electrode tube might be due to a retlex effect of the oscillating three-electrode tube used as a receiver. It was therefore agreed between Dr. Stone and myself that a crude form of "ticker", which could be quickly improvised, should be used, and this is indicated in my sketch just referred to, by a cross at the extreme right of the diagram, immediately under the convention denoting [fol. 1564] a telephone. In all tests, after the original tube was discarded, oscillations were received by the Court listening through the telephone, and also by representatives of plaintiff and defendant.

To prove to all parties that the tube was generating the oscillations heard, the filament of the tube was disconnected

from the battery, thereby stopping the emission of electrons. When this was done, the oscillations ceased. The demonstration was as openly conducted as it could possibly have been, and I know that I personally paid particular attention to having everything that was used or done, clearly apparent to everyone. Dr. Miller's assertions and accusations are, therefore, without the slightest foundation.

* * * * * * *

On P. R., p. 760 and at other places in his deposition, Dr. Miller has characterized the two-electrode vacuum tube oscillation as demonstrated before Judge Mayer as operating in view of a falling characteristic, and as being, in fact, an arc, and has, in substance, said that I was not telling the truth when I said that "I do not call that an arc, nor do I call that anything which in any way resembles an arc."

Fundamentally, the whole matter seems to me to be immaterial, because, if a "soft" two-electrode tube when oscillating, is an arc, then, also, the "soft" three-element tube when oscillating, is an arc, and if the "hard" three-element tube when oscillating, is not an arc, then the "hard" two-electrode tube when oscillating, is not an arc, and since they both act in the same way when constructed with the same order of vacuum, and can both oscillate by either a specific mode of explanation, even if the vacuum is "soft", I am quite unable to see what difference it makes, whether one name or another is applied to them.

In point of fact, I do not find that Dr. Miller has stated any reason for asserting that the tube demonstrated before Judge Mayer was an arc other than that it had a "falling characteristic". By the same token the oscillating crystal would be an arc, which reduces Dr. Miller's criterion to an absurdity.

According to my definition, an arc is a flow of current through a gaseous path between electrodes, the gases being composed of volatilized material from one of the electrodes. On that understanding of an arc, it is, of course, nonsense to speak of either the two or the three-electrode tubes with a soft vacuum as being an arc, when oscillating in the presence of ionization effects.

If any conduction in a vacuum tube in which ionization plays a part is an arc, then we have no line of demarcation between an arc and electronic conduction, which is not an

arc. An X-ray bulb, for example, becomes an arc and in [fol. 1565] general, one never could tell whether an arc did, or did not, exist. This, again, seems to me to be nonsense.

Everybody knows what an arc lamp is, and everyone is familiar at the present time, probably, with the Cooper-Hewitt green mercury arcs which are formed within a tube with a pool of mercury acting as one electrode and the vaporized mercury is the chief constituent of the arc-stream. Dr. Miller seems to admit that not all of these arcs are oscillators; in fact, he only seems to assert that the Poulsen arc is really an oscillator at high frequencies. Certainly, the two and three-electrode soft tubes do not in any way resemble anything that is customarily called an arc. While to say that anything that has a "falling characteristic" is an arc, would include crystals, which are not gaseous conductors at all, and hard vacuum three-electrode tubes (see Mr. Weagant's answer to Q. 250, P. R., pp. 1706-1710), as also arcs. As this is *reductio ad absurdum*, further comment seems to be unnecessary.

On P. R., p. 780, Dr. Miller refers to the circuits used in the test before Judge Mayer as being the circuits used with an oscillating arc. It seems sufficient in this connection to point out that they are also the circuits used with an oscillating crystal, and that, as has been shown in this case by demonstration and diagrams, there are numerous other circuits, which are not arc circuits in which the two-electrode tube will oscillate, whether the vacuum is hard or soft.

My understanding of the fact is that Judge Mayer was not interested in the theories by which oscillation of either the two-electrode or the three-electrode tube occurred. What he desired to have demonstrated was the fact. And the fact that the two-electrode tube did oscillate was so conclusively demonstrated, that nobody could deny it. It was after this demonstration of the fact that theorizing as to the causes came into prominence. My recollection is that Dr. Stone, in testifying before Judge Mayer on behalf of the defendant, stated that even the "blue glow" which existed in the first tube tested, was not an arc, but he expressed the opinion that the "blue glow" was necessary, in order that the two-electrode tube might oscillate, while it was not necessary in the three-electrode tube. It was then proven by demonstration that the "blue glow" was not necessary to the oscillation of a two-electrode tube. After this fact was conclusively demonstrated, my recol-

lection of the testimony is that all that Dr. Stone could say, in substance, was that he did not believe the two-electrode tube oscillator was very useful.

I have, many times, received signals with a two-electrode tube oscillating just as in the demonstration before Judge Mayer, without "blue glow" and with stable operation over long periods. When the two-electrode tube is oscillating as demonstrated by Mr. Weagant, by direct electrostatic action, and with a hard vacuum, it has all the stability and permanence that the hard vacuum naturally implies. If there had never been a three-electrode tube produced, I am convinced that the two-electrode tube would have been in widespread use as detector, amplifier and oscillator. We now know how to produce soft vacuum two-electrode tubes that oscillate steadily and reliably, as well as hard vacuum two-electrode tubes that have all of the stability and reliability of the best three-electrode tubes. But because the grid-electrode is so convenient a means of getting exactly the degree of electrostatic control desired, it is naturally used in preference to the less convenient two-electrode structure. Both [fol. 1566] forms, however operating, do so in virtue of that fundamental electrostatic control of electrons emitted from a hot filament which Fleming discovered and showed how to utilize. It has, of course, taken many years to unravel the intricate and mysterious actions going on within these tubes, and it is certain—in spite of the years of study by able men in great laboratories—that all is not known yet. It would also be the height of rashness to assert that all of the supposed knowledge corresponds to the true facts. We do know, however, how to use the bulbs and whether constructed in two-electrode or three-electrode form, they are enormously useful devices. It is also true that for every function and circuit of the three-electrode tube there is a corresponding function and circuit of the two-electrode tube, operating in substantially the same way, to produce the same results.

I feel certain that had Dr. Miller been more familiar with the facts, he would not have made the statements and accusations that he did, and it is certain that there was absolutely no foundation or valid excuse for them. It does not appear that he ever has had any experience with the two-electrode tube constructed for radio use. He used certain old DeForest tubes having three electrodes as two-electrode tubes, by connecting the grid and plate together, which is

a make-shift at best. Further, these old DeForest tubes were extremely poor tubes by present-day standards, or by any standards that have existed for many years. They were made with the knowledge of their day, and were very inferior. They were, as I understand it, of the same general sort that were before Judge Mayer. In that case certain three-element tubes were produced by the DeForest Company, defendant, and when first demonstrated before Judge Mayer, gave both detection and amplification effects. It appeared from the testimony that, before the end of that litigation, these tubes had ceased to act as amplifiers, although they still acted as detectors, and would repeat the received signals, but only with a "loss" and not with an amplification. I was personally present at the test when this fact was ascertained, and the testimony as to that fact was not a "quibble", and it is not true that these tubes, or either of them, was "a smashed, burned-out, or defective three-electrode tube" so far as careful visual inspection could determine. Dr. Miller's statement to this effect at the bottom of P. R., p. 813, is without foundation.

. . . . . .

Q. 19. Major Mauborgne, as justification for his answer to Q. 17 of his deposition (P. R., pp. 1224-1230), refers to tests made by him with some three-electrodes tubes, ten of [fol. 1567] which were found in the garret of the Bureau of Standards, and another three-electrode tube which he says was a "DeForest amplifier" tube, and in all of the tests, the grids and plates were connected together, and some of which oscillated under certain conditions and some did not. Have you any criticisms or observations to make regarding those tests and the tubes used in them, as being a basis for the conclusion expressed on page 1230 of his deposition? if so, please state them.

A. The record of unsuccessful tests is never impressive. Especially is this the case when the object of the tests appears to have been merely to prove something already demonstrated before the Court, in the presence of opposing Experts and affirmatively decided by the Court. I have, so many times, used two-element tubes as oscillators, both in the manner demonstrated before Judge Mayer, and that demonstrated by Mr. Weagant in this case, that there seems to be no comment possible for me to make, except to say that there was probably something wrong, either with Major

Mauborgne's tubes, or his methods. I do not know where he found authority for his statement that what he calls the "two-electrode tube of the Fleming type" "was a gas-filled tube". Certainly he did not get it from the Fleming patent, which lays special stress on having a high vacuum; for example, at page 1, line 96, the patent states:

"As a very high vacuum should be obtained in the bulb *a* and as a considerable quantity of air is occluded in the conductors, these should be heated when the bulb is being exhausted. The filament *b* can be conveniently heated by passing a current through it, while the cylinder *c* can be heated by surrounding the bulb *a* with a resistance-coil through which a current is passed, the whole being inclosed in a box lined with asbestos or the like."

Fleming also states that the cold element may be constructed of wire, with terminals brought out, in order that a current may be passed through it to heat it while it is being evacuated. If all of Major Mauborgne's testimony is as accurate, therefore, as his reference to the Fleming type as "a gas-filled tube", he certainly is not instructive.

The tubes which I have used were exhausted in an oven and with current passing through the filament, as instructed by Fleming, the oven heated as hot as it safely could be. They had a good incandescent lamp vacuum, and were not in any sense "gas-filled". On the contrary, they were gas-emptied, in accordance with the ordinary commercial practice of exhausting incandescent lamps at the date of the Fleming patent, with the added precautions specified by Fleming.

Since it has been conclusively proven that the two-electrode tube is not "simply a detector or rectifying device", but can display all of the functions and capacities of the three-electrode tube, Major Mauborgne's assertions to the contrary, it simply shows that he was mistaken in his knowledge and understanding of the facts.

Q. 20. In connection with Dr. Miller's testimony as to the incapability of the two-electrode tube to oscillate, will you please state what the facts were in respect to Mr. Weagant's demonstrations and particularly what facts they established, in your opinion, in respect to the capacity of a so-called "hard" or "high vacuum" tube of the Fleming

patent to oscillate, to act as a radio and audio-frequency amplifier and as a transmitter of high-frequency oscillations for use in wireless communication; also please explain [fol. 1568] the circuits used in such demonstrations.

A. I was present at the tests referred to. The facts as to the tests are correctly stated by Mr. Weagant in his deposition given as the tests proceeded, and the diagrams and photographs accompanying that deposition, which are marked "Claimant's Exhibits 225, 228, 229 and 227" correctly illustrate the circuits and apparatus which he employed. These tests conclusively demonstrated the ability of the two-electrode vacuum tube to detect, amplify and produce oscillations in circuits analogous to those in which the three-electrode tube can produce the same results. I understand that the tubes employed were exhausted by modern methods and had the so-called "hard" vacuum.

Referring to "Claimant's Exhibit No. 225", which appears opposite P. R., p. 1527, the apparatus is that shown in the photograph "Complainant's Exhibit No. 228". This circuit is the same as that shown in the Fleming patent, with the exception that a battery P, is shown in the tube circuit to furnish the energy for amplification and oscillation and the usual tuning condenser is inserted in the antenna circuit at R. I note, also, that telephones are employed instead of a galvanometer, for indicating purposes.

In the first test, music was heard, the tube acting as a detector. In the second test, the tube was caused to oscillate by adjusting the coupling between the coil *m*, *k*, and usual "squeals" or "whistles" denoting the oscillating state, were heard.

The two-electrode tube arrangement was then used as a generator of oscillations which were received in another receiver.

A second apparatus was then employed, containing four two-electrode tubes, all of which I understand were "high vacuum" or "hard" tubes arranged so that the first three tubes repeated and amplified the received signals, while the last tube rendered them audible. This apparatus was so arranged that by means of switches, either all four tubes could be used or only the last one. It was found that the signal was very much louder (about one hundred times, I should judge) when the four tubes were used, than when only one was used, thus demonstrating the capacity of the

tube to respond to, and amplify, high-frequency radio signals.

The circuit arrangement and apparatus are correctly illustrated in "Claimant's Exhibits Nos. 227 and 229". The construction of the tube is correctly described in his answer to Q. 9, P. R., p. 1529.

I have made extensive use of tubes of this general sort, both with extremely complete exhaustion, *i. e.*, very hard, and also with ordinary incandescent lamp exhaustion, and have found the same inherent capacity of the tubes to detect, amplify and oscillate, but I never used as many as four tubes in succession.

As explained by Mr. Weagant, these tests were performed with the tubes located so as to be directly influenced by the electrostatic field produced by a condenser or coil and the effect of the control of the electrons emitted by the filament was to cause the output circuit to respond as though a larger signal had been impressed directly on the plate.

The tests made by Mr. Weagant demonstrate the inherent capacity for that electrostatic control which Fleming discovered in the two-electrode tube, applied for all three purposes which Dr. Miller has referred to as special utilities of the three-electrode tube. They demonstrated that what DeForest did when he inserted the grid element, [fol. 1569] was simply to provide a more convenient way of utilizing this capacity or property of the electron-stream or, as it is, perhaps, better called, "cloud" emitted by the hot filament. DeForest added nothing to this fundamental property, but he did supply a very convenient and practical way of utilizing it. Subsequent use and study has led to the development of a variety of useful circuit arrangements whereby the production of amplification and the generation of oscillations is possible, and when these methods are applied to the two-electrode tube, similar results are obtained. Mr. Weagant's tests demonstrated these facts, and show that Dr. Miller was mistaken in such of his statements as imply the contrary.

Q. 21. The opinions of the lower court and of the Court of Appeals in the suit of Marconi Wireless Telegraph Company of America vs. DeForest Radio Telephone and Telegraph Company on the Fleming patent state, in effect, that DeForest in producing the three-electrode tube or audion,

began with the heated gas theory and ended by employing a commercial vacuum, but before he finally produced the audion he learned of the Fleming invention. Will you please refer to any facts within your personal knowledge, or any patents or publications on the subject, and briefly explain them?

A. The case of Marconi *vs.* DeForest, referred to, was brought by the Marconi Company on Fleming patent No. 803,684; the defendant answered and set up a counterclaim under a number of patents to DeForest, some of which were subsequently withdrawn. The patents remaining in the counterclaim case included patents 824,637, 836,070, 841,386, 867,876, 867,877, 867,878, and 979,275.

In the testimony adduced by defendant, there was naturally a great deal relating to the history of DeForest's work, and on the basis of that history, the decision referred to in the present inquiry, was reached, as I understand the matter.

Of the several patents referred to just above, patent 979,275 issued on an original application of February 2, 1905, and, although latest in date, was earliest in date of application. Patents 867,876, 867,877 and 867,878 all issued on applications filed as divisions of the original application of February 2, 1905, just referred to. All of the devices of these four patents were avowedly heated-gas devices, and all of the figures of all of the patents are contained in the patent 979,275, which issued on the original application. There are six figures in this patent, of which Figs. 1, 3, 4 and 5 show gas flames and circuits variously arranged, while Figs. 2 and 6 show devices in which the heating is done by an electric current from the dynamo G. So far as I know, Figs. 2 and 6 are totally inoperative. In any case, all of these devices depended upon flame or other production of intensely heated gases, according to the disclosure of the specification, and the patent points out that different salts might be introduced into the flame to vary its sensitiveness.

Patent 824,637, issued on an original application filed January 18, 1906 and patent 836,070, issued on a division of said original application. During the trial of the case DeForest patent 823,402 was offered in evidence. It was filed December, 1905, and contained a reference to, and a description of, the Fleming "electric valve" which has

been fully described by J. A. Fleming in a paper published in the *Proceedings of the Royal Society of London*, March [fol. 1570] 16, 1905, to which reference may be had for a more complete description thereof than need be set forth herein."

Patent 824,637 was referred to in the Marconi *vs.* DeForest case as the "gas oven patent". Figs. 1, 2 and 3 are described as depending upon heating of the gas. The same is true of the single device of patent 836,070, which corresponds to Fig. 3 of the last-considered patent.

Patent 841,386, while showing tubes containing a heated and a cold element in an evacuated bulb, was held to be invalid, because inoperative.

It was shown to the Court by these several patents that DeForest was working on a theory that heated gas could constitute a radio detector, and that he did not come to a vacuum tube type of device until after he had full knowledge of Fleming's device, the construction and operation of which was completely disclosed in the Fleming paper which DeForest mentioned in his patent 823,402, filed December, 1905, and issued June 12, 1906, both dates being earlier than the application for any patent by DeForest showing the two-electrode tube as an evacuated bulb, or any patent showing a three-electrode tube as an evacuated bulb. DeForest's earliest patent for a three-electrode tube was 841,387, filed October 25, 1906, and his next three-electrode tube patent, wherein the grid-type of tube was disclosed, was patent 879,532, which was applied for January 29, 1907.

It was on the basis of this evidence, as well as some other evidence, including some correspondence of DeForest, produced by defendant, that the Court found that DeForest began with the heated gas theory and ended by employing a commercial vacuum.

* * * * * * *

The evidence in that case showed that the DeForest three-electrode bulbs, which were offered in evidence by plaintiff and defendant respectively, had a commercial vacuum corresponding to the ordinary commercial electric lamp vacuum of Fleming's day. This was stated by plaintiff's witnesses and not denied.

One of the evidences of this fact was the instruction sheet which came with the DeForest apparatus and which

was offered in evidence in that case. I find the same or a similar instruction sheet in evidence in this case as "Plaintiff's Exhibit No. 108" (printed opposite P. R., p. 224). This instruction sheet contains a diagram of the tube in the P N circuit, and I find thereon the following statement:

"If too much 'Battery B' voltage be applied a blue glow will appear in the bulb, or tube, or may be seen merely around the edges of the 'plate' or wing. When this blue [fol. 1571] glow fills the bulb it is usually not very sensitive, and can be removed by simply reducing the B voltage by the 4-point switch on front of box."

This statement shows that the tubes referred to had the so-called soft vacuum and not the extremely high vacuum that is employed in some present-day tubes.

Comparison of these tubes, which I personally made with commercial two-electrode tubes which were in commercial radio receiving apparatus, showed that the vacuum was substantially the same.

Mr. Vaill: Counsel for claimant offers in evidence the binder containing DeForest patents Nos. 824,637, 836,070, 841,386, 867,876, 867,877, 867,878 and 979,275, and requests that the same be marked "Claimant's Exhibit No. 327".

(Said exhibit marked as requested.)

Q. 22. In answer to Q. 16 of his deposition regarding the gaseous two-electrode tubes (P. R., p. 785), Dr. Miller stated as follows:

"In the present state of the radio art, it is impossible to construct tubes to have gas present to a definite degree as to have such tubes exhibit characteristic, depending upon the gas, with any certainty whatsoever."

Will you please state whether or not you agree with Dr. Miller as to this portion of his answer?

A. I do not. I know of no authority for any such statement. It is well known to users of radio tubes that tubes having a relatively soft vacuum have been constantly on the market, and as to the tube known as UV 200, with which I am very familiar, I know that these tubes are consistent performers and oscillate readily, either with ionization

effects or with direct electrostatic control. I do not think that Dr. Miller's statement is true.

As I have pointed out, the production of the three-electrode tube followed very soon, as the result of Fleming's disclosure, and the two-electrode tube also is capable of oscillating reliably and satisfactorily without any gas phenomena whatever. For these reasons it has never been necessary for manufacturers to produce tubes oscillating in virtue of gas ionization. It is, therefore, doubtful whether anyone could say with positiveness what could be accomplished in large-scale production, where oscillation was the sole criterion of definiteness.

I do know from personal experience, that the UV 200 tubes were reliable tubes and that they oscillated readily and stably in the ways in which they were intended to function, and also oscillated readily and with good, although not equal, stability with the grids and plates connected together to act as two-element tubes. Of course, this is not an ideal or advantageous way to produce a two-element tube, and it has not operated to change the two-element tube performance on this basis. I understand, however, that Dr. Miller has had no other experience, and that he has only used the old DeForest tubes, which were notoriously erratic, whether used as two-element tubes or as three-element tubes. The production of tubes which are definite in their characteristics in the sense that they are all alike, is a distinctly modern achievement, and even at the present time large numbers have to be rejected on final test. Dr. Miller has produced no authority for his statement, and my personal belief is that there is none.

[fol. 1572] Q. 23. Referring to Dr. Miller's answers to Qs. 19 and 22 of his deposition (P. R., pp. 793 and 811), which relate to "Plaintiff's Exhibits Nos. 85 and 110"—Audion Amplifiers Used by the Navy—will you please refer again to these exhibits which you considered in your direct testimony (P. R., pp. 225-227), and state, according to your knowledge of the matter, to what extent the arrangements of vacuum tubes shown in those exhibits comply with the substance of the Fleming invention as recited in claims 1 and 37 of the Fleming patent in suit, stating your reasons, if any, why you do not agree with Dr. Miller's answers?

A. As I understand the matter inquired about, the question is, whether a combination of tubes used to produce an

audible radio signal by several times amplifying the signal is a detector. Looking at "Plaintiff's Exhibit No. 110", a signal received on the antenna A is transferred to the associated circuits in the form of radio-frequency oscillations. In order that these may affect an indicating instrument, it is necessary that their frequency should be changed to an audio-frequency. In "Plaintiff's Exhibit 110" this is done by the first Tube T^1. If the signal is then readable, that is, audible, in the telephones, no further tubes are necessary. If, however, it is not readable, then the tube T^2 may be used. If it is still not readable, the tube T^3 may be employed.

As I understand the matter, Judge Mayer held that under these circumstances all of the tubes together constituted the detector. This is the usual use for such an amplifier. In "Plaintiff's Exhibit 85" no frequency-converting tube—which I understand Dr. Miller has referred to as a detector in the limited sense—is shown. Of course, there would be no difficulty in so using the first or either of the tubes of this arrangement, that it would act as the frequency-converter or detector in the limited sense. It may also be used in association with some other frequency-changing device, in which case it becomes a part of the detector in the broad sense of the term. So far as the condenser *h* is concerned, Dr. Miller is, of course, correct in saying that that condenser would not be employed if the terminals X Y were to be connected in the plate-circuit of a preceding tube of either two or three electrodes, if used with a local battery. For use with such a battery, the condenser *h* would, of course, be short-circuited by the user, that is, cut out of circuit in accordance with the ordinary knowledge of the art.

Q. 24. Will you please refer to Dr. Miller's answer Q. 7 (P. R., p. 768), and Dr. Millikan's answer to Q. 17 (P. R., p. 847), to the effect that the operation of the two or three electrode bulbs is not changed when operated at high frequency, or by radio currents, as distinguished from their operation at low-frequency or by audio-frequency currents, and state your understanding of the matter?

A. That, of course, was one of Fleming's great discoveries. Fleming discovered that the extremely feeble and enormously high frequency electrostatic fields produced by radio-frequency currents, were able to accurately and exactly control the electrons emitted by the hot filament. I agree that up to the highest frequencies used in radio, this is true. Of course, it is not true of devices in general. There are, for

example, efficient low-frequency rectifiers that are quite useless at high frequencies.

All that Dr. Miller does is to give what at present is as- [fol. 1573] sumed to be the explanation of the fact, while, so far as I remember, Dr. Millikan merely states it as a fact.

There is, of course, nothing new about that statement in this case. It was fully understood by Judge Mayer, as was also the fact that this was one of Fleming's great contributions to the knowledge of the art.

Q. 25. In view of your knowledge of the art as it existed at the date of the Fleming invention (*viz.*, November 16, 1904, the date of the application for the Fleming British patent), was it

"known to one skilled in the radio art that a rectifier would act as a detector or that anything that would rectify oscillations of low-frequency would rectify waves of the order used in radio-communication"?

In answering this question, please consider the substance of the patents and the publications referred to by Dr. Miller in his answer to Q. 28 (P. R., p. 823), and his conclusions reached as indicated on pages 826 and 827 of the Printed Record.

A. It is not a fact today, and was not, at the date of the Fleming invention, that anything that will rectify oscillations of low-frequency will rectify waves of the order used in radio-communication. Any statement to that effect would be untrue. It was known that some of the devices that were used as so-called detectors, acted as rectifiers in that anomalous use of the term "rectifier", which means merely that the device conducts in one direction better than in the other, or is conductive in one direction and not conductive in the other. At least, it was surmised that this was the fact as to some of these detectors. As Fleming himself points out in his patent 803,684 in suit, there were well-known forms of rectifiers that were useful for low frequency currents that would not act with high-frequency currents. The same is true today. No generalization such as Dr. Miller indulges in, is true, therefore; for example, Dr. Miller says (P. R., p. 827):

"It was known to men skilled in the art at the date of Fleming's application that a rectifier would act as a detector."

This statement is quite untrue. It was not true as of Fleming's day, and it is not true today. All that can be said is that it was well known that there were rectifiers that would not act as detectors, and it was known that there were some detectors which acted as rectifiers. The state of facts in this regard has not altered.

As to Dr. Miller's statement made near the foot of P. R., p. 826 and again near the top of P. R., p. 827, that a scientist or one skilled in the art "could predict" or "would have been able to predict that the Edison device would rectify waves of the order used in radio communication" that is merely assertion, with the evidence of history completely against it. The fact is that no one did predict it prior to Fleming's discovery, and since Fleming's discovery an enormously useful art has developed as a direct result.

As I pointed out in a former answer, DeForest's work followed almost immediately after Fleming's announcement, and DeForest in his patent 823,402, filed December 1905, specifically refers to Fleming's Royal Society Paper of March, 1905. DeForest's development of the three-electrode tube was, therefore, a direct outgrowth of Fleming's discovery, and Dr. Miller's assertion as to what one skilled in [fol. 1574] the art would have been able to predict is, at the best, merely his opinion, which seems to be emphatically contradicted by the historical facts.

Neither of these conclusions of Dr. Miller's on P. R., p. 827, is supported by the references to which he refers.

I believe it to be true that about 1883 Edison discovered the so-called "Edison Effect", and it is true, as Dr. Miller states, that this discovery aroused wide-spread interest and that the literature which followed in the next few years as a result of investigations by many scientific men reached a very wide-spread audience of scientists and engineers. In short, it attracted very wide attention and was studied extensively, and in spite of the study, it was twenty years before it was discovered that it had any usefulness in radio or in connection with the study of electro-magnetic waves.

The study of these waves began, I believe, about 1887, and radio began with Marconi's work, which, if I remember rightly, was about 1895. Fleming's British patent was applied for November, 1904. Wehnelt, who was a very distinguished scientist, disclosed, and, if my memory serves me, also patented the use of a tube similar to that of Edison.

with a special type of filament, known today as the oxide-coated filament, but it did not occur to him that the electrostatic control that could be produced by radio-frequency currents would be effective to produce rectification of currents of that frequency. Since the date of the Fleming patent, however, immense numbers of tubes with these Wehnelt oxide-coated filaments have been used for radio purposes. They were so used, however, as the result of Fleming's discovery. It did not occur to Edison or to Howell, or to Preece, or to Kennelly or, indeed, to Fleming, until after he had worked for many years and published many articles, that these tubes would be useful for radio purposes.

The Edison patent to which Dr. Miller refers, showed only a suggestion by Edison of the use of a tube applied to a direct-current power-circuit for the purpose of voltage regulation, a use which, so far as I can ascertain, has never proved practical.

Dr. Miller refers to the French patent to Valbreuze, No. 328,687, and says:

"In fact, Figure 2 of the Valbreuze patent is identical with Figure 2 of the Fleming patent."

It is not. Valbreuze shows vacuum tubes of the Geissler tube type, without heated or heatable filaments, and he shows a polarized relay useful only for low-frequencies. The Valbreuze tubes contain two electrodes, one of which is a sphere and the other of which is a point. Such tubes are essentially useless.

The testimony of E. H. Armstrong, referred to by Dr. Miller, was given in the case before Judge Mayer, many years after Fleming's discovery, and in the light of that discovery.

The several scientific publications of Townsend, C. T. R. Wilson, J. J. Thompson and H. A. Wilson, referred to on P. R., p. 825, are scientific publications having to do with the ratio of the charge of an electron to its mass, and have nothing whatever to do with the subject of two-element or three-element tubes for radio use. They relate to pure scientific investigation.

[fol. 1575] In point of fact, it was shown to Judge Mayer by similar scientific literature, published between the date of the Fleming patent and the date of the hearing before

Judge Mayer, that during the interval scientists had held various opinions as to the action of a heated filament and that there was no unanimity of opinion.

The fact, of course, is that today scientists are unlearning much of the supposed positive knowledge of a few years ago. The results of investigations published within the last six or eight weeks have, in fact, proved conclusively that much of the supposed knowledge regarding electrons was incorrect. What a scientist, from supposed knowledge, would be able to predict, would be quite as likely to be wrong as right. It is the discovery of the facts that advances the practical arts, and it was Fleming who made the discovery of the possibility of the electrostatic control of whatever it is that is emitted by the hot filament in the electron tube, and on this discovery the radio art, so far as it rests on vacuum tubes, is founded.

The publications to which Dr. Miller refers have nothing whatever to do with the subject. No one of them relates to the subject, nor do they all together constitute a disclosure of that which was disclosed by Fleming in his patent No. 803,684 in suit.

* * * * * * *

[fol. 1576] Q. 26. From your knowledge of the suit entitled Marconi Wireless Telegraph Company of America vs. DeForest Radio Telephone and Telegraph Company on Fleming patent 803,684 in the Southern District of New York and in the Court of Appeals for the Second Circuit, will you please state to what extent the patents and publications referred to in your last answer were before the Court in the trial of the DeForest case.

A. All of the subject-matter referred to by Dr. Miller in his answer to Q. 28, beginning at P. R., p. 823, which was inquired about in the last question, was before the Court. All of the publications referring to the "Edison effect", including the Edison patent, and the articles by Houston, Preece, Kennelly and Fleming, were before the Court in that case; also the Wehnelt publication and certain other Wehnelt patents and publications in addition. Also the work of Richardson, J. J. Thompson was presented in the testimony and the substance of all of the several publications by Richardson, Thompson, Townsend and Wilson, were before the Court. Most of these latter referred to by Dr. Miller, have to do with the ratio of

charge to the mass of the electrons and, obviously, have nothing to do with this case. They merely are referred to by Dr. Miller as authority for his statement that "During the decade prior to this date [November 16th, 1904], there was also taking place a tremendous revolution in the knowledge of mankind with respect to physics and the laws of physics." As a result of this "tremendous revolution" Dr. Miller now thinks that it would have been obvious to anyone, in view of the knowledge of the radio of the charge to the mass of the electrons that the "Edison effect" would enable the Edison bulb to act as a rectifier at all frequencies. In my opinion, nothing could be more absurd. The very publications which he cited show contradictory phenomena and, in my judgment, make it perfectly clear that no such conclusion would have been likely to have been drawn and historically, the fact is, as I have pointed out, that it was not drawn, nor was it known to anyone until it was discovered by Fleming.

The court was fully advised, also, as to the Valbreuze patent and the opinions of Armstrong, who, in fact, testified before Judge Mayer in the case inquired about. In short, Judge Mayer was fully informed as to the work of Edison and the very extensive scientific discussion and controversy to which it gave rise. He was fully informed as to the work of Wehnelt and Valbreuze and the value of the charge of the electron and of the mass of the electron were stated to him, not only as of the knowledge at a date prior to Fleming, but as to the knowledge at the date of the trial. I believe that there is no knowledge on the subject-matter of my last answer which is before this Court, which was not also before Judge Mayer in the case inquired about.

Q. 27. I invite your attention to Dr. Miller's answer to Q. 5. of his *dis*position (P. R., p. 763), and Dr. Millikan's answers to Qs. 21-23 (P. R., p. 850), and will ask you to state to what extent you agree or disagree with said answers, and to what extent, if any, the Hewitt patents Nos. 781,001 and 781,002 have a bearing upon the Fleming patent [fol. 1577] in suit. Also please state to what extent, if any, the decisions of the District Court and the Circuit Court of Appeals for the Second Circuit in the case of Hewitt *vs.* American Telephone & Telegraph Co. affect your opinion in respect to these Hewitt patents as bearing upon the Fleming patent in suit.

A. In my opinion, the Hewitt patents referred to, have no bearing whatever upon the Fleming disclosure of the Fleming patent in suit, either as shown in the drawings or referred to in the specification or claims. The decisions of the District and Circuit Courts also, in my opinion, do not influence, and have no bearing upon, this conclusion.

The Hewitt device comprises a tube having two electrodes, one of which is a pool of mercury and the other of which is a solid metal electrode. To start such tube in operation it requires some special means, or else an extremely high electrical voltage. In operation, the metal of the negative electrode is vaporized, and this metal vapor constitutes the current-path. In other words, this tube differs from an ordinary arc in that one of the electrodes is a liquid metal, viz., mercury, and the electrodes are enclosed in a tube.

These Hewitt patents do not show any device having an incandescent filament and a cold electrode enclosed in an evacuated bulb, nor do they disclose any device for operation with radio-frequency currents. It follows, of course, that they in no way disclose the control of the flow of electrons emitted by a heated filament in response to the electrostatic fields produced by radio-frequency or any other potentials applied between an incandescent filament and the cold electrode contained in an evacuated bulb. There is, in short, no resemblance between the disclosure of the Hewitt patents and the disclosure of the Fleming patent in suit.

When Dr. Miller states (P. R., p. 764):

"In other words, the Hewitt inventions referred to in the question are the same thing and oscillate for the same reason as the gaseous two-electrode device demonstrated before Judge Mayer in the record referred to in your Question 3."

he makes a wholly incorrect statement. How anyone with any sense of responsibility, either to the Court, or to the truth, can make such a statement, I am entirely unable to understand.

The Hewitt device is a long slender tube with a pool of mercury in one end and a solid electrode in the other. When in operation, the tube is filled with mercury vapor, the pressure is of the order of atmospheric pressure, and

the current flowing in this vapor produces an intense ghastly greenish light.

The Fleming device is an ordinary incandescent-lamp type of structure, having a filament arranged to be operated at incandescence and, in close proximity to the filament, a cold-plate electrode. The device demonstrated before Judge Mayer was of this type; it was a small incandescent lamp having in close juxtaposition to the filament a circular metallic plate with a lead-wire brought out through the glass. The air originally in the tube had been exhausted to an ordinary incandescent-lamp vacuum and when in operation, such a vacuum continued to exist. The current was not carried by metallic vapor, but, on the contrary, electrons were emitted and these electrons under the influence of the applied battery and of the oscillations pro- [fol. 1578] duced, were suitably controlled to pass in varying impulsive flow from the filament to the cold plate.

It is therefore evident that there is no part of Dr. Miller's above-quoted statement which is true; the devices are not the same and the current is not conveyed in the same manner.

Dr. Miller has persistently called the two-electrode tube, when oscillating as demonstrated before Judge Mayer, an arc. Dr. Millikan evidently recognized the distortion of meaning involved in such a terminology, for he says (P. R., p. 849) merely that he proposes to call it "an arc". He says:

"Any space between two electrodes in which it is possible to obtain a large amount of ionization of gases or vapors may under suitable conditions exhibit the peculiar property of having what is often termed a negative resistance. • • • If we insert such *a space, which for brevity I will henceforth term an arc*, in series with a circuit otherwise containing a battery and a resistance," • • • (Italics mine.)

In other words, the sole basis for such a terminology and for Dr. Miller's sweepingly untrue statement is that they are able to detect a property known as negative resistance, which they say is also characteristic of an arc. It would be as logical to say that a man and a dog are identical and operate in the same way, because both consume animal food.

I have already pointed out that the property of developing negative resistance is equally possessed by the three-element tube. Of course, neither tube alone develops such a resistance, but each develops it in appropriate circuits, under appropriate operating conditions, and by virtue of phenomena which, as I have already pointed out in previous answers, are fundamentally the same.

On P. R., p. 850, Dr. Millikan says:

"A three-electrode tube such as is used in the modern tube amplifier does not have a negative resistance at all. It amplifies as I have said above, by the relay principle, that is by tapping energy of an entirely new circuit" * * *

Does Dr. Millikan here mean to imply that a two-electrode tube, when amplifying (or, of course, when oscillating, which involves amplifying), does so without "tapping" an external source of energy? Such a statement would be a most amazing one; it would, in fact, be perpetual motion. I do not know what the statement was intended to imply, if it was *not* such a contrast.

It is, of course, true that arcs, including the Hewitt patent arcs, can amplify. It is true that two-electrode and three-electrode tubes can amplify. And as a result of their amplifying power they can produce oscillations in suitable circuits. This, however, does not make a two-electrode or a three-electrode tube out of a Hewitt mercury arc, nor does it make the two classes of devices "the same thing", as Dr. Miller states. Whether such a device as shown in the Hewitt patents can oscillate at radio-frequencies, I do not know with certainty, but my understanding is that it cannot, and I do not find any assertion by Dr. Miller that it can. If it cannot, as I believe to be the case, then it is most certainly untrue to say that they are "the same thing", and also untrue to say that they "oscillate for the [fol. 1579] same reason", unless that statement is accompanied by highly essential qualifications—nowhere hinted at, much less stated, by Dr. Miller.

I have, in a preceding answer, pointed out that a two-electrode or a three-electrode tube may operate in virtue of an electrostatic control influenced by gaseous ionization or, in other words, in virtue of a falling characteristic. This oscillation, however, occurs by virtue of the electrostatic control of electrons emitted by the heated filament in the highly-evacuated tube. Such is *not* the operation of

the Hewitt devices; these devices conduct electricity and operate in virtue of the conductivity of metallic, *i. e.*, mercury vapor given off by the liquid mercury-electrode of the arc.

I am unable to see that the decisions of Judge Mayer, or of the Court of Appeals, have any bearing whatever upon this matter. As I understand those decisions, the issues in that case were not the same nor similar to the issues in this case. In that case the question was, whether a licensee under the Hewitt patents, who had also used three-electrode tube amplifiers, should pay a license to the owners of the Hewitt patents, because of such use. The Court held that because of the nature of the disclosure and claims of the Hewitt patents, the licensee was not obligated to so pay. The statements of the Court, made after the hearing on that issue, would seem to me to have no bearing upon any issue in this case. Judge Mayer, in his opinion, held that the defendant's three-electrode tube in that case amplified, not because of any characteristic of the conducting space, as in the Hewitt inventions, but because of the use of the DeForest grid. Judge Mayer also held in the case of Marconi *vs.* DeForest, that three-electrode tubes having the DeForest grid, operated in virtue of the Fleming electrostatic control of electrons emitted by a hot filament in an evacuated bulb and constituted infringements of the Fleming patent here in suit. There is no inconsistency between these decisions. On the contrary, they are entirely consistent, whether the tubes are considered with reference to their so-called detecting, amplifying or oscillating functions.

The tubes demonstrated before Judge Mayer were normal examples of the Fleming two-element tube, constructed without any reference to their use, before Judge Mayer. They were, in fact, constructed before there was any such litigation pending; they were constructed for ordinary radio detecting use. They were demonstrated openly in the presence of highly skilled scientific men and of counsel for both sides. Judge Mayer had all of the information possessed by any of the witnesses, and nothing could be further from the truth than the implication implied by the testimony, that Judge Mayer was not fully informed.

Q. 28. Referring further to Mr. Loftin's answer to Q. 31 of his deposition (P. R., p. 1113), which you considered

in answer to Q. 9 of your present deposition, I will ask your attention to "Plaintiff's Exhibit No. 119", particularly to pages 27-33 thereof, inclusive, and to state in what respects this publication of the Signal Corps of the United States Army tends to confirm your previous opinion as to the similarity between open-gap transmitters and quenched gap transmitters, and also your opinion as concerns the question of resonance of such transmitters.

A. "Plaintiff's Exhibit No. 119" confirms me in the views that I have expressed. On page 27, Paragraph 60, it is stated:

"60. To produce a nearly pure wave, it has been found [fol. 1580] necessary to add another circuit in a radio transmitter to the one shown in figure 11. This is shown in figure 15, which is a typical diagram of a transmitter. It shows three distinct circuits which have been divided by broken lines in the diagram. Circuit A is the power circuit. Circuit B is the spark-gap circuit. Circuit C is the radiating circuit."

Looking at figure 11 referred to, it is found to be the circuit of the Marconi re-issue patent and has a radiating circuit comprising an antenna containing a spark gap and a power-supply circuit or induction coil. Referring to figure 15, which is said to be a typical diagram of a transmitter, it will be seen that the spark-gap has been removed from the antenna and placed in a local circuit containing a condenser, and that this circuit is associated with the antenna by means of an oscillation transformer. The circuit of figure 15 is, therefore, the circuit of the Marconi tuning patent No. 763,772. In other words, in April, 1921, the date of "Plaintiff's Exhibit No. 119", the circuit of this Marconi patent was still the "typical diagram of a transmitter".

On page 27, Paragraph 62, it is stated:

"62. A study of the action of the circuits in figure 15 shows more clearly the function of each. A *special* spark gap is supposed to be used in circuit B. Circuit A furnishes the power to circuit B, which acts as a trigger circuit. It stores up the energy until the spark gap breaks down and this breaking down allows the oscillations to occur. These oscillations are transferred to circuit C where they are radiated. Figure 16 shows this."

It will be seen that this is the same explanation as that given in the Marconi patent; in looking at figure 16, it is seen that the figure is essentially the same as that which I have given to illustrate the operation of the transmitter of the Marconi patent, and the same as that which Mr. Loftin has given as illustrating the operation of the so-called quenched-gap transmitter.

On page 28, Paragraph 64 points out that when the energy of the reservoir-circuit has once been transferred to the antenna circuit, it should not be re-transferred back to the reservoir circuit, because if this happens, a great deal of the energy is wasted.

Paragraph 65 then states as follows:

"65. There are two types of spark gaps in common use which prevent this retransfer of energy. Energy cannot get back in the B circuit if that circuit is broken immediately after it has transferred its energy to the antenna circuit. In other words, no oscillations can be set up in a broken circuit. Both types of spark-gap work on this principle."

This statement corresponds exactly with the testimony which I have given on this subject, and describes the operation which I understand is characteristic of the transmitter of the Marconi patent, when properly operating; that is, when operating to the best advantage.

Paragraphs 66 and 67 then describe by reference to figure 17, a multiple spark-gap similar to that shown in the Seibt patent and referred to as a quenched-gap, and an open gap of the rotary type. As stated in Paragraph 65, both of these gaps give the operation characteristic of the Marconi patent, illustrated in figure 16.

[fol. 1581] Beginning at page 31, Paragraph 75, the consideration of the tuning of the circuits to resonance is begun, and in Paragraph 78 it is stated:

"78. So in circuits that are coupled together. If they are not in resonance the effect of one on the other is very little. If the circuits are in resonance, very much energy is transferred from one to the other. So that, when circuits are coupled it is necessary to have them tuned with each other in order to transfer energy from one to the other."

Thus, this Signal Corps publication, "Plaintiff's Exhibit No. 119", states exactly what I have stated, that the reason

why it is possible to transfer a large quantity of energy from one circuit, viz., the reservoir circuit of the Marconi patent, to the other circuit, viz., the radiating circuit of the Marconi patent, in a few oscillations, as illustrated in figure 16 of this exhibit, is the reason which I have given, viz., because the circuits are in resonance with one another, and "resonance" is defined as meaning the same natural frequency or time-period.

I find, therefore, that this Signal Corps publication, being "Radio Communication Pamphlet No. 1," dated April, 1921, marked in evidence herein as "Plaintiff's Exhibit No. 119", exactly confirms the views and understanding of the operation of the transmitter of the Marconi patent which I have expressed.

* * * * * * *

Q. 29. Testimony has been given in this suit by defendant's witness Loftin (P. R., p. 1137), concerning the open-gap transmitting set on the United States battleships connected with the British Grand Fleet in the North Sea during the World War. Will you please consider the testimony of Mr. Lehr in his answers to Qs. 3-29, inclusive (P. R., 1472-5), and "Claimant's Exhibit No. 207", mentioned therein in respect to the open-gap 126-meter set used by the United States Navy, and state how it compares in construction and mode of operation with the transmitting apparatus of the Marconi tuning patent No. 763,772 in suit, and particularly recited in the transmitter claims thereof, Nos. 1, 3, 6, 8, 11 and 12, giving your reasons for any opinion you may express? In this connection you might also consider the testimony of Mr. G. H. Clark concerning the same sets, given on pages 1472-5 of the Printed Record. [fol. 1582] A. I have read the testimony referred to in the question and examined the diagrams. I produce a simplified diagram illustrating the transmitter referred to. In this diagram (Claimant's Ex. 328), I have indicated the various parts by the same legends as found on Mr. Lehr's diagram, "Claimant's Exhibit No. 207", using conventional indications for the coils and condensers and their variability by an arrow drawn across them.

This is an open-gap wireless transmitter having an open antenna circuit, which is a good radiator; this comprises the elevated conductor marked "Ant.", a coil marked "Loading Coil", a variable condenser marked "Coupling",

a measuring instrument marked "H. A." and an earth connection indicated by the usual symbol. There is a closed circuit, which is, therefore, a persistent oscillator, which comprises two condensers C, C, and two inductances P, P, the condenser marked "Coupling" and a spherical terminal spark-gap marked "Gap", all in series. The power is supplied by a power transformer marked "Trans.", the energy for which is derived from an alternating-current generator G, under control of a key marked "Main Key." The latter is a magnetically operated key worked by a hand-key. These details being shown in "Claimant's Exhibit No. 207", I have not reproduced them.

Specifically this differs from the literal showing of the Marconi tuning patent 763,772, in that the oscillation transformer *d*, *d'*, is replaced by a coupling condenser marked "Coupling". In other words, instead of the inductance in the closed circuit being made the coupling means, the capacity of the local circuit is made the coupling means. The local or closed circuit of this 126-meter transmitter has inductances marked P, which correspond in the make-up of the oscillatory circuit to the inductance *d* of Fig. 1 of the patent, while the condenser *c* of the latter is represented by the three condensers: C, "Coupling" and C, in series. It is quite common to subdivide condensers in this way, as it makes them less likely to be broken down by the voltages employed. One of these condensers, viz., that marked "Coupling" is used to couple the closed primary circuit to the radiating secondary circuit, the arrangement being known as "capacitative coupling" or "capacity coupling". The degree of coupling is determined in the usual manner, being the ratio of the mutual reactance to the square root of the product of the individual reactances. The same formula applies to the illustration of Fig. 1 of the patent and to the 126-meter transmitter in question. Where the circuits are inductively coupled, as in the patent, it is, of course, the inductive reactances that are considered in applying the formula; whereas, in a capacitative coupling it is the capacity reactances that are used in applying the formula.

Having reference to the descriptive matter of claim 1, there is, in this 126-meter transmitter, a signaling instrument which comprises an inductance coil, being the transformer, the secondary circuit of which includes a condenser. It is this condenser that is represented by the condensers

C, C, and the coupling condenser which, together, are the equivalent for the purposes of the primary circuit of the single condenser *d* of Fig. 1 and similarly serve to store the charge of energy supplied by the transformer. This condenser combination is arranged to discharge through the spark-gap which is specifically like that shown in the Marconi patent, according to the testimony of Mr. Lehr, being a so-called spherical gap. Since, according to the [fol. 1583] testimony of Mr. Lehr, the two circuits are separately put in resonance by having their electrical time periods made alike, the discharge of this spark-gap automatically causes oscillations of the desired frequency. There is also an open circuit, which is electrically connected with the oscillation-producer, which circuit includes the variable inductance marked "Loading Coil". The result is that upon the discharge of the spark-gap, oscillations are produced in the primary or closed circuit, the energy of which is transferred by resonance to the open or secondary circuit. The operation is, therefore, that which is set forth in the Marconi patent, and the arrangement is substantially that described by the language of claim 1. The recitation of claim 3 includes a generator for supplying the inductance coil and means for varying the primary circuit of the inductance coil, which is the operating key in this instance. In other respects the claim is similar to claim 1 and, hence, claim 3 is substantially descriptive of this 126-meter transmitter.

With respect to claims 6, 8, 11 and 12, I note that these claims refer to a "transformer whose secondary is connected to an open circuit". In the arrangement of this 126-meter transmitter the coupling is effected by the condenser arrangement which I have described, which is the operative equivalent of the particular form of oscillation transformer shown in the patent, and diagrammatically indicated in Fig. 1. Such an arrangement is, in fact, sometimes called a condenser transformer. I note that claims 11 and 12 refer to an "oscillation transformer" and "the secondary coil of the oscillation transformer". Of course, this 126-meter transmitter does not have an oscillation transformer which has "a secondary coil", although it has, as just stated, its operative equivalent. The application of claims 11 and 12 to this transmitter therefore, depends upon the interpretation which the Court gives to these claims. Claims 6 and 8 call for "a transformer whose secondary is connected to an

open-circuit including a radiating conductor at one end and capacity at the other end, and whose primary is connected to a condenser circuit discharging through a means which automatically causes oscillations of the desired frequency," this language is not, in terms, restricted to a transformer arrangement having coils and it would be proper usage to apply it to the condenser transformer arrangement of this 126-meter transmitter. As I have said, the operative results are the same, whether the inductance element of the primary and secondary effect the coupling, or whether it is done by the condenser element. As to claims 6 and 8, therefore, the structure of this transmitter is both equivalent to that shown and disclosed by the Marconi patent and recited in claims 6 and 8, when read literally on the structure shown in Fig. 1, and it is also properly within the language from a technical standpoint. I, of course, have no opinion as to any legal aspect that the question may have.

Mr. Vaill: Counsel for claimant offers in evidence the sketch produced by Mr. Waterman in answer to the last question, and requests that the same be marked "Claimant's Exhibit No. 328."

(The Notary marks said exhibit as requested.)

[fol. 1584] Cross-examination.

By Mr. Edwards:

X Q. 30. Is it your opinion today that if the bulbs demonstrated before Judge Mayer had been bulbs having a high vacuum, that is to say, of the order of ten to the minus six power millimeters that, using the bulbs in the circuits which were used before Judge Mayer that the oscillations which were there demonstrated would have occurred?

A. I am not able to answer as to the particular order of vacuum. I assume that any change in the bulb would very likely have required a re-adjustment of the circuit constants or battery, and speaking with my present-day information on the subject, I am of the opinion that if the vacuum were high enough, the oscillation with that circuit would not occur.

X Q. 31. Do you admit that, in order to attain the oscillations demonstrated before Judge Mayer in the circuits there used, it was necessary that the tube contain some residual gas?

A. Subsequent study of the matter indicates that the electrostatic control of the electron stream, in virtue of which the oscillations took place, was one in which the residual gas played a part, although there was no visible evidence of any such effect. Of course, it is not necessary that the residual gas should play a part in order that oscillations might have been obtained with the tubes used. Of course, there is always residual gas in all tubes, which may, or may not, play an important part in the operation.

X Q. 32. Do you admit that, using the circuits which were used in the demonstration before Judge Mayer, it was necessary, in order to obtain the oscillations, that the tube contain residual gas—at least, to such a degree as to exercise the electrostatic control to which you refer?

A. No, I do not say that it is necessary; what I said was I believe that the residual gas did, as a matter of fact, play a part in the operation.

X Q. 33. Do you claim today that if the bulbs used before Judge Mayer had been of such a high order of vacuum as ten to the minus six power millimeters, using the circuits which you used before Judge Mayer, that you would have succeeded in demonstrating the oscillations which were there demonstrated?

A. There would have been no difficulty in demonstrating oscillations with tubes having any degree of vacuum, as long as it is high enough. Of course, there must be an electrostatic control and, if that electrostatic control were not exerted through the residual gas, it would have to be exerted in some other way. I do not undertake to say whether the particular degree of vacuum mentioned would, or would not, give appreciable control of space-charge by the action of the gas.

X Q. 34. Do you admit that, using the circuits used in the demonstration before Judge Mayer, it was necessary, in order to obtain the oscillations, that there be enough residual [fol. 1585] gas to exert the necessary electrostatic control? In other words, that you would not have obtained the oscillations unless the tubes contained sufficient residual gas to exert the electrostatic control?

A. No, what I said was that while the tubes had a very good order of vacuum, it is my present opinion that the residual gas probably did play a part in the electrostatic control which produced the oscillations. I do not say, nor do I believe, that oscillations could not have been produced

without that effect. It would merely have been necessary to produce the control in some other way. As, for example, by placing the tube near enough to some part of the circuit so that it experienced a sufficient electrostatic field to effect the control.

X Q. 35. Are you to be understood as saying, or intimating, that the oscillations would have been produced in the circuits which were used before Judge Mayer, without there being present in the tube sufficient residual gas to exercise the necessary electrostatic control?

A. Yes, as explained in my preceding answers.

X Q. 36. That is to say, you do assert now, that the oscillations would have been produced in the circuits which were used before Judge Mayer, even though there was not present in the tube sufficient residual gas to exercise the necessary electrostatic control?

A. Yes. It is only necessary that the tube be sufficiently near to some element to experience an electrostatic field responsive to the oscillations produced.

X Q. 37. Please note that in all of my questions, beginning with X Q. 30, I have been limiting my questions to the circuits which were used before Judge Mayer. I do not understand that any claim has been made heretofore to the effect that any of the elements in or about those circuits were sufficiently near to the tube to exercise control over the electrostatic field. With this understanding of the circuits used before Judge Mayer, will you answer my preceding questions X Qs. 35 and 36?

A. I had noted that the questions referred to the circuits used before Judge Mayer, and my answers were made with that understanding. Changing the location of the tube on the table does not alter the circuit, and I did not have in mind such a limitation to the questions. I stated in my answer to X Q. 34 that my present opinion is that it would have been necessary to place the tube near enough to some part of the circuit, so that it experienced a sufficient electrostatic field to effect the control.

X Q. 38. Then, will you agree with me to the extent that it was necessary to exercise the necessary electrostatic control, either by the presence of sufficient residual gas, or by placing the tube near enough to some part of the circuit to experience sufficient electrostatic field to effect the control? I am still assuming that the tube is a two-electrode tube.

A. Yes, with the reservation that I have no other thought in mind at the present moment. There are too many things that happen in such a tube to indulge in unrestricted generalization.

X Q. 39. Then will you admit that, so far as your present knowledge goes, the demonstration before Judge Mayer would not have resulted in the production of oscillations, unless there was present in the tubes there used, a sufficient amount of residual gas to exercise control upon the electron stream, or unless the tube had been placed near enough to some part of the circuit to experience sufficient electrostatic field to effect the control?

A. I do not get the force of the word "admit". It is my [fol. 1586] understanding of the fact, and I have expressed it as my opinion, that the two things disclosed by Fleming, viz., the emission of electrons and their control by an electrostatic field, are necessary. I state that as my opinion and understanding of the fact. I do not understand that the tube will function in any way whatever as a radio device, except as both of these effects are present. I therefore express it as my opinion that there was, in the demonstration before Judge Mayer, and must necessarily be in any such demonstration, an electrostatic control produced either with, or without, the aid of residual gas. If the residual gas effect was absent or insufficient, then there must certainly be some other way of exerting it.

X Q. 40. Then I will change my last question by substituting the word "agree" for "admit", and ask you to answer the question. As changed, the question will read as follows: "Then will you agree, that so far as your present knowledge goes, the demonstration before Judge Mayer would not have resulted in the production of oscillations, unless there was present in the tubes there used, a sufficient amount of residual gas to exercise control upon the electron stream, or unless the tube had been placed near enough to some part of the circuit to experience sufficient electrostatic field to effect the control?"

A. I agree that it was necessary to the demonstration, that the electrostatic control should be exercised either through the existence of a certain amount of residual gas, or in some other manner, such as placing the tube near enough to some part of the circuit to experience the necessary control.

X Q. 41. Is there any reason why my last question, X Q.

40, could not be answered by a simple negative or affirmative?

A. Yes, I thought so; therefore, I changed the phraseology slightly in answering.

X Q. 42. What was the difficulty with the question that prevented you from giving a simple affirmative or negative?

A. I merely thought that the phraseology of my answer more exactly expressed my meaning.

X Q. 43. Well, will you not give a simple affirmative or negative to X Q. 40?

A. Yes, if I may understand it as having the same meaning as the answer which I did give.

X Q. 44. Will you not either answer X Q. 40 with a simple Yes, or No; or, if there is any difference between the meaning of your answer and the meaning of the question, please say so.

A. As I understand X Q. 40, my answer only differs from the statement in referring to the placing of the tube near enough to some part of the circuit as illustrative. I regard it as an essentially affirmative answer without, however, being subject to the restriction that altering the position of the tube itself was the only thing that might be done.

X Q. 45. Do you know of any other way at present?

A. Yes, I have done it by simply bending the wire a little closer to the tube.

X Q. 46. Is not that merely another way of placing the tube near enough to some part of the circuit to experience the necessary control?

A. Yes, but it does not involve moving the tube, as the question might imply.

X Q. 47. It is, of course, immaterial to me which way you answer X Q. 40, but I have followed the matter through in order to demonstrate the difficulty experienced by counsel in getting from you a simple affirmative or negative as to a matter concerning which there does not appear to be any essential controversy. Therefore, now that we have succeeded in getting you to say in answer to X Q. 44, that you [fol. 1587] regard your answer as "an essentially affirmative answer", I will ask you again if you cannot answer X Q. 40 with a simple affirmative or negative without the accompaniment of conditions, or explanations involving hidden meanings, or otherwise?

A. Since my answers have clearly stated my understanding of the fact, I am compelled to regard the insistence of

the cross-examiner upon my adopting his language, as evidence that that language probably means something to counsel that it does not to me; therefore I answer it in my own words, that my meaning may be clear.

X Q. 48. Regardless of what my purpose may be, are you able to answer X Q. 40 with a simple affirmative or negative?

A. If the answers which I have given are not a satisfactory answer to the question, then I certainly am not able to answer it categorically.

X Q. 49. Please note that even your last answer is conditional. Can you not tell me whether or not you are able to answer X Q. 40 with a simple affirmative or negative?

A. For the reasons stated, I am not.

X Q. 50. That is to say, you cannot answer X Q. 40 with a simple affirmative or negative; is that so?

A. For the reasons stated, I cannot.

X Q. 51. The only reason that I can discover in your testimony, is that in X Q. 47 you seem to fear adopting my language. Will you tell me if there is anything about X Q. 40 that is not clear to you?

A. If it differs in meaning from my answer to X Q. 40, then I do not know what it means. I answered the question as I understood it, in the first instance.

X Q. 52. Do you think that X Q. 40 does mean anything more than what you have said in your answer to the question?

A. No, I regarded my answer to X Q. 40 as being a complete and satisfactory answer to the question.

X Q. 53. The only difference between your answer and my question, so far as I can discover, is that in answer to X Q. 44 you pointed out that you are not subject to the restriction that altering the position of the tube was the only thing that might be done, and yet my question was limited to your present knowledge, and I have yet to see why X Q. 40 could not be answered by a simple negative or affirmative. If there is any substantial reason, I wish you would point it out.

A. I have pointed out the only difference that I had in mind in my answer to X Q. 44.

X Q. 54. Do you regard that difference as of any consequence?

A. I have not undertaken to form any opinion on that matter. I am simply answering the questions as clearly as I am able.

X Q. 55. Do you understand that in the demonstration before Judge Mayer the tube actually was placed near enough to some part of the circuit to experience the necessary electrostatic control?

A. My recollection is that the tube stood quite apart from the other circuit elements, and I assume that it was not influenced in any high degree, by the presence of those elements through the medium of their electrostatic field.

X Q. 56. Then, assuming that to be true, does it not follow that, so far as your present knowledge goes, the demonstration before Judge Mayer would not have resulted in the production of oscillations, unless there was present in the tubes there used, a sufficient amount of residual gas to exercise control upon the electron stream?

[fol. 1588] A. As I have several times stated, my present belief is that the electrostatic control in that demonstration was probably exercised by the changing ionization of residual gas, although there were no visible evidences of it. If that is what the question means, I answer it in the affirmative.

X Q. 57. I think the question clearly means to inquire whether or not, so far as your present knowledge goes, the demonstration before Judge Mayer would not have resulted in the production of oscillations, unless there was present in the tubes there used a sufficient amount of residual gas to exercise control upon the electron stream. Is there any ambiguity about the question which renders it impossible for you to answer it with an affirmative or a negative?

A. I understand that you are asking for my opinion, and as there is no possible way of proving the matter, I can only state what I regard as the probable fact, which I have done.

X Q. 58. The question only asked you so far as your present knowledge goes, whether or not the demonstration would have resulted as set forth in the last question. Is there any ambiguity about my X Q. 57 that makes it impossible for you to answer with a simple affirmative or negative?

A. So far as I can see, the question and the answer may be taken as having the same meaning, except that my an-

swer makes it clear that I am only stating what I regard as the probable fact in that test.

X Q. 59. Yes, but I am asking you whether or not, so far as your present knowledge goes, the demonstration before Judge Mayer would not have resulted in failure to produce oscillations unless there had been present in the tubes there used, a sufficient amount of residual gas to exercise control upon the electron stream. I am not asking you to split hairs about the shade of meaning to be given to your answer, or to compare the answer with the question. I am asking you now if there is any ambiguity about the question that makes it impossible for you to answer it with a simple affirmative or negative. It would seem to me that you could answer this question with a simple Yes, or No; if you can, please do so.

A. My present opinion is that the tube used would probably not have given rise to oscillations in the circuit, if the vacuum had been of the highest possible order, without some other manner of producing the electrostatic control, as I have already stated.

X Q. 60. Will you not say whether or not there is any ambiguity in my X Q. 59, which renders it impossible for you to answer that question with a simple affirmative or negative?

A. I take it that the reference is to the meaning of X Q. 56. I did answer that question in the affirmative, without any qualification, except that I understood it as asking for my opinion, and not for an assertion of fact.

X Q. 61. Then, is it not your opinion today, so far as your present knowledge goes, that if the bulbs which were demonstrated before Judge Mayer had been of a high order of vacuum, such, for example, ten to the minus six power millimeters, using the circuits which were used before Judge Mayer, the oscillations which were demonstrated to Judge Mayer would not have occurred?

A. As I have stated, I do not have in mind at the moment any facts that enable me to pass on the specific vacuum that the question names, but I do believe that it would be possible to produce a bulb of otherwise similar construction with vacuum so high that it would not have oscillated, without some other association which would give the necessary electrostatic control.

X Q. 62. Do you agree that in the so-called demonstration [fol. 1589] made by Mr. Weagant in this case, and testified

to by him at pp. 1526 to 1531 of the Printed Record, the amplification and oscillation attained by Mr. Weagant, would not have been attained by him, unless the coils and condensers located adjacent to the tube, and employed for the purpose of controlling the electron stream, had been so employed?

A. I understand that the reception and oscillation that was demonstrated by Mr. Weagant was brought about by the combination of circuits and tubes, and that the electrostatic control which existed was influenced by the association of the elements that he pointed out, and that it would not have been attained except for that, or some equivalent association.

X Q. 63. And am I correct in understanding that, in your view, the control of the electron stream by residual gas, or by an outside coil or condenser, such as employed by Mr. Weagant, or by a grid inside the tube, as in the ordinary three-electrode tube, are all, broadly speaking, equivalents?

A. In the sense that they are all means of exemplifying the same sort of electrostatic control at radio-frequencies, as disclosed by Fleming, yes.

X Q. 64. Was this your understanding at the time of the demonstration before Judge Mayer?

A. I would find it difficult to recall precisely what my understanding was at that time. I can only say that I do not remember that my understanding at that time was any different.

X Q. 65. In your answer to Q. 17, you set forth your understanding of the function of the gas in the paragraph beginning "In either the two-electrode or three-electrode tube", and in the following paragraphs of your answer. Were the views set forth in these paragraphs known to you, or understood by you, at the time of the demonstration before Judge Mayer?

A. At the time of the demonstration before Judge Mayer, I knew that an electrostatic control was necessary, but I did not know how it was brought about. There was no visible evidence of any gas action in the tube used, except as to the first one, which was replaced, and I did not know what it was, or what the mechanism of the action was, but I did know that under the conditions of the test the oscillations were produced.

X Q. 66. At the time of the test before Judge Mayer, was it your view that the higher the vacuum, other conditions

being equal, the more favorable would be the conditions for oscillation?

A. Yes. My experience had been that, in general, the higher the vacuum, the better the tubes worked.

X Q. 67. In the light of your present knowledge, do you consider that that view was erroneous?

A. In one sense no, and in another sense yes. At the present time it is known that for certain purposes it is advantageous not to have the vacuum in a three-element tube too high and, consequently, what are called "hard" and what are called "soft" tubes are made, the difference being in the degree of the vacuum. The same thing seems to be true of the two-element tubes; that is to say, there are some usages in which the gas present, even though an extremely small percentage of one per cent. of atmospheric pressure, does play a part in the operation. Tubes of about the order of vacuum described by Fleming, would now be classed as "soft", while tubes exhausted by the improved methods which are available today, have a higher vacuum, and are called "hard". There is, of course, no sharp dividing line. I did not know these facts at the time of the demonstration before Judge Mayer.

[fol. 1590] X Q. 68. If I understand you correctly, it is your present view that the degree of vacuum is not controlling, but that the controlling essential, in order to attain oscillations, is that if the vacuum is low enough to leave residual gas, the gas will control the electron stream, and, on the other hand, if the vacuum is too high, there will be not enough gas to control the electron stream, and resort must be had to some other means, such, for example, as a grid within, or some element outside of the tube, to exert control upon the electron stream. Is that, in substance, your present-day view?

A. Yes, I think that states it, with the addition of the fact that I pointed out in my direct examination that, regardless of the precise degree of vacuum, as long as it is sufficiently good, the control by an impressed electrostatic field is effective, whether it be produced by one of the circuit elements influencing the tube, or by a grid-element within the tube.

X Q. 69. By referring to page 33 of "Claimant's Exhibit No. 171", I note that in the testimony before Judge Mayer,

when you were asked to give all of the elements necessary to make the two-electrode tube oscillate, you stated:

"The two conditions are that you should be able to heat the filament to a high temperature and that you should have a high vacuum in the bulb."

Do you not think, in the light of your present knowledge, that the reference to the "high vacuum" in this quotation, should be qualified somewhat as indicated in your last answer?

A. The next sentence on page 33 of "Claimant's Exhibit No. 171" goes on to say:

"Now, it is true that not all bulbs, as far as I know, which have a high vacuum, and which can have the filament heated to a high temperature within the limits of the apparatus, will oscillate, and what the critical condition that makes them oscillate is I do not know."

I went on to explain further what I meant. From my present point of view, with fuller knowledge, the statement of my last answer is a proper extension of the answer that I then made.

X Q. 70. In the light of your present knowledge, it would not be proper to understand the reference to a high vacuum in the testimony before Judge Mayer, just referred to, to mean that to attain oscillation with a two-electrode tube in the absence of some such means for controlling the electron stream, as a grid or outside means such, for example, as used by Mr. Weagant, one should make the vacuum as high as possible, would it?

A. If I understand the question, I should say no. I had a good deal to do with the making of many of the tubes that I used, and I did have them made with the highest vacuum possible with that apparatus, but, so far as I know, tubes that have the highest possible vacuum obtainable today, have to have an electrostatic field impressed on them from some part of the associated apparatus. Speaking only of the perfection and stability of the oscillations, it is still true that up to the highest vacuum I have any knowledge of, the higher the vacuum the better.

[fol. 1591] X Q. 71. In your answer to Q. 4 you state in effect that Mr. Loftin accuses you of suppressing the alleged fact that with a very tight coupling two oscillations would

exist. Is there any dispute between you and Mr. Loftin regarding the fact of whether or not if two tubed circuits are tightly coupled, the resultant frequency will have a double hump?

A. The subject under discussion in the testimony referred to was Mr. Loftin's Criticisms of my "Sketch No. 2", found opposite page 151 of the Printed Record. That sketch shows a coupling of about ten per cent., which is not within any ordinary usage of the term "tight coupling". In Mr. Loftin's correction, as he chooses to regard it, found in his "Sketch K", opposite P. R., p. 1057, he indicates a coupling of about three and a half per cent., which, as I pointed out, is lower than the illustrations of the Marconi patent, and would rank as an exceedingly loose coupling. As I stated in my answer referred to in the question, such a coupling as my "Sketch No. 2" shows, does not necessarily result in two frequencies; that is to say, in a double humped resonance curve.

As I pointed out in my direct examination, whether any given coupling does, or does not, result in two humps in the resonance curve of the wave transmitted, depends, primarily, upon the behavior of the spark-gap, and this is true, without regard to the particular construction of the gap.

X Q. 72. In discussing this same subject, you criticised Mr. Loftin's "Sketches G and H." Am I correct in understanding that the basis of this criticism is that you think Mr. Loftin has the erroneous impression that the current in a circuit can be going in two directions at once?

A. Yes, that is what Mr. Loftin appears to say. I refer, for example, to P. R., p. 1040, where Mr. Loftin describes his sketch G.

X Q. 73. Is it not common, in the consideration of coupled circuits of this character, to describe them as though there are as many currents as there are circuits?

A. Certainly not in the way that Mr. Loftin does it, or with the understanding that he seems to express. Further, his sketches are incorrect, if I understand them from any view whatever.

X Q. 74. Do you question the fact that in coupled circuits there will be as many frequencies as there are circuits?

A. The question is too broad to be accurate, if it can be interpreted as being a correct expression at all. Speaking of two circuits, which is what we are interested in, it is correct to say that two coupled circuits have two degrees of free-

dom. It is also correct to say that the current flowing when one such circuit is excited by the other, that the current flowing in each has not a simple sine wave-form, but is such a current as would result from the application to each circuit simultaneously, of two damped oscillation-frequencies. The current that results is a single current, and the com- [fol. 1592] ponent e. m. f.'s that produce it are damped oscillations, and in no case do they bear any resemblance to what Mr. Loftin has illustrated in his Figs. 2 and 2*a*, for example, of his sketch G.

X Q. 75. Will you point to the precise question or language on page 1040 of the Printed Record, to which you referred as indicative of Mr. Loftin having the impression that current in a circuit can be going in two directions at once?

A. I refer particularly to the last two paragraphs of that page. I may note, also that in Mr. Loftin's Figs. 2 and 2*a* of his sketch G, he shows the two currents that he describes in the next to the last paragraph on page 1040, as both of them waxing and waning. Such an assertion is an absurdity, which is only consistent with the interpretation which I placed upon it. In other words, the language and the sketch both lead to the same conclusion. If Mr. Loftin had been trying to show theoretical component currents, neither one would have waxed and waned.

X Q. 76. I do not find in the paragraph to which you refer any statement to the effect that the current in a circuit can be going in two directions at once. If you do find such a statement, will you please call my attention to it, and if you do not, please call attention to such statements, if any, that you think may justify the inference that Mr. Loftin's testimony is based upon such an impression?

A. What I said was:

"Mr. Loftin seems to have the erroneous impression that the current in a circuit can be going in two directions at once."

This, as I have pointed out in my last answer, is the necessary deduction from his showing two waxing and waning, or, as Mr. Loftin, I believe, has sometimes called them, "beating" currents in each circuit. If he had been trying to illustrate a theoretical analysis of a single waxing and waning current into two components of different frequencies, he would have shown two simple damped oscillation

trains, neither of them waxing and waning, as he illustrates. On Printed Page 1040 he says:

"Figure 2 represents the oscillations in the lateral circuit and Figure 2*a* the oscillations in the antenna or elevated conductor circuit derived from the interlinkage of the two circuits."

Again he says:

"Examining Figure 2 it will be seen that the oscillations start strong but soon die down to practically zero at the point I have marked *p*. Examining Figure 2*a* it will be seen that the oscillations at first are weak, and gradually build up to a maximum at the point p^1, opposite the point *p*, or point of minimum energy in the lateral circuit."

The quoted statements admit of no other interpretation, if I understand them, than that the green and red lines were intended by Mr. Loftin to represent currents flowing in these circuits, and looking at the figures it will be seen that there are many places where his two supposed currents are going in opposite directions at the same moment.

X Q. 77. Do you think it is incorrect or misleading to describe the operation of these coupled circuits as though there are, in fact, at least as many currents as there are circuits?

A. I prefer to stick to two circuits, for the reason that [fol. 1593] when we get to the consideration of three or more, we arrive at complexities not easily summarized. Understanding the question as referring to two circuits, it is incorrect to state and illustrate the matter as Mr. Loftin has done in his sketch G, for example, found on page 1040 of the Printed Record. It would not be incorrect or misleading to analyze a complex wave-form into two components, which would jointly result in the single complex current actually flowing. This, however, is not what Mr. Loftin shows, or what he describes, but, on the contrary, he does make an entirely erroneous showing, and his language leads one to infer that he is purporting to illustrate facts, which he does not.

X Q. 78. In the endeavor to meet your preference, I will re-phrase my question to read as follows:

Do you think it is incorrect or misleading to describe the operation of these two coupled circuits as though there are,

in fact, two currents, one in each circuit, and reacting upon each other?

A. No, not if the description is correct. There are, of course, two currents, one in each circuit, at the start, and while this condition exists, they do react on one another. What Mr. Loftin shows is two currents in each circuit, both showing evidence of reaction, which is impossible and incorrect, from any point of view.

X Q. 79. Do you question that there will be two currents in each circuit?

A. Yes, there will not; there will be a single current, of more or less disturbed wave-form, so long as both circuits are active and coupled. The single current of either circuit may, as a matter of analysis, be regarded as split into two components, but neither of these components will bear the slightest resemblance to either of Mr. Loftin's currents in either Fig. 2 or Fig. 2*a*.

X Q. 80. In your answer to X Q. 74, you said it is correct to say that two coupled circuits have two degrees of freedom. That expression "two degrees of freedom" is taken from the Stone patent 714,756, is it not?

A. No, if the expression occurs in the Stone patent, it is simply because we were both speaking the language of the art.

X Q. 81. You testified in the case of Radio Corporation of America *vs.* Splitdorf Electrical Company in the District of New Jersey, in or about June, 1926, did you not?

A. Yes.

X Q. 82. And there you testified concerning the operation of the Stone patent 714,756, did you not?

A. I testified regarding a Stone patent, but I do not remember the number.

X Q. 83. In that case did you not testify as follows:

"By the Court:

Q. 143. This is the Stone patent?

A. Yes.

(Answer to Q. 142 continuing): This illustrates what happens when it is undertaken to transfer energy from one circuit to another after the manner illustrated in Fig. 3 of the Stone patent, and in this case the two coils used are placed close together, side by side. The upper line of curves marked A shows what was happening in the first circuit, shows the first circuit; in other words, in action, in select-

ing, prior to the closure of the second circuit. The fact that the second circuit was not closed is indicated by the horizontal line B where that horizontal line terminates the [fol. 1594] second circuit was closed and the violent and irregular oscillations which thereafter occurred in both circuits illustrate the interaction effects with which Stone's mathematical theory deals, and illustrate the truth of his statement that there will be when two circuits are so coupled, there will be in those circuits as many currents as there are circuits, at least at a minimum.

"These circuits interacting upon one another produce reaction phenomena, and these at first are violent in view of the creation there of the effects referred to by Stone at various places, as, for example, the second column of page 2, and first column of page 3, which are known as transients, and thereafter as these transients gradually die out we get a small ineffective double frequency current in each of the circuits, in other words, the effectiveness of both circuits is destroyed."

A. The question appears to correctly quote a portion of my reported testimony in that case. To understand it, it is necessary to know that I was talking about a certain oscillogram which was in evidence and that the oscillogram illustrated a single current in each circuit, of complex form, which I said might be analyzed in accordance with Stone's statement. I note that Stone, in the passage referred to, makes the statement that if a number of simple circuits are associated by conductive or inductive connections, that the oscillations, that is, the current in each circuit, will consist of the superposition of at least n currents; that is, as many currents as there are circuits. This is not necessarily a true statement, although it might be, under some circumstances, but the subject is a highly involved one, and there seems to be no point in going into it.

X Q. 84. The oscillogram to which you referred, was oscillogram CD120089, shown on Printed Record page 229 of the Splitdorf record, which page I now show you, was it not?

A. Yes.

X Q. 85. And the Stone patent to which reference was made, was the Stone patent No. 714,756, was it not?

A. Yes.

X Q. 86. And you also testified in the same case as follows, did you not:

"I had agreed with the statement of the Stone patent, which I understand is also accepted by Mr. Loftin, that in the arrangement of the Stone patent, when the coils of two successive circuits are associated so as to pass on received energy from one to the other, there inevitably results the development of two different frequencies, neither of which is the frequency of the received signal, and I had agreed with Mr. Loftin that they can be minimized in the way that I showed by separating the coils. * * *"

Mr. Vaill: Same objection.

[fol. 1595] A. Yes. To understand it, it must be borne in mind that I was talking about receiving circuits and their performance as illustrated by the oscillograms, and not an organization wherein one of the circuits contains a spark-gap, and I said in the same context:

"It can be shown mathematically that when two circuits are coupled, in accordance with the Stone patent, the effect of one upon the other is to always alter the effective tuning of the circuit away from the desired signal and toward the interfering signal."

It will be seen that the subject-matter under discussion was subject-matter germane to the issues of that case.

Mr. Edwards: Defendant's counsel ask the Notary to mark for identification the copy of the oscillogram CD120089 shown the witness as "Defendant's Exhibit For Identification CD120089".

(The Notary so marks said oscillogram.)

X Q. 87. And you also testified in the Splitdorf case as follows, did you not:

"This sketch, Exhibit D-11-a, made by Mr. Loftin, illustrates the same sort of performance ascribed to the Alexanderson arrangement, which I have just described with reference to Stone".

And also:

"The presence of the double hump and the spreading out of this curve is due to the fact that in the Stone arrange-

ment, we have, I believe, the question asked me to refer to Fig. 9—a circuit L, I will say, associated with a circuit L'. Both of these circuits are resonance circuits, having the inductances I L and I'_2 and the condenser C in the circuit I have called L, and the inductance I_1', L', I_2'', and the condenser C'' in the second of these circuits, which I take for illustration. Each of those two circuits is tuned to the frequency of the desired signal, which would tend, of itself, to give a resonance curve of the form shown in A' in the curve sheet that I have just referred to."

* * * * * * *

A. Yes, in comparing the curves of "Plaintiff's Exhibit No. 22" in that case with "Defendant's Exhibit 11-A".

Mr. Edwards: Defendant's counsel asks the Notary to mark "Plaintiff's Exhibit No. 22" and "Defendant's Exhibit 11-A", which were referred to by the witness as "Plaintiff's Exhibit No. 22 for Identification" and "Defendant's Exhibit 11-A for Identification".

(Said Exhibits so marked by the Notary.)

* * * * * * *

Last Question by the Notary: Do you know of any other matter relative to this claim?

Answer. I do not.

* * * * * * *

[fol. 1596] Deposition of GEORGE H. CLARK, recalled as a witness on behalf of the claimant in rebuttal, taken at New York, N. Y., on the 26th day of March, A. D., 1928.

Direct examination.

By Mr. Cosgrove:

Q. 144. Are you the same George H. Clark who has heretofore testified herein?

A. Yes.

Q. 145. Will you briefly describe the construction of the vacuum tubes purchased and used by the United States Navy subsequent to June, 1910, and prior to the time you left the Navy in June, 1919, and which you particularly re-

ferred to in paragraph 9 of your answer to Q. 2, found on page 234 of the Printed Record herein?

A. These consisted essentially of a sealed glass tube from which the air had been withdrawn to as great an extent as possible, before sealing. Mounted in this tube was a filament, a grid, and a plate. The grid was always between the filament and the plate, and sometimes consisted of a spiral surrounding the filament, and sometimes a zig-zag form in one plane between filament and plate. In some forms of tubes, the filament was in duplicate, so that when one side burned out, the other could be substituted. The earlier forms of tube had one plate and one grid, both of these being plane surfaces. Later types re-duplicated the grid and plate on the other side of the filament, so that there were two plates and two grids, each in parallel. Still later came the form where the grid was spiraled around the filament and the plate was a cylinder with the filament at its center. This last form is the modern type, modified sometimes by the plate being rectangular or oval. The first tubes we obtained were called "audions"; later the term was changed to vacuum tubes, valves, and still later to trade names, such as the "radiotron".

Referring back to the construction, the filament, the grid, and the plates were connected by terminals leading out of one sealed end of the tube and connected on the outside of the tube to suitable terminals held in place by a base, into which latter the sealed glass tube was cemented. In the earlier types, no base was used, in the form above described, but instead the two filament terminals were brought out to a screw-type base of the form used in American incandescent lamps, while the grid and plate wires came out at the other end of the tube. These latter wires were usually covered with insulating tubing colored to indicate the terminal they represented. The grid was always green and the plate red.

Q. 146. Your attention is called to "Plaintiff's Exhibits Nos. 72 to 76", inclusive, contracts for the year 1914 between the Radio Telephone and Telegraph Company and the United States, represented by officials of the Navy Department, calling for certain radio apparatus, including bulbs. Have you any knowledge of the delivery to, and use by the United States Navy, of any of the bulbs called for in any of these contracts and, if so, please state what that

knowledge is, specifying the dates of delivery and use of the bulbs, approximately?

[fol. 1597] A. Yes, I have knowledge of both delivery and use by the Navy of these bulbs. I saw the amplifiers and bulbs in process of manufacture before they were delivered to the Navy, and these were delivered at the Navy Yard, New York, and I had a number of these amplifiers and bulbs officially transferred to the Washington Navy Yard for study, and then for use in the Service. The bulbs which I used at the Washington Yard both to study, and often to use in receiving from distant Naval stations, were of the type described in my previous answer, more especially referring to the first type therein described. I recall that this actual use of amplifiers and bulbs by me was in the early part of 1914. In August, 1914, I prepared an official bulletin for the Navy, in which these amplifiers and bulbs were described and pictured, and their use in the Service explained. The amplifiers and bulbs were delivered at the Washington Navy Yard from the New York Yard early in 1914, certainly before May.

The foregoing covers "Plaintiff's Exhibits Nos. 72 and 73".

"Plaintiff's Exhibit No. 74" covers ultra-audion receivers, detectors, and bulbs, which were delivered at the Washington Navy Yard, and which were personally passed and inspected by me. These were immediately sent out from the Washington Navy Yard by order of the Bureau for installation on ships and at shore stations, and I used them myself on various ships and at shore stations in 1914 and thereafter. The bulbs submitted on the requisition covered by "Plaintiff's Exhibit No. 74" likewise are described by my answer to Q. 145, the type of bulb being that having two grids and two plates.

"Plaintiff's Exhibit No. 75" calls for five generating sets complete, of the audion type, and for the spare bulbs for the same. These bulbs were specified as of 20-watt capacity. These sets and bulbs were delivered at the Washington Navy Yard. I inspected them and passed them, and later used at least one of them in 1915 and thereafter, for official work at the Washington Yard. Other sets and bulbs under this contract were shipped from the Washington Yard by order of the Bureau to other Navy Yards. I recall, especially, one that was shipped to Mare Island Navy Yard, and I saw that in use later at that point.

"Plaintiff's Exhibit No. 76" calls for Hudson filament 6-volt bulbs with double grid and plate. These were delivered at the Washington Navy Yard in the latter part of 1916, and were inspected and passed by me. They were subsequently issued to the Service for use in receivers on ships and at shore stations.

Referring back to "Plaintiff's Exhibit No. 74", I recall that these devices were delivered in June or July of 1914, probably the latter. I recall this because my first recommendation for purchase of these devices was made in May, 1914, and I recollect that we got them in about two months.

Referring to "Plaintiff's Exhibit No. 75" again, the delivery of this apparatus was either in the latter part of 1914, or very early in 1915. I recall, and have records of, using this apparatus very early in 1915, thereby fixing the date as at least prior to that time.

Q. 147. Do you know what is meant by "double bulbs" or bulbs with "Hudson filaments", mentioned in some of these contracts?

A. The term "double bulb" was sometimes used to express an audion with two filaments, and sometimes to mean an audion with two plates and two grids. The term was loosely used. The expression "Hudson filament" refers to [fol. 1598] a modified type of filament brought out by an inventor named Hudson, and used in some of the audions supplied to the Navy by the Radio Telephone and Telegraph Company.

Q. 148. I show you a bulb forming part of "Plaintiff's Exhibit No. 82"; if you recognize it, will you please state what it is, and how it compares with any tubes delivered to, and used by the Navy, subsequent to June, 1940, and prior to the time when you left the Navy?

A. I recognize this bulb as one of the audions of the type purchased and used by the Navy in 1914. It is the double filament type with a single grid and plate on one side of the filament.

Q. 149. Will you please answer the same question with respect to the bulb now handed to you?

A. I recognize this as an audion of the type purchased by the Navy in 1914, and used in the Service that same year and thereafter. It is of the double plate and grid type, and was designed for a filament-voltage of twelve volts.

Mr. Cosgrove: I offer in evidence the bulb last referred to by the witness and the same is marked "Claimant's Exhibit No. 329", Type of Navy Audion Bulb."

(Said exhibit so marked.)

Q. 150. I also show you two more bulbs and ask you to answer Q. 149 with respect to these bulbs.

A. The first that I pick up I recognize as a type of vacuum tube which was purchased by the Navy and of which I have personal knowledge of the use of, about the year 1916. This tube is type CG-886, the letters showing that it was made by the General Electric Company.

I similarly identify the second tube, marked CG-1162, as a type of tube made by the General Electric Company for the U. S. Navy, and which I have personal knowledge of use of by the Navy aroand the years 1916 or 1917. The specifications and official inspection for vacuum tubes being specially under my charge at that time. The delivery of the first tubes of these two types were about the same dates as those I have given for use thereof, viz., 1916, and 1916 or 1917, respectively.

Mr. Cosgrove: I offer in evidence the tubes last identified by the witness as "Claimant's Exhibits 330-A and 330-B, G. E. Navy Tubes".

(Said exhibits so marked.)

Q. 151. Please examine "Plaintiff's Exhibit No. 82, De-Forest P N Audion used by the Navy", and state what, if any, relation it bears to audion control boxes and audion detectors, referred to in paragraph 11 of your answer to Q. 2 found on P. R., page 235 herein.

A. The exhibit is identical with the type which I described in section 11 of my answer to Q. 2, where I referred to such devices under the type "P N". The modified design of audion control boxes which I testified were made up by me later, were of the same general nature and circuit as "Plaintiff's Exhibit No. 82".

Q. 152. What was done by the Navy with these control boxes, after they were obtained in May, 1914, as stated by you in paragraph 11 of your answer to Q. 2 of your previous deposition?

A. The P N detectors obtained in May, 1914, were used by the Navy in Service on ships and shore stations. I

recall, and have record of, taking one of these P N detectors [fol. 1599] from the Washington Navy Yard, where it had been in service use, to the high power station at Tuckerton, in September or October, 1914. This station had just been taken over by the United States Navy and when I arrived there and used the detector to copy signals officially, the station was in charge of a Naval Officer of the United States Navy.

Q. 153. Referring to "Plaintiff's Exhibit No. 74", and the ultra-audion receivers mentioned in your answer to Q. 146, will you please state what, if any, relation those ultra-audion receivers had to the audion receivers referred to in paragraph 6 of your answer to Q. 2, found on P. R., page 232, of your previous deposition, the circuit of which you stated was illustrated in "Plaintiff's Exhibit No. 109"?

A. The ultra-audion receivers contained under item 3 of the requisition forming "Plaintiff's Exhibit No. 74", are identical with those referred to in my answer referred to in the question. It is a fact that the detector and receiver in item 3 were specified to be in separate cabinets and, at first sight, it might appear that these receivers did not coincide with the type mentioned in my answer above referred to, in which "the vacuum tubes are located in the receiver itself". However, examination of item 3 shows that the receiving cabinets were specifically designed for use with, and to include, the ultra-audion detector, and hence, in use, the receiver and detector were wired up together, side by side, and remained in this way. They thus fulfilled all requirements for inclusion in the type of receiver I mentioned in paragraph 6 of my previously quoted answer. "Plaintiff's Exhibit No. 109" correctly represents a receiving cabinet wired up to its associated ultra-audion detector, as called for in item 3 of "Plaintiff's Exhibit No. 74".

Q. 154. Referring to "Plaintiff's Exhibits Nos. 72 and 73", and the amplifiers mentioned in your answer to Q. 146, will you state when those amplifiers were delivered to the Navy Department and what, if any, relation they bear to the audion-amplifiers referred to by you in paragraph 12 of your answer to Q. 2, found on P. R., pages 235 and 236 of your former deposition, and illustrated in "Plaintiff's Exhibit No. 85"?

A. The amplifiers referred to were delivered at the New York Navy Yard, and I have no personal knowledge or data at hand to state just when they were delivered. I can

say that they were delivered between January, 1914, when I saw them in process of manufacture, and May, 1914, when I used these devices after they had been forwarded from the New York Yard to the Washington Yard. I recall these amplifiers very clearly, because they were the first purchased by the Navy. They consisted of three stages, the box being narrow and tall, and I have clear recollection of, and considerable data concerning, the interior circuits of these devices.

Referring to the last part of your question, these amplifiers I have just referred to, are identical with those mentioned by me in my answer referred to in the question. "Plaintiff's Exhibit No. 85" shows correctly the wiring of these first amplifiers which I tested at the Washington Yard.

Q. 155. Referring to the vacuum tube transmitters illustrated in your drawing "Plaintiff's Exhibit No. 116", and mentioned in paragraph 14 of your answer to Q. 2, found at pages 236-238 of the Printed Record of your previous deposition, will you state, if you know, whether any of such transmitters were actually used by the Navy, and if so, when, where and how?

A. The Navy purchased and used a large number of sets [fol. 1600] of the type referred to in your question, which were manufactured by the Western Electric Company, and were known as CW 936. The wiring diagram for these is identical with that shown in "Plaintiff's Exhibit No. 116" under the title "Western Electric". These sets were purchased and installed by the Navy about 1917, in large quantities, and were particularly used on sub-chasers. I operated a great many of these transmitters and their associated receivers myself, as installed on such boats.

Q. 156. Referring to the three-stage audion amplifiers, which you have testified to in your present deposition, can you mention any station where you used, or saw used, such amplifiers, and about the time when you used them, or saw them used?

A. I used this type of amplifier myself at the Washington Navy Yard and at the Bureau of Standards, both in 1914.

Q. 157. Referring to paragraph 5 of your answer to Q. 2 of your former deposition, found on P. R., page 232, do you wish to explain any part of that answer? If so, please do so.

A. My answer incorrectly limited such receivers to those arranged for use with the oscillating audion, as well as with

other detectors, and therefore left out of the picture a large number of receivers purchased by the Navy prior to May, 1914, when the oscillating audion first came into notice, and subsequent to June, 1910.

To make my answer complete, the following should be added at the end of paragraph 5 of my answer to Q. 2, of my deposition on R., p. 211:

* In addition to the foregoing, the Navy purchased between the dates of June, 1910, and May, 1914, a number of receivers which fall under the classification of paragraph 5 of my answer to Q. 2, but which were designed for use with detectors of the type common in the Navy prior to the oscillating audion. These detectors, for example, were of the crystal type, the electrolytic detector, the magnetic detector, and the tickler. These receivers differed from those described above only in that no feed-back coil was employed.

* The schematic drawing which I showed in "Plaintiff's Exhibit No. 113" is correct for the type of receiver that I am describing, providing that in this exhibit the coil marked j', the wires leading from it to the two binding posts respectively shown above and below the word "tickler", these binding posts, and the word "tickler" itself, are removed.

* Referring back to my answer to Q. 2, on P. R., page 232 of my previous deposition, paragraph 5 should be amended by changing the words "purchased by or made by" to "purchased by and made by". It should further be modified by changing the word "being" to "beginning", and also the words "bought by or manufactured by" to "bought by and manufactured by", both of these changes occurring in the second last line of paragraph 5. The date "1915" in the last line of paragraph 5, should read "1914".

Coming back to the additions and changes which I have just made to my previous paragraph 5, these additions and changes beginning on typewritten page 1577 of my present deposition, the receivers referred to were used by the Navy in service. I have personal knowledge of their use in 1910 [fol. 1601] and subsequent years, by having used them myself in many ships and shore stations of the Navy, and in having witnessed their use by operators in these locations.

The receivers which I described in my answer to Q. 2,

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* These are additions and changes to paragraph 5 of my answer to Q. 2, Record, page 211.

paragraph 5, as amended by my answer to this present question, were likewise used by the Navy officially in their various stations ashore and afloat. This I know, because I used them myself between the dates of July, 1914 and my leaving the Navy in June, 1919, and likewise saw them being used by Naval operators in regular work.

Q. 158. Referring to paragraph 7 of your answer to Q. 2 of your former deposition, found on page 233 of the Printed Record herein, what was done with the receivers mentioned therein after they were purchased or made by the Navy, from about the middle of 1915, until you left the Navy in 1919?

A. This type of receiver was similarly used by the Navy in Naval service. I have operated a number of them during inspection and test, and have witnessed the operation of many others by Naval operators in the course of their duties, during the period above referred to.

Q. 158-a. What part of 1910 were the synchronous rotary-gaps referred to in paragraph 1 of your answer to question 2, found on Printed Record page 231 of your former deposition, purchased from the National Electric Signaling Company and when were any of them delivered to and installed and used by the United States Navy?

A. I do not know the date of contract of any of these sets, but I do know that some were installed later than the year 1910. Specifically, the 100 kilo-watt rotary-gap transmitter at the Arlington Radio Station, Radio, Virginia, was installed in 1912, for I helped put in this set myself. In December, 1912, while en route to the Panama Canal Zone on the U. S. S. Arkansas, I made some comparisons of the signals from this 100 kilo-watt spark station at Arlington and a temporary arc installation at the same point. In February, 1913, I was in charge of the acceptance test of the Arlington Station, carried out on the U. S. S. Salem, and after my return the original contract was modified and the station paid for. I operated the station a number of times after acceptance and saw it in operation by the enlisted personnel many times thereafter.

I also know that a number of synchronous gap sets were obtained from this same company by the Navy, for use on torpedo boat destroyers and the like, and the installations of these were subsequent to 1910. I have tested these sets on several ships, and I have a record of one of these sets having been installed on the U. S. S. McCall in the New

York Navy Yard on December 1911, this set remaining in use until January, 1916.

Referring again to the Arlington Station, during the acceptance tests in February, 1913, both arc and spark signals were copied, but the former were for technical information only. The whole purpose of the voyage was to see if the 100 kilo-watt rotary-gap installation at Arlington was satisfactory and met the terms of the contract.

I do not know the exact date of delivery of the rotary-gap set at Arlington, but I do know that it arrived there in first-hand condition and that it had not been used before.

Q. 159. Can you state approximately when the radio apparatus of the Arlington station, including the rotary spark gap installed there, was paid for?

A. Not for a considerable time after the acceptance test [fol. 1602] in February, 1913. There were many changes in the list of apparatus to be submitted, and I recall that it was probably not until the end of 1913 that payments were made.

Q. 160. What relation has the synchronous rotary-gap set which you helped to install at Arlington with the one illustrated and described by Captain Bullard's article on pages 421-431 of "Plaintiff's Exhibit No. 81"?

A. It is the same set that I helped to install in 1912 at Arlington and that I operated after its acceptance.

Q. 161. Where and when were the open-gap and non-synchronous rotary sets, referred to in paragraph 1 of your answer to Q. 2 of your previous deposition, found on P. R., page 231, used?

A. They were used for service communication between the various installations of the Navy, between the years 1911 and the time when I left the Naval service in the middle of 1919. I have used this type of set myself at times during the above period and have often seen these sets operated by the enlisted men.

Q. 162. Does your drawing, "Plaintiff's Exhibit No. 112, Typical Rotary-Gap Set", represent the circuit arrangement of both the synchronous and non-synchronous spark-gaps, concerning which you have testified in this case?

A. Yes, it correctly represents the circuit arrangements for both types of gap. However, the drawing as shown signifies a non-synchronous gap, in that no physical connection is shown schematically between the gap and the

alternator. To represent correctly in schematic form a synchronous gap installation, a dotted line should be drawn between the center of the circle marked G, and the center of the inner circle of the two concentric circles marked A.

Q. 163. You have stated in paragraph 2 of your answer to Q. 2, found on page 231 of the Printed Record herein, that quenched-gap sets manufactured for the Navy came into use around 1911. In your second deposition, found on page 1493 of the Printed Record herein, you state that about 1910 the open-gap began to be replaced by the quenched-gap. Commander Loftin in his deposition states (P. R., pp. 1112 and 1137) that the quenched-gap transmitter was not available in May, 1910, and that it became an assured success about 1911, was at once adopted by the Navy, and that many sets of the Telefunken type as illustrated in "Plaintiff's Exhigit 79", were purchased. Will you state, if you can, somewhat more definitely when, and from whom, the United States Navy obtained its first quenched-gap radio transmitting set?

A. The Navy obtained its first quenched-gap sets from the Telefunken Company, the date being September, 1910.

Q. 164. Had the United States Navy obtained, or been in possession of, or had it used any quenched-gap transmitting apparatus, prior to July, 1910?

A. No.

Q. 165. How do you know that the first quenched-gap wireless transmitting apparatus was obtained by the United States Navy from the Telefunken Company in September, 1910?

A. The introduction of this type of gap was quite novel and when the circuit drawings of the first sets installed in the Navy reached Washington I studied them very carefully. I recall that the data that I thus obtained was used by me in July, 1911, in tuning up a similar set in the Navy and later in installating several. The exact date of September, 1910, I establish by records which I have looked up.

Q. 166. What are these records you referred to in your last answer?

A. The records I referred to were of two general classes. [fol. 1603] First, were the annual reports made out on a regular form in a printed booklet by every Navy ship and shore station, telling the list of all radio apparatus at the station, with full data as to size, kilo-watts, voltage, etc., maker's name, requisition and contract, and date of in-

stallation of the whole set or of parts thereof. This form was gotten up by the Bureau of Steam Engineering and contained some 30 pages. The form for shore stations was known as "Form MSE 25-A" and for ships "NSE 25-B". These record books were sent to the Bureau and were kept on file for a number of years, when they were supposed to be packed up and either sent away or destroyed. These records were accessible to me and I constantly used them in carrying on my work with the Navy. It was to some of these records that I referred in my answer to the last question, since I examined some of these record books in January and February of this present year, 1928, and found therein data referring to these first two Telefunken installations of quenched-gap transmitters.

The second source of information that I referred to consisted of the regular files of letters, contracts and the like, covering Navy purchase, acceptances, installation, assignment of apparatus, and the like. These records are filed in various file rooms of the Bureau of Supplies and Accounts, the Bureau of Engineering, the various Navy Yards, and other places. I was familiar with these files, particularly with those in the Bureau of Steam Engineering (as the Bureau was known originally until change of the name to "Bureau of Engineering"), during my duties with the Navy Department, and examined many of them in January and February, 1928.

Included in these latter records I may add the files of Navy drawings and specifications available at the Bureau, and also a complete card record showing the assignment of every set purchased under every contract through specific ships, and their transfer from this ship to another if this were done. This also includes, of course, a record of assignment to shore stations as well.

Q. 167. How voluminous were the Ship and Shore Books referred to in your last answer, and how complete did you find them in your recent examination?

A. The current file for these record books would include several thousand. Many thousand other records of this kind, which are out of date, have been destroyed or filed away in some forgotten place. As a matter of fact, many of these books which I examined last January and February had been packed up to be sent away to storage and I happened to gain access to them just before they were sent away. The letter files take up a huge room but are not

destroyed in the same way as the record books. This is true for the Bureau files, but is not true for Navy Yard records. I found in a number of cases that payments had been made for radio apparatus through the New York Yard and that the records of payment had been filed in that Yard, but I was told by the Bureau authorities that these records at the New York Yard could not be obtained because they had been destroyed.

Q. 168. From your knowledge of the procedure in the Bureau of Engineering, could anyone seeking information from these records you have referred to, between 1916 and the time you left the Navy, have obtained information therefrom?

A. I do not think such information could have been obtained. The entire time of the personnel was taken up with work connected with the war, and I know that it was decided [fol. 1604] that no outside interference of this sort would be permitted, as it would seriously interfere with work in getting equipment ready for ships and shore stations.

Q. 169. Specifically, what records or data did you find in your recent examination of the Bureau of Engineering's records with respect to the first Telefunken quenched-gap sets obtained by the Navy in September, 1910?

A. I found the NSE 25-B report of the U. S. S. Reid for 1915, in which it was stated that the transmitter was a 2-k. w. Telefunken, obtained on Requisition 91 of 9-23-10, and that the transmitter was installed at the Norfolk Navy Yard on September 23, 1910. The receiver was also a Telefunken type KOHF, appt. No. 1237.

I also saw the NSE 25-B report of the U. S. Flusser for 1914. This stated that she had a Telefunken transmitter, which was installed in Norfolk in September, 1910. The receiver was a Telefunken Type GAH No. 1122. The report of this same ship, dated January, 1916, stated that the transmitter was a 2-k. w. Telefunken type, installed by representatives of the Telefunken Company and the ship's force at the Navy Yard, Norfolk, in September, 1910. The receiver is listed as above.

These two ships, the U. S. S. Flusser and the U. S. S. Reid, are the two that I recall very clearly as the two that had the first Telefunken apparatus installed in the U. S. Navy.

Q. 170. In your answer to Q. 165 you state that you used certain data in tuning up a similar set in the Navy and later in installing several. Will you please explain this statement a little more fully?

A. In July, 1911, I went to the Navy Yard in Portsmouth, New Hampshire, to adjust the 2 kilo-watt Telefunken quenched-gap transmitter, which had just been installed at that station. A little later, in August, 1911, I was instructed to install a Telefunken quenched-gap transmitter, which had just been purchased by the Navy on the U. S. S. Eagle, at the Portsmouth Navy Yard, and this I did. I operated the transmitter and receiver and then turned the set over to the ship's force, who operated it for some time under my supervision.

Q. 171. Has your recollection of the installation of the Telefunken quenched-gap set on the Eagle been confirmed in any way, and if so, in what way?

A. I have looked up my daily log records for that period and find numerous references to putting on this quenched-gap set on the Eagle in August, 1911.

The card records, which I examined at the Bureau of Engineering in January and February, 1928, showed that a Telefunken quenched-gap transmitter, purchased under Requisition 82, Contract 144, was installed on the U. S. S. Eagle. In the Bureau files I found a letter dated August 10, 1911, No. 45712-195-6 from the Bureau of Engineering to the Commandant, Portsmouth, New Hampshire. Re disposition of material obtained on NSA requisition 82 of August 7, 1911. The letter states that Item No. 2 of this requisition is intended for the U. S. S. Eagle, and requests installation on board the U. S. S. Eagle upon delivery from the Telefunken Company O. K.

Q. 172. I call your attention to "Plaintiff's Exhibit No. 46", part of which consists of a contract No. 144, dated September 20, 1911, between the Telefunken Company and the United States Navy, Requisition 82. What relation has this contract to that referred to in your last answer and to the apparatus you installed on the Eagle?

A. This part of "Plaintiff's Exhibit 46" is the contract [fol. 1605] which was based on Requisition 82 NSA, which I have just referred to in my answer to Q. 171. The contract specifies that Item 2 is one 1-k.-w. Wireless telegraph set. Under the heading "Delivery" it is stated that Item 2 is to be delivered to the General Store-keeper, Navy Yard,

Portsmouth, New Hampshire. It is to be noted that the requisition is dated August 7, 1911, installation was made toward the latter part of August, 1911, and the contract was not signed until September 20, 1911.

Q. 173. How do you explain the installation being made before the signing of the contract?

A. This was on account of some emergency, and during the time that I was with the Navy, such action was not uncommon. Drawing up of the requisition gave the Bureau authority to order shipment in advance of actual signing of contract.

Q. 174. I notice that "Plaintiff's Exhibit No. 46, Telefunken Contract 144", has attached to it a letter of the Telefunken of August 22, 1912, and a bid of the Telefunken Company of August 23, 1912, based on "Requisition No. 69". What connection has that bid and letter with the contract?

A. None. There is evidently a mistake in the assembly of "Plaintiff's Exhibit 46".

Q. 175. Please state, if you know, what, if any, connection there is between the bid of August 23, 1912 based on Requisition No. 69, and the Telefunken Company's letter of August 22, 1912, with a contract of September 4, 1912, between the Telefunken Company and the United States, based on Requisition No. 96, a certified copy of which contract I hand you—that is, if you know, will you explain the connection or relation between these documents?

A. To make this clear, I wish to tabulate "Plaintiff's Exhibit 46" in its three separate items:

(1) Contract 144, Requisition 82.

(2) Telefunken letter of August 22, 1912, explaining a bid.

(3) Bid of Telefunken Company on Requisition 69 dated August 23, 1912.

The sequence of operation as to these items and others to follow is this: The Bureau first drew up a requisition No. 69, for 2 5-KW quenched-gap transmitting sets. This was bid on by two companies, the Telefunken Company, and the Wireless Specialty Apparatus Company. The bid of the Telefunken Company is Item 3 above, and their letter of August 22, 1912 (Item 2 above) explained their bid.

The contract on Requisition No. 69 was awarded to the

Wireless Specialty Apparatus Company, the Contract being No. 133 of 1912.

Some short time thereafter it became necessary to make a quick installation on the U. S. S. Arkansas, which ship was due to get a Lowenstein set, but it was found that this set would not be ready on time. A new and up-to-date set had to be installed, because the President of the United States was due to sail on that ship within a short time for the Canal Zone.

In this emergency, the Bureau barked back to the previous bid of the Telefunken Company, Item 3 above, for it recalled that the Telefunken Company had stated that this apparatus was ready for delivery. Therefore a new requisition was drawn on Requisition No. 96, to obtain this set for the Arkansas, and at the same time its companion set for aaother ship. The contract awarded to the Telefunken Company waiving competition, for the two 5 KW quenched-gap sets on this new Requisition 96, was numbered 123, dated September 4, 1912, and it is a copy of this contract which you have just handed me.

[fol. 1606] The sets were delivered on Requisition 96, Contract 123, to the U. S. S. Arkansas and the U. S. S. Louisiana. I am fully conversant with the drawing up of these various contracts as I was in touch with this work at the Bureau. I also operated the set that was installed on the U. S. S. Arkansas under this requisition, and saw it being operated by the ship's radio force as well. I also later saw the set on the Louisiana.

I am especially conversant with the details of the installation on the Arkansas and with the type of apparatus delivered, because I was assigned by the Bureau to sail as Radio Expert Aid on that vessel when then President Taft was taken to the Canal Zone on her. It was during this period of time that I operated the set as explained above, and it was also during this cruise that I made tests with the rotary spark transmitter which had just been installed at the Naval Radio Station at Arlington, concerning which I testified in my answer to Question 158.

Q. 176. About when was the installation of the Telefunken set made on the Arkansas, and when did you sail on that vessel?

A. I sailed on the Arkansas on December 19, 1912. From records which I used in connection with the Hill-Clark-Lowenstein suit, with permission of the Navy Department, I find

a statement that the Telefunken 5 KW quenched-gap transmitter was installed on the Arkansas on September 30, 1912.

Q. 177. In referring to the Telefunken set installed on the Arkansas, did the installation or set include any receivers, and if so, what type of receivers?

A. The two receivers on the Arkansas, when I made the trip above referred to, were supplied by the Telefunken Company along with the 5 KW quenched-gap transmitter. One of these was the upright form, Type E-5, and one of these was the horizontal form, Type E-4. I operated both of these sets during the trip and am thoroughly conversant with them. The same receivers were supplied on the Louisiana.

Q. 178. In your answer to Q. 65 of your former deposition, found on page 1503 of the Printed Record, it appears that you sailed on the Arkansas in Christmas week of 1913. How do you explain this in view of your above answer to Q. 176?

A. The date 1913 is a typographical error, as I meant to have the date coincide with the preceding one of 1912, in my answer to Q. 65.

Q. 179. Has your recollection with respect to the installations of the Telefunken sets, referred to in your last few answers, on the Arkansas and Louisiana, been confirmed in any way, and if so, in what way?

A. The Bureau card records which I examined last January and February, show that the two sets delivered under Requisition 96, Contract 123, were installed on the U. S. S. Arkansas and the U. S. S. Louisiana, respectively. A letter in the Bureau files, dated January 9, 1913, No. 88002-121-6, from the Commanding Officer of the U. S. S. Arkansas, to the Bureau of Engineering, states that the apparatus is a 5 KW-500 cycle Telefunken quenched system, Contract 123, Requisition 96.

I also found, in the Bureau files, a letter dated October 12, 1914, No. 135300-268-6, from the Commanding Officer of the U. S. S. Louisiana to the Bureau of Engineering, stating that two Telefunken receivers are installed in the radio station of the ship.

[fol. 1607] Q. 180. What was the construction and operation of the Telefunken transmitter installed and operated on the U. S. S. Eagle and the construction and operation of the Telefunken transmitter and receivers you operated on the U. S. S. Arkansas, and how did they compare with

the Telefunken transmitters and E-4 and E-5 receivers, described by Mr. Graham, whose testimony you referred to on page 271 of the Printed Record herein, and which are illustrated in Mr. Graham's drawing, "Plaintiff's Exhibit No. 79"?

A. The transmitters on the U. S. S. Eagle and the U. S. S. Arkansas were both of the quenched-gap, two-tuned circuit type and were identical with the set described by Mr. Graham, as far as circuit and operation are concerned. "Plaintiff's Exhibit No. 79" correctly shows these two sets schematically, as far as the left hand drawing of "Plaintiff's Exhibit No. 79" is concerned.

The receivers which I used on the Arkansas were of the two-tuned circuit inductively-coupled type using crystal detectors, and were identical with those described by Mr. Graham. Both of these receivers are correctly represented schematically by the right hand drawing of "Plaintiff's Exhibit No. 79."

Mr. Cosgrove: I offer in evidence the Telefunken Contract of September 4, 1912, No. 123, Requisition No. 96, referred to by the witness, and the same is marked "Claimant's Exhibit No. 331, Telefunken Navy Contract of September 4, 1912."

(The Notary so marks said exhibit.)

Q. 181. In paragraph 2 of your answer to Q. 21 found on Printed Record, page 231 of your previous testimony, you referred to the quenched-gap transmitter described in the testimony of plaintiff's witnesses, Messrs. Graham, Langley and Weagant, and stated that in some cases you had seen the identical apparatus those witnesses referred to. Did you see the Telefunken transmitter described by Mr. Graham, illustrated in his drawing "Plaintiff's Exhibit No. 79", and which he testified he installed at the U. S. Naval Station in San Juan, Porto Rico, in 1914? If so, will you please explain the circumstances under which you saw it and where and when you saw it?

A. I saw this Telefunken quenched-gap transmitter in the New York Navy Yard several times prior to its shipment to San Juan. I think that the last time I saw it was early in 1914, and I know I saw it in 1913. I was going through the storeroom in the New York Yard on both these occasions checking up on the apparatus in store. From my

connection with the work at the Bureau I knew at the time and I now recall that this set had originally been purchased for use at Beaufort, N. C., but that the assignment had been changed for San Juan. I was much impressed by the fact that this set lay so long in the New York Yard before installation, knowing that all other sets were installed as quickly as they came, but I knew, however, that this particular set was being held, pending a decision as to dismantling or retaining the San Juan Naval base. I know that a working party was sent from the New York Yard to superintend the installation of this set in San Juan.

Q. 182. In your recent examination of the records of the Navy Department, did you find any reference to this Telefunken quenched-gap transmitter referred to in your last [fol. 1608] answer; if so, what did you find?

A. I found Report Book NSE 25-A for San Juan, January, 1914, which stated that a composite type of transmitter was installed at the station, and then I found in a NSE 25-A report for the same station, dated January 1, 1915, that a 5 KW Telefunken transmitter was then in the station. This establishes the installation date as some time between January 1, 1914, and January 1, 1915.

In the Bureau files I found a letter dated March 9, 1914, No. 119475-835-W from the Bureau of Engineering to the Bureau of Supplies and Accounts, requesting shipment from the Navy Yard, New York, to San Juan, of one Telefunken set with receiver, purchased under Contract 458 of 1911.

Also letter dated June 12, 1913, No. 99448-835 from Machinery Division, New York Yard, to Commandant. General Storekeeper reports 5 KW Telefunken set on Requisition 261, Contract 458, 1911, is in store reserved for Radio Station, San Juan.

Q. 183. Please look at the certified copy of the contract dated April 24, 1911, between the Telefunken Company and the United States, calling for certain wireless apparatus, and state, if you know, what, if any, relation there is between the apparatus called for in this contract and the Telefunken apparatus referred to in your last few answers, which was installed, or intended for installation at San Juan.

A. The document which you hand me is a copy of Contract 458 of 1911, Requisition NSE Bureau 261, the date of contract being April 24, 1911, for radio apparatus to be supplied to the Navy Department by the Telefunken Company. This requisition and contract number coincides with

that just given for the quenched-gap apparatus finally installed at San Juan.

Item 1 of this contract calls for one 5 KW wireless telegraph set and Item 2 calls for one generator and transformer for the same. The contract also contains the statement that these Items 1 and 2 are intended for the wireless telegraph station at Beaufort, N. C.

This completely identifies this contract as that calling for the Telefunken quenched-gap apparatus which, as I have previously testified, was originally purchased for Beaufort and finally installed at San Juan.

Q. 184. What was the condition of the Telefunken quenched-gap transmitter which you saw in the New York Navy Yard and which you say was intended for the San Juan station, the last time you saw it?

A. It bore no marks or other indications of ever having been used. I considered it as absolutely new.

Mr. Cosgrove: I offer in evidence the contract referred to by the witness in his answer to Q. 183, and the same is marked "Claimant's Exhibit No. 332, Telefunken Navy Contract of April 24, 1911."

(The Notary so marks said exhibit.)

[fol. 1609] Q. 185. Referring again to paragraph 2 of your answer to Q. 2 of your former deposition, found on page 231 of the Printed Record herein, you state:

"The Wireless Specialty Apparatus quenched-gap transmitter is correctly shown in schematic diagram in Plaintiff's Exhibit 87, and the description of the parts and the method of adjustment and operation by Langley, whose deposition I have read, is correct."

Will you please state, if you know, when the first Wireless Specialty Apparatus quenched-gap transmitter such as described by Mr. Langley in "Plaintiff's Exhibit No. 87" was purchased by, and delivered to the United States and used by it, and how you became familiar with such transmitter?

A. I know that the first quenched-gap sets made by the Wireless Specialty Company were the two which they made under Requisition 69, Contract 133, awarded to them about September, 1912. I saw the sets being manufactured at their factory in Boston, some time in the early part of 1913, and during October and November, 1913, I had a

great deal to do with the remodeling of these transmitters while they were on acceptance tests at the New York Navy Yard. I remember especially my inspection of the sets at Boston, because at that time I was impressed by the amount of white porcelain insulators used in the sets, other types of insulation having broken down. During the tests at the New York Yard I made frequent reports to the officer in charge of Radio in the Bureau of Engineering, Washington, concerning the changes made in these sets while on acceptance test.

I saw one of these sets on the U. S. S. Idaho some time later, probably two years later. This was at a time when I was inspecting a large number of ships, and I remember this particular installation because of the fact that the transmitter was much larger than any other one of similar rating and took up almost all the available space in the Idaho's Radio Room. I operated this set during this inspection, and I saw it being used for regular Naval work.

These two Wireless Specialty Apparatus quenched-gap sets which I have just described, are the same as those described by Langley and illustrated schematically by "Plaintiff's Exhibit No. 87".

Q. 186. In your recent examination of the records of the Bureau of Engineering, did you find any record relating to the installation at any Naval Radio station of the Wireless Specialty Apparatus referred to in the last question and answer; if so, what records did you find?

A. The Bureau of Card Records show that one 5-kilo Wireless Specialty quenched-gap transmitter purchased on Requisition 69, Contract 133, was installed on the U. S. S. Maryland, the name of which ship was later changed to the U. S. S. Frederick, and that the second set under the same requisition and contract was installed on the U. S. S. Idaho.

[fol. 1610] The Bureau files also contained the following information:

A telegram dated January 27, 1914, No. 116,100,280-6-W from Bureau of Engineering to Navy Yard, New York, asking when 5-k. w. Wireless Specialty set under Contract 133 will be ready for shipment and stating that same is needed for U. S. S. Maryland.

A letter dated January 28, 1914, No. 116,100-280-6-W from Bureau of Engineering to Bureau of Supplies and Account, requesting shipment of one 5-k. w. Wireless Specialty

set purchased under Contract 133, N. P. O., N. Y.,' from New York Yard to Mare Island Yard, for U. S. S. Maryland.

A letter dated February 2, 1914, No. 116,100-280-6-W from Bureau of Engineering to Commandant Mare Island Yard. Shipment has been made from Navy Yard, New York to Mare Island Yard of one 5-kilo-watt set from Wireless Specialty Company, Contract 133. This due Mare Island February 23, 1914.

A letter dated January 6, 1915, No. 143-768-280-6-W from Bureau of Engineering to Commanding Office of U. S. S. Maryland, stating that the Bureau records indicate that there are now on the Maryland one IP76-1914, and one IP76-1912, both supplied with 5-k. w. sets purchased on Contract 133. The fourth endorsement to this letter by the commanding officer states that IP76-1914, No. 116, and IP76-1912, No. 362, are on that vessel.

A letter dated January 28, 1914, No. 116,203-237-6-W, from Bureau of Engineering to Commandant Philadelphia Navy Yard, stating that the Bureau has requested shipment from New York Yard to Philadelphia Yard for the U. S. S. Idaho, one 5-k. w. radio set purchased from Wireless Specialty Company under Contract 133.

A telegram dated July 17, 1914, No. 130,145-237-6, from Commandant Philadelphia Yard to Bureau of Engineering. The installation of the 5-k. w. Wireless Specialty Apparatus Company set was completed on the U. S. S. Idaho on April 25, 1914.

Referring to references in the above letters to receivers IP76-1912 or IP76-1914, the data following this designation, in the form of the abbreviation "No." followed by a number, refers to the serial number stamped on the particular receiver referred to.

Letter dated July 20, 1914, No. 131,555-280-6, from the U. S. S. Maryland to the Superintendent Naval Radio Service, Washington. Report of heating of quenched-gaps on Wireless Specialty Company set.

The statement in the letter immediately preceding, indicates that the 5-k. w. Wireless Specialty Company set whose shipment to the U. S. S. Maryland was requested in the letter dated January 28, 1914, above quoted, had been installed prior to date of July 20, 1914.

I have examined ships radio inventory NSE 25-B for the U. S. S. Frederick, formerly the U. S. S. Maryland, stating the apparatus on board January, 1918. This in-

cludes a Wireless Specialty Company transmitter obtained on Contract 133, Requisition 69, N. P. O. 1913, a receiver type IP76, serial number 436, and a receiver type IP76, serial number 362.

Q. 187. I show you "Plaintiff's Exhibit No. 60". Will you state what relation that exhibit has with reference to the testimony you have given in regard to the Wireless Specialty Apparatus transmitters and receivers?

A. This is Contract 133 made by the United States Navy [fol. 1611] under Requisition 69 with the Wireless Specialty Apparatus Company on September 21, 1912, for the purchase of two 5-k. w. quenched-gap transmitters, each transmitter to have three IP76 receivers. This is the contract to which I have referred in my answer to the preceding question, and under which the sets were obtained concerning which I have just testified in my answer to the preceding question.

Q. 188. Will you please state to what extent the United States Navy purchased and used Wireless Specialty Apparatus Company IP76 receivers during the period from June, 1910, to June, 1919, specifying, if you can, the various kinds, types or models of such receivers which were purchased and used during that period?

A. During the period above-mentioned, a very large number of receivers of the general type known as IP76, were purchased by the United States Navy from the Wireless Specialty Apparatus Company, and installed and used by the former in ship and shore stations for regular service communication. More of these receivers were obtained during the above period, than of any other one type.

All receivers of the IP76 class were of the two-tuned circuits form. From time — time physical changes were made, and as the crystal detector art progressed, different crystal detectors were furnished with the receiver, and these minor changes, which did not affect the class of receiver as a whole, led to the use of the designations "IP76-1912", meaning that modification of the IP76 receiver brought out in the year 1912. Similarly, models IP76-1913, IP76-1914, and so on, were brought out.

I have personally used all the foregoing models of IP76 receivers in official work for the Navy Department, and have seen every one of these designs operated by the enlisted personnel in their regular duty. I installed many of these IP76 type receivers myself in various ships and

shore stations during my term of duty with the Navy Department, such as, for example, on the U. S. S. Eagle, in August, 1911, and at the Washington Navy Yard, at which latter point new models were installed for use as they were purchased by the Navy Department.

Q. 189. How did the IP76 receivers, referred to in your last answer, compare in construction and operation with the IP76 receivers described by Mr. Langley and illustrated in "Plaintiff's Exhibit No. 87"?

A. All the IP76 receivers which I have described in my last answer, are correctly illustrated by "Plaintiff's Exhibit 87" and are identical in construction and operation with those described by Mr. Langley.

Q. 190. I call your attention to "Plaintiff's Exhibit No. 62", Contract No. 170, "Plaintiff's Exhibit No. 63", Contract No. 19,882, both entered into in the years 1912 and 1913, with the Wireless Specialty Apparatus Company, calling for certain receivers. If you know, will you state what relation the receivers of these two contracts bear to the IP76 receivers, referred to in your answer to Q. 188?

A. The receivers called for in these two contracts are of the type included among those described in my answer to Q. 188.

Q. 191. In your recent examination of the records of the Bureau of Engineering, did you find any record relating to the purchase and installation of any type IP76 receivers [fol. 1612] called for by "Plaintiff's Exhibits Nos. 62 and 63"?

A. The records show hundreds of installations of IP76 receivers subsequent to June, 1910, and before June, 1919. Ship reports NSE 25-B and shore station reports NSE 25-B, contain a great many references to the possession by the station of IP-76-1912 receivers, for example, which are identical with the IP76-1912 type which was supplied under Contract 19,882. However, none of these records that I have examined, states specifically that such receivers were supplied under either Contract 170 or Contract 19,882, the reason being that name-plate data giving the contract and requisition number was rarely placed on receivers of this type and, hence, the operator making the report had no data available to include in his report.

Q. 192. Did you find any record in your recent examination of the files of the Bureau of Engineering, Navy Depart-

ment, relating to the apparatus called for in "Plaintiff's Exhibit No. 57", Contract No. 14,746, of April 22, 1911, with Fritz Lowenstein; if so, will you please state what such record disclosed in respect to such apparatus?

A. Yes, I did. For example, in the Bureau files I found a letter dated November 26, 1912, No. 83,482-488-6-W, from Bureau of Engineering to F. Lowenstein, New York, regarding Contract 14,746-5 k. w. set for Wyoming. The Bureau notes that one 5-k. w. transmitting set has been delivered at New York, and is ready for test. This set to be installed on the U. S. S. Wyoming if it passes test.

Letter dated January 1, 1914, No. 114,622-132-6-W, from Bureau of Engineering to Commandant, Navy Yard, New York. The 5-k. w. Lowenstein transmitter under Contract 14,746, now on board the U. S. S. Texas, temporarily installed, should be permanently installed for battle radio on that vessel.

Q. 193. Did you see any of the Lowenstein transmitters referred to in the last question and answer, and if so, when where and under what circumstances?

A. Yes, I saw one of the Lowenstein 5-k. w. transmitters of the quenched-gap type made under Contract 14,746, when it was on test at the New York Navy Yard in the latter part of 1912, probably in November or December. I saw this set early in 1913, after it had been installed on the U. S. S. Wyoming after acceptance, and used this set myself, and also saw it operated by the personnel attached to the vessel. This set I especially recall, on account of the fact that it was the first set submitted by Lowenstein which contained a quick wave-changer, a device in which the Bureau was very much interested, and it was for this reason that I inspected the set closely, when it was on test at the New York Yard, and also made very many tests with it on the U. S. S. Wyoming. I also passed on the specifications on which this set was made, and am very familiar with them. I discussed these specifications very many times with Lowenstein when he brought them up before the Bureau as a new form of transmitter, and I later recommended purchase of the set which I have already said was finally installed on the Wyoming.

Q. 194. What was the construction and operation of this Lowenstein transmitter in the arrangement of circuits, which you saw operated on the U. S. S. Wyoming? You

may refer to the contract or any other exhibit in the record with which you are familiar.

A. This transmitter was of the two tuned circuits, quenched-gap type and the circuits are correctly represented by drawing T-8, which forms a part of "Plaintiff's [fol. 1613] Exhibit No. 57". The construction of the transmitter was in accordance with Navy Specifications 16-T 5, as modified by Lowenstein in papers attached to Contract 14,746, forming "Plaintiff's Exhibit 57". The transmitter is correctly shown schematically by "Plaintiff's Exhibit No. 101", entitled "Waterman Sketch, Lowenstein Transmitter".

Q. 195. Mr. Graham, in his testimony herein, in answer to Q. 41, found on pages 54 of the Printed Record herein, which you previously stated you had read, testified that he recognized sheet T-8, forming part of "Plaintiff's Exhibit No. 57", as a Lowenstein transmitter which he saw in the New York Navy Yard in the latter part of 1914; whereas, you state that the Lowenstein transmitter of this contract was installed on the Wyoming in 1912. Have you any explanation of the different dates specified by you and Mr. Graham?

A. I saw the Lowenstein transmitter which Mr. Graham testified he saw in the New York Yard in 1914, and my inspection of it was at that same place, and during that same year. I clearly recall the type of quenched-gap described by Mr. Graham, and made tests of this gap while the set was on test at the New York Yard. This was a later type of set, designed by Lowenstein, and of later date than the set which he made and which was installed on the Wyoming, but schematically, the 1914 set, above referred to, is correctly represented by the diagram T-8, in "Plaintiff's Exhibit No. 57". The two sets referred to were electrically the same, but differed in mechanically construction.

Q. 196. Please examine "Plaintiff's Exhibit No. 55", Navy Contract 415, of June 5, 1913, with the Wireless Improvement Company, Requisition No. 98, calling for certain wireless telegraph apparatus, including one 5-k. w. high frequency quenched-gap transmitter, and state what knowledge you have of the delivery to, and installation and use by the United States Navy, of any of the apparatus called

for by that contract, specifying, if you know, the approximate date of delivery and use of such apparatus.

A. This contract calls for delivery of one 5-k. w. quenched-gap transmitter to the United States Navy Department at the U. S. Naval Radio Station, Radio, Virginia, by the Wireless Improvement Company. The contract is dated June 5, 1913, and delivery is specified within ninety days. The set is to conform to Specification 16-R-1, which same specifications I myself prepared at the Bureau. The station specified for delivery is commonly known as the Arlington Radio Station.

I know that in the latter part of 1913, or early in 1914, this 5-k. w. quenched-gap transmitter made by the Wireless Improvement Company was delivered at the Naval Radio Station, Radio, Va. I assisted in installing this set and calibrated it for wave-length after installation. I operated the set from time to time and saw it handled in the routine operation of Navy message work by the enlisted personnel during 1914 and thereafter, but not since leaving the Navy in June, 1919.

Q. 197. What, in general, was the construction and operation of the Wireless Improvement quenched-gap transmitter referred to in your last answer, and how did that construction and operation compare with the Wireless Improvement transmitter described in Mr. Langley's testimony, illustrated in "Plaintiff's Exhibit No. 88", referred to in paragraph 2, in answer to Q. 2, found on page 231 [fol. 1614] of the Printed Record herein?

A. The transmitter referred to in your question was a quenched-gap type, two-coupled circuits form of transmitter, each of the both circuits being tuned. The construction and operation were the same as described by Mr. Langley, and the schematic diagram corresponds with the circuit drawing shown in "Plaintiff's Exhibit No. 88".

Q. 198. Do you know anything about the delivery to, installation and use by the United States Navy of any of the apparatus called for in "Plaintiff's Exhibit No. 70", Contract No. 24,605, dated September 2nd, 1915, with Emil J. Simon; if so, state what you know.

A. The contract calls for 25 radio sets in accordance with schedule 8121. This schedule forms a part of "Plaintiff's Exhibit No. 70", and specifies the power of the sets to be ½-k. w.

I know that these sets were delivered an passed by the Navy Department and installed in various locations, chiefly on submarines. I operated many of these sets in submarines of the United States Navy, in 1916, and saw the sets being operated by the Naval personnel in regular work. I have no knowledge of the specific date of delivery, but delivery was made between the date of September 2, 1915, when the contract was signed, and some time in 1916, when I operated sets obtained under this contract.

Q. 199. What was the construction and circuit arrangement of the Simon transmitters referred to in your last answer, and how did they compare with the transmitters described by Mr. Langley, referred to in paragraph 2 of your answer to Q. 2 of your previous deposition, found on page 231 of the Printed Record herein, and illustrated in "Plaintiff's Exhibit No. 89"?

A. These transmitters were identical with those described by Mr. Langley. They were of the quenched-gap, two tuned circuits type, and schematically are correctly represented by "Plaintiff's Exhibit No. 89".

Q. 200. Did you find in the files of the Bureau of Engineering of the Navy Department any records of the installation of any of the Simon transmitters referred to in your answers to Qs. 198 and 199; if so, please refer to some of these records.

A. On examination of the Official inventory report of Naval ships, forming NSE 25-B, a number of records of Simon transmitters of the types referred to in my answers to the last two questions, were found. Among these were the following:

Report of radio equipment on board the submarine U. S. S. D-3, dated 1919, shows that the transmitter was a Simon ½-k. w. set installed March, 1916, and obtained on Requisition 233, Contract 24,605, September 2, 1915.

Report of the U. S. S. Barry, for 1917, states that the transmitter was a Simon ½-k. w. set installed February 2, 1917, and obtained on Contract 24,605, Requisition 233 of 1915.

Report of Fire Island Light Vessel No. 68, dated September, 1918, states that the transmitter was a ½-k. w. Simon set obtained on Contract 24,605, Requisition 233, and installed February, 1916.

Many other similar records were found showing the installation of Simon ½-k. w. sets under the above requisition and contract on U. S. submarines and other vessels.

Q. 201. Have you any knowledge relating to the radio sets called for in "Plaintiff's Exhibit No. 69", Contract [fol. 1615] No. 225 of January 31st, 1914, with the Kilbourne & Clark Manufacturing Company? If so, what was such knowledge?

A. This contract called for five 5-k. w. quenched-gap radio sets. I was present at the New York Yard under orders, in October and November, 1913, to test a sample transmitter submitted by the Kilbourne & Clark Company, in order to see whether or not it complied with specifications. My report was that it did not, and that the set was unsatisfactory. I was informed by the Bureau that despite these faults, a contract would be given to that company for five transmitters of 5-k. w. size. From my official work at the Bureau I know that this contract was awarded, and that the contract thus awarded is the one shown in "Plaintiff's Exhibit No. 69". I also know, for the same reason, that the sets were delivered and accepted, and that they were installed and used for actual service. I also know that I saw one or more of these sets in operation some time between the years 1915 and the date that I left the Navy, in June, 1919.

Q. 202. In your recent examination of the records of the Bureau of Engineering of the Navy Department, what, if anything, did you find as to the installation and use by the United States of any of the apparatus called for in "Plaintiff's Exhibit 69"?

A. The Bureau's card records indicated that the five 5-k. w. transmitting sets obtained from Kilbourne & Clark, Contract 225, Requisition 186, were installed on the S. S. Achilles, the S. S. Ulysses, the U. S. S. Saturn, the U. S. S. Denver, and at the Great Lakes Training Station. From the Bureau's files a number of letters were found, which are herein briefly abstracted:

Letter of March 13, 1915, No. 149,220-557-6-W, from Bureau of Engineering, to Industrial Manager, Navy Yard, New York, stating that the Bureau has assigned the second 5-k. w. set purchased from Kilbourne & Clark under Contract 225, to the S. S. Achilles.

Letter dated June 17, 1915, No. 158,390-557-6, from E. A. Drake, Panama Railroad Company, to Chief of Office, Pan-

ama Canal, Washington, stating that he recently visited the S. S. Achilles and the S. S. Ulysses, and recommends that the Kilbourne & Clark sets be removed from those vessels.

By reference to the foregoing two letters, it is clear that the installation on the Achilles of the 5-k. w. quenched-gap Kilbourne & Clark set, obtained on Contract 225, was between the date March 13, 1915, when the Bureau assigned this set to that ship, and the date June 17, 1915, when recommendation was made that this set be removed from that ship.

Continuing with the Bureau records:

Letter of December 19, 1916, No. 209,653-391-6, from Fleet Radio Officer, Pacific Fleet, to Bureau of Engineering. The U. S. S. Saturn was inspected December 19, 1916, and is equipped with a 5-k. w. Kilbourne & Clark set.

Letter dated November 26, 1916, No. 207,162-184-6, from Pacific Fleet Radio Officer to Commander-in-Chief, Pacific Fleet, and forwarded to Bureau of Engineering. Inspection of radio apparatus on U. S. S. Denver. This ship has just been equipped with a new 5-k. w. Kilbourne & Clark radio set.

Letter dated March 15, 1915, No. 148,991-557-6-W, from Bureau of Engineering to C. E. Dole, Purchasing Agent, [fol. 1616] Panama Canal, Washington, stating that the wireless equipment for the S. S. Ulysses and the S. S. Achilles will be supplied by the Navy Yard, New York.

Report of Expert Radio Aide Hallborg, dated June 11, 1915, No. 158,054-557-6, states that a 5-k. w. Kilbourne & Clark set was installed by him on the S. S. Ulysses, beginning May 18, 1915.

Q. 203. Did the Bureau of Engineering records contain any reference to the Maryland Steel Company or the U. S. Panama Canal Commission, having any connection with the installation of the Kilbourne & Clark sets on the S. S. Achilles and S. S. Ulysses, and if so, what did they disclose in this respect?

A. Yes, I found records which disclosed that two of the 5-k. w. sets purchased by the Navy Department under "Plaintiff's Exhibit No. 69" were delivered to the New York Navy Yard, and furnished by that Yard to the Maryland Steel Company with the approval of the U. S. Panama Canal Commission, for installation on the S. S. Achilles and Ulysses, which the Maryland Steel Company was building. It was stated that the cost was to be charged to "Miscellaneous Material, Purchases, etc., on Isthmian Canal. Pan-

ama Canal Colliers Ulysses and Achilles", to be deducted from the contract price of the vessels. Among such records were the following:

Letter dated September 4, 1914, No. 133,806-557-6, from Maryland Steel Company to Bureau of Engineering, requesting specifications of radio apparatus to be installed on Panama colliers Ulysses and Achilles.

Letter dated February 9, 1915, No. 146,812-557-6, from Maryland Steel Company to Bureau of Engineering, requesting delivery date of sets for Achilles and Ulysses.

Letter dated February 13, 1915, No. 146,812-557-6-W, from Bureau of Engineering to Maryland Steel Company, stating that proposed date of delivery of sets for Ulysses and Achilles probably cannot be anticipated.

Letter dated March 15, 1915, No. 148,391-557-6-W, from Bureau of Engineering, to C. E. Dole, Purchasing Agent, Panama Canal, Washington, stating that wireless equipment for Ulysses and Achilles is to be supplied by New York Navy Yard.

Letter dated April 3, 1915, No. 149,220-557-6-W, from Bureau of Engineering to Industrial Manager, Navy Yard, New York, stating that cost of radio sets for Achilles and Ulysses should be charged to "Miscellaneous material purchases, etc. on Isthmus, Isthmian Canal, sub head Panama Canal colliers Ulysses and Achilles".

Letter dated September 9, 1915, No. 162,976-557-6, from Maryland Steel Company to Bureau of Engineering, estimating decrease of $4,400 in contract price of Ulysses and Achilles because each vessel's radio set furnished by Government.

Letter dated September 1, 1915, No. 164,916-557-6, from Assisting Purchasing Officer, Panama Railroad Company, New York, requesting instruction books for Kilbourne & Clark sets on Ulysses and Achilles, books to be charged against Panama Railroad Company.

Letter dated November 10, 1915, No. 169,171-557-6, from Maryland Steel Company to Bureau of Engineering acknowledging letter reporting decrease of cost on Ulysses and Achilles.

Letter dated May 9, 1916, No. 187,284-557-6, from Josephus Daniels, Secretary of Navy, to Major E. I. Brown, General Purchasing Officer, Panama Canal, Washington, [fol. 1617] replying to their letter of the 15th ult., stating that Panama Railroad Company wishes Kilbourne & Clark

sets now on Ulysses and Achilles returned to Navy Department. States that sets were installed not at the instance of the Navy Department, but at the instance of the Maryland Steel Company, which stated to Bureau of Engineering that they could not provide sets for the Ulysses and Achilles, and requesting same to be furnished by the Bureau.

Navy Department invoice 22950-4282, dated January 21, 1916, giving the charge by the Navy Department to the Panama Canal for the Kilbourne & Clark sets and installations on Ulysses and Achilles.

Letter dated March 10, 1915, No. 148,542-557-6-W, from Bureau of Engineering to Maryland Steel Company, stating set for Achilles will be ready for shipment from New York about March 25.

Letter dated March 29, 1915, No. 149,220-557-6, from Bureau of Engineering to Bureau of Supplies and Accounts, stating that the cost of sets from Ulysses and Achilles to be charged to Panama Canal and deducted from contract price of colliers.

The Bureau records also show that in November, 1917, both Kilbourne and Clark sets were removed from the Ulysses and Achilles and were purchased by the Navy Department from the Panama Canal. $1,630.00 paid for set from Ulysses and $1,295.00 for set from Achilles.

Q. 204. What, if any, knowledge have you of the purchase by the United States Navy from the National Electrical Supply Company and delivery to, and use by, the United States Navy subsequent to June, 1910, and prior to June, 1919, of the field radio pack sets of the type described in Mr. Graham's testimony mentioned in paragraph 2 of your answer to Q. 2, found on Printed Record page 231 of your previous deposition, and illustrated in Mr. Graham's drawing, "Plaintiff's Exhibit No. 80"? Please specify the date of purchase, delivery and use, if you recollect them.

A. I personally know that between the dates 1910 and 1919, the United States Navy purchased, installed and used in regular Navy communication, many of the field or pack or portable sets of the type described by Mr. Graham, and illustrated in his schematic drawing, "Plaintiff's Exhibit No. 80". These sets were all obtained from the National Electrical Supply Company, in Washington, D. C. I prepared the Navy specifications for these sets, followed their construction at the factory, tested them for acceptance at the Washington Navy Yard, and recommended acceptance. I

know that all these sets between the dates mentioned were accepted and turned into store at the Washington Yard. With the exception of the last type delivered in 1918 and 1919, some of which were not taken from store, all preceding types I know were issued to the Service, and I have personally used in official work, and seen used by operators in Navy communication, all of these types of sets.

The types of pack sets which conform with that described by Mr. Graham, are type A, B, C, D, and E, with all of which I am familiar as stated above.

Q. 205. Did you find any record in the Bureau of Engineering as to any portable field pack set of the National Electrical Supply Company having been installed and used on the U. S. S. Georgia?

A. Yes, I did. During my search through the Bureau files in January and February, 1928, I found a letter dated May 16, 1914, No. 123,022-897-W, from the Commander-in-Chief to the U. S. S. Arkansas, Flag Ship of the Fleet, at Vera Cruz, giving the names of the vessels equipped with [fol. 1618] pack sets supplied to the Navy by the National Electrical Supply Company. This states that the U. S. S. Georgia had a type A, Serial No. 103 set. I also found a letter dated May 12, 1917, No. 227,924-771-W, from the Bureau of Engineering to the Commanding Officer of the U. S. S. Georgia, requesting that a pack set from the National Electrical Supply Company made on NSA Requisition No. 42 of July 6, 1912, be shipped to the New York Navy Yard, and stating that the shipment was made May 15, 1917.

The particular set type A, Serial No. 103, referred to in the preceding letters, is identical with that described by Mr. Graham, and its circuit diagram is the same as that schematically shown in "Plaintiff's Exhibit No. 80".

Q. 206. Did the files of the Bureau of Engineering of the Navy Department contain any records as to purchase by, and delivery to, the United States Navy, and the use by it, of any of the radio apparatus called for in "Plaintiff's Exhibit No. 71", Contract of March 5, 1914, No. 20,437, with the Radio Telephone and Telegraph Company, and if so, will you briefly state what those records disclose?

A. Yes, the inventory book NSE-25-B of the U. S. S. Olympia, dated March, 1918, states that the transmitter is a 5-k. w. set, obtained from the Radio Telephone and Telegraph Company on Contract 20,437, Requisition 180, of

March 5, 1914, and that this set was installed at the New York Navy Yard February, 1918.

This contract and requisition are the same as those contained in "Plaintiff's Exhibit No. 71", which calls for two k. w. sets for use on the U. S. S. Olympia and San Francisco.

Q. 207. Have you made any copies of any of the records of the Bureau of Engineering of the Navy Department which you have referred to, and if not, how have you been able to refer to these records in detail?

A. No. I have not made any copies of Navy documents for use in this deposition. My replies have been based on abstracts and notes which I made from such records and documents during January and February, 1928.

Q. 208. Have you read the testimony of Mr. Roy A. Weagant, at Printed Record, pages 101 and 102, herein describing certain radio apparatus which he testifies was manufactured by the Navy, and have you examined his drawing of such apparatus, "Plaintiff's Exhibit No. 93"?

A. Yes, I have.

Q. 209. Have you any personal knowledge as to whether such apparatus, described by Mr. Weagant, and illustrated by "Plaintiff's Exhibit No. 93", was manufactured by the Navy and, if so, please state approximately the date of manufacture and also use by the Navy.

A. Yes, I know that transmitters and receivers of the type described by Mr. Weagant, and whose circuit drawings correspond with the schematic sketch of "Plaintiff's Exhibit No. 93", were manufactured by the Navy and installed and used at ship and shore stations, and I have used this apparatus myself, and have seen it used in Service work by operators. This manufacture, installation and use began about 1915. I had much to do at the Bureau with getting up the system whereby each Navy Yard would manufacture a specific piece of apparatus, for example, the Philadelphia Navy Yard making non-synchronous gaps. The various parts were assembled at the New York Navy Yard and the Mare Island Yard, to form what was known [fol. 1619] as the "Navy Composite Set". The Washington Navy Yard designed and made receivers and audion control boxes, which were sometimes used with these composite sets. Not all the material in these sets was manufactured by the Navy, as different parts were, from time to time, purchased from contractors.

Q. 210. Who supplied the antenna for the wireless transmitters and receivers purchased and used by the U. S. Navy since June, 1910, and prior to June, 1919, concerning which you have testified herein, and which you used and operated, and how was the ground connection made in such apparatus, installed on United States vessels?

A. The Navy Department itself always supplied and constructed the antenna for the transmitters and receivers which it purchased, installed and used. In the case of vessels using such equipment, the ground was made to some part of the vessel if the hull were of metal, or to a metallic plate attached outside the hull, if the latter were of wood, or non-conducting material.

Q. 211. In your present and former depositions herein, you have referred to the purchase, installation and use by the United States Navy between June, 1910, and June, 1919, of various types of radio transmitters and receivers. Will you please state what the procedure was in the Navy Department in ordering and in distributing such radio apparatus to Naval stations, and for what purpose such apparatus was used during that period?

A. In some cases, transmitters and receivers were ordered in the same requisition, in other cases separate requisitions were made for transmitters and receivers. However, when both transmitter and receiver were ordered in the same requisition, it did not necessarily mean that both would be used in the same location. Assignments of each class of apparatus, that is, transmitter and receiver, were made independently of each other, to suit the needs of the Service.

For example, the set purchased by the U. S. S. Eagle, in 1911, included both transmitter and receiver of the Telefunken type, but when I installed the set on that ship, the transmitter only was put on, and a 1P76 receiver was used with this Telefunken transmitter. On the other hand, the transmitter and receiver obtained together on Requisition 96, Contract 123, for the U. S. S. Arkansas, were installed together on that vessel.

As to use of such apparatus, a receiver of a given make, such as the 1P76, whether installed at a shore or a ship station, would, in the course of official Naval work, receive messages from transmitters of all kinds for which it was adopted, such as transmitters made by the Telefunken Company, the Wireless Specialty Apparatus Company, the Wire-

less Improvement Company, the National Electric Signalling Company, and others. With the exception of some few sets remaining in store and not issued to the Service at the time I left the Navy in 1919, all sets, both transmitters and receivers, purchased, installed and used by the Navy, were so used for the purpose of radio communication between ships, between shore stations and between ships and shore stations.

Q. 212. Do you know whether the Navy Department ever sold, or offered for sale, any of the types of radio apparatus that you have referred to in your depositions herein, and if so, will you state generally what apparatus was sold, when it was sold, and the circumstances under which it was sold?

A. After the war, and before I left the Navy Department, preparations were made by the Navy to sell a large amount [fol. 1620] of radio apparatus, including tuned coupled circuit receivers, tuned coupled circuit quenched-gap transmitters, rotary-gaps, vacuum tubes, quenched gaps and other apparatus. Some of this apparatus was manufactured by the Telefunken Company, the Wireless Specialty Apparatus Company, the Wireless Improvement Company, Emil J. Simon, the National Electrical Supply Company and F. Lowenstein.

In December, 1920, a year and a half after I left the Navy, a mimeographed catalogue was issued, offering this material for sale. I have seen this catalogue, and from time to time I have visited one of the Navy Yards where this material was exposed for review of purchasers, and I know that large quantities of it was sold.

* * * * * * *

[fol. 1621] Last Question by the Notary: Do you know of any other matter relative to this claim?

Answer. No.

* * * * * * *

Mr. Vail: Counsel for claimant offers in evidence a photostat copy of pages 344 to 347, inclusive, of the Proceedings of the Royal Society of London, under date of June 10, 1902, which contain an article by G. Marconi, entitled "A Note on the Effect of Daylight Upon the Propagation of Electromagnetic Impulses Over Long Distances", and requests that the same be marked "Claimant's Exhibit No. 333".

Also, a photostat copy of page 86 of "Manual of Wireless Telegraphy for the Use of Naval Electricians", by Lieutenant-Commander S. S. Robison, U. S. Navy, 1906, as "Claimant's Exhibit No. 334".

Pages 239 to 241, inclusive, of "Robison's Manual of Radio Telegraphy and Telephony for Use of Naval Radiomen", by Commander (now Admiral) Robison, U. S. Navy, revised by Commander S. C. Hooper, U. S. Navy, 1924 (6th Edition), as "Claimant's Exhibit No. 335".

Pages 3, 4, 5, 6, 8, and page of diagrams accompanying the same, of book entitled "Wireless Telegraphy, Signal Corps, U. S. Army", by Major Edgar Russell, Signal Corps, U. S. A., Fort Leavenworth, Kansas, 1910, as "Claimant's Exhibit No. 336".

Pages 176 to 178, inclusive, of a book entitled "Wireless Telegraphy", by Dr. Zenneck, translated from the German by A. E. Selig, 1st Edition, 1915 (book from which "Defendant's Exhibits D 5 and H 6" were taken), as "Claimant's Exhibit No. 337".

Certified copy of contract dated June 29, 1912, between Captain R. J. Burt, Signal Corps, U. S. Army, and The Marconi Wireless Telegraph Company of America, No. 536, together with the additional papers appearing upon the records and files of the Returns Office, Department of the Interior, as "Claimant's Exhibit No. 338".

Certified copy of the Provisional Specification as lodged on the 2nd June, 1896, in connection with Marconi's application for patent No. 12,039, of 1896, filed on the 2nd June, 1896, as "Claimant's Exhibit No. 339".

Certified copy of the File Wrapper and Contents of the application for Letters Patent of Nikola Tesla, No. 645,576, granted March 20th, 1900, as "Claimant's Exhibit No. 340".

(The Notary marks all of said exhibits as requested.)

* * * * * * *

[fol. 1622] "Stipulation as to Foote-Pierson Pack Sets

"It is hereby stipulated and agreed, subject to correction should error appear, that one or more of the Field Wireless Pack Sets called for by Plaintiff's Exhibit No. 53, contract dated June 27, 1910, between C. De F. Chandler, Captain, Signal Corps United States Army, and the Foote-Pierson Company, Order No. 8503, and diagrammatically

illustrated in Plaintiff's Exhibit No. 102, Waterman Sketch Foote-Pierson Pack Set (P. R., p. 196) was or were delivered to, accepted and used by the Signal Corps of the United States Army in wireless communication subsequent to the date of said contract and some time in the latter part of the year 1910 and thereafter."

"Stipulation

"It is stipulated and agreed, by and between counsel for [fol. 1623] the respective parties herein, that if James J. Cosgrove were called as a witness in this suit and duly sworn, he would testify as follows:

"That he is a member of the firm of Sheffield & Betts, of 27 Cedar Street, New York City, who acted as solicitors for the plaintiff in the suit in the United States District Court for the District of Delaware brought against Radio Audion Company for infringement of claims 1 and 37 of Fleming patent No. 803,684, and that he was familiar with the proceedings in that suit.

"That a motion for preliminary injunction was made in said suit to restrain the defendant therein from infringing upon claims 1 and 37 of the Fleming patent by manufacturing and selling three-element vacuum tubes for use in radio reception as detectors, amplifiers and oscillators.

"That said motion for preliminary injunction was argued on affidavits filed on behalf of both parties, and on or about January 20, 1922, the District Court granted a preliminary injunction restraining the Radio Audion Company from infringing claim 1 of said patent by the manufacture, use or sale of three-element vacuum valves or tubes for use in any arrangement wherein they constituted a detector of wireless waves, but the court was not satisfied on the record before it, consisting largely of *ex parte* affidavits, that the defendant's tubes, when used as amplifiers or as generators of high frequency oscillations, fell within the scope of either claim 1 or claim 37 of the Fleming patent. (See 278 Fed., 628.)

"That the said suit was never brought to trial, but that the amended and supplemental bill *were* dismissed therein without prejudice on plaintiff's motion, for the reasons that the Fleming patent had expired on November 7, 1922, the Radio Audion Company, as Mr. Cosgrove is informed and believes, had discontinued, in April, 1922, the manu-

facture and sale of the three-element vacuum tubes for use as detectors, amplifiers and oscillators, and said Radio Audion Company, on or about December 1, 1922, in a suit in equity in the United States District Court for the District of New Jersey, was placed in the hands of receivers, its liabilities being much in excess of its assets, so that any possible recovery by the plaintiff in the suit for the infringement of the Fleming patent in the District of DeJaware would be so inconsiderable as not to compensate the plaintiff for the expense of prosecuting that suit through a trial to final judgment."

* * * * * * *

Counsel for Claimant offers in evidence the following certified copies of decrees obtained in prior litigation relating to the patents involved in the present claim against the United States, and requests that the same be marked as indicated:

"Claimant's Exhibit No. 341", *Marconi Wireless Telegraph Company of American* v. *United Wireless Telegraph Company and Clyde Steamship Company*, Southern District of New York, in Equity No. 7/200, final decree dated March 25, 1912, on Marconi Patent No. 763,772.

"Claimant's Exhibit No. 342", *Marconi Wireless Tele-*
[fol. 1624] *graph Company of America* v. *National Electric Signalling Company*, Eastern District of New York, in Equity DE-23, final decree dated April 6, 1914, on Marconi Reissue Patent No. 11,913, and Lodge Patent No. 609,154.

"Claimant's Exhibit No. 343", *Marconi Wireless Telegraph Company of America* v. *National Electric Signalling Company*, Eastern District of New York, in Equity DE-31, interlocutory decree dated April 6, 1914, on Marconi Patent No. 763,772.

"Claimant's Exhibit No. 344", *Marconi Wireless Telegraph Company of America* v. *National Electric Signalling Company*, Eastern District of New York, in Equity DE-31, final decree dated November 18, 1914, on Marconi Patent No. 763,772.

"Claimant's Exhibit No. 345", *Marconi Wireless Telegraph Company of America* v. *Atlantic Communication Company, et al.*, Eastern District of New York, in Equity No. 161, interlocutory decree on order for preliminary injunction dated October 15, 1914, on Lodge Patent No. 609,154 and Marconi Patent No. 763,772.

"Claimant's Exhibit No. 346", *Marconi Wireless Telegraph Company of America* v. *DeForest Radio Telephone & Telegraph Company, Standard Oil Company of New York and Lee DeForest*, Southern District of New York, in Equity No. 12/23, interlocutory decree for preliminary injunction dated November 16, 1914, on Lodge Patent No. 609,154 and Marconi Patent No. 763,772.

"Claimant's Exhibit No. 347", *Marconi Wireless Telegraph Company of America* v. *DeForest Radio Telephone & Telegraph Company, et al.*, Southern District of New York, in Equity No. 12/31, interlocutory decree dated October 9, 1916, on Fleming Patent No. 803,684.

"Claimant's Exhibit No. 348", *Marconi Wireless Telegraph Company of America* v. *DeForest Radio Telephone & Telegraph Company*, Southern District of New York, in Equity No. 12/31, interlocutory decree, order re "Amplifiers", dated July 18, 1917, on Fleming Patent No. 803,684.

"Claimant's Exhibit No. 349", *Marconi Wireless Telegraph Company of America* v. *DeForest Radio Telephone & Telegraph Company*, Southern District of New York, in Equity No. 12/31, interlocutory decree re "Oscillions", dated July 9, 1919, on Fleming Patent No. 803,684.

(The Notary marked said exhibits as requested.)

* * * * * * *

(Stipulation of October 16, 1929, re Mr. MacConnach's Evidence)

The parties have entered into and filed herein a stipulation that if Mr. Lewis MacConnach were called as a witness herein, and duly sworn, he would testify as follows:

"1. That he has been Assistant Secretary of the Marconi [fol. 1625] Wireless Telegraph Company of America, the claimant herein, since July 11, 1918, that he was Assistant Secretary of the Radio Corporation of America from November 20, 1919, to December 1923, and from that date to the present time has been and now is Secretary of the Radio Corporation of America.

"2. That on November 20, 1919, the claimant entered into an agreement with the Radio Corporation of America, a copy of which is marked herein as Defendant's Exhibit C-7, and that said agreement has not been terminated or

cancelled, nor has it been modified except as stated below in carrying out some of the provisions thereof.

"3. That shares of stock of the claimant company have been and, when authorized by the Board of Directors of Radio Corporation of America, are from time to time being exchanged for shares of stock of the Radio Corporation of America, such exchange being made directly with stockholders instead of first issuing the shares of stock of the Radio Corporation of America to the claimant, as provided in Art. II, Sec. 2 of said agreement of November 20, 1919; that in such exchange of shares of stock which has taken place the stockholders' certificates of shares of stock of the claimant have been returned to such stockholders, and in any exchange of such shares of stock that may hereafter taken place, when and if authorized by the Board of Directors of the Radio Corporation of America, the stockholders' certificates of shares of stock of the claimant will also be returned to such stockholders, and that all of said certificates of shares of stock of the claimant which have been so exchanged and returned were stamped, and those that may hereafter be so exchanged and returned will be stamped, with a statement that they represent such stockholders' interest or share in the reserved assets referred to in said agreement of November 20, 1919.

"4. That in 1919 the claimant company had outstanding two million shares of stock of the par value of $5.00. Of this amount 1,965,319 shares were delivered by the holders thereof to the Radio Corporation; were stamped by the Corporation Trust Company of New Jersey as agents for the Radio Corporation and returned to the said stockholders. The stamp or imprint made upon each of these certificates was as follows:

"The holder and owner of this certificate by the receipt hereof thus stamped by the undersigned as agent of the Marconi Wireless Telegraph Company of America (herein called the Company) has assented to action of the stockholders' meeting of the Company held on November 20th, 1919, and, in accordance with the circular signed by Radio Corporation of America dated December 20th, 1919 (and as also set out in a stockholders' agreement dated December 20, 1919, which is assented to by the holder hereof), has (1) consented to the dissolution of the Com-

pany, (2) accepted shares of stock of the Radio Corporation of America in full of all claims against and rights in the Company of every kind except as to the Reserved Assets described in said stockholders' action (consisting of certain [fol. 1626] claims against the United States Government and certain private corporations and firms arising from the unlicensed use of apparatus covered by the patents of the Company) and certain claims against the British Government, (3) consented that such Reserved Assets be liquidated as set out in said stockholders' agreement of December 20, 1919 and (4) agrees that this certificate henceforth represents only the right of the owner hereof as stockholder of the Company to share in the proceeds of the liquidation of the Reserved Assets above described by the Trustees in dissolution of the Company.

'The certificate stamped and the interest represented thereby is not transferable upon the books or transfer books of the Company. The Trustees in Dissolution and Radio Corporation of America may treat the holder hereof as the owner for all purposes including distribution of proceeds of Reserved Assets.

Jersey City, January 2, 1920.

Corporation Trust Company of New Jersey,
Agent as above stated.'

"5. That there are now outstanding 34,690 shares of the capital stock of the claimant company not stamped as above.

"6. That the Radio Corporation owns no stock in the claimant company.

"7. That on August 2, 1920, the claimant caused to be filed in the office of the Secretary of State of New Jersey a certificate of dissolution of which a certified copy is offered in evidence by claimant and marked Claimant's Exhibit No. 359."

Pursuant to said stipulation the Notary marks the documents referred to therein as follows:

The agreement of November 20, 1919, between the claimant and the Radio Corporation of America as "Defendant's Exhibit C-7".

The certificate of dissolution as "Claimant's Exhibit No. 359".

Claimant's counsel objects to "Defendant's Exhibit C-7" as immaterial and irrelevant.

(Stipulation of October 16, 1929, Re Mr. Cosgrove's Evidence.)

The parties hereto have also entered into and filed herein a stipulation that if Mr. James J. Cosgrove were called as a witness herein, and duly sworn, he would testify as follows:

"1. I am by profession an attorney and counsellor at law and a member of the firm of Sheffield & Betts, attorneys and counsellors at law, of the Borough of Manhattan. Since November, 1914, I have been a member of said firm and its predecessors in business. Between 1899 and December 1, 1914, I was a practicing lawyer associated with and employed as such by the predecessors in business of said firm of Sheffield & Betts.

"2. Ever since the organization in the year 1900 of the Marconi Wireless Telegraph Company of America, the claimant herein, and down to the present time, the said firm of Sheffield & Betts or its predecessors in business have [fol. 1627] acted as attorneys in law for said Marconi Wireless Telegraph Company of America, particularly in all matters relating to Letters Patent for inventions, such as applying for said Letters Patent, preparing licenses under or agreements relating to all Letters Patent for inventions owned by the claimant and prosecuting or defending suits for infringement of patents in which it was a party.

"3. I am familiar with the license agreements of the claimant herein during the period from the year 1899 to December 8, 1919, under United States Letters Patent in suit herein and the dates when said license agreements were cancelled or terminated.

"4. I am familiar with the proceedings in this suit. I have acted as counsel in introducing some of the evidence herein on behalf of the claimant, including its evidence relating to the types of radio apparatus manufactured by and/or for the United States and/or used by it which it is claimed herein embodies the inventions of one or more of the Letters Patent in suit herein. I am generally familiar with all of the types of radio apparatus manufac-

tured by and/or for the United States and/or used by it and relied upon in claimant's evidence herein as embodiments of the inventions of one or more of the Letters Patent in suit herein, and the names of the manufacturers thereof or the contractors or others who sold or supplied such apparatus to the United States.

"5. That the claimant herein, during the period from 1899 to December 8, 1919, never granted any release of claims for infringement of any of the Letters Patent in suit herein, nor any license under any of the said Letters Patent, to manufacturers of the aforesaid radio apparatus referred to in paragraph 4 hereof, or any other radio apparatus, nor granted any such release or license to any contractors or others who sold or supplied said or any radio apparatus to the United States, except the written licenses and/or releases granted to the following corporations on the dates and under the Letters Patent in suit herein set opposite their names respectively:

"(*a*) National Electric Signalling Company, October 15, 1914. Lodge Patent No. 609,154, and Marconi Patent No. 763,772.

"(*b*) National Electric Supply Company, July 14, 1914, and April 15, 1915. Lodge Patent No. 609,154 and Marconi Patent No. 763,772.

"(*c*) Moorhead Laboratories, Inc., November 30, 1918; Fleming Patent No. 803,684.

"(*d*) Otis B. Moorhead and Moorhead Laboratories, Inc., April 30, 1919; Fleming Patent No. 803,684.

"(*e*) Otis B. Moorhead and Moorhead Laboratories, Inc., June 6, 1919; Fleming Patent No. 803,684.

"Copies of the foregoing instruments are offered in evidence by claimant and marked 'Claimant's Exhibit No. 360,' the making and execution of which being admitted by defendant.

"(*f*) General Electric Company, October 22, 1919; all patents.

[fol. 1628] "A copy of the foregoing instrument is offered in evidence by defendant and marked 'Defendant's Exhibit A-7', the making and execution of which is admitted by claimant.

"6. That a notice of cancellation of said license to the National Electric Signalling Company of April 15, 1915,

was given to the latter by the claimant on March 1, 1917, such cancellation taking effect on May 30, 1917; that the said license of July 14, 1914, to the National Electric Supply Company was limited to portable apparatus of approximately ¼ kilowatt capacity, and substantially as specified in the United States Navy Schedule No. 6896 and to apparatus manufactured for and sold to the United States and that said license to the National Electric Supply Company of April 15, 1915, was also limited to apparatus manufactured for and sold to the United States, and that notice of the cancellation of said licenses to the National Electric Supply Company was given to it by the claimant on December 24, 1915, such cancellation taking effect January 24, 1916; that said license of November 30, 1918, to Moorhead Laboratories, Inc., and said license of April 30, 1919, to Otis B. Moorhead and Moorhead Laboratories, Inc., were terminated on June 6, 1919, and that notices of the cancellation of said license of June 6, 1919, to Otis B. Moorhead and Moorhead Laboratories, Inc., were given to them by the claimant on January 30, 1919, such cancellation taking effect on July 30, 1920.

"7. That the claimant herein, during the period from 1899 to December 8, 1919, never entered into any agreement with the United States or its officers or employees relating to the manufacture, use or sale by the United States of any of the aforesaid types of radio apparatus referred to in paragraph 4 herein, or any other radio apparatus under any of the Letters Patent in suit hereing except such agreements between the United States and the claimant as relate to the manufacture for and or sale to the United States of claimant's radio apparatus, generally entered into on proposals of the United States and bids by claimant, and an agreement of November 26, 1918, to take effect November 30, 1918, between the United States and the claimant, a copy of which agreement is offered in evidence by defendant and marked Defendant's Exhibit B-7, the making and execution of which said agreement is admitted by claimant."

The said stipulation also includes the following paragraphs:

"8. That it is stipulated by the parties that some or all of the transmitting apparatus of the stations referred to in said agreement of November 26, 1918, included the com-

bination of an elevated antenna, variable self-inductance or loading coils, inductively coupled tuned circuits, synchronous, non-synchronous and/or quenched spark gaps, and an earth connection, and that some or all of the receiving apparatus of said stations included the combination of an elevated antenna, variable self inductance or loading coils, inductively coupled tuned circuits, crystal detectors, and an earth connection; and it is further stipulated that some or all of said apparatus included the combination or combinations of one or more of the claims in issue of the Marconi Reissue Patent No. 11913, the [fol. 1629] Lodge Patent No. 609,154, and the Marconi Patent No. 763,772 in suit.

"9. That there appears in the Congressional Record of February 11, 1919, a copy of a letter dated February 3, 1919, relating in part to the purchase of the stations mentioned in said agreement of November 26, 1918, which copy is marked herein as Claimant's Exhibit No. 361, and it is further stipulated, subject to correction should error appear, that ex-Secretary of the Navy Josephus Daniels signed the original of the aforesaid letter and caused the same to be delivered to Hon. L. P. Padgett.

"10. That copies of said Defendant's Exhibits A-7 and B-7, and Claimant's Exhibits Nos. 359, 360 and 361, may be and hereby are offered in evidence with the same force and effect as the originals thereof."

Pursuant to the last-mentioned stipulation the Notary marks the documents referred to therein as follows:

The agreements between claimant and the National Electric Signalling Company, National Electric Supply Company, Moorhead Laboratories, Inc. and Otis B. Moorhead, as "Claimant's Exhibit No. 360".

Copy of letter dated February 3, 1919, from ex-Secretary of the Navy Josephus Daniels, to Hon. L. P. Padgett, as "Claimant's Exhibit No. 361".

Defendant's counsel objects to the latter exhibit as immaterial and irrelevant.

The agreement of October 22, 1919, between the General Electric Company and Marconi Company, as "Defendant's Exhibit A-7".

The agreement of November 26, 1918, between the claimant and the United States, is marked by the Notary "Defendant's Exhibit B-7".

Claimant's counsel objects to the latter exhibits as immaterial and irrelevant.

* * * * * * *

The parties hereto have entered into and filed herein a stipulation as follows:

"It is hereby stipulated that Claimant's Exhibit No. 36 herein (R. p. 321), a copy of which is annexed hereto, may be accepted in evidence herein as a correct translation of the judgment of the Civil Tribunal of the Seine, in the action of Marconi's Wireless Telegraph Company, Limited, *vs.* Societe Generale Des Transports Maritimes, Compagnie Radio electrique and Others, subject to correction should error appear."

The parties hereto have also entered into and filed herein a stipulation reading as follows:

[fol. 1630] "WHEREAS, a stipulation was entered into herein on July 7, 1925, appearing at pages 756 and 757 of the record herein, which stipulation provides that certain Letters Patent and certain publications offered by the defendant herein may be received in evidence as exhibits with the same force and effect as the originals thereof, and that they were published on the dates printed on said exhibits respectively or stated in the record at the time of the introduction thereof in evidence herein."

"Now, it is further stipulated and agreed that said provisions of said stipulation shall apply to copies of all patents and publications which have been or may be introduced herein by either the claimant or the defendant herein, subject, however, to correction if error should appear, and subject to objections as to relevancy or pertinency of the exhibits (other than on the grounds that they are copies or that the date of publication thereof had not been proved) which were or may be made at the time of the introduction of said exhibits."

Claimant's counsel offers in evidence certified copies from the United States Patent Office of three instruments in writing between claimant and Radio Corporation of America, one of which instruments bears no date, the other two

bearing date as of December 8, 1919, and the same are marked "Claimant's Exhibit No. 362".

IT IS HEREBY STIPULATED that the foregoing certified copies of instruments may be used in evidence herein with the same force and effect as the originals, and it is FURTHER STIPULATED, for the purposes of this case only, and subject to correction should error appear, that the undated instrument was executed and delivered on November 20, 1919, by the claimant, and that the instruments dated November 8, 1919, were executed and delivered by the claimant on that date.

Claimant's counsel offers in evidence the following:

A printed copy of the report of the Committee on Military Affairs of the House of Representatives, on the Bill for "Settlement of Damages for Infringements of Radio Patents", which is to be marked "Claimant's Exhibit No. 363".

A copy of the final judgment in the case of *Marconi Wireless Telegraph Company of America* vs. *Kilbourne & Clark Manufacturing Company*, the same to be marked "Claimant's Exhibit No. 364".

(The Notary marks said exhibits as requested.)

(STIPULATION OF NOVEMBER 26, 1929, AS TO ATLANTIC COMMUNICATION COMPANY AND DEFOREST COMPANY APPARATUS)

At the request of the claimant herein, it is hereby stipulated, subject to correction should error appear, as follows:

1. That an examination of the record in the Atlantic Communication case shows that the drawings hereto annexed marked "Waterman Exhibit B, Defendant's Sayville Apparatus, Atlantic Communication Case", and "Martin Drawing 'Herman Frasch' Set" represent, diagrammatically, the apparatus which was charged in said suit to be an infringement of the Lodge and Marconi Patents [fol. 1634] in suit herein, and the apparatus that is referred to in the order for preliminary injunction in the suit against the Atlantic Communication Company, *et al.*, heretofore offered in evidence herein as "Claimant's Exhibit No. 345".

2. That the transmitting apparatus represented in the said drawings "Waterman's Exhibit B, Defendant's Say-

ville Apparatus, Atlantic Communication Case" and "Martin Drawing 'Herman Frasch' Set" were the quenched gap type of transmitting apparatus.

3. That an examination of the record in the DeForest case shows that the drawing hereto annexed marked "DeForest System—S. S. Vesta" represents diagrammatically the apparatus which was charged in said suit to be an infringement of the Lodge and Marconi patents in suit herein and which apparatus is that referred to in the order for preliminary injunction in the said against the DeForest Radio Telephone & Telegraph Company, *et al.*, heretofore offered in evidence herein as "Claimant's Exhibit No. 346".

4. That the transmitting apparatus represented in the said drawing "DeForest System—S. S. Vesta" was the quenched gap type of transmitting apparatus.

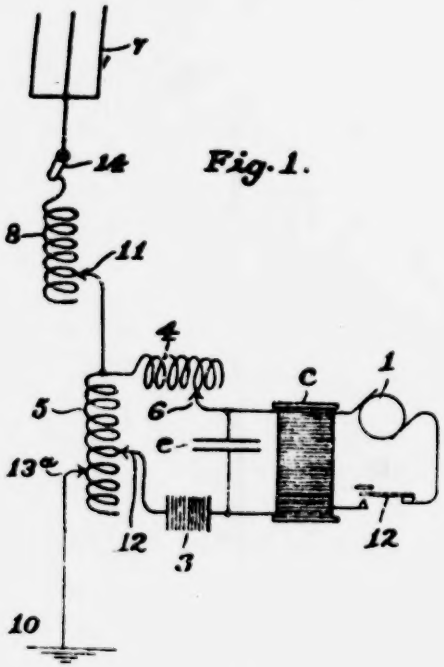


Fig. 1.

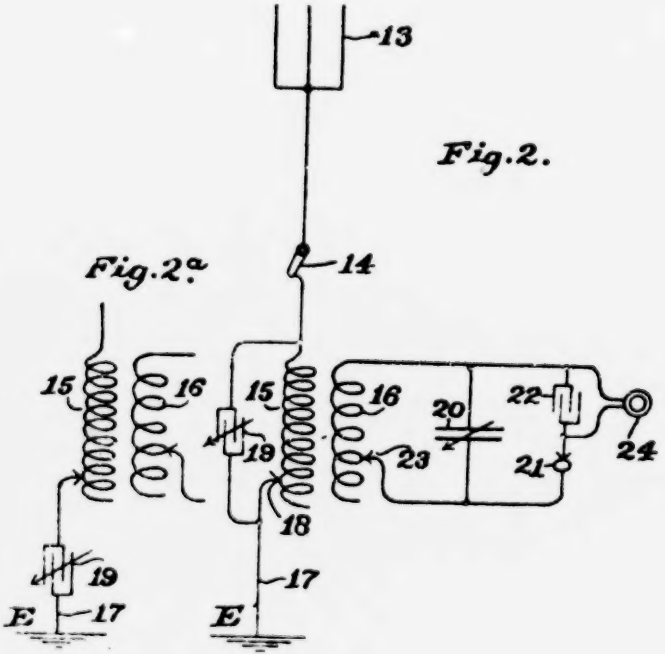


Fig. 2.

Fig. 2a

Waterman Exhibit B Defendant's Sayville Station Apparatus
Atlantic Communication Case

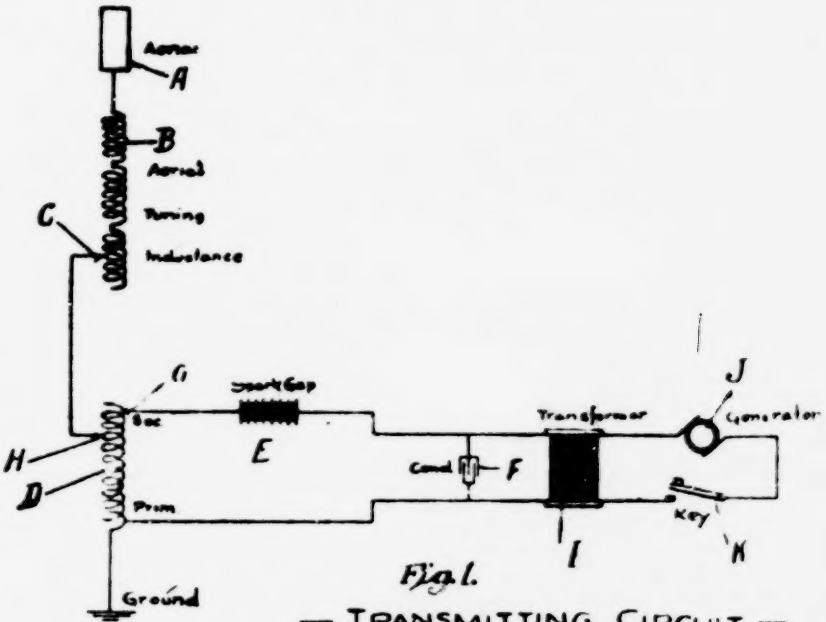


Fig. 1.

— TRANSMITTING CIRCUIT —

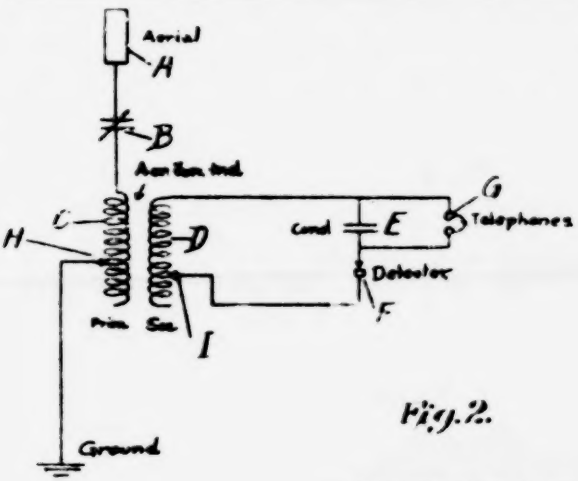
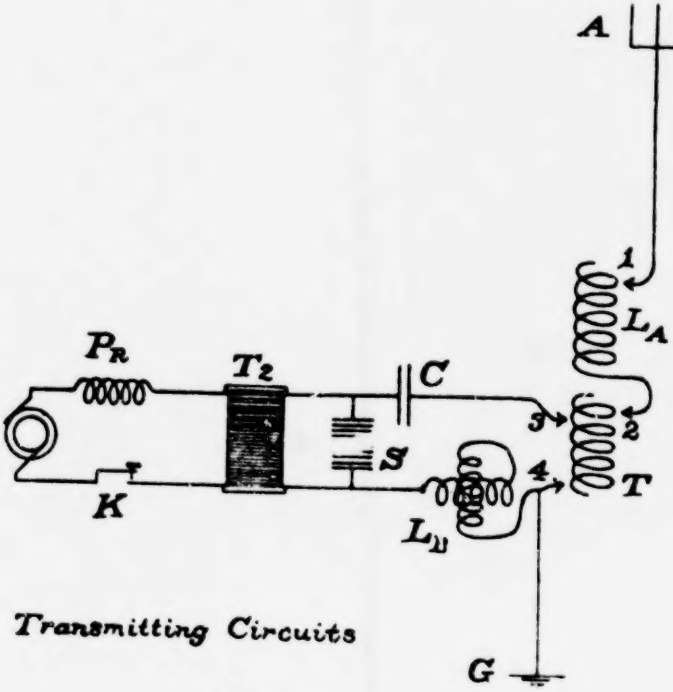


Fig. 2.

— RECEIVING CIRCUIT —

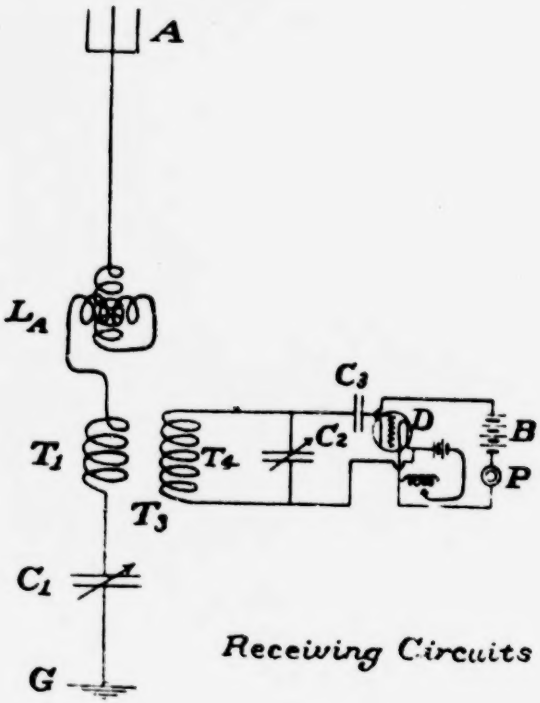
Martin Drawing "Herman Fresch" Set

DeForest System-S.S. Vesta



Transmitting Circuits

Fig.1.



Receiving Circuits

Fig.2.

2107

(Stipulation of December 10, 1929, Re Evidence Relating to Apparatus of General Electric Company on Issue of Compensation.)

Whereas, the claimant relies herein upon certain apparatus made by the General Electric Company and substantially similar apparatus made by others as infringements of one or more of said patents;

Now, Therefore, it is hereby stipulated, subject to the approval of this Court, that the evidence as to what particular apparatus made by the General Electric Company and purchased or used by the defendant, the Defendant's Exhibit A-7, an agreement between General Electric Company and the Marconi Wireless Telegraph Company, Claimant, of October 22, 1919, does or does not apply, and or evidence that the defendant has or has not guaranteed or agreed to assume all responsibility, indemnify or hold harmless the General Electric Company against any claim or demand in respect to the infringement of any of the patents in suit by the purchase or use by the defendant of any apparatus made by the General Electric Company, may be and hereby is postponed until the further order or direction of this Court and until after the hearing and determination of the issues of validity and infringement, and until after the determination as to whether or not said Defendant's Exhibit A-7 constitutes any release of the payment by the defendant to the claimant of reasonable compensation for damages and profits on any apparatus made by the General Electric Company and purchased or used by the defendant.

[fol. 1635] Court of Claims of the United States

No. 33,642

Marconi Wireless Telegraph Co. of America

v.

The United States

Order

It is ordered by the Court this 4th day of February, 1930, that this case be and it is hereby referred to Hayner H. Gordon, one of the commissioners of this court, for an ascertainment and report of the facts to the court.

The commissioner shall ascertain whether both parties have closed their proof; and if not, shall call upon either or both of them to produce witnesses within such reasonable time as the commissioner may prescribe. Where deemed necessary by him, he shall have the witnesses summoned. He shall fix the time and place for the taking of testimony, giving notice to either side thereof; and having concluded the taking of testimony he shall make a report of the facts to the court, filing with his report the evidence adduced by the parties. In the event both parties have concluded the taking of testimony at the time of this reference the commissioner shall proceed to ascertain the facts from the evidence on file, making his report, as already stated. Upon the filing of the commission's report the clerk shall mail notice to the parties of the filing of the same.

Each party may have 30 days from the date of the filing of the commissioner's report to file exceptions thereto. Each exception, at the end thereof, shall have appropriate references to the parts of the record relied upon for its support. The plaintiff may have 15 additional days from the date of the filing of exceptions within which to file briefs, and the defendant may have 15 days thereafter within which to file briefs.

The commissioner may rule upon the relevancy and admissibility of any evidence, any exceptions by either party to his rulings to be noted at the hearing by him.

All other questions are reserved.

It is further ordered that the former order referring the above-entitled case to a commission be and the same is vacated, set aside and withdrawn.

By the Court.

F. W. B., *Ch. J.*

* * * * * * *

[fol. 1636] Testimony of George H. Clark

George H. Clark, a witness recalled on behalf of the Claimant, having been previously sworn, testifies as follows:

Direct examination.

By Mr. Vaill:

Q. 213. Are you the same George H. Clark who has heretofore testified in this case?

A. Yes.

Q. 214. Will you look at the cabinet or apparatus which is on the table before you, and state if you know what it is?

A. I recognize this apparatus as a complete receiver in testing of two-circuit tuner, detector system, and associated control apparatus. It is a receiver of several types manufactured by the Wireless Specialty Apparatus Company and I personally have inspected and passed for acceptance and use in the United States Navy a large number of receivers of this class, during the time that I was employed as Expert by the Navy Department in Washington, D. C. I have used in service conditions a great many of these receivers on Naval vessels and at Shore Stations.

The receiver is of the IP76 type, and may be further described as belonging to a sub-classification "1912". The receiver known as the IP76-1912 was very commonly used in the Navy, and appeared in a number of slightly modified forms, none of which, in any way, changed the radio side of the apparatus, or its operation. The changes I recall were of the nature of substituting a key for a push-button in handling the test buzzer; the providing of a key-switch to control the battery supply to the potentiometer in some cases, and its omission in others; and the placing of the "send-receive" key in some cases on the right of the tuner, and in other cases on the left. Incidentally the sub-designation 1912 was more of an identification of type than a rigid date of manufacture, as I know that this type of receiver was in Naval use at least a year before 1912.

Q. 215. Will you please state how the apparatus before you corresponds with those which you worked and which you operated as concerns the type of detector or detectors used?

A. The receiver before me contains portions of two detectors, which I clearly recognize as the two standard ones furnished with this type of receiver. Either of the two detectors might be used, and a switch determined this. The left hand detector is the Perikon-Electra type, which originally had a single crystal on the movable or searching mem- [fol. 1637] ber, and a number of crystals embedded in the fixed member. I note that in this receiver before me the movable crystal has been replaced by an obviously homemade pointed piece of metal.

The right hand detector is the Pyron. It had a metal point on an adjustable steel spring for the one element, and a crystal held in an alloy for the other element. In the receiver before me, the crystal is not present. Both of the detectors I see before me have sufficient of their original material to enable me to identify them completely. These two types were purchased by the Navy Department in large quantities, and I passed very many of them for payment while I was on duty at the Washington Navy Yard, and I used both these types in actual work in the Navy.

Q. 216. How does the IP76 receiver before you compare with any of the IP76 receivers which you stated in your previous testimony were purchased and used by the Navy subsequent to June, 1910?

A. It is the same, except for obvious missing parts, with the receiver referred to in my testimony. I note, for example, that the rack normally furnished for moving the secondary coil back-and-forward, is present, but the pinion wheel for this purpose is missing. The switch for throwing the antenna loading coil in-and-out of service, is missing. Binding-post for attaching the detector battery, for the buzzer battery, and for the telephone receivers, are missing, though the holes in the hard rubber top for these still bear the markings indicating the use of the binding-posts that were once there. Some of the binding-posts still present are obviously not the type originally submitted with the instrument. None of these lacking devices make it difficult in any way to identify the instrument.

Mr. Vaill: The apparatus referred to by the witness in his previous answers made at this session is offered in evidence as "Claimant's Exhibit No. 366."

The Commissioner: Without objection, it is so accepted.

Q. 217. Will you please state whether or not a considerable number of these receivers similar to "Claimant's Exhibit No. 366" were purchased by the Navy subsequent to June, 1910, and prior to some subsequent date?

A. Up to the middle of 1919, at which time I left the Government service, a large number of these receivers had been purchased by the Navy, and were in use.

. . . . . .

Q. 219. How does the circuit arrangement of the IP76 receiver before you compare with the circuit of the receiver illustrated in "Plaintiff's Exhibit No. 87", Wireless Specialty Apparatus type?

A. The circuits are identical, if it be understood that the device shown symbolically at B in the exhibit is a battery, and not a condenser. The symbol used in the drawing is universally understood as a condenser, but it is obvious to [fol. 1638] me that the device, shown connected to the potentiometer P, must be intended to represent a battery.

Q. 220. I hand you a photograph which I have had taken of the IP76 receiver before you, and to which you have, at my request, applied certain reference numerals and letters. Will you please designate the various controls and parts shown thereon by reference letters, and point out how these controls and parts relate to the diagram of the IP76 receiver shown on the right hand portion of "Plaintiff's Exhibit No. 87"?

A. Referring first to the letters and figures in the receiving diagram of "Plaintiff's Exhibit No. 87", and their reproduction on the photograph of the IP76 receiver, which is "Claimant's Exhibit No. 366", the antenna and its lead-in A on the drawing is not physically represented with the actual receiver, and on the photograph the binding-post to which the antenna was connected in practice, is marked "Antenna 'A' to here". In the same way the ground E on the drawing is shown as "Ground E to here" with an arrow pointing to the binding-post where the ground lead was connected in practice. The loading coil in the primary circuit of the diagram, g', is represented in the photograph by the same designation, and an arrow leading to one of the contacts which is connected by wire to the actual loading coil. The primary coupling coil marked j' in the diagram is shown by the same designation in the photograph, with two arrows leading respectively to one of the two

series of contacts connected by wires to the actual primary coil. One of these series of contacts varied turns, ten at a time, and the other series one at a time. The two knobs 5 and 6 in the diagram represent the knobs on the apparatus which control the two series of primary contacts just referred to, and these knobs are so numbered on the photograph. The secondary, movable coil, j^2 in the diagram, has that same designation on the clearly seen secondary coil of the photograph, and the contact 7 in the diagram for changing the number of active turns of that coil, is applied to the knob of the similar switch in the photograph. The variable condenser b', shown as a tuning condenser in the secondary circuit in the diagram, has the same designation in the photograph, with an arrow pointing to the handle provided for moving the condenser. The detector T in the diagram, has the same letter in the photograph, with one arrow pointing to the Perikon-Electra detector, and another arrow to the Pyron detector. The stopping condenser j^3 cannot be seen in the photograph, though it is present in the actual receiver which I have here, "Claimant's Exhibit No. 366". The telephone receiver R in the diagram, is represented by arrows running to the holes in the cover, where the telephone receiver binding-posts were ordinarily attached, and which is clearly marked "Tel." in "Claimant's Exhibit No. 366". The detector potentiometer P in the diagram, is indicated by an arrow pointing to the switch controlling that potentiometer, in the photograph. Finally, the battery B in the diagram is shown by two arrows pointing to the two holes in the receiver cover, where the binding-posts for attaching the external battery were located in practice. These binding-posts in "Exhibit 366" have the word "Bat." stamped between them, which I see clearly in the exhibit before me.

For additional clearness in pointing out parts of the receiver, a few further letters have been added to the photograph, which do not appear in the diagram. These are: the letter S has been added to indicate the switch for select- [fol. 1639] ing either one of the crystal detectors. The rack along which the coupling coil j^2 moves, has been lettered K, the two flexible leads from this coupling coil to the binding-posts connecting with the variable condenser b' are marked M, M. The knob of the secondary variable condenser is marked N.

Mr. Vaill: A copy of the photograph referred to by the witness in his preceding answer is offered in evidence as "Claimant's Exhibit No. 367".

The Commissioner: The same is accepted.

Q. 221. Your attention is directed to Fig. 111A, page 179 of "Plaintiff's Exhibit No. 100, Navy Manual of 1911", Fig. 101 on page 154 of "Plaintiff's Exhibit No. 78, Navy Manual of 1913", and Fig. 101 on page 155, also a part of "Plaintiff's Exhibit No. 78, Navy Manual of 1915". Will you please state what type of apparatus is illustrated in the figures just referred to?

A. All three show a form of the IP76 receiver, of the 1912 type. All three photographs represent receivers identical in characteristics with the receivers I have referred to in my previous testimony, and in my testimony today.

Mr. Vaill: The three Navy Manuals referred to in the previous question having already been offered in evidence as parts of "Plaintiff's Exhibits No. 100 *and* No. 78", notice is given that such exhibits will be specifically referred to in connection with the testimony of the present witness at the hearing of this case.

* * * * * * *

Cross-examination.

By Mr. Edwards:

X Q. 222. When did you first see this "Claimant's Exhibit No. 366"?

A. About three weeks or a month ago.

X Q. 223. You have no personal knowledge of when or where it was made, have you?

A. No.

X Q. 224. So far as you have personal knowledge, the exhibit is merely typical of the IP76 receiver, such as diagrammatically indicated in "Plaintiff's Exhibit No. 87"; that is correct, is it not?

A. Yes.

* * * * * * *

Redirect examination.

By Mr. Vaill:

* * * * * * *

R. D. Q. 226. According to your knowledge of this apparatus, "Claimant's Exhibit No. 366", would you be able to say whether or not the appearance of this exhibit would indicate that it was one of the original apparatus manufactured at about the time you have testified to, that is, subsequent to June, 1910?

[fol. 1640] A. "Claimant's Exhibit No. 366" appears to me to be, without doubt, a relic of an operated receiver which has seen much service and abuse. I am strengthened in this belief by the fact that when I first saw this receiver it was in the usual carrying wooden case which was provided with all receivers of this type, and that I noted on this case a name-plate with the familiar insignia of the Wireless Specialty Apparatus, the name IP76 Receiver, and a serial number, which I recall as being less than 1,000. This at the time led me to believe that I was looking at one of the earliest receivers built by the Wireless Specialty Company of the IP76-1912 type.

Mr. Vaill: It is requested that the wooden case referred to by the witness in his last answer be considered as a part of "Claimant's Exhibit No. 366", and the same is offered as such.

The Commissioner: It is so accepted.

R. D. Q. 227. Will you kindly look at the label on the case which is now a part of "Claimant's Exhibit No. 366", and explain, if you can, what the serial number is to which you have referred?

A. The serial number is 152.

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[fols. 1641-1642] EVIDENCE FOR DEFENDANT

Deposition of Joseph O. Mauborgne (recalled), for defendants, taken at New York City on the 20th day of December, A. D. 1927

Direct examination.

By Clifton V. Edwards, Esq.

JOSEPH O. MAUBORGNE, being recalled as a witness on behalf of the defendant, testifies in answer to interrogatories as follows:

1. Question. Are you the same Joseph O. Mauborgne who has heretofore testified in this case?

Answer. I am.

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[fol. 1643] 4. Question. Have you read the testimony of Mr. Roy A. Weagant, as given on printed pages 1526 to 1542 of the record in this case?

Answer. I have.

5. Question. Do you agree that Mr. Weagant succeeded in demonstrating the inherent capability of the 2-electrode tube to amplify and oscillate?

Answer. From the statement contained in the record made by Mr. Weagant, and from the description of the demonstrations made in connection with this case by Mr. Weagant, I do not agree that Mr. Weagant succeeded in demonstrating the inherent capability of the 2-electrode tube to amplify and oscillate. Mr. Weagant produced for these experiments 2-electrode tubes specially manufactured for the purpose of showing that such a 2-electrode tube with the addition of other apparatus outside of the tube and affecting the tube or its action could be made to amplify and oscillate in a circuit such as he used. That he made the tubes he used with the circuit arrangements he set up operate, I do not doubt, either as amplifiers or as oscillators. The arrangement he used was a poor equivalent of a 3-electrode tube, and he knew it to be such, for his testimony in various places practically admits the fact. These 2-electrode tubes had their filaments and plates separated to such an extent that it was possible by another part of the circuit which approached as closely as possible to the tube to cause the electron stream between the filament and the plate

to be electrostatically operated upon in such a way that amplification or oscillation resulted in the circuit. I might define this as a trick circuit not at all proposed by Fleming, Marconi, or anybody else but Mr. Weagant, who I understand has taken out patent applications for just such circuit arrangements, providing that the tubes used in such circuit are the special design enabling the control of the electron stream in the way which he demonstrated to the court. The device producing the electrostatic control was the equivalent of the grid of a 3-electrode tube, and in my opinion the patents taken out by Mr. Weagant covering these arrangements were designed to get around the 3-electrode tube, by producing the equivalent of the third electrode in such a way that it was not sold with the tube.

Had Mr. Weagant tried to make this demonstration, using the type of tube shown in the Fleming patent in the case where the plate of the 2-electrode tube shown completely surrounds the filament, he would have failed completely in his demonstration, in any opinion. He likewise would have failed with any other 2-electrode tube in practical use in the art, where the plate entirely surrounds the filament, for this effectively screens the space between the filament and the plate from the action of the third element which Mr. Weagant has brought as closely as possible to the tube in his experiments. I therefore must conclude that Mr. Weagant has not succeeded in demonstrating the inherent capability of a 2-electrode tube *per se* to amplify and oscillate.

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[fol. 1644] 6. Question. In these tests of Mr. Weagant what was the effect of causing another part of the circuit to approach as closely as possible to the tube, and how does that action compare with the action of the 3-electrode tube?

Answer. The approach of the condenser in the one case or the coil of wire in the other case shown in the demonstrations was to exercise control electrostatically of the electron flow between the filament and the plate in such a way as to cause a reinforcement in the case of amplification, and, practically, if the coupling were close enough, and the space between the electrode wide enough, or of the proper width, to produce oscillation. The action was somewhat similar to that taking place in a regenerative circuit of ordinary type using the 3-electrode tube, and in

fact, as I stated previously, turned the arrangement into what might be said to be a poor 3-electrode tube arrangement with what corresponded to the grid outside the glass tube instead of being placed between the filament and the plate, as in the ordinary type of tube used in the art to-day.

7. Question. Please refer to Mr. Weagant's answer to question 154, at page 1557 of the printed record, and say if you agree with him that the Tesla system operates upon a different principle from that of the Marconi tuning patent 763772 here in suit.

Answer. I think that Mr. Weagant's answer does not make a comparison of the Tesla arrangement and the tuning arrangements of the Marconi patent 763772, but rather is concerned with the arrangements of Tesla as compared with those of Marconi given in the Marconi reissue patent 11913.

8. Question. Please refer to the answer to question 211 of Mr. Weagant's testimony, beginning on page 1643, and say if you agree with this view of the Tesla patent.

Answer. I do not agree with Mr. Weagant concerning his view of the Tesla patent. Mr. Weagant has quoted at least two paragraphs which to me indicate that he did have in mind the practicability of tuning the secondary or output circuit. He speaks of proportioning the wire in the secondary in such a way as to produce resonance between the primary circuit or the circuit next to the secondary, or what we might call the antenna circuit, if the wires used were of the right length, and uses the expression quoted by Mr Weagant on page 1645 of the record, "By such an adjustment or proportioning of the length of wire in the secondary coil or coils the points of highest potential are made to coincide with the elevated terminals D, D', and it should be understood that whatever length be given to the wires, this condition should be complied with in order to attain the best results." To anyone skilled in the radio art this means that the tuning of the antenna system, whether to a fundamental or the harmonic of an antenna in such a way that a potential loop is produced at the upper extremity of the antenna. To me this clearly means tuning, and I can see no difference between the tuning as he has described it, and as shown in the Marconi tuning patent 763772 here in the suit.

9. Question. Please refer to the testimony of Mr. John V. L. Hogan, on behalf of the claimant, particularly the

[fol. 1645] answers to questions 5 and 6 thereof, and to the testimony of Mr. Weagant in answer to question 208 at page 1636 of the printed record, and say if you agree with Mr. Weagant that the Lodge patent is inoperative to produce transfer of energy to the antenna with an impulsive rush.

Answer. I do not agree with Mr. Weagant that the Lodge circuit is inoperatve to produce transfer of energy to the antenna with an "impulsive rush." Mr. Weagant assumes that the spark gaps marked h^6 and h^7 of the Lodge patent No. 609154 "would have to cool so rapidly that they would be extinguished after the first half of the oscillation of the condenser circuit." I do not believe that this would have been necessary for the functioning of the circuit on the "impulsive rush" idea of transferring energy from the closed circuit to the open circuit of the transmitter. Mr. Weagant has just assumed that this is necessary. My understanding of Figure 4 of the patent quoted is that the spark gaps h^2 and h^3, as pointed out by Loftin in his direct testimony, might be removed and the gap closed, as disclosed by the inventor in the patent. I see no reason why the coil shown as k in said Figure 4 placed in shunt to the spark gap terminals of the transformer or induction coil or rather in shunt to the outer terminals of the Leyden jars whose inner terminals were connected to the spark gap mentioned, as shown in Figure 4, should not function as an ordinary inductance in an oscillating circuit and not as a short circuit, as Mr. Weagant has pointed out in his testimony. By the happy choice of the proper coil k and the inductances shown in the antenna circuit of Figure 4, I see no reason why Lodge should not have had in this device three coupled circuits tuned to approximately the same frequency. The circuit h^{10}, h^{11}, j, j, k, forming one of the circuits, the circuit k, h^5, h^7, h^1, h^4, h^6, and h^5, forming another circuit, corresponding to the lateral circuit which ordinarily supplies energy to an antenna circuit, and finally the antenna circuit itself h, h^4, and h^1. In order that the antenna circuit last mentioned might have a sufficiently low resistance so that the oscillations might not decay at too rapid a rate after this system had been energized by impulsive rush from the intermediate circuit, advantage could be taken of Lodge's proposal to short-circuit the gap h^2 and H^3. I am of the opinion that such a circuit could be made to operate very satisfactorily in the manner described

by the inventor in that it would supply energy by "impulsive rush" to the antenna circuit, and then, due to the cooling of the gaps h^6 and h^7, permit a more persistent oscillation in the antenna than that in the circuit immediately coupled thereto in which the oscillation would be comparatively rapidly damped out, due to the high resistance of the gaps h^6 and h^7.

10. Question. In a system such as shown in the Lodge Figure 1, would all of the energy be transferred from the charging circuit to the antenna in one swing or one alternation of the charging current?

Answer. I think not. The gaps of those days did not permit of such rapid quenching, but that is no reason why we should not accept Lodge's term of charging by impulsive rush, since, I believe, that by that he meant that there would be a comparatively rapid cessation of the oscillations in the charging circuit and a comparatively persistent set of oscillations maintained in the antenna circuit.

11. Question. Please refer to the testimony of Mr. Weagant in answer to question 200 at page 1623 of the printed [fol. 1646] record, and say if you agree with Mr. Weagant's testimony to the effect that there is a resonant transfer of energy in the defendant's quenched gap systems.

Answer. I do not agree with Mr. Weagant's testimony to the effect that there is a resonant transfer of energy in the defendant's quenched gap system, or any other quenched gap system. My direct testimony covered my viewpoint of how this is accomplished. (Refer to answers to questions 20 and 21, p. 1232 of the record.) Mr. Weagant apparently has attacked my testimony on the ground that I admit that there must be a certain amount of so-called tuning done in order to place the primary and secondary circuits in resonance with each other. He has also attacked my argument that if the frequencies of the lateral and antenna circuits of a quenched spark transmitter after having been carefully adjusted to radiate but one wave should be examined separately, that they would not be found to be identical, and states generally that the effect of coupling the antenna circuit to the lateral circuit would produce such a final result that if the measurement of frequencies which I indicated were made the results would not indicate the condition of affairs in either circuit when adjusted to give the greatest efficiency of transmission. I am willing now to admit that his statement is correct, but later I shall

be very glad to make use of this same statement in connection with a statement concerning the method of tuning a quenched gap transmitter, which I hope to make at a later time.

I maintain that there is not a resonant transfer of energy in a properly tuned quenched gap system affording the highest efficiency of transmission, as I stated in my direct testimony heretofore. When these circuits are tuned or rather adjusted to produce the optimum effect, notwithstanding the fact that one might follow the rule of first adjusting the primary circuit, then the secondary circuit, then the coupling and the gap, I am still satisfied that there is a difference in frequency between the primary circuit and the secondary circuit. In fact, as I have pointed out in my direct testimony, the difference between these frequencies is such as to cause beats which assist in the quenching action of the gap, and I am quite satisfied that if methods were found to examine the various frequencies in these different circuits that my statement would be verified. I will not repeat what I gave in my direct testimony, as what I consider the methods of transfer of energy from the lateral circuit to the antenna circuit. The reference to that testimony has already been given. I do not admit that my statement that the primary and secondary are more or less in tune is sufficient to justify the statement that I believe there is a resonant transfer of energy from the primary to the secondary circuit of a quenched gap system. Mr. Weagant has quoted me as saying that it is not necessary to adjust the product of L and C in each of these circuits of a quenched gap transmitter to be the same and quotes the file wrapper of the Seibt patent and the Manual of Radio Telephony and Telegraphy by Robison and Hooper, 1924 edition.

I should like at this time to state that the Manuals of the Navy Department and the Manuals of the War Department concerning the adjustment of various pieces of apparatus, including those of the quenched gap systems, were primarily designed for the use of practically unskilled technical personnel, and hence can not be quoted as containing [fol. 1647] an exact technical description of some of these circuits; for example, the quenched-gap circuit. I shall, perhaps, have occasion to refer to this matter again concerning certain data introduced by the witness, Mr. Cram.

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12. Question. Please refer now to the testimony of Mr. Cram, beginning at page 1450 of the record, and say if Mr. Cram's testimony regarding the tuning of quenched gap or other sets is in accordance with practice in the Signal Corps.

Answer. I do not believe that the tuning of quenched-gap sets described by Mr. Cram represents the best practice of the Signal Corps. (I should have said, "I do not believe that the *method of* tuning quenched-gap sets described by Mr. Cram.") I am satisfied that the correctly tuned Signal Corps transmitter has a slight detuning as between the primary and the second circuits, which I have mentioned heretofore in my testimony.

I note that Mr. Cram has quoted some operation directions given by the Telefunken Co. concerning the method of operating the Telefunken wireless telegraph field wagon set supplied on Signal Corps Order No. 9648. I believe that I operated many times this same set, and that the operating instructions which were used by the Signal Corps men in charge of the set were identical with those given in the revised edition of Circular No. 1, Office of the Chief Signal Officer, 1914, revised under date of May, 1915, which are found on page 93. These instructions found in small type, I know, were copied directly from the Telefunken list of instructions which came with that set. At any rate, they were those under which the enlisted men operated and adjusted the apparatus. They follow:

"Transmitter and receiver: The connections of both are clearly shown in the drawing and require no further description.

"To adjust the transmitter for any wave length within the range of the set proceed as follows, assuming that the desired wave length is 1,000 meters:

"1. If it is intended to send at full power, adjust the voltage of the generator by means of the slide rheostat (at the left) to about 85 volts.

"2. If it is intended to send at less than full power, short circuit one or more of the gaps by means of the clips provided and at the same time reduce the generator voltage about 10 per cent per gap short circuited.

"3. Set the primary variometer (at the left) at the wave length desired, viz, 1,000.

"4. Put the aerial-coil plug (at the right) in hole No. 1, marked 680/1050. This adds sufficient inductance to the aerial to bring the final adjustment within range of the aerial variometer.

"5. Make the final adjustment with the aerial variometer (also on the right and on one side of the aerial coils) by turning it slowly up from zero until the ammeter in the aerial ground circuit indicates a maximum.

[fol. 1648] "6. The transmitter is now adjusted for the most efficient production and radiation of the wave length selected when used with the aerial and counterpoise supplied with the set."

* * * * * * *

There is a difference between these directions and the directions for operating quoted by Mr. Cram on page 1463 of the record, wherein paragraph 2 reads:

"This will result in a certain definite wave length or period in the primary circuit, and all that remains to be done is to put the aerial circuit in resonance with the primary circuit by means of the aerial variometer in (V)."

This paragraph does not appear in the list of instructions of the set actually used by troops wherein no instructions are given to put the aerial circuit in resonance with the primary circuit. I should like to point out that these instructions in Circular No. 1, referred to above, including all the data in small type on pages 92 and 93 of this circular were seen by me about the year 1910, and that after a number of tests in the field I wrote the additional instructions contained on pages 94, 95, 96, 97, 98, 99, 100, 101, and 102 of the circular mentioned, and they were sent to the Signal Office and published with the data which had been submitted by the Telefunken Co. These instructions give the idea which I have put forth in my direct testimony that there is some variation between the frequency of the primary circuit and that of the secondary, or at least that they permit of that interpretation.

As I have stated elsewhere in the testimony, that while as a matter of procedure one might set up a certain frequency in the primary circuit which is approximately that to which the set is to be tuned, that circuit if entirely un-

coupled from the secondary would not have the same frequency as if it were tightly coupled to the antenna circuit because of the relation of that circuit to it and the effect on the constants of the primary circuit. Hence, it can only be said that these instructions or other instructions which state that the operator shall first tune the primary circuit to the wave length which he desires to emit can only result in an approximate adjustment of frequency if we are to consider the effect of a coupled secondary circuit which must be adjusted thereafter, and which will therefore at such time react upon the frequency of the primary circuit. The operators are further instructed to make the final adjustment of the antenna circuit by the variation of the variometer in that circuit.

As I have pointed out, the instructions on page 83 of circular No. 1 omit any reference to the fact that, as stated by some, the secondary circuit should be placed in resonance with the primary, and justly so, for such is not the case. The secondary is adjusted to be in the neighborhood of the frequency of the primary and when a close coupling is obtained, such as is necessary to secure the proper transfer of energy from the primary circuit to the secondary circuit in such a way that there will be an abrupt cut-off of the oscillations in the primary circuit at the time when the oscillations in the secondary circuit have reached their maximum value, it will be found that there may be a still further difference in the frequency of the primary and the secondary circuits, even with reference to the frequency [fol. 1649] first established in the primary circuit of the transmitter, as a basis from which to start the adjustment. The adjustment of the gap then follows to get the clear note, and the ammeter in the antenna circuit should give a maximum reading when the adjustments have been properly made, but the fact that the ammeter does give a maximum reading does not at all mean that the products of the inductance and capacity in the primary circuit are exactly equal to the product of the inductance and capacity in the secondary circuit. In other words, as I have before stated, the operations in adjusting the apparatus are such that as a result there is not a resonant transfer of energy from the primary to the secondary circuits in the case of the quenched spark apparatus. The secondary circuit has a frequency somewhere in the vicinity of the frequency of the primary circuit.

By comparison the Marconi open-gap transmitter is quite a different arrangement. In the case of this apparatus it is absolutely essential that the frequencies of the primary and secondary circuits shall be carefully and separately adjusted to the same frequency and then coupled with the least practicable degree of coupling so that there may be constantly a resonant transfer of energy from the primary to the secondary.

Mr. Cram's statements concerning the adjustment of quenched-gap transmitters are, in my opinion, not in conformity with Signal Corps practice. In this connection I shall further refer to the fact that Mr. Cram himself wrote the instructions for the pack sets which are contained in circular No. 1 of the office of the chief signal officer, above referred to, and which are found on pages 107, 108, 109, and 110 of that document. From that it is seen that Mr. Cram had the erroneous idea that resonance must be obtained between the primary and secondary circuits of the quenched-gap transmitter, and he was further of the erroneous opinion that the ammeter indication of a maximum meant that such resonance had been obtained. I believe that a number of engineers will not support that view.

13. Question. What is the essential difference in operation between a tightly coupled quenched-gap set in which the charging and antenna circuits are tuned in the vicinity of each other, as contrasted with a plain gap loosely coupled set in which the two circuits are tuned in the vicinity of each other?

* * * * * * *

Answer. From my experience with both types of apparatus I should say that if the plain gap loosely coupled set were to have its two circuits tuned in the vicinity of each other, instead of being exactly in resonance with each other, that the result would be very inefficient transmission and the radiation of two humps or two frequencies would undoubtedly result; whereas, when, as I have stated, a quenched-gap set has its two circuits tightly coupled, the greatest efficiency is obtained and the radiation of a single wave length results when the coupling is exactly right.

(Defendant's counsel offers in evidence a copy of page 93 of the circular No. 1 from the office of the chief signal officer for 1915, referred to by the witness in answer to question 12. This publication is the same publication as

the publication Radio Telegraphy, heretofore referred to [fol. 1650] by claimant's witnesses Waterman and Cram. The Exhibit is marked "Defendant's Exhibit No. U-6.")

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14. Question. Please refer to Mr. Hogan's answer to question 31 and say if you agree with this testimony.

Answer. This matter has been more or less covered in my comments upon some of the statements made by Mr. Weagant. I do not agree with Mr. Hogan that "This adjustment is most likely, if not certain, to bring the two circuits practically exactly in tune with each other so as to give the best resonant transfer of energy from the closed primary circuit to the open antenna circuit."

As to the suggestion about the measurement of the frequencies of the two circuits after the antenna and ground have been disconnected, I should like to state that I admit Mr. Hogan's objection to my method, but that I further suggest that it is perfectly feasible to measure one or the other circuits and find its frequency after both circuits have been adjusted and the correct degree of coupling attained, and I am quite certain that if this be done the differences in frequency which I maintain exist will be found to exist.

15. Question. Please refer to Mr. Hogan's testimony in answer to question 23 and to Mr. Weagant's testimony in answer to question 213 at printed page 1650, and say if you agree with the contentions of these witnesses to the effect that Stone did not describe a system having a lateral circuit and an antenna circuit tuned to the same frequency.

Answer. A perusal of Mr. Hogan's testimony seems to bring out the idea that the antenna system in no case was tuned to the frequency of the associated closed circuit. He further states:

"He (Stone) even gave the option of making the closed-circuit frequency the same as the fundamental of the aerial *wire* used, but he nowhere suggested that it could be the same as the natural or tuned frequency of the aerial system or circuit, *including both vertical wire and transformer coil.*"

I am satisfied that Mr. Hogan is not correct in this particular. Stone provided a transformer coil in the antenna circuit and the ground connection, and it is inconceivable

since the ground was connected, that he should mean to infer that the closed circuit might be tuned to the frequency of the vertical wire only, since this would be utterly senseless and of no use from a practical standpoint. It goes without saying that the coil, the vertical wire, and the ground must all have been connected together in practice. From this we see that Stone did not always intend to use "forced oscillations." He foresaw the actual tuning to resonance of the two related circuits, or rather provided for such tuning. I therefore must disagree with the contentions of the witnesses to the effect that Stone did not describe a system having a lateral circuit and an antenna circuit tuned to the same frequency.

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[fol. 1651] Cross-examination.

By Mr. Vaill:

17. Cross-question. Are you still a commissioned officer in the United States Army?

Answer. Yes, sir.

18. Cross-question. What is your present rank?

Answer. Lieutenant colonel, Signal Corps.

* * * * * * *

[fol. 1652] 19. Cross-question. In answer to question 5 of your present deposition you referred to "a trick circuit not at all proposed by Fleming, Marconi, or anybody else but Mr. Weagant." Did you intend to mean or refer by use of the word "trick" that it was a deceptive or misleading circuit?

Answer. To the extent that it purported to show that it was an inherent characteristic of a 2-electrode tube in normal operation in a normal circuit, I do; and furthermore, I believe that Mr. Weagant was perfectly honest and perfectly within his rights in attempting to take out patents designed for the purpose which I have stated in the last sentence of the paragraph to which you refer.

* * * * * * *

20. Cross-question. By your last answer do you mean to infer that testimony of this type relating to the oscillation of a hard 2-electrode tube as testified to by Mr. Weagant and other witnesses for claimant amounted to an attempt to deceive the court?

Answer. To the extent that it was offered as evidence in rebuttal of the Government's claim, that a 2-electrode tube did not inherently possess the properties of amplification and oscillation, I do.

21. Cross-question. You agree, do you not, that in causing a high vacuum or hard 3-electrode vacuum tube to oscillate and amplify, that such a 3-electrode tube requires "The addition of other apparatus outside of the tube and effecting the tube or its action."

Answer. I do.

22. Cross-question. And in that respect, as stated in the last question, the action produced by these outside apparatus when amplifying or oscillating is substantially the same in the 2-electrode as well as the 3-electrode hard or high-vacuum tubes?

Answer. I do not. You are talking about two different sets of outside apparatus and they must not be confused.

23. Cross-question. Have you examined prior to your direct examination claimant's Exhibit No. 225, opposite page 1527 of the printed record, and introduced during Mr. Weagant's deposition?

Answer. I have.

24. Cross-question. In view of your reference to the Fleming patent on your direct examination, I assume that you examined that patent prior to your direct examination. Will you now kindly compare the circuit of Figure 1 of the Fleming patent 803684 and Exhibit 225, above referred to, and state wherein you consider that Mr. Weagant used connections or arrangements of apparatus which were not in substantial accord with the diagram of Figure 1 of the Fleming patent.

Answer. Exhibit 225 has a plate battery in circuit not shown in Figure 1 of Fleming. It has telephone receivers [fol. 1653] instead of the indicator *I* of Figure 1 of Fleming. The diagram of the tube is entirely dissimilar to the extent that the plate does not surround the filament, as in Fleming. This I consider as vital, and in the experiment which Mr. Weagant performed, and to which his Exhibit 225 purports to pertain, I find that he stated in the text that he has used a coupling between the condenser R and the plate or the tube *a* which does not show in the Exhibit 225.

25. Cross-question. You mean to infer from your last answer that a 3-electrode high-vacuum tube could be made to

oscillate without the use of a plate battery which you object to Mr. Weagant's having used for that purpose?

Answer. I did not mean to infer from my last answer that a 3-electrode high-vacuum tube could be made to oscillate without the use of a plate battery, nor did I make any objection in that answer to Mr. Weagant's having used such a battery for this purpose. You asked me to point out if there was any substantial difference between the Fleming diagram and Exhibit 225, and I believe I have pointed out substantial differences and also the fact that Exhibit 225 is not in accordance with the text concerning Mr. Weagant's demonstration.

26. Cross-question. Do you consider the use of a plate battery by Mr. Weagant, as indicated in claimant's Exhibit No. 225, one of the elements constituting what you have termed a "trick" circuit?

Answer. The addition of such a battery to the Fleming circuit was undoubtedly made for the purpose of assisting in the production of oscillation; the real trick, however, consisted in coupling back the condenser R to the tube in such a way, as Mr. Weagant himself has pointed out, as to control electrostatically the electron flow from filament to plate.

27. Cross-question. Then you admit that Mr. Weagant did not attempt to in any way conceal the fact that one end of the condenser was so placed as to effect the electron stream in the circuit of claimant's Exhibit No. 225, and therefore you used the word "trick" as being an expert manipulation without any idea of concealing its real action, did you not?

Answer. I think that Mr. Weagant's statements made it perfectly clear to any engineer just how he was bringing about the result which he obtained, but I do think that, since the court is ordinarily not composed of an engineer or engineers, the slight difference which amounted to the trick might not readily be understood by the court in its consideration of the testimony placed before it in written form.

* * * * * * *

28. Cross-question. Do you still deny that a hard or high vacuum 2-element vacuum tube having the filament and [fol. 1654] plate arranged as indicated in claimant's Ex-

hibit No. 225, when used with the addition of other apparatus outside of the tube and affecting the tube or its action, is inherently capable of oscillating or amplifying?

Answer. If arranged as shown in the diagram, claimant's Exhibit No. 225, with the inductances well removed from the 2-electrode tube, as shown in the diagram, and with the condenser marked R so removed, as shown in the diagram, I maintain that even the vacuum tube introduced by Mr. Weagant can not be made to amplify or oscillate. Furthermore, that a 2-electrode tube, even such as he used, which was specially constructed for the purpose of permitting an outside action upon it, is not inherently capable of amplifying or oscillating in normal 2-electrode circuits.

* * * * * * *

29. Cross-question. Following the thought expressed in your previous answer, do you deny that if what you have referred to in your direct examination as "the addition of other apparatus outside of the tube and affecting the tube or its action" includes the necessary correct position of what you have termed "the inductances"; do you still deny that such a tube, as indicated in claimant's Exhibit No. 225 by letters a, b, and c, is inherently capable of oscillating by virtue of the control of electron stream between the filament and plate?

Answer. I never denied that such a tube was capable of oscillating by virtue of the control of the electron stream between the filament and plate exercised by the application of electrostatic control applied from without the tube. The quality of oscillation or amplification is inherent in the circuit and not in the tube, in my opinion.

30. Cross-question. Do you mean to imply by the last answer that an oscillating circuit which would ordinarily be used with a three element or two element high vacuum tube would oscillate with the tube removed?

Answer. If supplied with energy from an outside source, it would.

31. Cross-question. Will you kindly take a piece of paper and draw a circuit such as you may have had in mind in making your last answer.

Answer. This di-gram which I have made and marked "Manborgne sketch on cross-examination" illustrates a simple circuit from which the vacuum tube has been removed as shown by the dotted lines. The leads formerly

connected to the grid and plate terminals of the tube marked "G" and "P," respectively, have been connected by a wire. With the tube removed the circuit becomes a simple oscillatory circuit in which oscillations can be produced by the application of a high frequency from an outside source. In other words, the circuit reduces itself to a simple circuit having inductance and capacity in which oscillations will be set up and the presence of which can be determined by suitable means well known to the art. I did not intend to give the idea that the circuit of itself would be capable of the production of oscillations without the use of a vacuum tube and suitable means for coupling the plate and grid circuits.

[fol. 1655] 32. Cross-question. Have you ever tested a circuit like that illustrated in full lines in your sketch just made to ascertain whether it would oscillate and amplify like a vacuum tube in the circuits usually used with such tubes?

Answer. No; I have not, nor do I maintain that such a circuit will amplify or oscillate like a vacuum tube circuit using a vacuum tube and provided with proper arrangements for producing oscillation.

* * * * * * *

The Notary. Do you know any other matter or thing relative to the claim in question? If so, please state it.

Answer. I do not.

Mr. Vail. Counsel for claimant offers in evidence the sketch made by the witness as claimant's Exhibit No. 318, "Mauborgne sketch on cross-examination," and request that it be so marked by the notary.

Deposition of John M. Miller (recalled), for Defendants, Taken at New York City on the 2d to 11th days of October, A. D. 1928

Direct examination.

By Clifton V. Edwards, Esq.:

JOHN M. MILLER, being recalled as a witness on behalf of the defendant, testifies in answer to interrogatories as follows:

1. Question. Are you the same John M. Miller who has heretofore testified in this case?

Answer. I am.

2. Question. Have you read that part of the testimony of Roy A. Weagant, a witness for the claimant, in which he describes certain experiments which he considers to demonstrate that a 2-electrode vacuum tube is inherently capable of producing oscillations?

Answer. I have.

3. Question. Please consider the testimony of Mr. Weagant and say if you agree that Mr. Weagant demonstrated the capability of the 2-electrode vacuum tube to generate oscillations, and explain your reasons.

Answer. In my previous deposition in answer to question 4 (printed record, p. 758) I denied the statement that the 2-element valve, such as that of Edison or Fleming, possesses inherently the same capacity for generating radio waves as is possessed by the 3-element De Forest valve. I discussed the experiments of Mr. Weagant and Mr. Waterman before Judge Mayer, which were intended to prove that the 2-element device did have the capability. I pointed out that this demonstration was a "trick" demonstration—that with a critical amount of gas in the tube and with critical operating conditions the tube could be made to generate oscillations in a worthless manner.

By reason of this critical amount of residual gas and operating conditions the tube could be given a "falling characteristic," like that of the arc, and in a circuit similar to that of the arc could be made to generate unstable and varying oscillations. In doing this the mode of operation is totaliy different from the operation of the 3-electrode device of De Forest

[fol. 1656] I also pointed out that Mr. Waterman's testimony relative to this demonstration was not in accordance with the facts. Mr. Waterman stated that his operation "does not in any way resemble an arc." As a matter of fact the fundamental mode of operation was entirely similar to the operation of an arc, and the circuits employed were similar to those employed with the arc. These facts relative to the demonstration before Judge Mayer are not contradicted in the rebuttal testimony of Mr. Weagant and Mr. Waterman. In fact the plea of ignorance is now entered and Mr. Weagant states in answer to question 255 (printed record, p. 1714):

"At the time that the demonstration was made to Judge Mayer, while we had succeeded in making the 2-electrode

tube oscillate, we did not know the mechanism which was responsible for the action."

And later.

"The fact that the 2-electrode tube possessed the falling characteristic, which is also possessed by the arc, was quite unknown to any of the witnesses for the plaintiff at that time."

It is evident, therefore, that Judge Mayer was not informed as to the facts concerning this demonstration, but was in reality misinformed by Mr. Waterman with respect to a very vital fact.

In the present case we have another "trick" demonstration by Mr. Weagant, purporting to show that a high-vacuum 2-electrode tube is capable of generating oscillations and of operation as an amplifier. These demonstrations are based upon nothing more than a quibble on words, and it is hard to believe that they would be advanced seriously. They appear to me to be more satisfactory as demonstrations that the 2-element device is incapable of such operation, for, in order to make these demonstrations, Mr. Weagant has added to the 2-electrode device a third element which is identical in functioning and made of operation to the control member or grid of the De Forest device. The addition of this control member, even though it is less effective and partially disguised, makes a 3-element device out of the 2-electrode device and permits the 3-element operation.

In simple terms, what Mr. Weagant has done in these demonstrations is to employ circuits customarily employed with the 3-electrode device. He has positioned the portions of these circuits, which are normally connected to the grid of the 3-electrode device, very close to the walls of a specially constructed 2-electrode tube. These portions of the circuit, which are normally connected to the grid of the 3-electrode tube, have the same electrical condition or potential as the grid. Since these portions of the circuit have the same electrical condition or potential that the grid would have the electrostatic field from these portions would be similar to that of the grid, and if they are positioned near the electron stream from plate to filament within the tube this electrostatic field will operate in a manner similar to that of the grid, but less effective.

For example, we could start with a usual 3-electrode tube circuit including a 3-electrode tube and could continuously shorten the lead connecting the grid of the tube to the circuit. In doing this the portions of the circuit connected to the grid, and which have the same electrical conditions as the grid, would be brought closer and closer to the tube. [fol. 1657] The electrostatic field from these portions of the circuit would be additive to the electrostatic field and cooperate with the electrostatic field of the grid. If the tube is specially constructed so that it is possible to bring these portions of the circuit very close to the electron stream within the tube it is possible that this additive and cooperating field can be made sufficient to operate by itself, in which case the connection to the grid could be cut out the grid itself dispensed with. However, although the functioning is not as effective, it still remains the same in character, and we still have a 3-element device operating in a 3-element circuit. The device which was demonstrated was not a 2-electrode device, but a 2-electrode device to which a controlling element had been added, making it a 3-element device entirely similar to the De Forest 3-element device. In fact the De Forest 3-element device with the grid might just as well have been employed in these demonstrations in so far as these demonstrations prove anything.

That such an additional control element was added to the 2-electrode tube is shown by Mr. Weagant's testimony in explanation of these demonstrations. For example, in connection with the oscillation demonstration (claimant's Exhibit No. 225) in answer to question 5 (printed record, p. 1528):

"One side of condenser R, namely, the side which is connected to inductance *m*, is close to the glass of the 2-electrode tube at a point midway between the 2-electrode. This physical association of the apparatus results in the electric field which exists on condenser R effecting the electron stream which passes between the hot electrode *a* and the cold plate *c*, giving thereby an electrostatic control of the electron flow. As the result of this control, this arrangement is able to oscillate, since small electromotive forces on this condenser can release relatively greater amounts of energy flowing between the plate *c* and the filament *a*."

Thus Mr. Weagant is employing in this demonstration an electrostatic control element in addition to the 2-electrode tube, and it is this electrostatic control element which De Forest first introduced into the 2-electrode tube of Edison. In passing, I would like to draw attention to Mr. Weagant's use of the term "control" in the above answer. The way he has used it here is in accordance with the usage of the art. It is the way Doctor Van der Bijl used it in the quotations that I have taken from him, and it is the way that I have used it in my deposition. I shall have occasion later to point out that in other places both Mr. Weagant and Mr. Waterman have misused this term "control," and have used it in a manner not in accordance with the art.

Proceeding now to the amplifier demonstration (claimant's Exhibit No. 227), Mr. Weagant states in explanation of this demonstration at printed record, page 1530:

"In the arrangement of the amplifier tubes in the apparatus which I have just demonstrated the 2-element vacuum tube is arranged so that the glass of the tube is close to one end of the winding of the input circuit. This is illustrated in the diagram which I have produced, where it will be noted that one end of coils L_3, L_5, and L_7 are close to the 2-electrode tube. This end of the coil is what is commonly referred to as the high potential end, and it is the electric [fol. 1658] field from this coil which influences the electron stream in the tube, with the result that the 2-electrode tube functions as an amplifier."

Here again it will be seen that Mr. Weagant has added an additional element to the 2-electrode device which he now calls an "influence" instead of "control," as in the preceding answer. As he states, it is this added "influence" or "control" which makes possible the functioning of the device as an amplifier. The device again is nothing other than the 3-element De Forest device.

Again, in connection with claimant's Exhibit No. 301 (printed record, opposite p. 1770), which is cited by Mr. Weagant as showing the possibility of using a 2-electrode tube in a regenerative circuit, his explanation shows that he has added a third element in this case likewise. Thus, in his explanation, Mr. Weagant states near the bottom of page 1770.

"In the actual arrangement of the apparatus the upper end of the coil f^2 is placed as closely as possible to the space between the cold plate P and the filament F. Under these circumstances, the electrostatic field existing at the terminus of this coil influences the electron stream in the valve, and this, in conjunction with the feed back action between the coils f^3 and f^2, results in the production of sustained oscillations."

The circuit which Mr. Weagant is employing is identical with the 3-electrode tube circuit of plaintiff's Exhibit No. 114, excepting that Mr. Weagant has located the upper end of the coil f^2 which is normally connected to the grid of the 3-electrode tube close to the glass wall of the tube and hence close to the electron stream between the plate and the filament. This portion of the circuit has the same electrical condition as the grid and, as I have explained above, the electrostatic field from this portion of the circuit can function as a sort of inferior grid or control element. Thus, again, Mr. Weagant is utilizing nothing different from a 3-element device in a 3-element circuit. As he states, it is the added "influence" or better "control" which makes the production of sustained oscillations possible. The justification for these experiments seems to lie in a contention by Mr. Weagant and Mr. Waterman that there is a "control" and a "controlling action" in the 2-electrode tube. This is not at all correct. I have pointed out that Mr. Weagant, perhaps unwittingly, used the term "control" in its correct technical meaning and in accordance with the art of explaining his oscillation demonstration. Mr. Weagant and Mr. Waterman have used the same term "control" in connection with the 2-electrode tube and its operation where it does not apply. In the sense in which this term is used in connection with a 2-electrode tube it is broad enough to cover practically any case of the flow of electrical current in the electrical art. Such a loose use of a technical term, which has a definite meaning in the art, leads to confusion and can not be tolerated in a discussion of matters of invention where it is necessary to distinguish between different devices and different modes of functioning. The way Mr. Weagant and Mr. Waterman have used the term "control" in connection with the 2-electrode tube would enable this same term to be employed in connection with almost any electrical process. As a matter of fact, the

term "control" has a very definite meaning in the art, and the meaning corresponds with Mr. Weagant's use of the [fol. 1659] term in connection with his explanation of the oscillation demonstration.' The loose use of the term which follows can only be for the purpose of introducing confusion into the discussion of two devices which are different and have different modes of functioning.

The question naturally arises that if there is a "control" or "controlling action" in the 2-electrode device, why did Mr. Weagant have to add a control identical with that of the De Forest grid in order to make his demonstrations of oscillation generation and amplification? The answer is: There is no control in the 2-electrode device, and it was De Forest who first introduced a control and controlling action into that device. The Weagant demonstrations are, therefore, nothing other than demonstrations that the De Forest 3-element vacuum tube is capable of oscillation generation and amplification.

It is of interest to point out the things which Mr. Weagant did in making his demonstrations which have no foundation in the disclosure of the Fleming patent. First, Mr. Weagant used a special form of 2-electrode tube, differing widely from that disclosed in the drawings of the Fleming patent. Despite the fact that Mr. Weagant has taken out a number of patents (cross-question 26, printed record, p. 1539) concerned with an "outside control element or electrode," which is a modification of the De Forest device, and in fact similar to the device employed in his demonstrations, Mr. Weagant specified a variety of constructions (cross-questions 104, 105, printed record, p. 1537) in order to obtain one suitable for his purpose. In his answer to question 9 (printed record, 1529) Mr. Weagant describes the special form of 2-electrode tube which he used in these demonstrations, and it is interesting to compare this tube with the tube shown in Figure 1 of the Fleming disclosure. Thus the tube used by Mr. Weagant was long and narrow, approximately 1 inch in diameter and 4 inches long. The tube of Figure 1 of the Fleming disclosure in contrast is a short, thick tube. In the Weagant tube the plate element was a circular disk of metal slightly smaller in diameter than the inside of the glass tube, and spaced at a distance along the axis of the tube from the filament. In the Fleming disclosure the plate element was a cylinder of metal

completely surrounding the filament and spaced a considerable distance from the glass walls of the tube. Thus it is evident that the special tube employed by Mr. Weagant is so constructed as to make it easy to get an "outside control element or electrode" close to the space between the filament and plate inside of the tube which is carrying the electron stream. The tube shown in the Fleming patent is totally unsuited for this purpose. First, even if the external control element is located close to the glass wall of the tube, it would not be near the space between filament and plate which is carrying the electron stream, and furthermore the cylindrical metal plate surrounding the filament which Fleming employed would operate as a "shield" to prevent the electrostatic field reaching the space between the filament and the plate. Second, Mr. Weagant located particular portions of the apparatus close to the glass walls of the tube in order to obtain his result. Other portions of the apparatus would be neutral or have no effect, and in the case of oscillation generation might even act to oppose the generation of oscillation. There is, of course, nothing in the Fleming disclosure telling one to locate any portion [fol. 1660] of the apparatus close to the glass wall of the tube, and of course there is nothing instructing one to locate particular portions of the apparatus close to the tube. Third, the battery P of claimant's Exhibit No. 225, or the battery marked "180" at the right of Exhibit 227, is not shown in the Fleming disclosure, and in fact, as I will show, the use of such a battery in the Fleming circuit would be detrimental to the operation of the device, as Fleming described it. These batteries are the "B" battery of the De Forest 3-element device and are totally different in magnitude and in purpose from the so-called "biasing" battery which had previously been employed in some cases with detectors. The voltage of these batteries was very high (180 volts, cross-question 74, printed record, p. 1535-1536). This is even higher than the usual voltage of 115 volts, which is employed by power companies for power, lighting, and heating purposes. This voltage is the characteristic "B" battery voltage of De Forest, which is essential with an amplifying device. The so-called "biasing" voltage employed with detectors was normally of a few volts or a few tenths of a volt. As I have pointed out in my direct examination, in answer to question 18 (printed record, p. 791), the use of such a "biasing" voltage with

a detector may serve to make the detector more sensitive, but its use is optional and not necessarily required. The use of the De Forest "B" battery with the 3-element amplifier is indispensable.

These two uses of batteries for different purposes are well illustrated in Mr. Weagant's amplification demonstration, of which the circuit diagram is claimant's Exhibit No. 227. The battery marked "180" at the right of the figure is the "B" battery, and it is to be noted that this battery is connected through the coils L_2, L_4, L_6 to the plate elements of the vacuum tubes V_1, V_2, and V_3. These are the tubes which Mr. Weagant states are operating as amplifiers, and they are also provided with external control elements, viz., the coils L_1, L_3, and L_5 of which the high potential terminals are located close to the glass walls of the tube. In other words, these amplifying tubes have the De Forest "B" battery and have the third control element of the De Forest 3-element device. The tube V_4 is stated by Mr. Weagant to be the detector. The "B" battery is not connected to the plate of this tube and neither is this tube provided with a control element. The plate element of this tube V_4 is connected through coil L_7 and the indicating devices T_1 and T_2 back to one terminal of the filament, a circuit very similar to that of the Fleming disclosure. Instead, however, of the return of this circuit being connected to the negative terminal of the filament, as in the Fleming disclosure, the return in this case is to the positive end of the filament. This amounts to including in this circuit a small biasing voltage amounting to the drop-in voltage in the filament of the tube, or about 4 volts. This connection probably improves the operation of the tube V_4 as a detector over the connection where the return is made to the negative end of the filament without a biasing voltage.

[fol. 1661] As is shown by Mr. Waterman's drawing No. 6, plaintiff's Exhibit No. 323, which I will discuss later, the inclusion of a battery such as this 180-volt "B" battery in the circuit of the tube V_4 or in the circuit of the Fleming disclosure would be ruinous to the desired operation of the device as a detector. Thus Mr. Weagant's own diagram of his amplifier demonstration is a nice illustration of the difference in magnitude and functioning of the "B" battery as employed with an amplifier and a biasing battery as employed with a detector.

Fourth, in connection with Mr. Weagant's oscillation demonstration, there is also another particular feature which does not originate in the Fleming disclosure. In order for oscillations to be obtained with the circuit of claimant's Exhibit No. 225 and in accordance with Mr. Weagant's explanation, it is necessary that there be definite connections between the coil system *m*, *k*, and the rest of the system and a definite sense of winding of the coils *m*, *k*. Thus if the connections to either coil *m* or coil *k* were reversed, or if the sense of winding of either of these coils were reversed, the action would be such as to oppose the generation of oscillations instead of favoring them. In order that oscillations can be generated it is necessary that the connections and sense of winding of the coils *m*, *k* be such that during an oscillation the upper part of coil *m* is positive in polarity at the same instant that the upper end of coil *k* is negative in polarity. This is a fact well known in connection with 3-element vacuum tube operation, and in fact this demonstration is nothing but a demonstration of a 3-element device. I find no instructions in the Fleming disclosure specific as to the connections or sense of winding of the similarly lettered coil system in that disclosure. In fact there is no reason why there should be such instructions in this disclosure, for it has no effect upon the operation of the Fleming device as a detector.

4. Question. Do you agree with the testimony of Mr. Weagant (R. 1705) to the effect that the grid added no new mode of operation to the 2-electrode tube?

Answer. I do not agree with Mr. Weagant's statement to the effect that the grid added no new mode of operation to the 2-electrode tube, and excepting a possible quibble on words the statement is contrary to facts. The term "grid" is symbolical of a control element which De Forest was the first to employ with a 2-electrode device. By a control element I mean an element which by the effect of its electrostatic field and without requiring or consuming appreciable energy, is capable of controlling the electron stream between the plate and filament elements of the tube. Without this control element the 2-electrode device is only capable of operating as a rectifier. With this control element the 3-element device is capable of operation as an amplifier. Thus the 3-element device has an entirely new mode of operation from that of a 2-electrode tube.

The term "grid" carries with it more significance than merely a structure. In De Forest's earliest patent, showing the control element (Patent No. 841,387, claimant's Exhibit [fol. 1662] No. 270) this control element takes the form of a plate (D' of fig. 2). A little later (patent No. 879,532, defendant's Exhibit K) De Forest showed the control element as a grid-like structure interposed between the filament and the plate. In Mr. Weagant's patents, mentioned on page 1539 of the record, and considerably later in date, the control element takes the form of a plate surrounding the glass wall of the tube. In Mr. Weagant's demonstrations the control element is likewise located outside of the tube and takes the form of the metal of a condenser or the end of a coil. Of all of these forms of control element, the grid control element is most effective, and the term "grid" is therefore synonymous with a control element.

All of these forms of control element operate the same, the only difference being in the degree of effectiveness. De Forest was the first to have introduced the control element and to have obtained the new mode of operation resulting therefrom, and excepting for a quibble on words, Mr. Weagant's statement is contrary to the facts.

5. Question. Will you refer to the testimony of Mr. Weagant, at record 1706, relative to the 3-electrode tube having a falling characteristic, and say to what extent you agree with Mr. Weagant?

Answer. Mr. Weagant was asked to state whether and under what conditions a high-vacuum 2-electrode tube involves an action having a falling characteristic. I have shown that the characteristics of a high-vacuum 2-electrode tube are always rising characteristics, and hence the answer is that a high-vacuum 2-electrode tube never involves an action having a falling characteristic. Mr. Weagant, in the first part of his answer, states that he has demonstrated that a high-vacuum 2-electrode tube will generate oscillations, and in the remainder of his answer deals with 3-electrode tubes. As I have pointed out, Mr. Weagant's demonstrations did not employ a high-vacuum 2-electrode tube, but did employ a 2-electrode tube with an added control element or 3-element device, so that Mr. Weagant's answer deals throughout with 3-element devices and operation. Apparently his answer is intended to show that

3-element devices can show a falling characteristic and operate by reason of a falling characteristic.

The De Forest device in this issue does not have a falling characteristic, and does not operate by reason of a falling characteristic, but operates with a rising characteristic by reason of the controlling action of the third element. Any device, whether it has two electrodes or three, if it operates by reason of a falling characteristic, is a different device from the DeForest device employed by defendant.

Mr. Weagant refers to a 3-element device of a patent to White, No. 1393594, and to another 3-element device, called the "dynatron," described in an article by Doctor Hull, of the General Electric Co. Mr. Weagant states that both of these devices are 3-element devices which show falling characteristics and operate by reason of these falling characteristics.

It is a fact that the devices shown in these references do operate by reason of a falling charactertistic, and it is also a fact that they are fundamentally different in operation [fol. 1663] from the De Forest device in this issue—a fact which Mr. Weagant's references themselves are sufficient to show.

First, let us consider the White patent. Mr. Weagant did not quote enough from Mr. White's disclosure. Thus, starting at line 16, page 1, Mr. White states:

"Electron discharge devices of the type comprising an evacuated container inclosing a filamentary cathode, a plate-shaped anode, and a grid, interposed between cathode and anode, are well known. Various connections have also been employed with such devices to cause them to operate to produce high-frequency oscillations. In all of the connections which have previously been used, however, so far as I am aware, the same fundamental principle has been employed; that is, a portion of the amplified energy in the plate circuit of the device has been fed back to the grid circuit by some form of coupling so as to make the system self-exciting."

This prior use to which Mr. White refers in this paragraph is the use of the DeForest device as an oscillation generator as employed by defendant and as I have explained the operation in my direct examination. Mr. White then proceeds to explain his invention, and continues:

"In carrying my invention into effect, however, I employ a materially different principle. I have found that under certain conditions with devices of this type the current in the grid circuit may have a dropping characteristic; that is, as the voltage impressed upon the grid increases the current in the grid circuit will decrease."

Thus Mr. White himself points out that by employing a 3-electrode device which operates by reason of a "dropping characteristic" he is employing a "materially different principle" from that of defendant's De Forest device. As a matter of fact this "materially different principle" of operation results from the ionization of residual gas in the vacuum tube, which leads to this "dropping characteristic," and is quite similar to the "gas" demonstration before Judge Mayer, which was likewise an operation which depended upon ionization of residual gas and a falling characteristic. Mr. Weagant states that the tube employed by Mr. White had a very good vacuum, and he finds in an obscure corner of the patent that Mr. White employed a plate voltage of 375 volts, which indicated that the vacuum was good. However, Mr. Weagant passed over Mr. White's statement on page 2, line 7, as follows:

"This characteristic of the current curve is probably due to the effect of slight traces of residual gas in the device and the consequent positive ionization. The greater the negative grid voltage the lower the plate current, and therefore the lower the amount of positive ionization in the device due to residual gas therein."

Thus Mr. White points out that the different principle which he is employing to generate oscillations depends upon gas ionization just the same as the gas demonstration before Judge Mayer depended upon gas ionization. This gas characteristic, which Mr. White employed, is quite well known and well understood, and anyone at all conversant with vacuum tube devices should be familiar with this whether Mr. White pointed it out or not. In fact this very characteristic which Mr. White employs for oscillation generation is the basis of a widely used test to determine when [fol. 1664] the vacuum in a 3-electrode tube is defective. Thus this very characteristic has been employed by the United States Signal Corps and by the United States Navy as an acceptance test for 3-electrode vacuum tubes, and

these tubes are accepted on the basis that this gas ionization characteristic shall be absent to an extent that it will be negligible in the operation of the tubes under normal operating conditions. Thus Mr. Weagant's own reference shows that the White 3-electrode device, in so far as it depends upon this dropping characteristic, is a totally different device from the De Forest device in this issue.

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Mr. Weagant then refers to the "dynatron" of Doctor Hull as being another 3-electrode device having a falling characteristic. This device is described in a paper by Doctor Hull in the Proceedings of the Institute of Radio Engineers, which is claimant's Exhibit No. 262. The "dynatron" of Doctor Hull is a 3-electrode device which has a falling characteristic and operates by reason of this falling characteristic. The characteristic in this device does not depend upon gas action, but upon a phenomena called "secondary emission." Since the device is a high-vacuum device it is thoroughly dependable in operation and probably would have wide use excepting for the prior De Forest device over which it has no advantage and some practical disadvantages. Its mode of operation is entirely different from that of the De Forest device and depends, as I have said, upon what is called "secondary emission" of electrons. An electron moving at a very high velocity and striking a metal plate can dislodge one or more electrons from the metal plate, and this is called "secondary emission."

In the "dynatron" this effect leads to a falling characteristic like that of the arc, but not due to the ionization of a gas, as in the arc. By reason of this falling characteristic, the "dynatron" can operate as an amplifier, and in a circuit resembling that of the arc can operate as an oscillation generator.

The device has a filament which emits what we will call "primary electrons," a gridlike structure maintained at a high positive voltage, and which operates to give these "primary electrons," a gridlike structure maintained at a a plate maintained at a lower positive voltage which is bombarded by the high-speed primary electrons and emits secondary electrons as a result of the bombardment. The gridlike electrode also operates as a collector for these secondary electrons emitted by the plate. The net result of this action is to give the plate circuit of the device a fall-

ing characteristic, and excepting for the action of the grid-like element in giving the plate circuit this falling characteristic the gridlike structure does not enter further into the operation of the device. In so far as connections are made between the outside circuits for utilizing the device these connections are made solely between the plate electrode and the filament electrode, and therefore in its utilization it is practically a 2-electrode device possessing the falling characteristic. The circuit employed with the device is likewise similar to that employed with the arc or other 2-element device possessing a falling characteristic. [fol. 1665] The grid electrode of the De Forest device is never employed with a steady high positive voltage in practice; usually it is made negative instead. It is evident that the "dynatron" is an entirely different device, that it operates in a totally different manner and on a totally different principle.

While Mr. Weagant refers to Doctor Hull's paper on the "dynatron," claimant's Exhibit No. 262, he neglects to quote a part of this paper which is very important, for Doctor Hull very definitely points out that the 2-electrode rectifier, the De Forest 3-electrode device, and the "dynatron" are three devices fundamentally different in principle and operation. In this paper Doctor Hull makes use of the General Electric Co. trade names "Kenotron" rectifier for the high-vacuum Edison device, "Pliotron" for the high-vacuum De Forest device, and "Dynatron" for his own device. On page 5 of this reference Doctor Hull states:

"In construction the dynatron resembles the kenotron rectifier and the pliotron. In principle and operation, however, the three are fundamentally different. Each utilizes a single important principle of vacuum condition. The kenotron rectifier utilizes the unidirectional property of the current between a hot and cold electrode in vacuum. The pliotron utilizes the space charge property of this current, which allows the current to be controlled by the electrostatic effect of a grid. The dynatron utilizes the secondary emission of electrons by a plate upon which the primary electrons fall."

Thus the dynatron, though a high-vacuum device, is similar to the "gas" tube demonstrated before Judge

Mayer in that both have falling characteristics, and by reason of the falling characteristics can operate as amplifiers or oscillation generators. The high-vacuum 2-electrode tube is only a rectifier. The De Forest device is fundamentally different in principle and operation from all of these. It will be noted that while Mr. Weagant and Mr. Waterman have misused the term "control" time after time in discussing the 2-electrode tube, Doctor Hull does not use this term in connection with the 2-electrode tube or the dynatron, but in accordance with my use and that of the art reserves it for the functioning of the grid electrode of the De Forest device.

I have previously quoted in several places from Doctor Van der Bijl's book on vacuum tubes, which quotations show that he also uses this term "control" as a distinguishing term for the operation of the grid electrode in the De Forest device. Thus it appears that Mr. Weagant and Mr. Waterman differ from the art both in respect to the use of the technical terms employed in describing the operation of these devices and also with respect to the fundamental principles which underlie the operation of these various devices.

This matter of distinguishing between a device operating by reason of a falling characteristic and the De Forest device, which operates by reason of a controlling grid, is a proposition which, as I pointed out in my direct examination at question 5 (printed record, p. 763) came up before Judge Mayer at a later date in the case of Hewitt *v.* American Telephone & Telegraph Co. In this later case Judge Mayer was fully informed as to the fact that the Hewitt device operated by reason of a falling characteristic, and he recognized the fundamental difference in principle of operation of such a device and of the De Forest device.

[fol. 1666] The remainder of this answer of Mr. Weagant deals with the matter of "negative resistance reaction" and "alternating current negative characteristics." The terms, which I will show, are of no significance in differentiating as to the fundamental principle of operation of these various devices. Thus (printed record, p. 1701), Mr. Weagant states that we must consider both the device and its circuits, and that when we do this the various systems can show what he calls "negative resistance reaction" or "alternating current negative characteristics," as proven by his experiments on the circuit of Weagant sketch No. 4.

or the patent No. 1334165 to Pupin and Armstrong. Just what his point is here is not very clear. These terms mean nothing more than that a device with its circuits which shows these effects is capable of approaching the oscillating condition or of operation as an oscillator. They do not distinguish at all with respect to the fundamental principle of operation which makes this possible. The high vacuum 2-electrode device which can not either approach the oscillating condition or function as an oscillation generator is likewise incapable of showing "negative resistance reaction" or "alternating current negative characteristics." The "gassy" 2-electrode device, as demonstrated before Judge Mayer and which operates by reason of a falling characteristic, can show this "negative resistance reaction" and "alternating current negative characteristics." The 3-electrode device of De Forest, which operates by reason of the added control element, can also show this "negative resistance reaction," or "alternating current negative characteristics." As I have stated above, these terms mean nothing more than that the particular device with its circuits can approach the oscillating condition or operate as an oscillation generator. It is conceivable that we might have a dozen such devices, such as the arc, gassy 2-electrode tube, dynatron and De Forest 3-element device, all of which are capable of approaching the oscillating condition but do so with wide differences in the fundamental mode of operation. Therefore these terms employed by Mr. Weagant have no significance in differentiating between devices which are totally different in operation.

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6. Question. In Mr. Waterman's answer to question 14 (printed record, p. 1919) he criticizes your explanation of the fundamentals on which the operation of these vacuum devices rests and introduces Waterman's drawings 5 and 6 to illustrate correct comparisions of the 2 and 3 electrode devices. Do you agree with this testimony?

Answer. Mr. Waterman prefaces his answer to this question by stating that the testimony of Doctor Millikan and myself was given in 1923, the Fleming patent, applied for in 1905, and the De Forest grid patent in 1907, and that we were entirely unable to get back to the fundamental basis on which these structures rest. Mr. Waterman states that he will endeavor to get back to the fundamentals in-

volved which constituted the great disclosure of Fleming on which the whole radio art of vacuum tube devices rests. I have discussed these fundamental matters in my answer to question 28 (printed record, p. 823). I showed there [fol. 1667] that the 2-electrode device goes back to Edison in 1883, who discovered the property of unilateral conduction possessed by that device. I also pointed out that prior to the Fleming disclosure, the 2-electrode device was a well-known rectifier of alternating currents to Howell, Wehnelt, and Fleming himself. I also pointed out that prior to the Fleming disclosure, and through the work of J. J. Thomson, O. W. Richardson, and others, the fundamental features underlying the operation of this device were well understood. So that the knowledge necessary for Doctor Millikan and myself to discuss the operation of the 2-electrode device of the Fleming disclosure was all available prior to the date of that disclosure. It is true that subsequent to 1907 much knowledge has been added with respect to the 3-element device of De Forest. Such knowledge, however, merely insures that Doctor Millikan and myself could speak as to what the operation of the De Forest device must have been in 1907 with decided confidence.

Now let us look at the uses and development of the two devices, the 2-element and the 3-element, in the electrical art, and see if the whole radio art of vacuum tubes rests upon the "great discovery of Fleming." As I have pointed out, the 2-electrode device was a well-known rectifier of alternating current prior to the Fleming disclosure. Two electrode tubes have been continuously employed as rectifiers of low-frequency alternating currents, and at the present date are widely used as such in the electrical art and specifically in connection with radio signals. They are not used as radio detectors, but the primary use is to rectify low-frequency alternating currents to supply direct current power to radio receiving sets. The old 2-electrode tube is used to some extent but more frequently it is a type of double 2-electrode tube in one evacuated inclosure; that is, the single-plate electrode of the earlier structure has been divided into two parts, each of these parts operating as separate rectifiers in exactly the same manner as the single plate element of the old device. It is called a double wave or biphase rectifier, it serves to rectify both halves or alternations of the current wave.

and is similar in result to what Fleming obtained with two separate rectifying devices in his Figure 2 of the Fleming disclosure, or what Valbreuze similarly obtained by the use of two separate rectifying devices in his prior French patent No. 328687, which I discussed in my direct examination.

Thus the use of a 2-electrode Edison device as a rectifier of alternating currents, in particular of low frequency, which started prior to the Fleming disclosure, still continues up to the present day. What Fleming did in his disclosure was to substitute this well-known rectifier of alternating currents for another well-known rectifier of alternating currents in the circuit of the prior Valbreuze patent. The result is the same in both cases; that is, the device functions as a rectifier of high frequency alternating currents, or a detector. This, I pointed out in answer to this same question 28 (printed record, p. 826) and illustrated in Miller drawing M, opposite page 826. I also pointed out that this was an obvious step, that sufficient exact information was available prior to the Fleming disclosure to predict that the 2-electrode Edison device would operate just the same as a rectifier of alternating currents, whether the frequency be high or low. I have also pointed out that [fol. 1668] this step was also a failure as far as practical results are concerned, and that the use of the 2-electrode device as a rectifier of high-frequency alternating currents or detector made no impression upon the radio art. The art has used, and continues to use, ~~the~~ 2-element device as a low-frequency rectifier, whereas the Fleming use has proven to be an insignificant offshoot of this low-frequency use.

The De Forest 3-element device likewise originated and had its first wide use as an amplifier of low-frequency alternating currents. Thus the earlier De Forest patent, No. 841387 (claimant's Exhibit No. 270), to which Mr. Waterman has referred, was concerned with the amplification of low or audio frequency alternating currents. The first wide use and perhaps the most important use of the De Forest amplifier was in connection with ordinary telephony over wires. It is this device which made practical long-distance telephony possible, and even to-day it is a question as to whether this use is not the one of greatest utility to mankind. The first use of the De Forest device by the United States Navy in connection with radio signaling was this same use of the device as an amplifier of

low-frequency alternating currents. At a later date other important uses of the De Forest device were discovered, all of which, however, are fundamentally based upon this amplifying property which originated and first developed at low frequencies. These important properties were regenerative amplification, oscillation generation, and radio-frequency amplification, and it is by reason of all of these properties, all based on the amplification property, that the 3-element De Forest device has found wide use in connection with radio signaling. In combination with one of these amplifying properties, the De Forest device has also been used as a detector of radio waves. The detecting function, however, has been of little importance and is not responsible at all for the wide use of this device in radio. As I pointed out in my direct examination, in any of the uses of the De Forest device as a combined detector and amplifier, the well-known crystal detector could be substituted for the detecting function without any loss in results, in some cases with even better results, and in no case with more loss than a mild inconvenience. Thus it is evident that the Fleming disclosure amounted to nothing more than an unimportant offshoot of the prior Edison device, and it is not in accordance with fact to state that the whole radio art of vacuum-tube devices depends upon this disclosure of Fleming which made no impression upon the art, in particular when this radio art of vacuum tubes is largely comprised of the 3-element De Forest device which had its origin as a low-frequency amplifying device and which stands upon its own legs, whether it is used at high or low frequency.

On page 1923 Mr. Waterman refers to my drawing, "Miller drawing B," opposite printed record, page 765, and which is a comparison of the operation of a 2-electrode rectifier and a 3-electrode amplifier, and he states that this drawing does not illustrate these two devices under similar conditions and therefore is a misleading diagram. Mr. Waterman then produces two diagrams, "Waterman draw[fol. 1669] ing No. 5" (claimant's Exhibit No. 322), and "Waterman drawing No. 6" (claimant's Exhibit No. 323) in which he proposes to compare these devices in the way that it should be done. The 2-electrode rectifier and the 3-element amplifier are two devices which function in a totally different manner and operate under different operating conditions. When it is attempted to operate either

one of the devices under the operating conditions of the other device the characteristic operation is destroyed. In Waterman drawing No. 5 Mr. Waterman is attempting to operate the 3-element De Forest device under conditions similar to those of the 2-element rectifier. In doing this he destroys the fundamental function of the 3-element device which is that of amplification. In this Waterman drawing No. 5 Figure 1 is the same as Figure 1 of my "Miller drawing B," and correctly represents the functioning of the 2-electrode vacuum tube as a rectifier which is its only useful function. In Figure 2 of this drawing Mr. Waterman attempts to employ the 3-electrode device under similar conditions. In doing this he has left out any connection to the plate element, so that the device has no plate circuit, and he has likewise left out the B battery which is a characteristic of the 3-electrode operation. In Figure 3 of this drawing in another attempt to employ the 3-electrode tube under conditions similar to the 2-electrode tube there is again the absence of the B battery, and furthermore the grid of the 3-electrode device is connected to nothing, and hence left out in the cold. Mr. Waterman states that the results indicated by the diagrams below, the individual figures are identical. This is a fact. The 2-electrode device of Figure 1 is a rectifier and a rectifier alone and the result of its operation as shown below the figure is that of rectification. The identical results obtained in Figures 2 and 3 show that when it is attempted to employ the 3-element amplifying device of De Forest under conditions similar to those of the 2-electrode device, it loses its characteristic amplifying property and degenerates into nothing more than a rectifier. Defendant has not employed the 3-element device in circuits like these of Figures 2 and 3. In fact, it is obvious that the 3-element device can not function as a 3-element device under these conditions. In Figure 2 there is no plate circuit and no B battery, hence there is no plate current for the grid electrode to control. In Figure 3 there is no B battery and no plate current for the grid to control and there is no grid circuit by which a controlling voltage can be applied to the grid electrode. As circuit diagrams of the 3-element device these diagrams are truly absurd.

In Waterman drawing No. 6 the attempt is made to operate the 2-electrode device with a B battery and to get an operation similar to that of the 3-electrode device. This

is even more absurd though perhaps not as obvious. The addition of a B battery to the 2-electrode device not only does not give it any of the amplifying property of the 3-electrode device, but actually takes away from the 2-electrode tube, its only useful mode of functioning; that is, rectification. Figure 2 of this Waterman drawing No. 6 is taken from "Miller drawing B," and represents in simple form the functioning of the 3-element De Forest device as an amplifier. The wavy curve below this figure represents the alternating component of current in the plate or output circuit and which flows through the indicator I. In wave form this is a reproduction of the alternating volt- [fol. 1670] age applied to the grid or input circuit, the source of which is represented on the left of the figure by an alternator. What this figure does not show by itself, but which I have explained in connection with this same figure at the bottom of page 767 of the record, is the fact that the power represented by this alternating current which flows through the indicating device is many times, perhaps thousands of times, as great as the power which must be supplied by the alternator or alternating voltage applied to the grid or input circuit. This input alternating voltage may, for example, be the weak telephone signal at the end of a long telephone line, while the output device or indicator may be a telephone receiver and the power represented by the current flowing through this receiver will be many times the original signal and hence correspondingly louder. The two fundamental requirements of an amplifying device are first, the wave form of the alternating current in the output of the device should be a duplicate of the alternating voltage applied to the input; second, the power represented by this output current should exceed the power which is required to be supplied in the input of the device. In Mr. Waterman's Figure 1 of this drawing No. 6 where the attempt is made to operate a 2-electrode device with a B battery, it is true that a similar wavy current curve is obtained. However, the alternating current which this wavy form of curve represents flows in a single circuit in which the alternator, the indicator I, and the vacuum tube are in series. The alternating current which flows in this series circuit is produced by the alternator itself and all of the power represented by this current is supplied by the alternator. Since this is the case we are not dealing with amplification. In fact,

the same identical result would be obtained if the vacuum tube in this figure were replaced by an ordinary resistance of suitable magnitude, such as a wire coil. Conditions are the same or worse in Figure 3 of this Waterman drawing No. 6 which again purports to show the use of a 2-electrode tube with a B battery. In this case the alternator supplies alternating current through the condenser and then through the indicator I and the vacuum tube in parallel. The alternator must supply all of the power both for the current which flows through the vacuum tube and the current which flows through the indicator. Only the latter is useful, hence the operation would, if anything, be improved if the vacuum tube were entirely omitted. Since the alternator again supplies at least all of the useful current flowing through the indicator, we are again not concerned with amplification. Therefore, the use of the B battery with the 2-electrode device does not make an amplifying device out of it. What, however, is still more serious is the fact that by trying to utilize a B battery with the 2-electrode device, Mr. Waterman has destroyed its only useful function, that of a rectifier. In all of the figures the dash line in the lower portion of the figure represents the steady current which is drawn from the B battery. Superimposed upon this is the wavy curve form which represents the action of the alternator. It will be noted that in all three of the figures this wavy curve is symmetrical with respect to the dash line, or, in other words, a rising portion of the curve above the dash line is immediately followed by a portion similar in shape below the dash line. The portion above the line leads to an increase in current, but it is immediately followed by a corresponding portion below the dash line [fol. 1671] which cancels and annuls it so that the average current is unchanged by the action of the alternator and is just the same as the steady current drawn from the B battery. The function of a rectifier is to convert from alternating current into direct or continuous current. Since the direct current is unchanged in these figures by the action of the alternating voltage there is no conversion from alternating current to direct current and hence no rectification. Thus, in Figures 1 and 3 the 2-electrode tube not only does not function as an amplifier by reason of the addition of a B battery, but actually loses the capability of operating as a rectifier. In Figure 2 the 3-electrode vacuum tube with a B battery is exhibiting its character-

istic operation as an amplifier and likewise is not operating as a rectifier. Thus, Figures 1 and 3 of this Waterman drawing No. 6 are worthless and represent no useful function. Neither these figures nor Figures 2 and 3 of his drawing No. 5 show anything of value in this issue. Earlier in this answer, on page 1921, Mr. Waterman states "De Forest improved the Fleming 2-element vacuum tube by putting into it the third or grid element. That it was an improvement no one would deny, but he did not thereby take away from the device any of its former properties." The proper statement would be that De Forest converted the Edison 2-element rectifier into a device capable of an entirely new operation, amplification, by inserting in the Edison device a third or control element by using with it a B battery and by employing it in new circuits. In the earlier De Forest patent, as I have pointed out, the device was used as an amplifier for speech or telephony. In order that the device shall operate to reproduce speech distinctly and faithfully or to operate as a "distortionless amplifier" it is essential that rectification be absent to an extent as to be negligible. In Figure 2 of Waterman's drawing No. 6, which is also my drawing and which represents the operation of the 3-element device as an amplifier, I have just pointed out that rectification is absent. Thus the second part of Mr. Waterman's statement is not in accordance with the facts, for the essential step which De Forest took in converting the 2-electrode rectifier into a 3-electrode amplifier was to take away the property of rectification. Later, on page 1924, Mr. Waterman states after discussing the introduction of the grid into the tube by De Forest, "But in adding this device, De Forest did not abandon anything which Fleming had, nor anything which affected the fundamental mode of operation, by electrostatically controlling the emitted electrons. On the contrary, what he did was to perfect and extend this control." What I have just pointed out is the fact that the fundamental thing which De Forest did was to abandon the rectification of the 2-element device and obtain a new device, an amplifying device. With respect to abandoning the electrostatic control of the emitted electrons, it was impossible for De Forest to abandon something not possessed by the Edison or Fleming device. In this answer Mr. Waterman not only confuses the two totally different functionings of rectification and amplification, but he also is confused in his

use of the term "control" to describe these two different operations, and he seems to consider amplification to be nothing different from improved rectification. In my direct examination in answer to question 6, printed record, page 764, I explained very carefully the difference between the functioning of an amplifier and a rectifier, and in particu-[fol. 1672] lar on page 766 pointed out "the function of an amplifier is to keep the character of the alternating quantities unchanged but to increase their power. This is quite the opposite from the function of a rectifier which is required to change the character, viz., convert from alternating current to direct current and in which the power is all supplied by the source." To summarize, the 2-electrode tube is a rectifier and nothing but a rectifier. The 3-element De Forest device is an amplifier, and it is this property of amplification which is entirely responsible for its wide use in the electrical art. It is obvious, therefore, why, in my direct examination in connection with Miller drawing B, I passed directly from the description of the 2-electrode device as a rectifier to the 3-element device of De Forest as an amplifier without interposing worthless diagrams such as those introduced by Mr. Waterman in his drawings Nos. 5 and 6.

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Cross-examination.

By Mr. Vaill.

7. Cross-question. In your answer to question 3 in which you made some rather severe criticisms of Mr. Weagant's demonstrations relating to the capability of the 2-electrode tube to oscillate, I would ask you to compare Figure 1 of the Fleming patent No. 803684 in issue (plaintiff's Exhibit No. 22) with claimant's Exhibit No. 225 (opposite page 1527 of the printed record) and to state as a matter of fact whether the arrangement illustrated in claimant's Exhibit No. 225 includes all of the circuit arrangements of Figure 1 of the Fleming patent except that the variable condenser R has been added in the antenna circuit for the purpose of tuning, a battery P has been added to the plate circuit through the coil k, and a variable resistance R_1 has been added for the purpose of adjusting the amount of the filament current.

Answer. With these exceptions stated in the question, and with some more exceptions, there is a resemblance between the circuit diagram of Exhibit 225 and Figure 1 of the Fleming disclosure. One exception additional to those cited in the question is the construction of the vacuum tube shown in Exhibit 225 as compared with the construction shown in Figure 1 of the Fleming disclosure. In my answer to question 3 I called particular attention to the difference in construction in the two tubes illustrated in these respective diagrams, and pointed out that the tube employed by Mr. Weagant in his demonstration was one particularly suited for the application of an additional control element, whereas the tube disclosed in Figure 1 of the Fleming patent is entirely unsuited to this purpose. I note another apparent difference in the two diagrams, that is, that while in the coil system *k*, *m* of the Fleming disclosure, the sense [fol. 1673] of winding of the two coils as indicated by the spirals employed to designate these coils seems to be the same, whereas in the circuit diagram of Exhibit 225 the spirals representing the coils *m*, *k* indicate that the two coils have opposite senses of winding. This difference in claimant's Exhibit No. 225 may be accidental or intentional—at any rate, as I have pointed out in this same question 3, it was necessary for Mr. Weagant to have a definite sense of winding in this coil system *m*, *k* in connection with proper connections between these coils and the other elements of the circuit in order to make his demonstration, whereas in so far as the purpose of the Fleming disclosure is concerned, the matter of this sense of winding or of connections is of no importance.

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8. Cross-question. Was your use of the word "trick" in your answer to question 3 intended to imply an attempt to mislead the court as to actually what took place during Mr. Weagant's demonstrations on account of any failure of Mr. Weagant to disclose during the demonstrations anything which should have been disclosed, or are you using the term simply as indicating that an expert radio engineer arranged the circuits in an efficient way to produce the desired results?

Answer. My use of the word "trick" in answer to question 3 was not intended to imply an attempt to mislead the court or any failure of Mr. Weagant to disclose anything

which should have been disclosed. In fact it will be noted that in discussing these demonstrations I employed and quoted Mr. Weagant's explanations throughout. On the other hand, I did not use the term simply as indicating that an expert radio engineer arranged the circuits in an efficient way to produce the desired results corresponding with the latter part of the question.

9. Cross-question. If you did not use the term as stated in the last sentence of your previous answer, what did you intend to imply by it?

Answer. I intended to imply by the use of the word "trick" the same meaning that would be implied in speaking of the "trick" of a magician. The trick of a magician comprises doing something that is well recognized as being something impossible to perform. The demonstration of Mr. Weagant purported to be the demonstration of the generation of oscillations by a high-vacuum 2-electrode tube. The high-vacuum 2-electrode tube does not possess this capability, which is a matter well known and well understood by those skilled in the art. Therefore Mr. Weagant's demonstration was an attempt to demonstrate something not possible of demonstration. Just as in the case of the magician's trick, there is an explanation as to how the trick was done. I pointed out that in the case of Mr. Weagant's demonstration, this demonstration was made possible by the addition of a third, or control, element. The facts upon which I base this statement are contained in Mr. Weagant's testimony, but he does not put these facts in the form in which I have put them and in which the fact that he was employing the 3-element device and not a 2-element device becomes completely evident.

[fol. 1674] 10. Cross-question. It is true, is it not, that in the work of a magician or a prestidigitator, the attempt is always to conceal from his audience the facts or means employed to produce a particular result with a certain set of materials which is well within the vision of the audience. In other words, the purpose of the work of a magician or prestidigitator is to mystify and to produce results apparently contrary to well-recognized physical laws. You did not use the word "trick" in this sense, did you?

Answer. The avowed intent of Mr. Weagant in this demonstration was to show that a high-vacuum 2-electrode vacuum tube was capable of operating as an oscillation generator. This is a result contrary to well-recognized physical

laws. In this respect there seems to me to be a resemblance between this demonstration and the trick of a magician. It is true that Mr. Weagant gave a technical explanation as to how his results were obtained, which made it very evident to me how the trick was performed. On the other hand, he does not give the very simple and nontechnical explanation of his demonstration which is possible; that is, that the device was not a high-vacuum 2-electrode device, but a device comprising a third element, or control element. Thus, as far as results which this demonstration purports to produce, the use of my term "trick" seems to be appropriate, and in so far as the explanation of the operation was not reduced to the simplest possible terms, there is a possibility that the way in which the trick was worked might not be entirely clear to everyone.

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11. Cross-question. Assuming that you have read the stipulation on page 1546 of the printed record regarding the amount of vacuum in the tubes used by Mr. Weagant in his demonstrations, I show you tube No. 665 mentioned in said stipulation and which was offered in evidence as a part of "Claimant's Exhibit No. 224." This is a 2-electrode vacuum tube having two conductors adjacent but not touching each other inclosed therein, one of said conductors adapted to be heated by a battery and the other conductor, the circular plate, being an opposed electrode, is it not?

Answer. This tube No. 665 appears to me to be a 2-electrode vacuum tube as described in the latter part of the question, excepting that I do not know what is meant by "opposed electrode."

12. Cross-question. You understand, do you not, that this tube was used in Mr. Weagant's demonstration in which oscillations were produced, in the identical physical form that it is now submitted to you for examination, referring particularly to the tube as shown in the photograph, claimant's Exhibit No. 228, opposite page 1528 of the printed record?

Answer. In so far as the tube per se is concerned, I have no reason to doubt that this physical form of tube was employed in Mr. Weagant's oscillation demonstration. It seems to correspond very closely with the description given by Mr. Weagant and discussed in my question 3.

13. Cross-question. Your previous answer, as I understand it, involves the fact that no third electrode was added to this tube during the demonstration by Mr. Weagant, as [fol. 1675] illustrated by the arrangement shown in claimant's Exhibit No. 228 when taken in connection with the diagram of claimant's Exhibit No. 225. Is my understanding correct?

Answer. If the term "electrode" is restricted to something sealed inside of the tube, I am willing to state that to the best of my understanding no such electrode was employed by Mr. Weagant during his demonstration. The term "electrode" probably should be restricted to this form, but is also frequently used for a piece of metal or something similar on the outside of the tube and which operates in connection with the electrical functioning of the tube. Mr. Weagant apparently does not draw any sharp distinction in this respect, and in his cross-examination states, on page 1540, that the matter depends largely on the significance and meaning given to the word "electrode." I know that in Mr. Weagant's patents which were under discussion at this time, he frequently speaks of an external control element or electrode. In the sense that there was no electrode sealed within the tube, I will agree that no third electrode was added to this tube during the demonstration by Mr. Weagant.

14. Cross-question. Referring again to claimant's Exhibit No. 22, Fleming patent No. 803684, particularly to Figure 1 thereof, I would ask you whether, according to your understanding of Mr. Weagant's demonstration, as illustrated in claimant's Exhibit No. 225 and claimant's Exhibit No. 228 relating to the oscillating properties of the 2-electrode tube, any physical element was added to the parts and constituting a third electrode over what is shown in Figure 1 of said Fleming patent?

Answer. In the broad sense in which Mr. Weagant has used the term "electrode" in his patents mentioned above, the condenser R of claimant's Exhibit No. 225 is a third or added electrode to the disclosure of Figure 1 of the Fleming patent. In the narrow sense of an electrode as being something sealed within the tube, such an electrode was not employed in Mr. Weagant's demonstrations.

15. Cross-question. Then, as I understand your last answer, you are in accord with my understanding that no third electrode forming a part of the tube structure was

added during the demonstrations which were made by Mr. Weagant and as illustrated in claimant's Exhibits Nos. 225 and 228?

Answer. Whether or not I am in accord with your understanding depends upon your understanding of the meaning of the term "electrode." The condenser R, as employed in a demonstration, of which Exhibit No. 225 is a circuit diagram, was placed very close to the glass wall of the vacuum tube, and was, as accords with Mr. Weagant's explanation of this demonstration, an essential factor in the operation of the tube. In this respect the condenser R is just as much an electrode added to the tube as the external electrode which is added in Mr. Weagant's patent disclosures above referred to.

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16. Cross-question. The condenser R referred to by you in your last answer and indicated in claimant's Exhibit No. 225 and claimant's Exhibit No. 228, which latter is a photograph and shows the condenser as a cylindrical black casing with a white dial and black knobs on the top thereof, is [fol. 1676] what is commonly known in the art as a variable condenser and has long been used in the radio art in circuits in which it has been desired to vary the capacitance of a circuit for tuning or other purposes affecting the electrical period of the circuit and never has formed a part of a vacuum tube, either a 2-electrode tube or 3-electrode tube. Is that correct?

Answer. Excepting for Mr. Weagant's demonstration with which we are here concerned, this statement is perhaps generally true. Such a condenser is generally used for tuning purposes alone. However, in accordance with Mr. Weagant's explanation of his demonstrations, this condenser R is here operating as a control element over the electron stream flowing within the vacuum tube by reason of the fact that the condenser is physically located very close to the walls of the tube so that its electrostatic field is capable of controlling the current flow within the tube. Thus functionally it is just as much a part of the tube as the grid electrode of the DeForest device. As I have pointed out, the action of this condenser, though less effective, is identical in functioning, both to the grid electrode of the DeForest device, or the external electrode of the Weagant patents.

Thus functionally it is just as much a part of the tube as either of the other two.

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17. Cross-question. Now, Doctor Miller, will you kindly confine yourself to the answers to my questions, as put, and not wander off into argumentative dissertations on your interpretation of the facts inquired about? I will ask you again whether the condenser R is known in the art as a variable condenser for varying the cap-itance in an electrical circuit which has been in common use for a long time and is one of the accepted elements usually employed in various rādio circuits for tuning them. Will you please answer my questions specially, yes or no?

Answer. I can not answer this question yes or no, by reason of the specific reference to the condenser R.

18. Cross-question. You know, of course, do you not, that what I refer to as a condenser R is the same condenser referred to in my previous question and which was used in Mr. Weagant's demonstrations of the oscillations occurring through the use of a 2-electrode vacuum tube, and as previously referred to as being indicated in claimant's Exhibits Nos. 225 and 228. Will you kindly answer the question specifically, if you did not before understand that condenser R was the one just indicated in those exhibits?

Answer. Since this question makes it clear that the condenser R of Mr. Weagant's demonstrations was specifically referred to in the preceding question, and not variable condensers in general, it is not possible for me to answer the preceding question, yes or no. As I have pointed out, this condenser R is used in a dual function.

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(Witness continues answer.) With the understanding that by condenser R nothing more is meant than variable condensers in general, my answer to question 17 is "Yes."

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[fol. 1677] 19. Cross-question. In your direct examination you referred to the demonstrations or tests made before Judge Mayer and characterized the demonstration made by Mr. Weagant in this case by similar derogatory terms. In view of this I will ask you to examine the sketch "Defendant's Exhibit A" printed opposite page 266 of the printed

record, and ask you if the vacuum tube shown in that sketch is not physically the substantial equivalent of the vacuum tube No. 665 of claimant's Exhibit 224, which I have already shown you?

Answer. The sketch "Defendant's Exhibit A" shows a vacuum tube quite similar in construction to the vacuum tube No. 665 of claimant's Exhibit No. 224, which has been shown to me. As to the term "physically the substantial equivalent" I am not sure as to what is implied, and to whether it could be shown by a sketch.

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20. Cross-question. Are you willing to say that the electrode tube illustrated in defendant's Exhibit A and the tube No. 665 of claimant's Exhibit No. 224 are the same type of 2-electrode vacuum tube. Please answer specifically, yes or no.

Answer. I can not answer this question, yes or no, by reason of the fact that there are two parts to the question which require different answers.

21. Cross-question. My question was whether you are willing to answer the question, or say under the wording of my question whether you are willing to state that the two tubes referred to are the same type of 2-electrode vacuum tube. Will you answer that question, yes or no?

Answer. I am willing to answer the question yes or no providing you point out specifically what you mean by "the same type of 2-electrode vacuum tube."

22. Cross-question. Although I can not see that my designation of the tubes requires any explanation, if you require it I will say that I intend to include under the term "type" a 2-electrode tube inclosed in a glass container in which there is evacuated space, one of the electrodes being capable of being heated, while the other electrode is separated from the first electrode in the evacuated space and capable of receiving the electrons emitted by the first or heated electrode. With this explanation in mind as to the use of the word "type," will you please state specifically by yes or no, whether the vacuum tube No. 665 of claimant's Exhibit No. 224 is the same type as the vacuum tube illustrated in defendant's Exhibit A?

Answer. Yes.

23. Cross-question. In your direct examination where you referred to the demonstrations made by Mr. Weagant

in which the 2-electrode tube used by him was caused to produce oscillations, you had a great deal to say about the part located outside of the tube itself. In view of this, I will ask you if it isn't a fact that in order to make a 3-electrode tube containing a high vacuum—that is, a tube having a so-called plate, grid, and a filament adapted to be heated—that the conditions which produce or enable the oscillations to be produced in the tube depend upon the [fol. 1678] arrangements of the wires of circuits exterior to the tube as much, if not more, than the fact that the tube contains three electrodes, such as in a De Forest audion?

Answer. Both the tube and the circuit are essential in the production of oscillations. Therefore I can not state that one is more important than the other.

24. Cross-question. The audion or 3-electrode vacuum tube will not generate oscillations, will it, except that by the addition of a special outside circuit and instrumentalities such as a circuit capable of oscillatory currents, means of applying a controlling voltage to the grid, and means for supplying power from the plate circuit of the tube to maintain the oscillations?

Answer. It will not.

25. Cross-question. In answer to question 6 on your direct examination you stated as follows:

"In order that the device shall operate to reproduce speech distinctly and faithfully, or to operate as a 'distortionless amplifier' it is essential that rectification be absent to an extent as to be negligible."

In making this statement I understand you were referring to the 3-electrode tube of "the earlier De Forest patent." With this understanding I will ask you if it is true that the 3-electrode De Forest tube has two cold electrodes and one hot electrode?

Answer. I see no connection between the two portions of this question, and hence must comment on both. The statement quoted in the first portion of the question applies to the 3-electrode tube as a speech amplifier in general, and hence includes the earlier De Forest patent. The last sentence of the question is generally true.

26. Cross-question. Still considering that the 3-electrode De Forest tube inquired about may be used either for a

speech amplifier or a radio-frequency amplifier, it is true, is it not, that if you connect an electrical circuit to either of the cold electrodes and apply an alternating potential between either one of them and the hot electrode, the current will flow through each of these circuits in one direction but not in the other, whether the grid or the plate is the cold electrode selected?

Answer. This is not true.

27. Cross-question. In order to avoid inserting unnecessary conditions in your answer, which I think you contemplate doing, if the question is persisted upon, I may explain that the 3-electrode tube under consideration is in no other circuit than a circuit which may be connected between the hot filament and the grid, or the hot filament and the plate, and an alternating p tential applied between those elements independently. Under these conditions I take it that you will assent to the proposition that in either case the current will flow but in one direction, whether it be the grid or the plate that is connected with the filament. Is that so? If you desire a diagrammatic representation of the two conditions under which the current will flow in one direction only, I will say that you may refer to Figures 2 and 3 of claimant's Exhibit No. 322, Waterman drawing No. 5, printed opposite page 1923, which you considered during your direct examination.

Answer. Yes, I will agree that if the attempt is made to operate a 3-electrode tube in circuits such as Figures 2 and [fol. 1679] 3 of Waterman drawing referred to, in either of the cases there shown the current will flow but in one direction. As I pointed out in my answer to question 6 in discussing this Waterman drawing, this attempted operation causes the 3-electrode tube to lose its function of amplification and degenerate into nothing but a rectifier. This does not change my answer to the preceding question which was concerned with the 3-electrode De Forest tube as an amplifier.

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28. Cross-question. Doctor Miller, will you please confine your answers to my questions without injecting other considerations? By so doing we shall save much time. When this action is taking place between the grid and the filament or the plate and the filament, as inquired about

in cross-question 27, it is commonly known in the art as rectification, is it not?

Answer. Yes.

29. Cross-question. And the vacuum tube under either of these conditions would then be rectifying, would it not?

Answer. Yes.

30. Cross-question. When the 3-electrode De Forest tube is employed as an amplifier, there is a circuit connection between the cold plate and the hot filament, is there not?

Answer. There is.

31. Cross-question. In such a De Forest tube so used the current through this circuit between the hot filament and the cold plate flows in one direction only, does it not?

Answer. No.

32. Cross-question. Do you mean that it flows in two directions?

Answer. When it is operating as an amplifier the current with which we are concerned in the amplifying process can flow in either direction in the plate circuit.

33. Cross-question. Assuming that you understand the part of the circuit within the tube is included in the plate circuit, do you mean to say seriously that there can be an electron flow in both directions within a 3-electrode De Forest tube when the tube is acting as an amplifier: of course I mean the electron flow between the plate and filament?

Answer. If you mean the steady flow of electrons which is produced by the B battery in the plate circuit of the De Forest amplifying device, it is a fact that this flow can not be reversed. However, what we are concerned with in the amplification process is an alternating current superimposed upon this steady direct current. It is well known that an alternating current flows in both directions in a circuit. Hence in so far as we are concerned with the De Forest device as an amplifier, we are concerned with a current which flows in either direction in the plate circuit of the device.

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34. Cross-question. Now, Doctor Miller, it is a fact, is it not, that when a 3-electrode tube is acting as an amplifier, there is absolutely no reverse flow of the current between the filament and the plate, although what you have termed "superimposed alternating current" may act upon the

potential produced by the B battery. In other words, when a 3-electrode De Forest tube acts as an amplifier [fol. 1680] there is always and only a flow in one direction, between the filament and the plate, although this may fluctuate according to the vibration of the voice or music. Please state whether or not this is correct, specifically by the answer yes or no.

Answer. I can not answer this question yes or no, by reason of the fact that it is necessary that my answer be qualified as in the preceding answer.

35. Cross-question. Will you please answer specifically by yes or no whether in a 3-electrode De Forest tube when it is acting as an amplifier, there is any actual flow of electrons between the filament and plate in any other than one direction?

Answer. I can not answer this question yes or no and without qualifying the answer. To do so would lead by implification to the existence in the plate circuit of the De Forest amplifying device of an operation which is not present in the plate circuit of that device.

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36. Cross-question. In view of your last answer and your opportunity to consider the last question since the termination of the last session of testimony, I will ask you to please answer specifically by yes or no whether in a 3-electrode De Forest tube when it is acting as an amplifier there is any actual flow of electrons between the filament and plate in any other than one direction? If your answer is "No," and you consider that such an answer by itself would lead by implication to the deduction that there may exist in the plate circuit of the De Forest amplifying tube something that is not present in the plate circuit of that device, you may for your own satisfaction qualify that answer.

Answer. My answer is "No" if the flow of electrons which is being considered is the total flow of electrons, or that corresponding to the steady direct current produced by the battery with an alternating flow superimposed upon this steady flow, which latter is the thing of interest when we are considering the device as an amplifying device. The whole phenomenon is not one which depends upon the fact as to whether a vacuum tube is included in the circuit or not. It is merely a matter of the superposition of an

alternating-current flow upon a steady direct-current flow and does not differ from what would occur under these same conditions in any electrical circuit, whether it contains a vacuum tube or not. This assumes of course that the amplitude of the alternating-current component does not exceed the value of the steady current in the circuit. If this were to happen then there would be a difference in the case of the vacuum tube over that occurring in an ordinary [fol. 1681] electrical circuit. However, this merely means that the vacuum tube is being overloaded and the practice in the art would be to take a larger tube carrying a larger direct current so that this could not occur.

37. Cross-question. The alternating-current flow which you say is superimposed upon the steady flow produced by the so-called B battery, as a matter of fact never produces an actual reverse flow in the plate circuit; that is, in opposite direction to the flow produced by the B battery, does it? Will you please answer the question, yes or no? You may assume, of course, that I am referring to the normal operation of the tube in amplifying without what you have termed in your last answer as the vacuum tube "being overloaded."

Answer. If you mean the total current is never reversed, the answer is "No," under the conditions of the question.

38. Cross-question. I did not qualify my question by the use of the word "total" and I do not know how you use that term, but I will again ask you whether the alternating-current flow which you said is superimposed upon the steady flow produced by the B battery ever produces any actual reverse flow at all in the plate circuit; that is, in a direction opposite to the flow produced by the B battery. Will you please answer the question by yes or no?

Answer. Your question refers to two currents superimposed upon each other. The answer is "no" if you have in mind the sum or resultant of these two currents.

39. Cross-question. Then, as I understand your last answer, you would admit that if a current meter capable of showing the positive or negative flow of a current through it were placed in the plate circuit of a vacuum tube when acting normally as an amplifier, of course I refer to a De Forest 3-electrode tube, that meter would always show a current flowing in one direction only. Is that so?

Answer. That would depend upon the characteristics of the meter. If this were an ordinary direct-current meter

it would show merely the plate battery current. If the meter could respond rapidly enough to follow the alternating current fluctuations in the circuit, it would show superimposed upon this battery current an alternating current flowing first in one direction in the circuit and then in the other direction.

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40. Cross-question. Now, Doctor Miller, I will repeat the above question with the additional limitation or explanation that the meter referred to is a direct-current milliammeter capable of showing current flow in either direction above or below the zero reading when it is detached from any circuit. Such a meter when placed in a plate circuit as stated in the previous question would never show a current flowing in opposition to the current produced by the B battery when the tube is operating normally, would it? Please answer this questoin by "It would not." or "It would," whichever you consider to be correct.

Answer. I can not answer this question "It would not." or "It would," by reason of the fact that my answer depends upon the possible rapidity of response of the meter, as discussed in my previous answer.

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[fol. 1682] 41. Cross-question. Now, Doctor Miller, will you allow me to ask you the following question, and will you confine your answer either affirmatively or negatively, as the case may be? When a 3-electrode De Forest vacuum tube is being used as an amplifier and a milliammeter capable of indicating either a positive or a negative flow of current therethrough be inserted in the plate circuit when the tube is acting normally, would such a meter ever have its indicating pointer on the opposite side of the zero mark from that side on which it would be when indicating the normal flow through the plate circuit? Of course I am assuming that you understand that the tube is amplifying the received current which is of an alternating form and is impressed upon the plate current, or superimposed, as you have stated. Will you please answer this question by "It would," or "It would not"?

Answer. It would not.

42. Cross-question. Under the conditions stated in the last question the plate circuit would be a circuit containing a rectifier, would it not?

Answer: It would not.

43. Cross-question. Do you not consider that a device which having an alternating current applied to the input side of it resulting in a unidirectional flow in the output circuit, such as would be indicated by the ammeter under the conditions mentioned in cross-question 41, would constitute a rectifier?

Answer. Your question assumes that which is contrary to the facts. In the use of the De Forest device as an amplifier the application of an alternating current to the input side of the device does not result in a unidirectional flow in the output circuit, and an ammeter in the output circuit does not indicate such a result in this case. As I pointed out near the end of my answwer to question 6 in the surrebuttal testimony, the application of an alternating voltage to the input circuit of this amplifying device has no effect upon the steady or direct current flowing in the plate circuit of the device. There is, therefore, no conversion of alternating current into direct current, and hence no rectification, and the device does not constitute a rectifier.

44. Cross-question. When you say, as you did in your last answer, in referring to the De Forest tube as an amplifier, "the device does not result in a unidirectional flow in the output circuit, and an ammeter in the output circuit does not indicate such a result in this case," you mean, do you not, that the ammeter does not indicate that the current in the plate circuit consists of two components, one of which is a steady current due to the plate battery, and the other of which is a fluctuating or pulsating component, which varies in accordance with the alternating potentials impressed upon the tube? Am I correct in understanding this view of your statement?

Answer. No. The two components are a steady current due to the plate battery and an alternating component which corresponds with the alternating potentials impressed upon the tube. A direct-current meter in the plate circuit reads the same whether the alternating component is present or not; that is, it reads the same whether an alternating voltage [fol. 1683] is applied to the input of the device or not. There is, therefore, no change in the direct current, no conversion from alternating into direct current, and no rectification.

45. Cross-question. Do you consider that your last statement would be true for any rate of frequency impressed upon the input circuit of the tube; that is, whether of high frequency or low frequency?

Answer. There is no difference in so far as the operation of the vacuum tube is concerned. At very low frequencies the direct-current meter might not function in the way it is normally supposed to function; that is, to indicate the direct current, but may follow the alternating current variations to some extent.

46. Cross-question. Do you still consider that under the condition stated in your last answer—that is, when the direct-current meter is following "the alternating current variations to some extent"—the plate circuit would not be a circuit containing a rectifier?

Answer. Certainly. The tube is functioning in just the same way. It is merely a matter that the meter might not function properly as a direct-current meter.

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47. Cross-question. In order that there may be no uncertainty as to what you intended to say in your last answer, I will ask you, when the De Forest 3-electrode tube is employed as an amplifier and there is a circuit connection between the plate and the filament, the latter circuit is a circuit containing a rectifier, is it not?

Answer. It is not.

48. Cross-question. I believe you have already agreed that when the 3-electrode De Forest tube is employed as an amplifier there is a circuit connection between the plate and the filament. That is so, is it not?

Answer. Yes.

49. Cross-question. The current through this circuit flows in only one direction, does it not?

Answer. That dependends upon what current you are talking about. If you are talking about the steady battery current, the answer is "yes"; if you are talking about the alternating current, which results from the operation of the device as an amplifier, the answer is "no," for this latter current flows in both directions in the plate circuit.

50. Cross-question. Do you mean to say when you refer to the plate circuit in your last answer to that part of the circuit which exists between the plate and the filament?

Answer. I mean the complete plate circuit; that is, ex-

ternal to the tube between plate and filament of the tube, and internal of the tube between the same two electrodes. The same current flows at all parts of this circuit.

51. Cross-question. By your last answer do you mean that the current flows in both directions between the plate and the filament?

Answer. The alternating component of the current flows in both directions.

[fol. 1684] 52. Cross-question. By alternating current in your last answer do you not mean the up-and-down variation of the current in the plate circuit?

Answer. It is the superposition of this alternating-current component upon the direct-current component which produces the resultant or total current that fluctuates up and down in the plate circuit of the tube.

53. Cross-question. But that total current that fluctuates up and down in the plate circuit of the tube never in any case produces a flow in the tube in the opposite direction to the flow produced by the plate battery, does it?

Answer. No. I have stated before that the total plate current does not reverse. This is by reason of the fact that the amplitude of the alternating-current component is always less than that of the direct current.

54. Cross-question. When the DeForest 3-electrode device is employed as an amplifier the potential due to the incoming signal is applied between the grid and the filament, is it not?

Answer. In some cases it is—in other cases it is not.

55. Cross-question. In cases where the incoming signal is applied between the grid and the filament when the De Forest tube is being used as an amplifier and no biasing potential is applied to the grid, the potential due to the incoming signal causes the current to flow between the filament and grid in one direction but not in the other, does it not?

Answer. If such a current does flow it is harmful to the operation of the device as an amplifier, and it merely means that you are using an improper circuit for amplifying purposes.

56. Cross-question. I did not ask you anything about an improper circuit for amplifying purposes. Will you please confine your answer to the question asked, and if you did not know it, please assume that it is a proper circuit for amplifying purposes.

Answer. The answer is then that no appreciable current will flow between the grid and filament of the tube.

57. Cross-question. I understand of course that you are answering my previous question, as put, and that you have not injected other conditions, and that it assumes that there is no negative bias, as stated in that question. Is that correct?

Answer. Yes. I only assume, as stated in your previous question, that it is the proper circuit for amplifying purposes.

58. Cross-question. In order that there may be no misunderstanding about your last answer, will you please state specifically whether you did or did not assume that the amplifying tube was used under the conditions stated in cross-question 55, which provided that "no biasing potential is applied to the grid?"

Answer. I did assume that "no biasing potential is applied to the grid" and the circuit is a proper one for amplifying purposes, as stated in cross-question 56. I might add that these conditions can only be satisfied when the alternating voltage that is to be amplified is a very feeble one.

59. Cross-question. In order that there may be no misunderstanding as to the meaning of your answer to cross-question 55, I will ask it again as follows:

[fol. 1685] In cases where the incoming signal is applied between the grid and the filament when the De Forest tube is being used as an amplifier and no biasing potential is applied to the grid, the potential due to the incoming signal causes the current to flow between the filament and grid in one direction but not in the other, does it not? Please answer this question specifically, yes or no, without injecting conditions not inquired about.

Answer. Unless you have something unusual in mind, the answer is No; not to an appreciable extent.

60. Cross-question. What do you mean by the word "appreciable" in your last answer? Does it infer any flow at all, except in one direction?

Answer. As I have pointed out before, the current flow between the grid and filament is detrimental to the operation of the device as an amplifier, and it is usual to take steps such as the biasing battery, so as to absolutely prevent such a flow from taking place. It is possible that a

slight amount of such flow might be permissible if its effect upon the amplifying process is so slight as to be inappreciable. That is what I meant by the use of the word "appreciable"; that is, that such a current may flow to the extent that it is not appreciable in its effect upon the amplification. The only effect which such a current can have is one detrimental to the operation of the device as an amplifier.

61. Cross-question. Under the conditions stated in my cross-question 59, it is true, is it not, that the internal circuit between the grid and filament permits the flow in one direction only without appreciable flow in the other direction, and that the action between the grid and filament under those conditions is one of rectification, it is not?

Answer. It is true that under the assumed conditions and perhaps with a fairly strong signal that such rectification can occur in the input circuit of the tube. I must add, however, that under these conditions your circuit is not suitable for amplification purposes.

62. Cross-question. You state that "under these conditions your circuit is not suitable for amplification purposes." It is true, is it not, that even at the present day 3-electrode De Forest tubes are used for amplification purposes in many instances without a grid biasing battery or potential?

Answer. Yes, it is true that in many cases the De Forest tubes are used for amplification purposes without a grid biasing battery; usually in those cases where the alternating voltage which is being amplified is fairly feeble. Whenever the voltage which is to be amplified is rather large almost invariable the biasing battery is employed.

63. Cross-question. Under the conditions stated in the preceding answer in which the biasing battery is employed, there is then no current flowing in the grid circuit, is there?

Answer. There is no current of the kind which we have been considering if a suitable value of biasing potential is employed for the job on hand.

64. Cross-question. What is this "suitable value of biasing potential" applied to the grid under the conditions you have just stated?

[fol. 1686] Answer. Roughly, the magnitude of the biasing battery should be about the same in value as the amplitude of the maximum alternating voltage which is to be amplified.

65. Cross-question. Why is this "suitable value of biasing potential" applied to the grid under the conditions you have just stated?

Answer. To prevent an appreciable flow of current in the grid circuit which would be detrimental to the process of amplification under these conditions. I might add that the use of such a biasing potential is almost universal in the use of the De Forest device as an amplifier at the present day.

66. Cross-question. In what way would an appreciable flow of current in the grid circuit be detrimental to the process of amplification under these conditions?

Answer. In two ways. First, the actual amplification is reduced; second, in the case of audio or telephone frequency amplification there is distortion which operates to destroy the intelligibility of speech or the pleasing characteristics of music. In the case of tuned radio frequency amplifiers it also results in loss of selectivity, or in the facility of distinguishing between one signal and another.

67. Cross-question. This use of a biasing battery for the grid circuit of the 3-electrode De Forest tube is made possible by the rectifying capability of such a tube, is it not?

Answer. This is rather a peculiar statement, since the biasing battery is employed to prevent rectification. It is true that if there were no danger of rectification the biasing battery would probably not be employed, but I would not state that it is rectification that has made the biasing battery possible. I would rather state that it is the biasing battery which eliminates and prevents rectification.

68. Cross-question. It would not be possible, would it, to use a biasing battery in a 3-electrode De Forest amplifying tube if there were no rectification between the grid and the filament?

Answer. As I have stated previously, there is no rectification in the 3-electrode De Forest amplifying device, and it is the biasing battery in many cases which brings this about. It might be possible to use a biasing battery even if there were no possibility of rectification, but what the function of such a battery would be I do not know, for the function of the biasing battery is to prevent the possibility of rectification in the use of the 3-electrode De Forest device as an amplifier.

69. Cross-question. Then to state the fact in a slightly different way, it is true, is it not, that when a biasing

battery is used with a 3-electrode De Forest tube for amplification purposes there is no current flow at all between the grid and filament, although the grid itself may have a decided negative potential?

Answer. Yes; that is true.

70. Cross-question. During your direct examination I believe you mentioned the book written by Dr. H. J. Van der Bijl, which I believe was published by McGraw-Hill Book Co., (Inc.), I therefore desire to quote on the record a paragraph from page 149 of the first edition of that book (second impression) and ask you if you differ from the statements made in this paragraph, as follows:

"If, now an alternating E. M. F. be impressed on the grid circuit so that the grid becomes alternately positive [fol. 1687] and negative with respect to the filament or cathode, the resistance of the grid circuit GFE_g which is usually referred to as the input circuit, will, if the frequency is not too high, be practically infinite for the half cycle that the grid is negative and finite, but variable for the positive half cycle. If, on the other hand, the alternating E. M. F. be superimposed upon a constant negative grid potential, which is so chosen with respect to the value of the impressed alternating voltage that the grid always remains negative with respect to the filament, the resistance of the input circuit is infinite."

Answer. I agree with this statement of Dr. Van der Bijl generally, merely pointing out that in the first part of his statement the effect of which he is speaking would only be appreciable for alternating E. M. F.'s of relatively large magnitude.

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71. Cross-question. In view of your answer to cross-question 69 I will ask you to state your understanding of why it is that there is no current flow at all between the grid and filament when the grid itself has a decided negative potential, understanding, of course, that the 3-electrode De Forest tube referred to therein is being used as an amplifier?

Answer. This is a direct result of the property of unilateral conduction which was discovered by Edison. Thus Edison discovered that when we have a heated filament and a cold plate in an evacuated inclosure no current will

flow between the filament and the plate if the plate is negative with respect to the filament, but current will flow if the plate is positive with respect to the filament. It is the combination of these two effects which was employed by Howell, Wehnelt, and Fleming himself prior to the disclosure of the Fleming patent to make the device operate as a rectifier. In order for the device to operate as a rectifier the alternating voltage applied to it must on one swing cause the plate to become positive with respect to the filament and on the other swing to become negative, so that on one swing you get a current flow, but on the opposite swing there will be no current flow.

Now, if a steady biasing voltage is applied to the device so as to make the plate element always negative with respect to the filament element there will be no current flow between the two electrodes and hence no possibility of rectification, even though an alternating voltage be applied simultaneously with the biasing voltage. In other words, the presence of this steady biasing voltage removes one of the conditions of operation which would be essential for the device to operate as a rectifier.

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[fol. 1688] 72. Cross-question. It is true, is it not, that any 3-electrode tubes with a high vacuum, such as those used at the present day and known as "power tubes," may be used as detectors if desired?

Answer. They may be used as a combined detector and amplifier.

73. Cross-question. In your answer to question 3 of your present deposition (TW., p. 41) you stated, after referring to a voltage of 115 volts, as follows:

"This voltage is a characteristic 'B' battery voltage of De Forest, which is essential with an amplifying device."

It is a fact, is it not, that "B" battery voltages measuring all the way from 135 to 400 volts or more are now commonly employed in amplifying devices or 3-electrode tubes of the De Forest type?

Answer. Such voltages are employed to quite an extent.

74. Cross-question. If your knowledge extends so far, will you please state whether or not it is a fact that in using the early De Forest amplifying tube it was usual to use plate or "B" battery voltages ranging between 12

and 35 or 40 volts, depending upon the vacuum characteristics of such tubes?

Answer. From my knowledge of the use of the early De Forest amplifying tubes I would state that your upper limit of voltage is about right, but your lower limit is too low.

75. Cross-question. Do you mean to imply by your last answer that an early De Forest 3-electrode tube would not act as an amplifier if voltages of the order of 12 or 15 volts were applied to the plate electrode?

Answer. I do not. The operation would be inferior to that obtained with a higher voltage. Your question, I understood, was directed to the practice in the art.

76. Cross-question. My previous question simply asked you if an early 3-electrode De Forest tube would amplify if a "B" battery voltage of the order of 12 to 15 volts were applied to the plate electrode. I understand from your last answer that the answer is in effect in the alternative. Is my understanding correct?

Answer. Your understanding is correct.

77. Cross-question. According to your understanding, what change was made in the early De Forest type of 3-electrode tube which enabled higher voltage to be used, such as those of the order of 135, 180, or more? Of course I refer to the plate or "B" battery voltage.

Answer. The vacuum was improved.

78. Cross-question. What other changes have been made in the early De Forest tubes, according to your knowledge, which have improved their operation as amplifiers, oscillators, or detectors?

Answer. By your use of the term "detector," in answering your question, I must assume that you refer to the combined use of the De Forest type tubes as amplifiers and detectors. The improvements, rather than changes, which have led to improved amplification are primarily improvements in the material employed for the filament, in addition to the improvement in vacuum, mentioned above.

79. Cross-question. It is true, is it not, that in 3-electrode vacuum tubes in common use, or at least a large propor-[fol. 1689] tion of them, the plate electrode completely surrounds a filament, or hot electrode, as it did in the Fleming patent No. 803684, in suit?

Answer. In the Fleming patent the plate electrode is shown as a cylinder completely surrounding the filament;

probably the most general construction employed to-day is a sort of oval-shaped electrode surrounding the filament, though in many cases the plate electrode is split into two parts, one part located on either side of the filament, but the two being connected together and operating as a single plate electrode.

80. Cross-question. It is true, is it not, that 3-electrode tubes of modern construction are sold at the present day, and have been so sold for several years, that are intended to be used as detectors in receiving sets, and not as amplifiers?

Answer. Assuming that your question uses the term "detector" in the loose sense as referring to the combined use of the 3-electrode device as a detector and amplifier, I agree that tubes have been sold for this use exclusively.

81. Cross-question. In order to have specific examples of such 3-electrode tubes that have been sold as detectors within the last few years, of record in this case, in view of your direct examination which deals mainly with the amplification and oscillation of 3-electrode tubes I now show you two tubes contained within pasteboard cartons which I mark, respectively, "Radiotron, Model UX-200 Detector" and "Radiotron, Model UX-200-A Detector," and ask you if it is not correct, according to your knowledge, that such tubes as these contained in these cartons have not been available in the market for several years?

Answer. These tubes which are intended to be used as combined detectors and amplifiers, loosely termed "detectors," have been available in the market for several years.

Mr. Vaill: The tubes and the cartons with their contents are offered in evidence as claimant's cross Exhibits Nos. 350 and 351, respectively, and it is requested that they be so marked by the notary.

82. Cross-question. In a receiving circuit containing a 2-electrode vacuum tube such as the circuit illustrated in Figure 1 of the Fleming patent in suit No. 803684 (plaintiff's Exhibit No. 22), it is true, is it not, that the incoming signal, when impressed upon the cold electrode *c*, causes a variation in the electron stream flowing between the hot filament *f* and said cold electrode so that the signal is made intelligible in the receiver or indicator 1?

Answer. No, I would not express it that way. I would rather state it that when the signal is impressed in one direction upon the electrode *c* it may produce a variation which is different from that produced when the signal is impressed in the other direction, that is responsible for the fact that the signal is intelligible in the receiver or indicator 1.

83. Cross-question. Regardless of how you prefer to express it, am I to understand from your previous answer [fol. 1690] that you consider that my previous question, cross-question 82, is an incorrect statement?

Answer. Yes; the way I regard it, it is an incorrect statement.

84. Cross-question. In what respect do you regard it incorrect?

Answer. It is not the variation in the electron stream produced by the signal that makes the signal intelligible in the receiver or indicator, but it is the difference in variations in the electron stream for voltage variations in opposite directions that produces the signal which is intelligible in the receiver or indicator. The first of these I would consider to be a radio frequency variation in the electron stream which is incapable of affecting the receiver or indicator 1.

85. Cross-question. That is, I understand your last answer, you assent to the proposition that in the case referred to as illustrated in Figure 1 of the Fleming patent in suit, the action of the incoming signal, when applied to the cold electrode *c*, and also, of course, to the filament or hot electrode, as illustrated in said figure, does produce a variation in the electron stream between those electrodes?

Answer. Yes; I have stated this before.

86. Cross-question. It is also true, is it not, that when a 3-electrode De Forest tube is used in a detector circuit in the usual way, which I assume you will understand, the incoming signal, when applied to the cold grid electrode, and also, of course, the filament or hot electrode, produces a variation in the electron stream between those electrodes?

Answer. In one of the uses of the 3-electrode De Forest tube as a combined detector and amplifier, one of the things that happens is that the incoming signal does produce a variation in the electron stream between the grid and filament electrodes.

87. Cross-question. This variation last referred to, under the conditions previously stated, also produces a variation in the electron stream or flow between the filament or hot electrode and the plate or the other cold electrode, does it not?

Answer. Yes, this is another action which takes place simultaneously with the one discussed above. This latter action is due to the controlling action of the grid electrode upon the electron stream between the plate and filament electrodes or is an amplifying action, and this is the reason why I emphasize that the device in this use is operating both as a detector and an amplifier.

88. Cross-question. You will agree to the proposition, will you not, that there are a good many features of operation in common between the 2-electrode tube and the 3-electrode tube?

Answer. No, I would state that broadly and fundamentally the two devices are totally different in operation.

89. Cross-question. Both the 2-electrode tube and the 3-electrode tube involve or require an evacuated vessel, do they not?

Answer. They do.

90. Cross-question. Both the 2-electrode tube and the 3-electrode tube inclose and require one heated electrode or filament and at least one cold electrode, do they not?

Answer. They do.

91. Cross-question. In both the 2-electrode tube and the 3-electrode tube an electron stream or flow is produced between the heated electrode or filament and at least one cold electrode, is it not?

[fol. 1691] Answer. This question is so indefinite that I cannot answer it.

92. Cross-question. In any use to which the 2-electrode tube or the 3-electrode tube may be put, an electron stream or flow is produced between the heated electrode and one cold electrode, is it not?

Answer. This question is very indefinite; it does not state the agency by which the electron flow is supposed to be caused. As I understand it, the answer is no.

93. Cross-question. Do you mean to say that either a 2-electrode vacuum tube or a 3-electrode vacuum tube such as those of the Fleming and De Forest patents are capable of the use to which they are intended without the presence

of an electron stream between a heated electrode or filament and a cold electrode?

Answer. I do not.

94. Cross-question. Then as I understand you, either a 2-electrode vacuum tube or a 3-electrode vacuum tube such as those of the Fleming and De Forest patents are incapable of use for which they were intended without the presence of an electron stream between the heated electrode or filament and a cold electrode? Is that correct?

Answer. This is true of these devices in general, including the devices of the Fleming and De Forest patents.

95. Cross-question. The basis of the operation of both the 2-electrode and the 3-electrode tube depends upon the electron flow through a high vacuum, does it not?

Answer. They depend upon different characteristics of the electron flow through a high vacuum.

96. Cross-question. That is, I take it from your last answer you admit or agree that both the 2-electrode and the 3-electrode tube depend upon the electron flow through a high vacuum, although you consider that the flow may be of different characteristics, is that so?

Answer. I agree that both devices depend upon the electron flow. I would not say that the flow has different characteristics in the two cases, but rather that the operating conditions of the two devices are so different that two totally different characteristics of the electron flow are employed in the respective devices.

97. Cross-question. You are the John M. Miller who testified for the defendant in the case of Marconi Wireless Telegraph Co. of America *v.* De Forest Radio Telephone & Telegraph Co. in the southern district of New York during the accounting proceedings in that case, are you not?

Answer. I am.

98. Cross-question. You testified in that case, did you not, as follows (T. W. Rec., p. 444):

"The basic operation of both the 2 and 3 electrode tubes depends upon the electron flow through a high vacuum.

Answer. I believe that I did.

99. Cross-question. You also testified in that case during the accounting proceedings as follows, did you not? (T. W. Rec., p. 475):

"Q. And the operation of both the 2-electrode tubes and the 3-electrode tubes depends upon the impressing in some way of a received of incoming energy on the electron flow; that is to say, employing the incoming energy to modify the electron flow?—A. Yes."

Answer. I believe that I did.

[fol. 1692] 100. Cross-question. It is true, is it not, that the function of the 3-electrode tube, like the so-called De Forest audion, when used as a detector, is to convert the received signals of radio-frequency into an audio-frequency response that can be perceived, and in this operation it is similar in result to the crystal detector or coherer—that is, it performs a similar function of making the radio-frequency oscillations or signals observed either by the ear or by the recording or indicating device employed?

Answer. One of the functions of the 3-electrode tube or so-called De Forest audion when it is being used as a detector is to convert the received signals of radio-frequency into the form of response that would be audible if of sufficient intensity. In other words, it doesn't matter whether the signal is strong enough to be heard or not; if the device is producing this conversion it is operating as a detector. In this operation it is similar in result to the crystal detector. The coherer is a device with which I have had little or no familiarity.

101. Cross-question. On direct examination in answer to question 5 you quoted from the patent to White, No. 1393594, as regards the characteristic of the current curve shown in that patent as probably being due to the effect of slight traces of residual gas in the device and the consequent positive ionization. As concerns this statement, it is true, is it not, that practically all of the high-vacuum 3-electrode tubes of the present day contain some residual gas, such as referred to by Mr. White in his patent?

Answer. It is true that such a thing as a perfect vacuum is unknown. Therefore there is some residual gas present in all high-vacuum 3-electrode tubes. However, the practice in general is to evacuate 3-electrode tubes in general so that the gas plays no appreciable part in the operation of the tube under normal operating conditions. For one type of tube this may require the higher vacuum than for another, depending upon the operating conditions. In fact, as I stated in this discussion, the very absence of this char-

acteristic which White employed for oscillation generation is a very general test employed to show that the various devices have a suitable vacuum.

102. Cross-question. You do not find in the White patent, do you, any statement that he used anything in the way of a vacuum tube in producing his results described therein, other than a good 3-electrode vacuum tube of usual construction and degree of vacuum employed in radio circuits at the time he obtained his patent or filed his application?

Answer. Mr. White states that the operation which he was describing depended upon ionization of the residual gas. He does not state whether or not he considers the tube to be a good tube or not with respect to vacuum, but in general the criterion, as far as I know, has always been that when gas ionization enters appreciably into the operation of the tube it is not considered to be a high vacuum tube.

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103. Cross-question. Will you please answer my previous question specifically in the affirmative or negative.

Answer. I do. Mr. White points out that the operation which he obtained was due to the ionization of residual gas in the device.

[fol. 1693] 104. Cross-question. You have indicated in one of your previous answers that practically all tubes having a high vacuum have some residual gas. What reason, if any, have you for believing, if you do so believe, that there was any more residual gas in the tube used by White than is contained in the 3-electrode high vacuum tube in general use at the time of the White patent or used at the present day?

Answer. Prior to 1918, and through Mr. White himself, I had received and operated vacuum tubes manufactured by the General Electric Co., by whom Mr. White was employed, and I know that these tubes had vacua far superior to the tube disclosed in this White patent. I also know, by having made numerous measurements upon present-day high vacuum 3-electrode tubes utilizing this same White characteristic as a test, that present-day tubes intended to be operated at a voltage as high as that employed by Mr. White have a vacuum far superior to the vacuum in the tube of the White patent.

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105. Cross-question. From the last sentence of your answer I take it that you agree that the present-day tubes of high vacuum utilizing this same White characteristic can be operated as White described, in his patent No. 1393594?

Answer. Present-day tubes are not utilized in this way, and I do not agree that they can be utilized this way as long as the operating conditions for which the tubes are designed are adhered to. This is my belief by reason of the fact that, at least, as far as the Government is concerned, vacuum tubes are purchased on the basis that this White characteristic shall be present to a negligible degree. Any tube which under standard operating conditions would operate by reason of this White effect I would say is not a high vacuum tube.

106. Cross-question. Then, as I understand your position, it is that a modern, present-day high vacuum tube having the usual amount of residual gas present in such tubes will not operate as White described in his patent. Am I correct?

Answer. If it did it would not, in my mind, be a high vacuum tube.

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107. Cross-question. Will you please answer my question specifically, affirmatively or negatively?

Answer. If it is a high vacuum tube, as I regard it, the answer is no.

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Deposition of Edward H. Loftin (recalled), for defendants, taken at New York City on the 26th and 27th days of November, A. D. 1928, December 21, 27, 1928, and January 3 to February 4 to 11, 1929.

Direct examination.

By Clifton V. Edwards, Esq.:

[fol. 1694] Edward H. Loftin, being recalled as a witness on behalf of the defendant, testifies in answer to interrogatories as follows:

1. Question. Are you the same Edward H. Loftin who has heretofore testified in this case?

Answer. I am.

2. Question. Have you read that part of the testimony of Roy A. Weagant, a witness for the claimant, in which he describes certain exper-ments which he considers to demonstrate that a 2-electrode vacuum tube is inherently capable of producing oscillations and amplifying?

Answer. I have, and I witnessed the experiments.

3. Question. Please consider the testimony of Mr. Weagant and experiments witnessed by you, and say if you agree that Mr. Weagant demonstrated the capability of the 2-electrode vacuum tube to generate oscillations and to amplify and explain your reasons.

Answer. I do not agree that Mr. Weagant demonstrated the capability of the 2-electrode vacuum tube to generate oscillations and to amplify. To make my reasons for my opinion clear some explanation of the mode of operation of vacuum tubes and the experiments of Mr. Weagant is necessary. In question 4 to Mr. Weagant (printed record, 1527) he was asked to demonstrate the capability of *the* hard or high vacuum 2-element tube to oscillate and receive broadcast signals. He did not demonstrate *the* 2-element tube, but *a* particular and selected construction of such a tube, and the result of his careful selection of the construction of *a* particular tube I will bring out in detail later.

To understand the Weagant experiments a few of the fundamentals of the operation of vacuum tubes is helpful. A vacuum tube ordinarily comprises a glass vessel inclosing a highly evacuated space, the evacuation being carried to the extent that gas atoms are so few in the space that their presence is in effect negligible. There is included in the evacuated space a filament or other form of electrode which, when heated, is capable of emitting electrons in profuse number into the space surrounding the filament, these electrons originating in the atoms comprising the material of which the filament or emitting substance is composed. The filament is generally heated by the heat generated by an electric current passed from the outside of the tube through that part of the filament inclosed by the tube, and this heat sets the electrons of the atoms in the filament material into such activity that some of the electrons are accelerated into such velocity of motion that they break through the surface resistance of the atoms and fly out into space surrounding the filament, thus creating a cloud or field of electrons about the filament.

These electrons are extremely minute, there being many of them in each atom of matter, and are said in electrical terms to represent the smallest division of electrical energy. When an electron parts from its mother atom, as it does in flying out of the filament of the vacuum tube, there is immediately set up by the mother atom an influence, potential or force, tending to cause the departed electron to return. The electrical man refers to the electron as a negative element of electricity, and looks upon the atom from which one or more of electrons have departed as being a positive element of electricity because of the absence of one or more [fol. 1695] negative elements. It is thus seen that in the case of a heated electron emitting filament in a vacuum tube there is a continuous flying out into space of electrons accelerated into action by heat, and the maintenance of a force between the stationary atoms of the substance of which the filament is composed and the field of electrons thereabout, the field of electrons being native, electrically speaking, and the filament being positive. The result is that some of the electrons in the field are traveling away from the filament while others are traveling toward the filament.

Electrical current, whether it flows in wires or conductors, or through space, as in a vacuum tube, is merely the movement in these media of electrons, so that in the vacuum tube having a heated electron emitting filament there occurs simultaneously flow of electrical current away from and toward the filament.

The 2 electrode vacuum tube has, in addition to the electron emitting filament, a second electrode physically spaced from the filament, this second electrode being generally cylindrical or otherwise shaped to completely or substantially surround the emitting filament, and thus capable of acting, when called upon to do so, upon the greater part of the total electron emission from the filament.

The description so far is all that is needed to completely describe *the* 2-electrode vacuum tube. What this device is capable of doing depends entirely upon circuits and other associations externally thereof, and various adjustments of these circuits and associations.

If a circuit is connected externally between the electron emitting filament and the second electrode, which I will hereafter term the plate, to conform to the usual designation of the art, a variety of effects can be produced from

the electron field surrounding the filament, depending upon character and kind of electrical forces introduced on the plate through the aid of electrical potentials applied to the external circuit. For example, if the plate be given a fixed, steady, positive potential, as by connecting a battery in the external circuit, this positive plate potential will compete with the positive character of the filament for control of the movements of the space electrons, with the result that electrons will be drawn to the plate across the intervening space in number in proportion to the relative strengths of the positive influences existing on the plate and filament, and the electrons drawn to the plate will then return to the mother atoms in the filament by way of the external circuit, and this movement of electrons in the external circuit constitutes a current flow that is evident with the aid of any of the instruments devised for detecting current flow, such as ammeters, galvanometers, and the like. Obviously, the greater the potential applied to the plate or, in other words, the greater the potential of the battery in the external circuit, the more will be the number of electrons which move across the tube space to the plate, and correspondingly the greater the current in the external circuit.

It is thus seen that by adding to *the* 2-electrode vacuum tube *per se* an external circuit, and including in this external circuit a source of potential, the device becomes a different element in that there now does not exist merely a field of electrons surrounding the filament and flying out from and back to the filament, but now numbers of these electrons are engaged in constituting a constant stream of electrons, or current flow, to the plate, to ultimately pass [fol. 1696] through the external circuit to form a current flow in a wire or conductor where instruments and devices can be inserted for practical utilization of current flow effects.

Another fundamental effect that should be in mind is that the number of electrons diverted from the filament region by an electrical potential applied to the plate is not directly proportional to the potential applied to the plate except over but a portion of the range of potentials employed in practice. At the beginning of applying a plate potential it is obvious that the opposing potential of the filament predominates, so that the plate receives only a few electrons. As the plate potential is increased the predominancy of

effect gradually transfers from filament to plate, so that the rate of increase of electron flow to the plate increases out of proportion to increase of plate potential until a plate potential is reached where the predominancy is substantially all on the side of the plate potential when the rate of increase of electron flow to the plate is substantially proportional to the increase in plate potential, this until an approach is made to the point where the plate potential begins to take all of the electrons that are being omitted by the filament under the condition of heating thereof, it being obvious that if there are no more electrons available further increases of plate potential will not increase electron flow to the plate. These effects are usually illustrated in a curve known as a plate current characteristic curve, which is substantially straight in the middle and curved at both the lower and upper ends. In practice the curved portions have definite uses, and the straight portion has a definite use. It is thus obvious that in operating a vacuum tube for some purposes choice must be made as to the potential applied to the plate in addition to actually applying the potential to start an electron stream across the space within the tube.

In addition to the application of a steady, fixed potential to the plate as above described, uses are made of tubes involving the application of potentials which are alternately positive and negative, as by applying an alternating current potential effect to the external circuit connecting the plate and filament, and some of the fundamental effects resulting from the application of alternating current potential should be kept in mind. Considering that the cycle of events in an alternating current starts with zero or no potential, gradually builds up to a maximum positive potential, positively declines back to zero potential, negatively builds up to maximum negative potential, and finally negatively declines to zero potential, and so on cycle after cycle, it is obvious that as the plate first becomes positive electrons will be drawn from the field around the filament toward the plate, some of them passing through the external circuit. As the positive potential declines the force on these electrons en route to the plate will gradually be released, so that the movement of electrons toward the plate will recede. As the plate becomes negative it will actually repel electrons and force them away, and at the same time

the positive filament will aid this action, so that there will, in fact, be a reverse flow or movement of electrons within the tube space. It is obvious, however, that since a part of the electrons passed into the plate during the positive half of the cycle, there can not be as much backward movement of electrons during the negative half of the cycle as there [fol. 1697] was forward movement during the positive half of the cycle. The effect of this is that more current flows in one direction during the positive half of the cycle than there is current flow in the reverse direction during the negative half of the cycle, resulting in an unbalance or distortion commonly referred to as "rectification." It is pointed out, however, that this rectification is not complete to the extent that there is no current flow in the reverse direction, the effect being merely a partial one. This distortion or partial rectification effect is useful in what is known as "detecting" the very high frequency current effect used in radio signaling, as well as having other practical values.

It is also possible to simultaneously apply a steady, fixed potential to the plate and an alternating current potential, with the result that there will be a main body of electrons continuously flowing from the electron field about the filament to the plate which is modified or varied in accordance with the superimposed alternating current potential on the steady potential. When this is done the degree of distortion or partial rectification of the alternating current potential effect depends greatly upon the value of the initial steady potential, and at that portion of the plate current characteristic curve arrived at by fixing the steady potential where the curve is substantially straight distortion or partial rectification is substantially eliminated, so that a 2-electrode tube so connected and so energized with a fixed direct current potential is substantially useless in the matter of giving distortion or partial rectification to aid in detecting the alternating currents of high frequency common to radio practice, and for other purposes where partial rectification is needed.

There are, therefore, two conditions under which the 2-electrode vacuum tube may be operated. (1) With the alternating current applied to the plate without the presence of a steady direct current potential on the plate, in which condition there is partial rectification sufficient to be of practical utility; (2) with alternating current applied

to the plate in the presence of a steady, direct current potential applied to the plate, in which condition there may or may not be sufficient partial rectification to be of practical utility, depending upon the degree of direct current potential on the plate.

In either mode of operation there can be no amplification. Amplification requires that the result exceed in magnitude the cause. In other words, to have amplification out of a system involving a 2-electrode tube the current that flows in the external circuit as a result of applying an alternating current potential to the plate must exceed the applied alternating current needed to develop the actuating potential. Since the 2-electrode tube and circuits does not differ from any other physical machine in that losses are introduced in bringing about operation, it is obvious that some of the energy of the applied operating alternating current is lost, and the result or effect is less than the cause, but the result may include the partial rectification so necessary for some purposes.

As to the production of oscillation, it is an axiom in electrical practice that oscillations can not be produced without amplification, and since it is impossible for the 2-elec- [fol. 1698] trode tube to amplify because of losses which can not be recovered, it is likewise impossible for such a tube to produce oscillation.

In order for a tube to be able to amplify and, with the aid of amplification, to be able to oscillate, there must be means provided for controlling the action of a large amount of energy by the expenditure of a small amount of energy, which effect is no different in principle from that employed in steam engines where a small amount of the steam energy is employed to operate the valve mechanism which controls the large amount of steam acting on the piston to develop large energy for work purposes. In the tube if a large amount of direct current potential is applied to the plate to maintain a large stream of electrons continuously flowing from the electron field about the filament to the plate, there is thus available a large amount of energy from which amplification can be produced if the energy can be controlled by the expenditure of a small amount of controlling energy. I have previously pointed out how the electrons in the tube respond to potentials developed at the filament by the electron emission action and at the plate by poten-

tial from an external source. Obviously, the electrons can be influenced by other potentials, and if the influence of other potentials can be made greater with small expenditure of energy, then the influence had by the potential on the plate for a given amount of potential, then amplification can be produced at the expense of the energy-delivering device employed to apply the potential to the plate, as for example, the usual so-called plate circuit or "B" battery. It is also physically obvious that where an attempt is made to control movement the more intimate the relation between the thing controlled and the controller, the more effective is the resulting control. De Forest, often mentioned in this case, produced the 3-electrode tube as a device permitting of most effective control of the electron stream or flow to the plate in a vacuum tube by most correctly inserting the third or control electrode directly in the path of flow of electrons from the region of the filament to the plate, and it turns out that by expending a very small amount of electrical energy in developing a potential on this De Forest control electrode a large effect can be had on the flow of electrons to the plate, so much so that a high order of amplification is obtainable with the De Forest 3-electrode tube. Obviously, the amount of control effect and resulting amplification is reduced by altering the degree of controlling relation between the electron stream and the controlling potential. This third and controlling element of De Forest has been popularly termed the "grid," this because he early suggested a grid construction for the third electrode because of its insertion directly in the electron stream, and not wanting to physically obstruct the flow of electrons, but merely to electrically control their movements with the aid of potential. Obviously, if the grid or its equivalent is gradually removed from the main electron stream position of De Forest, the control effect will gradually decrease, thereby reducing amplifying ability of the tube. Mr. Weagant produced for the experiments I witnessed tubes so constructed in physical distribution that a grid effect located just outside of the wall of the glass container would still have enough control effect on the electron stream between the filament region and the plate in the tube to produce a fair order of amplification, but not that order of amplification securable with the correctly constructed De [fol. 1699] Forest 3-electrode tube, and by reason of this

special construction was enabled, by bringing elements of the circuits he used close to the wall of the tube immediately adjacent the electron stream, to bring about noticeable amplification and even oscillation with the aid of the De Forest effect.

In order to bring to bear the De Forest control effect Mr. Weagant departed from the usal tube construction of a globular glass container of proportionately large diameter inclosing a heated filament almost completely surrounded by a cylindrical or like shaped plate, to a highly elongated cylindrical tube of small diameter, and so located the filament in one end of the tube and the plate in the other end of the tube that the main electron stream would be rather long and completely exposed and near to the walls of the tube. In his testimony Mr. Weagant states that the tubes are approximately 4 inches long, 1 inch in diameter, and that the filament and plate separation of the tubes used for amplifying and oscillation was about three-quarters of an inch, though the separation appeared to be somewhat greater to me. He further testified, and I so observed, that the plate comprised a circular plate of diameter almost as large as the internal diameter of the tube, and that the filament comprised a circular arrangement of wire, the circle being of large diameter, thus providing for a large part of the electron stream being closely associated with the internal walls of the tube. It is thus easily seen that an element brought close to the outside of the wall of the tube could, when energized with a controlling potential, secure a fair amount of the De Forest controlling effect.

That Mr. Weagant used these tubes ingeniously constructed to aid him in securing the De Forest effect in ways to produce this effect is evidenced by the apparatus employed and described by him, one test including the apparatus of claimant's Exhibit 224 and a diagram covering the connections thereof, claimant's Exhibit 225, the second test including the apparatus of claimant's Exhibit 226, covered by a circuit diagram, claimant's Exhibit 227.

In the case of the test of the apparatus diagramed in claimant's Exhibit 225 (opposite p. 1527) the condenser R of the antenna circuit was located immediately at that part of the wall of the tube *a* surrounding the space due to the wide separation of filament *b* and plate *c*, so that varying potentials occurring on the condenser R were intimately effective on the electron stream just inside the walls of

the tube. In this way, and with a special tube, Mr. Weagant was enabled to produce amplification with the apparatus demonstrated. Further, by so associating the coupling coil *m* in the antenna with the coupling coil *k* in the external circuit of the tube that there existed a feed back of energy in the right phase, the amplification produced by him was enabled to produce oscillations by the well-known feed back or regenerative principle now commonly used in connection with 3-electrode vacuum tubes. If Mr. Weagant had reversed the polarity of the coupling between coils *m* and *k* he would have destroyed the amplification producing effect and would have been unable to produce oscillation, thus showing that the effect he did obtain depends not only upon the tube, its particular construction, the production of an electron stream, the control of the stream, but upon the mode of connection of circuits as well.

[fol. 1790] Mr. Weagant's diagram of Exhibit 225 on its face does not disclose the true condition of his test, his failure to show the condenser R close to that part of the tube adjacent the electron stream, which could easily have been done, being an unpardonable omission from the point of view of a technical man. For example, I am certain from my experience in filing patent applications in the Patent Office that had Mr. Weagant submitted the arrangement of the apparatus tested by him to the Patent Office in the form of a patent application accompanied by the drawing of claimants' Exhibit 225 he would have been required to modify the drawing to show the condenser R located adjacent the proper part of the tube, even though he had fully set forth the location in his written description.

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To make my point clear I have made a diagram of the apparatus of claimant's Exhibit No. 224 in a way I consider would clearly illustrate to the experienced man of the art the connections in fact of the Weagant test, which diagram I mark "Loftin Diagram of Apparatus of Claimant's Exhibit 224." My diagram readily suggests a special construction of the tube and the location of the condenser R in intimate relation with the electron stream in the tube, and the feed back effect between the external circuit of the tube and the antenna circuit in which the controlling condenser R is located, thus immediately suggest-

ing to one familiar with vacuum tubes and associated circuits the kind of operation to be expected.

In answer to question 4 (pp. 1527-1528) Mr. Weagant pointed out that he caused the apparatus of claimant's Exhibit 224 to produce oscillations by changing the coupling between coils *m* and *k*, illustrated in claimant's Exhibit 225, thus conclusively proving that he did not depend upon any capability of the 2-electrode tube *per se* to generate oscillations, but upon a feed-back connection between the external circuit of the tube and the antenna circuit in order that amplified energy could be fed back to amplify the controlling potential on the condenser R located adjacent the electron stream in the tube.

In view of the above it is my opinion that Mr. Weagant, in producing oscillations with the apparatus of claimant's Exhibit 224, did not demonstrate the capability of the 2-electrode tube *per se* to amplify and oscillate—that the result was obtained by a multiplicity of modifications and associations with the tube as follows:

(1) A very special construction of tube.

(2) Injecting a direct current potential (battery P, claimant's Exhibit 225) in the external circuit of the tube to change the electron condition within the tube from that of a field about the filament to a continuous stream of electrons from the region of the filament of the plate.

(3) Placing the condenser R in intimate relation with the electron stream in the tube to control the electron movement thereof.

(4) Coupling the external circuit of the tube with the antenna circuit with proper polarity to create potentials of correct polarity on controlling condenser R to give feed back of right phase to give feed-back amplification up to oscillation production.

[fol. 1701] In his test of apparatus of claimant's Exhibit 226, including four tubes connected in cascade, Mr. Weagant did secure noticeable amplification, but again, it was not by reason of any capability of the 2-electrode tube to amplify.

In this test he again used tubes of the very special construction I have referred to. As before, he employed a battery in the external circuit to create a continuous electron stream within the tube. He made the slight change of submitting a coil of wire located in intimate relation with

the electron stream in the tube for control of the electron movement instead of the condenser in the preceding test, which substitution makes no difference in the resulting electrical influencing effect. In this test Mr. Weagant availed himself not only of the amplification due to the De Forest effect of bringing to bear a controlling influence on the electron stream, but of further amplification due to feed back by reason of the particular type of circuits used, illustrated in the diagram of claimant's Exhibit 227 (opposite p. 1529). This circuit, as illustrated, is one commonly termed "tuned radio frequency," the circuit in general use for broadcast radio receivers. The great practical difficulty with these broadcast receivers is to so construct them that there will not be enough feed-back amplification to cause oscillation. This feed-back amplification in tuned radio frequency is caused by the internal capacity of the tube between the plate and grid electrode where the ordinary De Forest type of tube is used, it being well known that the amplified energy in the output circuit flows back to the controlling grid electrode by way of this internal capacity to reinforce the influencing potential on the grid electrode. The absence of a grid electrode in the tubes used by Mr. Weagant in his test does not obviate this capacity effect that permits feed back. For example, looking at tube V_1 in claimant's Exhibit 227 it is seen that the upper or plate electrode is diagrammatically illustrated to have rather large area, and that the coil L_2 is placed close thereto. The surface area of the wire of coil L_2 forms a capacity creating area with the area of the plate electrode fully commensurate with the capacity existing between the plate and grid of an ordinary De Forest 3-electrode tube, so that there is provided in the system of plaintiff's Exhibit 227 the same feed-back effect for increased amplification as exists in the ordinary tuned radio frequency receiver.

In answer to cross-question 112 and cross-question 114 (p. 1538) Mr. Weagant testified that the spacing between the detector tube V_1 in claimant's Exhibit 227 was but one-quarter of an inch, and that the lesser spacing operated better as a detector, and that the greater spacing operated better as an amplifier. It is my opinion that had Mr. Weagant tried to use tubes of the lesser spacing given to the detector tube in the amplifier position that he would have been unable to show any noticeable degree of amplification.

With the plate so close to the field of electrons about the filament, the influence of the plate potential on the electrons would have so far predominated over the influencing potential coming from the coil outside the tube that the amount of controlling influence would have been of no practical effect, which brings out the great importance of the third electrode or controlling effect in the matter of securing amplification.

[fol. 1702] I further point out that Mr. Weagant applied 180 volts direct-current potential to the plates of the amplifier tubes, an extremely high potential for vacuum-tube operation in connection with radio-frequency amplification, and only used about 6 volts on the plate of the detector tube, all evident from the data given on the diagram of claimant's Exhibit 227. This practical operation emphasizes what I have previously said as to the necessity for choosing proper potentials for the plate electrodes of tubes operating for different purposes. The high plate potential on the amplifier tube permitted of operating these tubes on the strait portion of the characteristic curve, where there was little or no practical partial rectification, and so operated, these tubes would be substantially useless as detectors. With the low voltage of 6 on the detector tube, the operation occurred at a curved portion of the characteristic curve, thus bringing in partial rectification, making detection practical. So operated, the arrangement would be practically useless as an amplifier even had Mr. Weagant used a tube of great spacing between the plate and filament and had brought to bear the controlling influence of the coil on the space between these elements.

In view of the above it is my opinion that Mr. Weagant did not produce amplification in his test of claimant's Exhibit No. 226 by reason of any capability of the 2-electrode tube *per se* to amplify, but did do so with the aid of specially constructed tubes, the development of a controllable electron stream therein, the location of apparatus to introduce the De Forest controlling effect on the electron stream, and by the use of circuits making feed-back amplification possible.

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4. Question. Do you find disclosed in the Fleming patent in suit any description or suggestion of the apparatus as

demonstrated by Mr. Weagant? Please state your reasons for your answer.

Answer. No. First of all the Fleming patent 803684 in suit shows a 2-electrode tube so connected with circuits that no provision is made for creating a continuous electron stream from the region about the filament to the plate. Referring to Figure 1 of the Fleming patent, or example, it is seen that the wire *j* connects the plate *c*, a cylinder surrounding the filament *b*, to the wire *e* which passes into the tube to the filament *b*, and that there is not included in this external connection any source of potential, such as a battery, for applying a positive potential to the plate absolutely necessary to the creation of an electron stream. Furthermore, this wire *j* in its connection to heating current wire *e*, is shown connected to the negative side of the heating current battery *h*, as a result of which the plate *c* is negative with respect to the average potential of the filament *b* by one-half of the potential of heating current battery *h*, which negative potential of the plate results in repelling electrons from the plate rather than creating a continuously moving stream of electrons to the plate.
[fol. 1703] If Mr. Weagant had connected the tube or tubes in his two tests in the manner shown in the Fleming patent, it would have availed him nothing to introduce the De Forest effect by bringing a condenser or coil of an external circuit close to the tube, as, since there would have been no electron stream to control, the controlling influence of the coil or condenser would not have been effective. The continuously moving electron stream and the energy it represents is an absolute essential to the amplification and oscillation obtained by Mr. Weagant, and the Fleming patent is devoid of this essential feature.

Again referring to Figure 1 of the Fleming patent, it will be noted that the glass vessel *a* of the tube is of relatively large diameter in proportion to its length; that the plate *c* is shown widely spaced from the wall of the tube; and of extreme importance, the cylindrical plate *c* almost completely houses the region about the filament *b* which would be occupied by emitted electrons, thus shielding the electrons from any possibility of useful external influencing. Thus, if Mr. Weagant had constructed a 2-electrode tube in anywise resembling that illustrated in the Fleming patent, and had been entitled to produce an electron stream

therein by some definite disclosure in the Fleming patent, he still would not have been able to introduce with such tube the control effect of De Forest which he successfully did with the tubes of his special construction.

Again, reference to Figure 1 of Fleming shows that he did not include any condenser in the antenna circuit *a* such as the condenser R included in Mr. Weagant's apparatus of the first test as shown in the diagram, claimant's Exhibit 225, clearly showing that Fleming in nowise contemplated any such procedure as that resorted to by Mr. Weagant in using the potential developed on condenser R as a controlling influence.

Referring to the diagram plaintiff's Exhibit 227, illustrating the circuit arrangements in Mr. Weagant's second test, it will be noted that the coils L_1, L_2, and L_3, used for influencing the electron streams in tubes V_1, V_2, and V_3, respectively, are connected in special or auxiliary circuits instead of in the circuit connecting the plate to the filament. No such special connections are shown or hinted at in the Fleming patent. In Figure 1 of Fleming there is shown a coil *b* connected in the circuit between the plate and filament. If Mr. Weagant had connected his coils in the same way and placed them close to the tube, even though the tube was of a special construction used by him and included an electron stream, no result such as that obtained by him by the introduction of the De Forest effect would have been obtained.

In my opinion Mr. Weagant went far beyond the disclosure in the Fleming patent in bringing about the results demonstrated by him, availing himself of knowledge and practice of various kinds which became available to the art many years after the filing of the application for the Fleming patent; that the Fleming patent is wholly incapable of producing, and fails to provide information for producing the amplifying and oscillation production results of the tests of Mr. Weagant.

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[fol. 1704] By Mr. Edwards. The sketch made by the witness in answer to question 3 is offered in evidence as defendant's Exhibit V-6.

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[fol. 1705] 9. Question. In his answer to question 74, printed page 1802, the witness Aull refers to experiments

by him in which he alleges to have used a "2-element electron tube" for producing oscillation. Do you agree that the experiment described by him depended upon a 2-element tube?

Answer. No. The answer of Mr. Aull makes it clear that he merely duplicated the work of the witness Weagant, and I have fully shown in the opening of my present testimony that these tests of the witness Weagant were not tests with a 2-electrode tube but in fact depended entirely upon 3-electrode tube action. The witness Aull states in the answer to question 74 that the result was obtained by placing the tuning inductance near the tube he used, and this, of course, was in order to control the electron flow in the tube just as was done by the witness Weagant.

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[fol. 1706] 11. Question. In his answer to question 8, page 1312, printed record, the witness Sarnoff for claimant refers to "a Marconi multiple tuner," and further refers to the arrangement as the "Franklin" tuner, and illustrates this device in Figure 4 of claimant's Exhibit No. 151, opposite printed page 1310. Further in his answers to questions 11 and 12, printed page 1313, the witness Sarnoff refers to this device as Marconi design or origin. At printed page 1358 claimant's witness Taylor refers to the same arrangement, and in his diagram of claimant's Exhibit No. 163 (opposite page 1359) entitles this device as "Marconi multiple tuner." Is it your understanding that the circuit arrangement referred to by these witnesses and illustrated in their diagrams originated with Marconi or personnel of the Marconi Co.?

Answer. No. It is not entitled to the designation "Franklin," an engineer of the Marconi Co., given it in one instance by the witness Sarnoff, or the designation "Marconi" given it by both the witnesses Sarnoff and Taylor. The circuit arrangement in question is most correctly popularly known in this country as the "Stone weeding out circuit," and so far as I am aware was first suggested for radio uses by John Stone Stone, and was shown by him in many forms of use in his United States patent 714756, defendant's Exhibit P-3, a tuning patent filed prior to the priority date of the Marconi tuning patent in suit. This weeding out or intermediate circuit arrangement is shown by Stone in his early patent in a number

of forms in Figures 7, 8, 9, 13, 14, 15, 16, and 17, and is clearly described by Stone as having the same purpose for which it was later used by the Marconi Co. and others, namely, securing a high order of selectivity through cascading or multiplying a number of tunable circuits.

12. Question. Claimant's witnesses Brennan, Weaver, Reoch, Hartley, Isbell, Rabbitts and Reinhard have given testimony as to their early uses of Fleming valves as detectors at wireless receiving stations and alleging comparisions with crystal detectors. State whether or not you have read the testimony of these witnesses, and if you have what have you to say as to conditions under which these comparisons were made.

Answer. I have read the testimony of all these witnesses, and it all relates to experiences had by them 10 or more years ago, and it all clearly shows that the experiences had by them these many years back were not had with any intention of going into the matter of the relative merits of Fleming valves and crystals, but rather that they, as radio operators, used in the ordinary course of their operating duties such apparatus as was supplied them. No one of the witnesses offers any testimony showing that at the time of the experiences he had any particular interest in the subject about which he was called to testify many years after. The collective testimony of them brings out that the practical use of the Fleming valve as a detector in Marconi instaliations did not endure for very long.

In geaeral this group of radio operator witnesses was asked to compare the sensitivity of the Fleming valve as a detector with the crystal detector. In general they claimed [fol. 1707] experience with carborundum as a crystal detector and claimed greater sensitivity for the Fleming valve over carborundum detection. It is pointed out that carborundum is generally recognized to be one of the least sensitive of the crystal elements which have been proposed for radio detection purposes, and the testimony in this case leaves it clear that sensitive crystals, such as galena, silicon, pyrites, and combinations of them, are superior to Fleming valves as detectors.

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13. Question. In answer to question 8, page 1473, claimant's witness Lehr testifies as to radio sets installed in

United States naval ships received from the British Government. What have you to say as to this testimony?

Answer. In my previous testimony I testified that subsequent to 1910 I had not encountered in the Navy use of the open-type gap radio transmitter except on United States naval vessels assigned to duty with the British Grand Fleet during the war, and that I had visited these United States naval ships in British waters and had seen on them special radio transmitters of this type secured from the British Government. I visited these ships in January or February, 1918. I note in the testimony of the witness Clark for claimant in answer to question 58, page 1501, he states that early in 1918 he was detailed by the Bureau of Engineering, Navy Department, to visit a British naval ship in Canada, and during this visit acquired the details of the type of open-gap radio transmitter I mentioned, and it was not until subsequent to his visit that effort at production of these transmitters in the United States was commenced. In view of Clark's testimony and the dates involved, it is obviously conclusive that the transmitters I saw on the United States naval ships with the British Grand Fleet were secured from the British Government as I was so told at the time of my visit.

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14. Question. Please refer to the testimony of claimant's witnesses Weagant, in answer to question 206, page 1634, and Hogan, in answer to question 22, page 1835, and say if you are in accord with their reasons why the secondary circuit in Marconi patent 627650 is not tunable as you pointed out in your previous testimony.

Answer. I am not in accord with the reasons given by claimant's witnesses Weagant and Hogan in their attempted endeavor to set up conditions around which to argue that the secondary circuit in Marconi patent 627650 is not tunable as intended by Marconi. The Marconi patent constitutes a clean-cut disclosure of adjusting the time periods of the antenna circuit and the secondary circuit at a receiving station to accord with the wave length of received oscillations, the language of patent 627650 being so clear as to features to be carried out to obtain the result as to leave no shadow of doubt as to the completeness of the disclosure. Because of the most definite instructions of Marconi in 627650 to tune both circuits the

witnesses Weagant and Hogan resort to contentions which, [fol. 1708] if true, would wholly vitiate the testimony of practically all of claimant's witnesses that disclosures in Marconi patent 763772 are disclosures for tuning the antenna circuit and secondary circuit in a receiving system.

The witness Weagant first points out that the coil *j'* of "Loftin sketch M" is not shown variable in the Marconi patent 627650, but he makes no reference to the fact that this coil is clearly described as variable, and variable for tuning, in the specification of 627650, page 1, lines 31-37 as follows:

"It is desirable that the induction coil should be in tune or syntony with the electrical oscillation transmitted, the most appropriate number of turns and most appropriate thickness of wire varying with the length of wave of the oscillation transmitted."

Thus, the instructions for making the coil *j'* variable, and variable for tuning, could not be more complete, and the comment of the witness Weagant is obviously a pure quibble, and also unquestionably unfair as I included in the subject matter of the legend accompanying my sketch M the informatory notice that my sketch was based on "Figure 1 and description" of patent 627650, and I did this to foreclose against a quibble such as that indulged in by the witness Weagant.

The witness Weagant next quotes the clear instructions in patent 627650 for varying the capacity of the condenser in the secondary circuit as the wave length of the incoming signal oscillation is varied. He does not deny that these are definite instructions intended for tuning the secondary circuit as in Marconi patent 763772 in suit, but tries to take refuge in a contention outside of the disclosure of patent 627650 as follows:

"Inspection of the diagram shows that condenser K is in series with induction *j'* and detector T and, due to the perfectly well-known fact that the resistance of detector T is relatively high, a condenser connected in the position shown at K is totally incapable of tuning the receiving circuit and it seems to me incredible that Mr. Loftin should not be aware of this fact."

I can not overemphasize the wildness and desperate character of this refuge of the witness Weagant of the location of the detector T and its relatively high resistance as a basis for contending that the tuning prescribed and provided for by Marconi in patent 627650 is not obtainable in view of the fact that the contention runs counter to the testimony of practically every one of claimant's witnesses in this case.

The doctrine that tuning exists in spite of the presence of the high resistance of a detector in a circuit begins with the opening testimony of claimant's own expert, Waterman, in this case in connection with Waterman's description of Marconi reissue patent in suit. On page 162 Waterman states:

"The idea of tuning as set forth in this reissue patent was therefore the idea of constructing the receiving station so that it should be identical with the transmitting station, to the end of localizing at the receiver the messages from this particular transmitter."

It is clear in this case that the receiving circuit of the Marconi reisue patent comprises simply a wire having a coherer (the high-resistance detector objected to by Weagant in connection with Marconi patent 627650), in series therewith, and Waterman does not hesitate to ascribe [fol. 1709] tunability to this receiving circuit of this first Marconi patent in spite of the presence of the high resistance of the detector. Again in his opening testimony in connection with Marconi patent 763772 Waterman shows in plaintiff's Exhibit No. 99, opposite page 157, four separate receiving systems, and ascribes to all of them the property of tunability of the secondary circuit. In the case of three of these circuits, namely, Figure G, Figure I, and Figure J, the detector is located in the secondary circuit in the same way as in Figure 1 of Marconi 627650; that is, in series relation with an inductance coil and a condenser. Waterman testifies that such a circuit will tune and, in fact, tuning of such a circuit is the very purpose and basis of this testimony. Weagant now testifies that such a circuit can not tune, and therefore Marconi's instructions in 627650 to do so are without effect.

Claimant's witness Sarnoff showed in his diagrams, claimant's Exhibit No. 151, opposite page 1310, radio receiving systems of Figures 2 and 2*a* in which a high-resistance detector is in series with the capacity and inductance elements of a secondary circuit, and Sarnoff testified to the effect that he used the apparatus in tuned condition.

Claimant's witness Taylor, who has testified that he was a construction engineer for the Marconi Co. in the very earliest days of the Marconi Co.'s radio operations, shows in the diagram of claimant's Exhibit No. 158, opposite page 1348, a radio receiving system having a secondary circuit in which the high-resistance detector is in series with the inductance and capacity elements forming the circuit, and Taylor testified that such a secondary circuit was used in a tuned condition. Taylor gave the same line of testimony in connection with the receiving system of claimant's Exhibit No. 160, opposite page 1351, and the receiving system of claimant's Exhibit No. 162, opposite page 1358, in both which cases a high-resistance detector is in series with the circuit.

The witness Weagant next suggests, page 1624, that Marconi 627650 can be made tunably operative by modification as follows:

"In order for condenser K to tune with inductance j^2, that terminal of the condenser K which goes to the detector T, should go to one terminal of inductance j' through a connecting path which does not contain a high resistance."

In other words, Weagant now contends that of the four receiving systems illustrated by plaintiff's expert Waterman in plaintiff's Exhibit No. 99, opposite page 157, the one of Figure H is the only one having tunability in the secondary circuit, this in spite of Waterman's testimony that all of them permit of the tuning claimed for the later Marconi patent 763772 in suit.

In this connection the testimony of claimant's witness Taylor as to the early practice of the Marconi Co. is significant and clearly refutes the erroneous testimony now presented by Weagant. On page 1360 Taylor was questioned and answered as follows:

"Question. Do you recall whether or not at any time, while you were in the employ of the American Marconi

Co., any means was provided for getting sharp tuning in the detector circuit of the receiver?

"Answer. Towards the end of the use of the coherer detector for commercial purposes, we used to put a variable [fol. 1710] condenser across the coherer itself, but that was only done occasionally, it was not general practice."

The arrangement for obtaining the "sharp tuning" specified in the question is the arrangement of Figure II of Waterman in plaintiff's Exhibit 99, and Taylor makes it clear that Marconi practice of the early days was satisfied with the less sharp tuning of Marconi patent 627650, and only resorted to the modification now suggested by Weagant occasionally, but Taylor's testimony contends that this less sharp tuning now condemned by Weagant was tuning nevertheless.

Claimant's witness Cram, in his testimony at pages 1460 and 1461, contends that certain receivers of defendant, such as the E_4 telefunken type of plaintiff's Exhibit 79, opposite page 180, are tuned in the matter of the secondary circuit, this in spite of the fact that the E_4 and other receivers of this kind have high resistance detectors in series with the secondary circuit, and thus are subject to the high resistance features which the witness Weagant relies upon for contending lack of tunability in Marconi patent 627650. In my previous testimony I have stated that receivers of this type are not tuned, this not because of the series relation of the detector but because of the way in which they are built and used. The witness Cram and other witnesses of claimant in testifying as to these receivers of the E_4 kind have not contended any variability of the condenser j^4 shown in the E_4 secondary in plaintiff's Exhibit 79, as is provided in Marconi patent 627650. Cram and these other witnesses point out that the inductance coil j^2 is provided with a series of taps by which the inductance can be varied in large steps rather than continuously, and point to five to six of these large steps of inductance selection in some of these receivers. Obviously, the secondary circuit has one natural period for each one of these steps of inductance selection in these receivers. For example, for a practical receiver the natural period may be at 450 meters, 650 meters, 900 meters, 1,250 meters, 1,800 meters, 2,500 meters, and 4,000 meters

as the inductance tap is changed from one position to another. With the inductance tap such that the secondary circuit has a natural period of 450 meters, the operator may adjust the antenna circuit to each and every wave length from 300 meters up to 600 meters without the two circuits being at any time in tune except when the operator may by chance have occasion to tune the primary or antenna circuit to 450 meters. In other words, the operator may employ several hundred adjustments of his antenna circuit for the operation of the receiver with the one setting of the adjustment tap on the inductance of the secondary circuit without ever having the two circuits in tune. There is no doubt, of course, that the reception is best at that point where the adjustment of the tune of the antenna circuit may happen to accord with the natural period of the secondary circuit, but because of the high resistance of the detector T the resonance point is not particularly prominent, so that the operator would not note any pronounced increase in signal strength at this point as compared to a sharply tuned secondary circuit in which the detector is connected across the tuning condenser, but the [fol. 1711] resonance point does exist in spite of Weagant's contention to the contrary. If defendant had made the condenser j' in the secondary circuit of the E_4 kind of receiver variable as instructed in Marconi patent 627650 so that the tuning of the secondary circuit could be varied as the wave length of the incoming signals and the tuning of the primary circuit were varied, then this not sharply defined resonance point could have been moved from one part of the band of wave lengths to all others in consonance with the varying of the wave length of the incoming signal and the tuning of the antenna circuit to maintain continuous tuning throughout the band, and under such circumstances the witness Cram could have correctly testified that the E_4 and other like receivers of defendant were tunable for the purpose of Marconi patent 763772 in suit, but in the manner provided for in the earlier Marconi patent 627650. This reference to the Cram testimony thus brings out that Cram contends for tuning within the terms of Marconi patent 763772 in apparatus with provisions for tuning less than those in the earlier Marconi patent 627650 at the same time that Weagant contends that no tuning at all can be accomplished because of the high resistance of the detector element.

Claimant's witness Clark, pages 1503 and 1504, testifies in the same manner as claimant's witness Cram as to defendant's receivers having a secondary circuit of the kind typified in E_1 telefunken type of receiver, thus adding another one to the list of claimant's witnesses opposed to the erroneous contention now made by the witness Weagant.

The confusion and contradiction that claimant has injected into the matter of resonance and tuning circuits one to another through claimant's multitude of witnesses in an effort to save the Marconi patent 763772 from the tuning of the prior art and yet bring defendant's apparatus within the patent in suit is particularly typified in some of the testimony of the witness Clark. For example, on page 1515 in answer to cross-question 119 Clark stated that two circuits, one of which is tuned to a wave length of 900 meters and the other to a wave length of 895 meters, are not in "exact resonance." In his answer to cross-question 120 he stated that in the case of two circuits, one tuned to 900 meters and the other to 850 meters, he would "consider this difference in wave length to be beyond that tolerance allowable for the word 'resonance' in operation." Again, in his answer to cross-question 122 he stated that in the case of one circuit tuned to 200 meters and the other to 250 meters he would say that they are not in resonance.

But in his testimony included from question 63 to question 68, pages 1503 and 1504, Clark contended that receivers having secondary circuits of the type of the E_1 receiver are tuned. In his answer to question 68 he tabulated the wave lengths' ranges covered by the different taps or plug positions for the inductance in the secondary circuit. For plug position 1, he gives a wave length range of 200-500 meters. Obviously, if such a secondary circuit will effectively cover from 200 to 500 meters, it would have a natural period or tune in the neighborhood of 325 to 350 meters, so that from this data Clark in the position of contending that when the incoming signal is 200 meters and the antenna tuned to 209 meters, the fixed secondary circuit [fol. 1712] with its natural period of from 325 to 350 meters is in tune with, or resonant to, the signals and antenna circuit of 200 meters, a difference of from 75 to 100 meters beyond what he said would not be resonance in his answer to cross-question 122. Like discrepancies in the case of his answers to cross-question 119 and cross-question 120 can be pointed out in the case of the plug positions for the

longer wave lengths given by Clark in his answer to question 68.

Returning to the testimony of the witness Weagant as to the secondary circuit of Marconi patent 627650, page 1634, after denying the capability of the condenser K to perform the tuning function allocated to it by Marconi, Weagant tries to give to this condenser another function to justify its presence within the secondary circuit, and accordingly states:

"The action referred to in the patent and quoted by Mr. Loftin is merely the ordinary action of what is known as the 'stopping condenser.' The purpose of condenser K is to stop the flow of the battery current from battery B, through the inductance j^2, which would short-circuit the battery, prevent potential being applied to detector T. Oscillating current does not flow through condenser K, but the rectified half cycle of the oscillating current, which are all in one direction."

It is difficult for me to reconcile the violent transgressions of technical and physical facts contained within this quotation with my familiarity with the witness Weagant's knowledge of the physical actions inherently involved. Weagant ascribes to condenser K the function of preventing the flow of current from the battery B through inductance coil j_2. With the position of condenser K shown it does so act, but no definite value of capacity of this condenser is required to bring into play the stopping function, so that it is immaterial whether the capacity of the condenser is extremely small or extremely large, and a condenser having all the requirements for tuning the secondary circuit prescribed by Marconi would adequately provide for the function of a stopping condenser and, at the same time, the variation of the capacity for the tuning function disclosed by Marconi would have no effect whatsoever upon the stopping function. Furthermore, the current from the battery B is simply a steady, one-direction current, so that any suggestion that the provision by Marconi for varying the capacity of this condenser as the wave length is varied has anything to do with a direct current from a battery is an untenable physical proposition. The quotation further contends that oscillating current does not flow through the condenser K, this in spite of the fact that the detector T de-

pends for its operation and function upon oscillating current and this detector is located on the opposite side of the condenser from the source of the oscillating current, namely, the antenna circuit. If, as contended by Weagant, the condenser K prevents oscillating current from reaching the detector T the system is obviously inoperative, but Weagant does not contend so far as this. Weagant further says that only rectified half cycles flow through the condenser K, and that these all flow in one direction. Marconi shows the detector as a coherer, the operation of which is not the partial rectification of crystal and other rectifying detectors, but one of the effect of high frequency currents on the filings within the tube to alter the resistance [fol. 1713] of the filings' path to the flow of direct current from the battery. Obviously, if the high frequency currents could not reach the filings' path within the tube the coherer would fail of response, and once more the system would be inoperative, which is not contended by Weagant. If the detector is made of the partial rectifying type, such as a crystal, it is still necessary for the high frequency currents to reach the detector, and this can only be done by flow through the condenser K directly in the path, as it is only through the high frequency currents reaching the rectifying device that partial rectification can be brought about. Furthermore, in the case of a rectifying device there are not as a result rectified half cycles, but merely a distortion or partial rectification, so that there is still high frequency current merely of greater amplitude during one half of the cycle than during the other half of the cycle.

The witness Hogan, in his answer to question 22, page 1535, also contends that the secondary circuit of Marconi patent 627650 is not tunable because of the high resistance of the detector and accounts for the presence of the condenser K on the same basis and the witness Weagant. Since the testimony of Hogan adds nothing to that of Weagant the preceding comments as to the testimony of Weagant apply as well to the testimony of Hogan.

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15. Question. Explain the relation, if any, between the resistance in a circuit and the tuning of the circuit.

Answer. Resistance in a circuit has no effect on the tunability of the circuit in so far as any practical consideration is involved, so that tuning or adjustment of the natural

period of a circuit is accomplished by selection of inductance and capacity values in the circuit. In other words, having a circuit with a given relation or product of inductance and capacity the resistance of this circuit can be changed from very low values to very high values without changing the tuning or natural period of the circuit. The effect of changing resistance in a circuit is to change the responsiveness of the circuit to electrical effects, or in other words the amplitude or degree of current flow in the circuit in response to the impressed electrical effects. The effect of resistance in a circuit upon the conduct of the circuit in response to impressed electrical effects is readily understood with the aid of diagrams generally employed by electrical workers, and I have made a sketch entitled "Loftin Sketch R, Effect of Resistance on Response of Circuit" to aid me in explaining this matter.

In Figure 1 of the sketch I show a circuit 1 having an inductance coil L and a condenser C, shown to be variable for tuning or changing the natural period of the circuit. In series with this circuit I show a variable resistance R, [fol. 1714] the slider connection to the resistance indicating that all of the resistance of the element can be removed in effect from circuit 1 or any portion of it included as desired. I show a detector D, such as a crystal detector, and telephone T associated with circuit 1 as means for indicating the degree of response of circuit 1 to electrical effects. As a means for impressing electrical effects or oscillations on circuit 1, I show an antenna circuit A including a coil coupled to inductance coil L in circuit 1, and my succeeding comments contemplate a sufficiently loose coupling between the antenna coil and the coil in circuit 1 to avoid a distorted or double-hump energy transfer from the antenna to circuit 1 in order that resonance or tuning results may be actually had.

It is assumed that the antenna circuit A is excited with high-frequency currents of many frequencies as is the case with an ordinary radio receiving antenna because of the many radio transmitting stations scattered about generating electrical effects of different frequencies.

The curves in Figure 2 graphically show the degree of response or current magnitude in circuit 1 under conditions of different values of resistances inserted in this circuit with the aid of the slider on resistance R. Ordinates I in Figure 2 represent current intensity or response in

circuit 1 and abscissae or horizontal dimensions F represent frequency of either the currents impressed upon the circuit 1 or natural period of adjustment of circuit 1.

Assuming circuit 1 to be adjusted to have a natural period represented by frequency f_1 in Figure 2, as by adjusting the variable condenser C to arrive at that definite product of capacity and inductance to give this circuit the time period corresponding to the chosen frequency f_1, the effect of varying the resistance R while leaving the condenser C untouched is shown by the four response curves of Figure 2 marked "Very Low Resistance," "Low Resistance," "High Resistance," and "Very High Resistance." If the slider is moved all the way to the left of resistance R to entirely eliminate this resistance from circuit 1, there will still remain some effective resistance in the circuit by reason of the resistance of the wire from which coil L is made and the wires used for connecting the several elements into a circuit, but by proper construction this inherent resistance can be made very low, and such a resistance condition of circuit 1 will result in a response curve somewhat as illustrated by the "Very Low Resistance" curve of Figure 2. It is seen that this curve is very peaked or what is termed "sharp" in electrical practice, indicating a very marked and proportionately large response of circuit 1 to impressed alternating currents of the frequency f_1 to which circuit 1 is tuned. It will be noted that for any other currents in antenna A of higher or lower frequency than f_1 to which circuit 1 is tuned—that is, to the left and right of f_1 in Figure 2—the low-resistance curve shows that the response of current intensity of circuit 1 falls off very rapidly in proportion to the maximum current had by signals of frequency f_1. For example, I have shown a vertical dotted line erected at frequency f_2 in Figure 2, and by noting where this vertical line cuts the low-resistance curve a measure of the response of circuit 2 to a signal of frequency f_2 in antenna A when circuit 1 is tuned to frequency f_1 is had.

[fol. 1715] Now if the slider on resistance R is moved to the right to increase the resistance in series with circuit 1, but at the same time leaving condenser C untouched in order to maintain the same product of inductance and capacity in circuit 1, a family of response curves can be had as shown by the several curves marked "Low Resistance,"

"High Resistance," and "Very High Resistance," as the resistance of R is increased, but I call particular attention to the fact that this changing of resistance while leaving the condenser C untouched does not cause the points of maximum response of the curves to depart from the vertical dotted line representing frequency f_1 to which circuit 1 is tuned by reason of a proper selection of the product of inductance and capacity, and this is true for a change of resistance from the small value of a fractional part of an ohm to thousands of ohms. In other words, the changing of resistance in a circuit does not have any effect on the tuning of the circuit as determined by a selected product of inductance and capacity.

It will be noted, however, that varying the resistance does affect the response or magnitude of current flow in the circuit, the higher the resistance the less the response, but no matter how high the resistance the response at resonance is always maximum, or exceeds the response at other frequencies, so that even though the over-all response is reduced, and may be greatly reduced in the case of a high resistance circuit, there always exists a tuned or resonant response, though it may not be sharply defined.

For the reason that high-resistance circuits, though responding poorly throughout a wide range of frequencies as compared to low-resistance circuits, do not show a marked difference between the maximum response at resonance and lesser responses at widely different frequencies, as well shown, in the "Very High Resistance" curve of Figure 2, such circuits are referred to in practice as "broadly tuned."

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In Figures 3 and 4 the effect of resistance in circuit 1 on the amplitude of current flow is shown. Figure 3 is intended to show the relative amplitudes of a current of frequency f_1 impressed upon circuit 1 when it is tuned to frequency f_1. For example, the alternating current on the line *a* of Figure 3 shows the amplitude of the current in circuit 1 when the resistance is very low, corresponding to "very low resistance" response curve in Figure 2. The alternating currents on lines *b*, *c*, and *d* of Figure 3 indicate the current amplitudes corresponding to the other three response curves in Figure 2. In Figure 4 the currents on lines a', b', c', and d' indicate the lesser amplitudes

of the currents when the incoming signal frequency is at f_2, shown by the vertical dotted line at f_2, Figure 2, when the circuit 1 remains tuned to frequency f_1, the amplitudes in Figure 4 corresponding to the resistance conditions covered by the response curves in Figure 2.

As a practical example of these effects in radio practice, the "very low resistance" response curve of Figure 2 may represent the result obtained when the secondary circuit of a receiver has the detector removed from the tunable circuit, as is shown in the detector location in Figure 1 of my [fol. 1716] sketch, and the circuit, not including deliberately any unnecessary resistance, such a circuit being commonly known as a "low loss" circuit; this as compared to a circuit like that of Figure 1 of Marconi patent 627650, discussed in my previous answer, in which the detector is included within the secondary circuit, thereby introducing a resistance in series just as is accomplished by the resistance R in Figure 1 of my sketch. In his case the response curve will become depressed very much in comparison with the curve resulting from the other location of the detector, and thus may take the form of the "high resistance" or "very high resistance" curves of Figure 2 of my sketch. Obviously, however, the tuning in the latter form of detector connection still exists, the only difference being that the response is not as efficient for any frequency as it is in the first case, and is not as sharp or well defined at resonance as in the first case.

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16. Question. In answer to question 152, pages 1551 and 1552, claimant's witness Weagant, refers to Dolbear patent 350299 and Edison patent 465971. Do you agree with his testimony to the effect that these patents do not utilize Hertzian waves, and therefore have no relation to the Marconi reissue patent in suit?

Answer. I do not agree with Mr. Weagant that there is a difference between the electrical effects at a distance resulting from the systems of Dolbear patent 350299 and Edison patent 465971 and the electrical effects at a distance of Marconi reissue patent 11913. Hertz experimented with alternating currents flowing in electrical conductors, and found that such current flow resulted in electrical effects which were manifested through space and could be detected as at a distance. After the work of Hertz had been pub-

lished it became popular to refer to the mode of propagation of the electrical effect through space as "Hertzian waves." Although the investigations of Hertz were conducted some 40 years ago, and the effects noted by Hertz continuously and extensively studied and used since that time, there has not as yet been proposed by anyone a theory of the manner of the propagation of the energy or effects through space that has been universally accepted. All agree, and practice compels agreement, that when alternating currents are caused to flow in an elevated wire or antenna that there results electrical effects which spread out in all directions with gradually diminishing energy, and that with proper apparatus these effects can be detected and utilized. Hertz did not connect his conductors to the ground. Marconi in reissue patent 11913 did connect his antenna or conductor to ground. The same is true in the Dolbear and Edison patents, both earlier than the Marconi reissue patent. Dolbear, Edison, and Marconi all caused alternating currents to flow in the elevated antennæ provided by them at the transmitting station, and all of them set up elevated wires at distant receiving stations for detecting the electrical effects resulting from these alternating currents flowing in the elevated wires at the transmitting stations. The work of Edison and Dolbear was done prior to the time of adoption of the popular name of "Hertzian waves" for the electrical effects operating through space, so of course their [fol. 1717] patents make no reference to "Hertzian waves," but both patents bring out clearly that the electrical effects did cover the distance between the transmitting and receiving stations. The Marconi reissue patent, coming some 10 years after the work of Hertz, refers to the effect as "Hertzian waves," but makes no attempt to explain any mode of propagation through space of energy by means of "Hertzian waves," and draws no distinction over the electrical effects at a distance of Dolbear and Edison. Weagant refers to the effect in the Edison arrangement as "electrostatic induction" and states that it is not a system of "Hertzian wave telegraphy." He makes no attempt to show any difference, or explain a difference, and in fact it is impossible to adhere to the fundamental physical facts, and do so. In both cases alternating currents are caused to flow in an elevated conductor, and the electrical effects resulting therefrom are collected and detected at a distance. In the early days of radio practice many of the electrical

engineers who took up radio work showed an inclination to develop mysterious aspects for radio as compared to general electrical practice, and to claim for the high-frequency currents of radio practice different conduct from the lower frequency currents of general practice. Some progress was made toward creating new and mysterious names for features of high-frequency practice, and for some time it was thought that reference to "Hertzian waves" drew an unquestionable distinction over the fundamental principles of electrical effects. Now that radio is becoming more and more common, it is happily being studied and considered in the light of the fundamental physical facts covering all electrical effects, and these fictitious differences are disappearing. The fact is that the electrical effects in the Dolbear and Edison systems are precisely those of Hertz and the Marconi reissue patent following Hertz.

17. Question. Claimant's witness Weagant, page 1558, refers to an alleged difference between the Tesla apparatus of the Martin book and the Marconi reissue patent, and in this connection claimant's witness Hogan, page 1834, alleges that there is no foundation in Tesla's work for the system of your Sketch A opposite page 957. What is your opinion as to these allegations?

Answer. On page 1558 the witness Weagant states that in Marconi reissue patent 11913 it was intended to generate oscillations of high frequency—that is, to cause alternating currents of high frequency to flow in the elevated wire connected to ground or antenna circuit—and thus emit "Hertzian waves" from the antenna. He does not deny that Tesla in the Martin book, defendant's Exhibit B 4, provides for an elevated wire connected to ground associated with means for causing alternating currents to flow in the wire, but takes the position that because Tesla did not give any definite mode of transmission of the effects over a distance he did not include any "thought or suggestion of the use or generation of Hertzian waves." In other words, according to Weagant, it was not alone sufficient for one to create a system for producing adequate electrical effects at a distance in the early days, but it was also necessary to in effect trade-mark the system with the then popular term "Hertzian waves." The contention of Weagant as to the Tesla work in the Martin book is substantially that [fol. 1718] of his contention as to Dolbear and Edison referred to in my answer to the last question.

On page 1834 the witness Hogan states that the organization of the Tesla transmitter shown in my Sketch A opposite page 957 can not be found in any of the Tesla publications. He states that that part of the system of my sketch which is based upon Figure 165 of the Martin book "illustrates several circuits for converting electric current." His description of the apparatus is thus far from being complete. Figure 165 is entitled to much more than the brief qualification "converting electric current." The figure shows means of the most modern kind for converting low-frequency alternating currents into high-frequency alternating currents for just such a purpose as creating so-called "Hertzian waves" for radio transmission. In fact, the figure is so complete in all of its details that it merely requires the substitution of the modern quenched gaps in lieu of the open gaps *dd* in order to have the generator of the quenched-gap system as it is still being used to-day.

In Figure 185 of the Martin book there is shown a typically modern transmitting antenna system, there being an elevated wire having an extended portion at the top to give additional capacity as is used in all modern transmitters, and the wire is adequately grounded, as by connecting to water mains buried in the ground, a usual practice where such means are available. Tesla well explained that such an elevated antenna system excited with alternating currents would transmit electrical effects over distance which could be detected as signals for communication. It is noted that Mr. Hogan qualifies the figure as having "nothing whatever to do with radio telegraphic transmission." The Tesla figures do not in fact include telegraph keys for carrying out what is generally known as "telegraphic" communication by use of the so-called Morse telegraphic code. Of course, telegraphic communication is communication of but one kind, and the absence of a telegraph key is not basis for disqualifying an otherwise effective communication system.

Hogan also states, page 1834, that the primary and secondary coils P and S_1 may have been taken by me from one of the Tesla patents. That they are not shown in association with the other apparatus of "Loftin Sketch A." Figure 165 of the Martin book shows that I did not have to refer to Tesla patents as an origin for the primary and secondary coils P and S_1. The Martin book clearly de-

scribes the second system of Figure 165, as well as others of the figure, as a source of high-frequency alternating currents, and includes a transformer having a primary winding P and a secondary winding S_1 for connecting this source to wherever use may be required of it, just as any properly designed electrical apparatus is provided with connections for making use of it. In his description of Figure 185, the antenna system, Tesla directs the use of a source of high-frequency oscillations inserted in the antenna to get the results described by him, and it requires no particular knowledge to use any one of the sources fully set forth in Figure 165, this including the primary and secondary coils therein provided.

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[fol. 1719] Mr. Edwards. Defendant's counsel offers in evidence a sketch made in answer to question 14, and the same is marked "Defendant's Exhibit W-6."

18. Question. Having in view your explanation of the effect of resistance given in answer to question 15, please again refer to Marconi patent 627650 and explain what, if any, effect the position of condenser k' with respect to the detector T has upon the tuning of the lateral circuit.

Answer. Marconi patent 627650 states, page 1, lines 38 to 43, that the condenser k' should be varied in order to obtain "best effects" if the length of the wave is varied. In speaking of a receiving system "best effects" means simply loudest signals, or in other words, Marconi directed varying the capacity of condenser k' until loudest signal was had. Referring to Figure 2 of my sketch R one, in following out the instructions of this Marconi patent, would vary the condenser k' when the wave length received corresponded to the frequency f' until a maximum or peak was had in response for the signal as shown, for example, by the "high resistance" curve in Figure 2 of my sketch. Because of the high resistance of the detector in series with the tuning condenser k' the response would not be as peaked or sharply defined as in the case of the "very low resistance" curve in Figure 2 of my sketch, but the "best effect" would be obtained under the limitation imposed by the high resistance of the detector. At this adjustment for "best effect" the secondary circuit would be in tune with the primary or antenna circuit and with frequency of the incoming signals.

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19. Question. Claimant's witness, Weagant, page 1558 and following, and Hogan, page 1832 and following, allege that Tesla patents 645576 and 649621 do not provide for tuning the antenna circuit to accord with the closed or lateral circuit. Will you consider the reasons given by these witnesses for their contention and state if you agree or not?

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Answer. On page 1833 the witness Hogan states that Tesla in patent 645576, defendant's Exhibit X-2, does not describe tuning his "entire secondary circuit with the elevated conductor attached (not merely the secondary coil alone)." The left-hand figure of the drawing of this Tesla [fol. 1720] patent, which shows a transmitting station, shows a coil A having one terminal connected to ground and the other terminal connected to an elevated wire B, thus constituting the usual complete secondary circuit of a radio transmitting station whether of the present day or of the early day of the Tesla patent. There is no possible way in which one element in an electrical circuit can be tuned by itself to the exclusion of other elements connected thereto, and the contention of Hogan that Tesla tuned merely the coil A without bringing into the tuning effect the whole antenna circuit is as absurd from an electrical point of view as would be a contention that a man jumps some such distance as 20 feet with his legs only and that other elements of his body do not participate in the action. It is true that a coil by itself without any connections has a definite natural period, and is therefore capable of being in tune with electrical currents of the same period, but Tesla in paten 654576 did not show an isolated coil, but a complete antenna system of a transmitting station with the coil included as merely one element thereof, and the taning specified in Tesla patent could only be brought about through the tuning of the whole circuit.

Again on page 1833 the witness Hogan states as to this Tesla patent the following:

"Tesla's explicit directions are to adjust a transformer secondary coil to produce a maximum voltage at its central terminal, and then to apply that exceedingly high voltage to the elevated conductor through the wire B (of his patent 645576)."

This is a misstatement of the tuning instruction in the Tesla patent, his actual instructions being found on page 3, lines 78 to 85, as follows:

"By such an adjustment or proportioning of the length of wire in the secondary coil or coils the points of highest potential are made to coincide with the elevated terminals DD', and it should be understood that whatever length be given to the wires this condition should be complied with in order to attain the best result."

Thus Hogan erroneously says that Tesla instructed to adjust to bring the highest potentials at the center of coil A of the left-hand figure, whereas Tesla in fact instructed adjusting to bring the highest potential in the terminal D at the top of the antenna, and examination of the figure shows that the full length of wire B separates the point actually stated by Tesla and the point erroneously stated by Hogan, so that Tesla did in fact provide for including the elevated wire and the other elements of the antenna circuit in addition to the coil in his instructions for tuning.

There is no contention made by Hogan that Tesla did not provide for generating or creating high-frequency alternating currents in the primary circuit for transfer to the antenna circuit in the transmitting system of the left-hand figure of the drawing, and in fact Hogan admits that all that was necessary for the system of Tesla in patent 645576 to be the system of Marconi in patent 763772 was the tuning of the antenna circuit. On page 1833 Hogans states:

"To make the Marconi invention Tesla would have to tune his entire secondary circuit * * *."

Since the very language of the Tesla patent provides for an adjustment of the antenna circuit to bring the point [fol. 1721] of highest potential at the top of the antenna, a true condition of tuning, instead of at the terminal in the middle of coil A as erroneously pointed out by Hogan, Tesla did provide for tuning the entire secondary or antenna circuit, and by so doing satisfied the requirements specified by Hogan as necessary to make up the alleged invention of Marconi patent 763772.

At the bottom of page 1832 Hogan admits that Tesla patent 645576 contemplated the transmission of intelligible messages, but states that this is not "wireless telegraphy"

as Marconi knew it, adding that it is not "Hertzian" or "radio telegraphy" which contention I can not understand unless a limitation is intended by reference to "telegraphy," as Tesla did not specifically refer to the use of a telegrapher's key for the transmission of the "intelligible messages" mentioned by him. Of course the limitation of the system to a telegraph one is not pertinent, as radio systems are most extensively used without employing telegraph apparatus as a means for forming the intelligible messages transmitted. For example, practically all of radio broadcast transmitters now used do not involve telegraph apparatus. There seems to be no dispute that the Tesla transmitter, having tuned antenna or not, provided for exciting the antenna with alternating currents, and there can be no question that the flow of these currents in the antenna circuit results in the production of electrical effect detectable at a distance, and it makes not the slightest difference whether or not the mode of transmission of these effects is given the name "Hertzian" or any other popular designation, the results are inevitably the same.

I do not find that the witness Weagant made reference to the matter of tuning as between the antenna circuit and the closed or lateral circuit in connection with Tesla patents 645576 and 649621 on page 1558 or the pages immediately following, but do find that he testified as to this matter on pages 1643 to 1649 and, like Hogan, contends that the tuning provided by Tesla refers, in the case of the antenna circuit, to tuning of the coil A by itself, basing his contention on some data of empirical character given by Tesla in patent 645576 for construction of the coil A. For example, at the bottom of page 1644, Weagant quotes from the Tesla patent to the effect that the wire forming the secondary coil in the transformer used by him should be "approximately" one quarter of the wave length of the electrical disturbance in the circuit, followed by fundamental reasoning on the part of Tesla as to why he suggested this approximation, and his reasoning is no more than that of every practical engineer in arriving from a first consideration point of view of a place from which to start in producing an electrical organization.

At the top of page 1645 Weagant quotes that part of the Tesla specification in patent 645756 as to adjustment to bring the highest potential at the top of the antenna which I quoted in referring to the testimony of Hogan in con-

section with these Tesla patents, and although the quotation is specific for the adjustment of the potential condition at the top of the antenna, and thus far removed from the coil near the base of the antenna, Weagant discusses this quotation as limited to an adjustment affecting the coil only. Weagant states:

[fol. 1722] "Tesla, however, adjusts the natural period of his secondary coil alone and then directs the attachment to the high potential point of an antenna of any length."

That Tesla had the whole antenna circuit in mind rather than the mere coil as contended by Weagant is positive from Tesla's final instructions as to what would determine the best adjustment as follows, lines 80 to 85, page 3:

"and it should be understood that whatever length be given to the wires this condition (highest potential at the top of the antenna) should be complied with in order to attain the best results." (Parentheses mine.)

That is, Tesla laid down an empirical rule for constructing coils for use in the antenna circuit, but did not depart from the subject until he had left a clear instruction and caution that no matter what happened to be the length of the wire an actual electrical condition definite of tuning was to be arrived at in determination of final adjustment for "best results," and Tesla makes it clear in his specification that "best results" refers to tuning or syntony as between the primary and secondary circuits.

Weagant, like Hogan, contends that because Tesla did not claim to use "Hertzian waves" his system as a whole differs from the systems of Marconi who wrote the words "Hertzian waves" into his patent specification, and, like Hogan, does not deny that Tesla provided for causing alternating currents to flow in an antenna circuit without pointing to any circumstances in the Tesla systems which would prevent them from producing electrical effects detectable at a distance in the same way as the Marconi systems.

20. Question. In answer to question 208, page 1636, the witness Weagant criticizes your "Sketch L" of Figure 4 of Lodge patent 609154 because you omitted the spark gap in the antenna circuit. What are the instructions of the Lodge patent in this respect?

Answer. In his answer to question 208, page 1636, Weagant states that I, in drawing the circuit for my "Sketch L," omitted the spark gap in the antenna circuit shown in Figure 4 of Lodge. My Sketch L makes specific reference to "Figure 4 and description," and I so labeled my sketch in order to make it clear that some of the features of it depended upon descriptive matter not definitely covered in Figure 4 itself. In Figure 4 of the drawing Lodge shows the coil h^1 in the antenna circuit interrupted by a spark gap formed by the spark balls h^2, h^3. As to this gap Lodge states, page 2, lines 35 to 39:

"The best width of this gap depends upon circumstances, and it may be closed altogether without stopping the action."

My sketch shows an arrangement in which the gap between the two parts of the coil h^4 is closed as provided for in this part of the disclosure of Lodge.

21. Question. In the same answer the witness Weagant states that if Lodge Figure 4 is constructed in accordance with the instructions in the patent it is inoperative, and if [fol. 1723] the coil *k* is omitted, the system will give rise to the emission of a complex wave train. What can you say as to these contentions?

Answer. Commencing at the bottom of page 1637 Weagant refers to apparatus that was set up and operated during the Kilbourne & Clark case for a demonstration of Figure 4 of Lodge, and objects to this apparatus on the ground that for the coil *k* used in the demonstration there was included an iron core, stating that this construction is nowhere disclosed in the patent and quite contrary to the usual practice when coils are used for the purpose of carrying high-frequency currents. Lodge does not state that the coil *k* is intended to carry high-frequency currents, the purpose being stated by Lodge, page 2, lines 49 to 53, as follows:

"The outer coats of the jars must not be insulated from each other, and I usually join them by an induction coil of fairly thin wire *k*, so as to permit thorough charging."

Lodge charged the condensers with very low-frequency currents, and obviously the coil *k* should have such high inductance as to prevent in effect a short circuit between the two condensers *j* at the low frequency of the charging currents. In other words, the function of this coil *k* is related

to low-frequency currents rather than high-frequency currents as contended by Weagant. To make a coil with sufficient inductance to provide the required high impedance for low-frequency currents requires a good many turns of fine wire. With our present knowledge of the effect of increasing inductance of a coil by using magnetic cores, such as iron, the same impedance can be obtained with the use of a much smaller number of turns of wire on an iron core than without such core, and it would be foolish to now construct a coil to produce the function of coil *k* in Figure 4 of the Lodge patent without an iron core.

The contention of Weagant is that the coil *k* should be built of a small number of turns in order to have small inductance in order to permit the flow of high-frequency currents quite readily, this in spite of the absence of any instructions in the Lodge patent covering a function in connection with high-frequency currents. If the coil *k* were constructed of a sufficiently small number of turns to be suitable for high-frequency current action it would amount to a short circuit between condensers *j* and prevent the "thorough charging" of these condensers by the low-frequency charging current contemplated in the Lodge patent, and the system would then be inoperative. The fact that such a construction of the coil *k* would result in inoperativeness makes it clear that Lodge did not contemplate the high frequency coil of the Weagant, and that the iron core of the coil used in the Kilbourne & Clark demonstration correctly followed the instructions of Lodge to provide a coil that would permit of "thorough charging" of the condensers *j*.

It is true that with the coil *k* omitted, as well as with the coil *k* of proper construction in play, the system of Figure 4 will give rise to the emission of a complex wave train, but this fact does not prove anything derogatory to the Lodge system. Figure 4 of Lodge provides for two circuits, an antenna circuit and a lateral circuit, having a coupling there between through which energy must be transferred. In my answer to question 21 in my prior testimony, [fol. 1724] between pages 1035 to 1041, I point out that wherever energy is transferred from one circuit to another there results a complex wave train by the interaction of the circuits, and that a multiplicity of frequencies of electrical effects results. Also that the separation of the frequencies depends upon the degree of coupling between the

two circuits. In my sketch G, opposite page 1039, I illustrate in Figure 3 this complexity of frequencies involved in this action. In my reference to the modern quenched gap system in connection with my sketch O, opposite page 1100, I show in Figure 6-B how this complexity is included in the quenched gap system, an improvement over the system of Figure 4 of Lodge which has now long had extensive use. While it is not altogether desirable to have this complex wave train, yet it has always been necessary to transfer energy from one circuit to another in radio transmitters that have been proposed so that this complexity has inherently existed. The fact is that rather than the presence of a complex wave train proving anything against the system it serves to prove that the system is operative and includes a feature inherent to all of those systems which found use in practice.

Referring to my sketch L, opposite page 1069, of the Lodge transmitter, and comparing this to the transmitter in Figure 37 of claimant's Exhibit 91, opposite page 181 in the testimony of claimant's expert Waterman, it will be seen that the two systems shown are substantially similar, particularly in the matter of having an inductance element common to both the antenna circuit and the local circuit, or what is generally known as direct coupling. Claimant's expert Waterman uses Figure 37 of claimant's Exhibit 91 to explain that the direct coupling is equivalent of the indirect coupling of Figure 36 of the same exhibit, that is the 2-winding transformer. The two systems of claimant's Exhibit 91 inherently produce a complex wave train as does Figure 4 of the Lodge patent.

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22. Question. Mr. Hogan, in answer to question 6, page 1819, refers to the operation of Lodge Figure 4 as a "single chunk" operation. Does the Lodge specification describe any apparatus purporting to act as indicated by Mr. Hogan?

Answer. It does not. I understand from the testimony of Hogan that his reference to the action in the arrangement of Lodge Figure 4 as a "single chunk method of exciting a transmitting antenna" is intended to convey the impression that it is his opinion that the description by Lodge of the operation of his system suggested the thought by Lodge that there was to be but a single rush or pulse of current in the primary circuit upon breakdown of the spark gap

and discharge of the charged condenser, and further that because the Lodge arrangement of Figure 4 can not and does not operate to give but a single pulse that it fails to operate in the way that Hogan has erroneously contended that Lodge describes.

[fol. 1725] That the "single chunk" contention of Hogan as the idea of Lodge as to the working of Figure 4 is erroneous and not based on a thorough study of Lodge's description is particularly obvious from that part of the Lodge patent, page 2, lines 27-32, which reads as follows:

"So that when the coil is in action the capacity areas receive their positive and negative charge by aerial disruption—that is, in a sudden manner—rather than by the slower process of metallic conduction."

Here Lodge specifically refers to the capacity areas of the antenna receiving both positive charges and negative charges by the action of his primary circuit. There is no limitation expressed as to the number of each kind of charge, but if limited to the minimum of but one of each kind of charge two pulses would be necessary rather than the "single chunk" of Hogan.

Nowhere in the Lodge specification is any reference made expressly to "single chunk," or any other equivalent language such as single impulse or single rush of current, which might well have been used by Lodge had he had the idea erroneously ascribed to him by Hogan.

Lodge clearly had the idea of transferring the energy from the primary circuit to the secondary circuit as quickly as possible in order that the period of time involved in the transfer of energy during which all sorts of complicated actions take place would be as short as possible compared to the time in which the energy would freely oscillate in the antenna circuit without any disturbing back connection to the primary circuit, the very basis and fudamental principle of the quenched gap system which later supplanted all other forms of spark telegraphy radio transmitters. Lodge refers to the charging of the antenna from the primary circuit as "in a sudden manner" and "impulsive rush." Appreciating that Lodge was dealing with alternating currents that involved millions of pulses per second, it is physically impossible that Lodge thought in terms of isolating one of these little pulses—a "single chunk"—and depend-

ing upon it for supplying all of the energy needed by his antenna to make up a radio transmitting system.

Again, if the "single chunk" suggestion of Hogan had any foundation it would mean that each time the spark gap breaks down to start a discharge there would be but one rush of current or spark at the gap, instead of a rapid succession of sparks occurring at the rate of millions per second. That Lodge did not think of the action in terms of but one rush of current across the gap, or but one spark, is clear from his description of the purpose of the coil *k*. Page 2, lines 53-56, Lodge states:

"When the discharge occurs, this wire acts as an alternative path or by-pass, but does not prevent the sparks at the supply gap."

Thus Lodge clearly visualizes that when the discharge had once taken place there would be a succession of "sparks" throughout the duration of which the action of the coil *k* would be helpful. If Lodge had foreseen but one spark comprising the discharge he would never have suggested the use of the coil *k*, as it could have no function in the absence of a plurality of discharges of currents across the gap.

The inaccuracy of Hogan's study of the Lodge patent is further illustrated in that part of his answer to question 6 in which he says:

"Lodge did not propose to take the spark gap out of the transmitting antenna."

[fol. 1726] There seems to be a serious objection among claimant's witnesses to admitting that Lodge provided for taking the spark gap out of the antenna. In a previous answer I referred to the criticism of the witness Weagant of my sketch L, opposite page 1069, because it does not include a spark gap in the antenna circuit, and pointed out that Lodge provided for removing the spark gap, page 2, lines 35-39.

23. Question. In his answer to question 209, pages 1639 and following, the witness Weagant refers to a paper by John H. Morecroft in the Proceedings of the Institute of Radio Engineers, volume 8, 1920, page 75, claimant's Exhibit 248. Is the action of the apparatus described in this paper the same as that of Lodge's Figure 4?

Answer. No. The Morecroft system referred to by Weagant in the part of his testimony covered by your question is in nowise the system of Figure 4 of Lodge. In the Morecroft system deliberate attempt was made to secure a single pulse or rush of current in a primary circuit coupled to a secondary circuit in order to determine the result in the conduct of the energy transferred to the secondary circuit from such a single pulse.

In the first paragraph of page 1640 Weagant makes it clear that the primary circuit of Morecroft was not the primary circuit of Figure 4 of Lodge in that Morecroft merely included a battery as a source of energy and a resistance, with a switch to suddenly start and stop a rush of direct current from the battery to form a pulse of duration determined by the length of time the switch was open. Such an arrangement is in nowise an oscillatory circuit, and can not produce alternating currents. In the case of Figure 4 of Lodge the primary circuit is an oscillatory circuit, including an inductance and a condenser for determining the period of the circuit and a spark gap for starting an oscillatory discharge in the circuit, so that once the spark gap breaks down currents will flow back and forth until some condition increases the resistance of the gap to current flow to such an extent that the remaining energy is insufficient to overcome the resistance. In other words, the primary circuit of Lodge is an oscillatory circuit of the same kind used in all spark radio transmitters for starting the electrical energy in motion to excite an antenna.

Thus referring to Figures 4, 5, 2, and 3 of claimant's Exhibit 248, opposite page 1640, there is shown in the upper part of each one of the oscillograms of these figures a single rise indicative of a single pulse of current in the primary circuit upon the opening and closing of the switch in the Morecroft arrangement. If the arrangement of Lodge Figure 4 were substituted these oscillograms would show alternating current above and below the line as long as the spark-gap remained conductive to the energy in the primary circuit, and with the arrangement of Lodge Figure 4 it would be impossible to produce the single pulse shown in Figures 2, 3, 4, and 5 of the Morecroft paper.

The figures do show very nicely, however, how an antenna circuit, when excited with energy from a primary circuit, oscillates with this energy in its own natural period after the influence of the primary circuit is removed. Thus

Figures 2 and 3 show that there is practically no influence on the oscillations in the secondary circuit when the switch in the primary circuit is closed very quickly after the opening thereof, while Figures 4 and 5 show that when the switch [fols. 1727-1728] is held open for a long time the energy in the secondary circuit reacts back onto the primary circuit to create the complex wave effect slightly noticeable in the second half cycle of the first alternation in Figure 4 and particularly noticeable in the same location in Figure 5. This effect clearly shows the understanding of Lodge of the desirability of removing the effect of the primary or charging circuit on the antenna as soon as the transfer of energy operation would permit, and the soundness of the principle for practical radio communication is demonstrated in the fact that the modern quenched gap system which, through substantial improvement of gap construction and coupling conditions, resulted in so effectively using this principle of Lodge that the system practically supplanted all other spark telegraphy systems.

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24. Question. Mr. Waterman, in answer to question 2, on page 1881, testified that the arrangement of figure 4 of Lodge was useless. Do you agree?

Answer. No. While Lodge did not provide in figure 4 all of the refinements for utilizing in the best manner the principle of quickly charging the antenna and disconnecting the charging circuit therefrom as are now embodied in quenched gap systems, at the very early date of the Lodge disclosure it was a substantial advance over prior suggestions for a practical communication system, and particularly so in the matter of removing the spark gap from the antenna circuit, the first step toward making it possible to excite the antenna and at a proper moment leave it free to oscillate without the influence of the spark gap. The system was particularly useful for operation as it stood, and of outstanding value because of pointing the way to the ultimate highly successful quenched gap system.

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[fol. 1729] 30. Question. In question 44, page 1497, the witness Clark was referred to a portion of your testimony of page 1125 in which you are quoted as stating that it was "not" possible to use the Navy wave changers with the open type of transmitter. Does the quoted part of

your testimony in question 44 give the correct sense of your statement concerning these wave changers?

Answer. The paragraph from which the quotation was taken, when correctly read, clearly shows that inclusion of the word "not" is an error and was not intended by me. In the same paragraph I definitely refer to using the marking on the dial if the wave changers should be used with an open-gap type of system.

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31. Question. Please consider the statements made by Mr. Weagant in answer to question 213, commencing on page 1650, and state whether you agree with his testimony, stating your reasons.

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[fol. 1730] Answer. I do not agree with the testimony in general of Mr. Weagant in answer to question 213. The testimony relates to the bearing of the letters which passed between Joseph D. Baker and John S. Stone of June 30, 1899, July 18, 1899, and July 22, 1899, defendant's Exhibits F-3, G-3, and E-3, respectively, the original application for patent No. 714756 of John Stone Stone, defendant's Exhibit R-3, and Stone patent 714756, defendant's Exhibit P-3, on the subject matter of Marconi patent 763772 in suit, and Weagant's statements relating to this matter are rather lengthy.

My general understanding of the Weagant testimony is that there is no denial by him that the Stone system in the Stone to Baker letters of June 30, 1899, and July 18, 1899, the original Stone application for patent 714756 and Stone patent 714756 include the elements forming the disclosure of the Marconi patent 763772 in suit, but that he merely argues that Stone provided for tuning but one portion of the antenna circuit instead of the entire circuit, and to this extent falls short of satisfying the Marconi disclosure. In the Stone to Baker letters and Stone patent, Stone referred to the antenna structure of both the transmitting and receiving stations as an "elevated wire" in some cases and an "elevated conductor" in some cases, and also included reference to the antenna as a "circuit" in some cases. In both the letters and the Stone patent Stone showed the antenna to be a complete circuit starting from a wire connection to ground through a coil

to a wire extending vertically, and it is my understanding of Weagant's present testimony that he contends all of Stone's references in the letters and patent to tuning having to do with the antenna were limited to that part of the antenna made up of the vertical wire above the coil in the antenna circuit, this as compared to Weagant's contention in connection with the tuning of the antenna in the Tesla patents being limited to the coil in the antenna only.

Thus again Weagant contends an absurdly impossible physical proceeding. Just as it is physically impossible to attach a weight to a spring and cause the spring to be tuned to vibrate in a period independent of the effect of the weight attached thereto, so is it impossible to include coils of wire in an electrical circuit and cause the circuit to respond in any way other than that involving the effect on the circuit of that part of the total inductance of the circuit contributed by the coil. Long prior to the Stone letters to Baker and the filing of the Stone application for patent, electricians understood that the tuning of a circuit depended upon all of the inductance of the circuit combined with all of the capacity of the circuit, and so this knowledge up in the form of a mathematical expression, which expression is found opposite line 105, page 5, of Stone patent 714756 under discussion. Just above the formula Stone refers to it as "the mathematical expression for the frequency to which a circuit is resonant when it is isolated from all other circuits"—thus, instead of Stone having any such foolish idea as that attributed to him by Weagant that he could mentally select parts of a complete [fol. 1731] electrical entity and refer to it as being tuned to the exclusion of the entire system, Stone most intelligently makes it clear in commenting on the mathematical expression for resonance of circuits that it is not possible to apply the expression to a circuit except when it is "isolated" from all other circuits. As between independent circuits it is, of course, possible to effectively isolate one from another, as by physically separating them, but it is absolutely impossible to electrically separate one portion of a circuit from another portion of the same circuit except by the aid of the imagination.

In addition to the electrical absurdity of Weagant's contention there is no basis physically for contending that

Stone's use of the term "elevated wire" or like terms limited the thing referred to by him to that portion of the antenna circuit above the coil. The fact is that such expressions as "elevated conductor," "vertical wire," and the like, were the forerunners of the later term "antenna," and I have no hesitation in saying that no reputable engineer of the present time would contend that a reference to tuning an antenna limited the idea of tuning to that portion of the whole circuit extending in antenna fashion above the coupling coil.

Weagant further contends that Stone's reference to the words "forced oscillations" or "forced vibrations" used in referring to the high-frequency currents in the antenna following generation of the currents in the primary circuit and transferring them to the antenna circuit through the coupling means that the antenna circuit was to be out of tune with the oscillation coming from the primary circuit. On page 1650 Weagant states as to these terms—"have but one significance in this art, viz., vibrations or oscillations differing in frequency from that of the circuit on which they are impressed."

This definition of Weagant is not a true one in fact even to day, and at the time of the filing of the Stone application for patent Stone was in a position of being more or less a pioneer in creating expressions for actions of this kind. The generally accepted understanding of these terms is in those cases where oscillations are generated and transferred in such a way that there can be no change in the frequency as generated by reason of the transfer, or, in other words, the oscillations are imposed upon the circuit receiving them in the form in which they are created rather than being modified by some influence had on them on the part of the receiving circuit, and if the oscillations are properly created and properly transferred it makes no difference where the receiving circuit is tuned or not, the fundamental frequency at which created will remain the same after transfer to the receiving circuit. For example, it is usual to generate alternating currents for lighting and power purposes by machines which, through the influence of mechanical speed-governing devices, operate to generate the currents at 60 cycles per second, and these 60-cycle commercial currents are transferred from place to place through numerous transformers still maintaining a frequency of 60 cycles per

second, and it makes no difference whether or not the circuits to which these currents are transferred are tuned or not, and in some cases some of the receiving circuits are tuned, or nearly so, under a condition commonly known among power electricians as maintaining "unity-power [fol. 1732] factor," a condition under which the losses are a minimum just as they are in radio practice when the circuits are tuned. In such power systems the 60-cycle oscillations are truly "forced" upon the distributing lines by the constantly acting machine generator under the influence of a constantly supervising governor, so that the electrical constants of the circuits can not alter this forced frequency.

Where oscillations are generated directly within one circuit, as by a spark-gap discharge within the circuit, the condition shown in Marconi reissue patent 11913, there is no way of forcing the resulting oscillations to take up a frequency which ignores the electrical time constants of the circuit; in fact, these electrical time constants have the sole determination of the frequency of the operation, and such oscillations are commonly known as "free" oscillations. It is well known that it is impossible to generate with practical apparatus absolutely pure oscillations, so that all generated oscillations include a fundamental accompanied by many harmonics, and the intensity of the harmonics in comparison with the intensity of the fundamental is a measure of the purity of the generated oscillations. For example, it is not uncommon to be able to receive a broadcast radio transmitter at two widely separated points on the dial if near enough to the station for the energy in the harmonic to reproduce in the receiver. If the oscillations are generated in one circuit to include a fundamental and harmonics obviously by tuning a second circuit to the fundamental a selective discrimination can be made between the fundamental and the harmonics. For example, if a circuit has generated therein a fundamental of 1,000 kilocycles and has a second harmonic of 2,000 kilocycles having 10 per cent of the intensity of the fundamental, a near-by receiving circuit tuned to the fundamental may so discriminate against the harmonic that in the receiving circuit the strength of the harmonic will only be one-tenth of 1 per cent of the received fundamental.

* * * * * * *

Thus in the vertical wire system of Marconi reissue patent 11913, with the spark gap located directly within the vertical wire, the generated oscillations had their frequency determined solely by the electrical constants of this vertical wire circuit, and the fundamental frequency with all of the accompanying harmonics were emitted directly out into space from this wire. In a circuit of the elevated wire type, including the damping effect of a spark gap therein, the production of harmonics along with the fundamental is quite pronounced, giving what is generally known in the art as an emission "rich in harmonics," an undesirable form of radio emission, because radio receivers which, in listening for other radio transmitting stations may, in doing so, tune to one of the harmonics and thus hear a signal from a station not wanted. That Stone most intelligently appreciated this condition of affairs in connection with the system of the Marconi reissue patent is certain from the way he handles the subject in his letter of July 18, 1899, to Baker, defendant's Exhibit G-3, and in his patent 714756. In the Baker letter of July 18 he shows in [fol. 1733] Figure 1, page 2, of the letter the transmitting system (at the left) and the receiving system (at the right) of the Marconi reissue patent. Beginning at the bottom of page 2 of the letter Stone states as to this Marconi system the following:

"The discharge of the vertical wire is oscillatory in character owing to the electrostatic capacity and inductance or coefficient of self-induction of the vertical wire, but owing to the fact that the electrostatic capacity is distributed along the wire and is moreover not uniformly distributed (the different points along the wire being at different distances from the earth) the oscillations are not simple harmonic in character, but may be represented by a Fournier's series,

$$A_1 \sin pt + A_2 \sin 2\,pt + A_3 \sin 3\,pt + \text{etc.} + B_0 + B_1 \cos pt + B_2 \cos 2\,pt + B_3 \cos 3\,pt + \text{etc.}$$

The oscillatory discharge of the vertical wire sets up corresponding electromagnetic waves surrounding it, part of which are radiated with the velocity of light. These electromagnetic radiations upon passing the vertical wire at the receiving station set up corresponding electromotive forces in it."

I particularly include in my quotation the mathematical expression of Stone of the fundamental and harmonics because it is of great importance, and technically in no wise warrants the unjustified flippant reference to it by claimant's expert, Waterman, on page 1918, as "a mere excursion into mathematical realms."

A "simple harmonic" oscillation is a fundamental oscillation free from harmonics, or, in other words, is a pure sine wave of but one frequency of oscillation. Stone gives in the quotation electrical and physical reasons why the transmitter of the Marconi reissue patent is incapable of generating pure sine or simple harmonic oscillations, and most ably and intelligently states in the mathematical expression made light of by Waterman what kind of oscillations could be expected, and the expression is a clear picture to any informed physicist Stone's idea of these oscillations, the mathematical expression giving the picture in two lines, whereas if expressed with words several pages would have been required. The expression simply says by its first term "$A_1 \sin pt$" that the oscillation includes a fundamental of frequency p with an amplitude or intensity of some value A_1 accompanied by a second harmonic set out in the second term "$A_2 \sin 2\ pt$" having $2p$ or double the frequency of the fundamental and the lesser amplitude or intensity A_2 than the fundamental, and other higher harmonics for each one of the additional terms, and there could certainly be no clearer way than this mathematical expression for Stone to address himself to those with whom he considered himself to be communicating.

The quotation from Stone's letter goes on to make it clear that with such a transmitter as that of the Marconi reissue patent emissions go out into space to reach the receiving antenna, including not only the fundamental "$A \sin pt$" but numerous harmonics represented by the succeeding terms of the expression.

Thus after having clearly pointed out the existence of impure oscillations and the undesirability of them in the Marconi reissue patent system, Stone points out in the letter that if simple harmonic oscillations are to be had in the antenna they must be generated in a medium outside of the [fol. 1734] antenna and be merely impressed or, as Stone expressed it, "forced" upon the antenna after creation elsewhere independently of the electrical constants of the antenna. Stone provided a primary circuit in which to

originally generate the oscillations, and merely coupled this to the antenna circuit. Because of the intelligent and clear understanding of Stone of the production of harmonics in a spark-gap circuit it is conclusive that he did not contemplate that the mere changing of the production of oscillation over to the primary circuit would eliminate the production of harmonics in addition to the fundamental in the primary circuit any more than in the vertical wire he employed for detailed discussion of the matter, and with this understanding the absurdity of contending that Stone's instructions to tune the antenna did not refer to the entire antenna circuit is obvious. Stone wanted only the simple harmonic fundamental in the antenna circuit, and he teaches too much about the matter of tuning and resonant energy transfer to make it believable that he did not know that if he left the antenna circuit untuned with respect to the fundamental in the primary circuit he was likely to resonantly select out of the antenna circuit by this detuning some one of the harmonics in lieu of the fundamental he so decidedly insisted upon having.

The next step of Stone further emphasizes that he had no mistaken ideas as to "forcing" simple harmonic oscillations of fundamental frequency upon the antenna circuit, which step had to do with the matter of coupling between the primary circuit in which the oscillations were generated and the antenna circuit where he desired the simple harmonic of the fundamental only. I have previously pointed out that Stone, in giving on page 5, opposite line 105, of his patent 714756 the mathematical expression for the relation between frequency and inductance and capacity for resonance of a circuit was most particular to point out that the expression holds true only when the circuit under consideration is isolated from all other circuits, so that with this fundamental knowledge so emphatically expressed by Stone he proceeded to isolate his primary circuit in which he generated the oscillations with the aid of a spark gap as much as was practically possible by the aid of "loose" coupling, for he well knew that without a sufficient amount or extent of loose coupling he had no hope of arriving at confining the oscillations transferred to the antenna circuit to the simple harmonic form he so clearly pointed out as necessary to the selective communication system he developed. In his letter of July 18, 1899, to Baker, page 7, he clearly points out a practical manner of securing loose cou-

pling between the primary circuit and the antenna circuit, and in the middle of page 8 of this letter states that he believes himself to be the first one to suggest his particular method of securing loose coupling.

In my previous testimony, pages 1075-1076, I referred to the provision in Tesla patent 645576 of tuning the two circuits at a transmitting station to the same time periods. That Stone knew of this work of Tesla in 1899 is disclosed in his comments in the paragraph commencing at the bottom of page 6 of Stone's letter of July 18, 1899, where Stone says that the transmitting circuit disclosed by him to Baker in a previous letter "is practically the same as that employed by Tesla for the production of high-frequency currents," and Stone goes on to say:

[fol. 1735] "Except that I place an inductance coil L in the circuit to give additional means of tuning and to swamp by its greater inductance the reactions from the induction coil *t*, which would tend to make the oscillations multiperiodic instead of simple harmonic."

Thus Stone made no distinction between his system and the tuned system of Tesla in the matter of tuning as between the two circuits, but that the additional inductance coil of Stone was an improvement over Tesla in two ways, one in the provision of additional means of tuning, and the other in the provision of means giving sufficiently loose coupling between the circuits to prevent the oscillation from being the undesired "multiperiodic" in the antenna instead of the desired "simple harmonic." Thus Stone did not take unto himself any credit for the adjustment of the time periods of the two circuits to be the same, leaving this to Tesla who had already suggested it, but did take credit for himself in the matter of using tuning of the two circuits in proper combination with coupling in order to secure a "simple harmonic" oscillation in the antenna, because he had so clearly pointed out that it is only with this kind of oscillation that the selectivity he desired for his communication system could be had. Thus Stone and Marconi patent 763772 both disclose the adjustment of the time periods of the two circuits to be the same already disclosed by Tesla. Stone takes no credit for it, but leaves it with Telsa, where it belongs, keeping for himself his loose coupling. Marconi claimed for himself the Tesla adjustment, and made no reference to loose coupling, but in an address by

Marconi in 1912, to which I referred in my previous testimony on page 1068, Marconi admitted that this loose coupling of Stone was an essential feature to the successful operation of the system disclosed by him in patent 763772.

* * * * * * *

On page 1650 Weagent states:

"Nowhere in the Stone-Baker letters, or in the subsequent patent, in which he reduced his ideas to practice, is there a disclosure of a variable inductance or other variable tuning element in the antenna circuit.

"While Stone illustrates in detail the principles of operation and the necessary apparatus for the tuning of the circuit associated with the antenna system, he neither shows in the sketches nor describes in words any method of tuning the antenna system."

That these assertions of Weagant are not in accordance with the facts is evident from examination of the language of the Stone-Baker letters and the patent 714,756. In the very first letter to Baker, June 30, 1899, page 2, Stone stated:

"I propose to impress upon this vertical wire oscillations from an oscillator, which oscillations shall be of a frequency corresponding to the fundamental of the wire."

Since Stone arranged to generate the oscillations to be impressed upon the vertical wire in a separate circuit with the aid of the discharge of a spark gap or, in other words, generated "free" oscillations, the electrical time period of the generating circuit was the same as the time period of [fol. 1736] the oscillations, Stone having stated that in such form of generation the period of the oscillation is determined by the period of the circuit. In the quotation above Stone states that the frequency of these generated oscillations is to correspond to the "fundamental" of the wire, the word "fundamental" having no meaning other than fundamental period determined by the electrical time constants of the wire. This, therefore, makes it clear that the primary circuit in which the oscillations were to be generated, the antenna circuit which was to receive the oscillations after generation, and the oscillations were all to have the same frequency, or, in other words, the antenna circuit was to be tuned to the primary circuit.

The last paragraph but one of the same letter clearly contradicts the statement of Weagant that Stone did not describe in words any method of tuning the antenna system. This paragraph reads:

"The tuning of these circuits one to another and all to the same frequency will probably be best accomplished empirically, though the best general proportions may be determined mathematically."

The first feature of importance in this quotation is that Stone definitely refers to the tuning of "circuits" in referring to all four of the circuits, two at the transmitter and two at the receiver, of the complete system shown on page 3, upper figure, of the June 30 letter, and did not distinguish between circuits and "vertical wires." If Weagant's contention were accepted Stone should have written this part of the letter to say the tuning of these circuits *and vertical wires per se* one to another and all to the same frequency, which Stone did not do because he was not the electrical fool that Weagant contends.

The quotation further gives two methods of accomplishing the tuning, rather than no method as contended by Weagant. Stone provided for accomplishing the tuning "empirically," the general practical method in use to day, adding that the general proportions may also be determined "mathematically," a method also much used in beginning the design of radio devices.

In the next letter to Baker, July 18, 1899, page 5, Stone stated "if the period of the impressed force be the same as that of the fundamental of the vertical wire," after which he points out that the radiations from the antenna will be "simple harmonic" and of the "same period distant." In other words, Stone made it clear that tuning the antenna permitted of maintaining the "simple harmonic" form of radiation in which he was so greatly interested.

On page 8 of this second letter Stone referred to the second set of transmitting and receiving stations shown on page 3 of his letter of June 30, pointing out that in this second system he differed from the first in adding one more circuit at each the transmitting and receiving stations, stating "an additional resonant circuit attuned to the same frequency as the others is interposed between the vertical wires and the transmitting and receiving apparatus for the

purpose of additionally sifting out the undesired harmonics."

I have previously pointed out that Stone appreciated that when he generated the oscillation in the separate circuit he would still have harmonics in additional to the fundamental in the same way as when the oscillations were generated directly in the antenna circuit as in Marconi reissue patent 11913, and by tuning the antenna circuit to the funda- [fol. 1737] mental of the oscillations there would be a discrimination in the transfer of energy from one to the other against the harmonics to which the antenna was not tuned in favor of the fundamental to which Stone said the antenna should be tuned. In this second system referred to by Stone he points out that he goes a step further in the matter of this discrimination against harmonics, stating that the addition of one more tuned circuit has the purpose of "additionally sifting out the undesired harmonics." Certainly this additional step to which Stone went to sift out undesired harmonics by tuning in three circuits makes it absurd to contend that he did not do the same thing in the system having but two circuits.

I further point out that Stone states that this additional circuit is "attuned to the same frequency as the others," the "others" referring to the two circuits of the first system. According to Weagant, Stone did not have the two circuits or "the others" of the first system tuned, but only one other, a wholly inconsistent contention with the plain language of Stone, to say nothing of the technical absurdities involved in the Weagant contention.

Weagant does not deny that the Stone patent 714756 as issued did not fully cover instructions to tune the antenna circuit as a whole, and thus that the Stone patent as issued was fully the disclosure of the Marconi patent 763772 in suit. On page 1658 Weagant states:

"This statement seems to be intended to indicate some sort of tuning of the aerial system, a statement quite unsupported by the drawings of the patent, and it was inserted into the application June 19, 1902, which was after the publication of the British Marconi patent No. 7777.

"These references are cited as showing that everything in the Stone patent 714756 which might be interpreted to mean tuning of the antenna circuits was put into the patent

after Marconi's work was known, and the importance of having all four circuits in tune appreciated."

In order to point out the error of Weagant's statement that everything in the Stone patent 714756 which might be interpreted to mean tuning of the antenna circuits was put into the application by amendment after Marconi's work was known, I refer to the following statement included in the application as originally filed for Stone patent 714756, at the top of page 14:

"When transmitting stations and a corresponding number of receiving stations are employed, by adjusting the electro-magnetic constants of these circuits at the various receiving stations, these circuits may be so proportioned or tuned that the energy of the electromagnetic wave emanating from any given transmitting station will be selectively received and absorbed at a given receiving station."

Remembering that Stone was clearly distinguishing his system from the one circuit system at each of the transmitting and receiving stations of the Marconi reissue patent 11913, it is clear that his reference to adjusting the electromagnetic constants of "the circuits" referred to both of the circuits in his system as distinguished from the one circuit in the system of Marconi reissue patent. It is also pointed out that at the end of the quotation he states that the waves will be "selectively received and absorbed." Thus he includes two operations at his receiving station, [fol. 1738] one being reception and the other absorption. Throughout the Stone literature he referred to the circuit he coupled to the antenna circuit as the "absorbing" circuit, so that the two steps set up by him at his receiving station are given definite meaning by Stone. His reference to "selectively received" makes it clear that the adjusting for tuning the "circuits" in the first part of the quotation included tuning the antenna circuit for selective reception as well as the absorbing circuit.

* * * * * * *

On page 1654 Weagant states that it is "quite contrary to the usage of the radio art, and it is not customary to speak of a circuit which is in tune as being 'forced' to accept oscillations of its own period."

Stone makes it clear in his patent 714756, page 5, in referring to the mathematical expression of the relation of fre-

quency or period of a circuit to the inductance and capacity of a circuit that the relation only holds true when the two circuits are substantially isolated, or, in other words, that when dealing with free oscillations the circuit can not be made to oscillate at one particular frequency or have any particular frequency of oscillation forced upon it unless substantially isolated by loose coupling, so that the word "forced" in the Stone literature is concerned with the matter of loose coupling and not tuning. Stone makes it clear that under some conditions his antenna is tuned, and under other conditions of multiple telegraphing from one antenna the antenna need not be tuned and, of course, can not be tuned to both frequencies of the multiple telegraph, but in both cases he desires to have only simple harmonic oscillations in the antenna and therefore relies upon loose coupling in order to isolate the antenna circuit from the primary circuit in which the oscillations are generated to a high degree.

On page 1655 Weagant states that my reference on page 1085 to the practice of Stone of removing the resistance of the detector from the tuned circuits is a teaching which I seem to have forgotten when I attempted to make the secondary circuit of Marconi patent 627650 a tuned circuit. I have not contended that the tuning provided for in Marconi patent 627650 is as sharp tuning as that contained in the arrangement of the Stone patent and Stone-to-Baker letters, but that it is the tuning of numerous figures and tunes given in the Marconi patent 763772 in suit in which the detector is included in the secondary circuit.

On pages 1656 and 1657 Weagant quotes from the testimony of John Stone Stone, the patentee of patent 714756, in the suit of Marconi Wireless Telegraph Co. of America *v.* Kilbourne & Clark Manufacturing Co., which testimony is stipulated in the present case. On page 1657 he includes the following testimony of Stone:

"197. Cross-question. And did you not also testify in that same case as follows:

"'The first very clear and complete exhibition of the use of a continuously variable tuning condenser in shunt to the primary of a transformer in a wireless telegraph receiver, so far as I am aware, is contained in the specifications and drawings of the English patent to Marconi, No. 7777, of 1900.'"

[fol. 1739] Referring to Figure 2 of Marconi patent 763772, there is shown a condenser *h* in shunt connection to the coil *j'* in the antenna circuit, and it is to this particular condenser and its location that Stone referred to in his quoted answer as "the first very clear and complete exhibition of the use of a continuously variable tuning condenser in shunt to the primary of a transformer," which is far from an admission by Stone that the English patent to Marconi, No. 7777, of 1900, corresponding to United States patent 763772, was the first showing of means for tuning the antenna circuit, but merely an admission by Stone that as far as he was aware Marconi was the first to show this particular form of connection by which tuning could be had. On page 1657 Weagant sums up this testimony of Stone to which he referred as Stone himself crediting Marconi with being the first to use "the tuning element in the aerial circuit." It is to be noted that Weagant does not refer broadly to tuning elements, but merely to "the tuning elements," thus limiting his summation to specific ones mentioned by Stone in his testimony and not to all tuning elements by which tuning of the antenna could be accomplished. In this case it is contended that the Lodge patent 609154 in suit, in inserting a mere inductance coil in the antenna circuit, was an outstanding advance in the matter of tuning an elevated conductor system. Both Tesla and Stone included this coil of Lodge in their antenna circuits, and it was also included in Marconi patent 627650 with instructions to adjust the number of turns of the wire in accordance with the frequency of the signal being received.

On page 1658 Weagant states:

"The original disclosures of the Stone patent 714756 in the matter of the drawing did not disclose any means for tuning the antenna circuits, * * *."

The original drawings are the same as the drawings in Stone patent 714756 as issued, and the drawings do disclose means for tuning the antenna circuit. For example, in Figures 5, 6, 7, and 8 both transmitting and receiving systems are fully illustrated by Stone. In every case it is seen that the antenna circuit comprises a vertical wire V connected to ground E through an inductance coil L. With the arrangement thus shown tuning of the antenna

circuit can be accomplished in two ways, or a combination of both, one way being to change coil I_2 in some way as by the simple expedient of changing the number of turns taught by Lodge, though changing the diameter of the turns or the spacing of them could also accomplish a variation of inductance giving the required tuning result. The second way would be to alter the length of the vertical wire, and obviously this expedient could be combined with the first way if desired. It is true that Stone did not include a second inductance coil in the antenna circuit above the inductance coil in the coupling, shown as the coil *g* in Figure 1 of Marconi patent 763772, but reference to the table of tunes for transmitting stations given on page 4 of the Marconi patent shows that out of six tunes specified four were obtained without the use of any inductance at *g*, thus showing that the only difference between Marconi and Stone was not essential to a drawing to show means for tuning the antenna circuit. Further, the testimony of claim-
[fol. 1740] ant's witnesses Sarnoff and Taylor in this case as to the early practice of the Marconi Co. clearly brings out that in using tunes "A" and "B," frequently referred to by them, the practice was not to use any variation in turns of a coil in the antenna circuit, but to actually change or substitute transformers permanently wound in the factory one for the other in making change from one tune to the other. Since these transformers were permanent, fixed affairs obviously when installed at some particular radio station on shore or on shipboard the length of the antenna had to be adjusted if there were to be any approach to tuning of the antenna circuit to the lateral circuit. Thus Stone disclosed in his patent and letters more means for tuning the antenna circuit than were used by the Marconi Co. in practice for some years thereafter.

On the bottom of page 1655 Weagant summarizes the matter of tuning of the antenna circuit by Stone and Tesla with respect to the Marconi patent 763772 as having "completely missed, one on one side of the fence, as it were, and the other on the other side, * * *" which refers, of course, to his contention that Stone provided for tuning only that portion of the vertical wire above the coil of wire connecting the vertical wire to ground, and Tesla tuned the coil only independently of the connection of the coil to ground and the vertical wire above the coil, neither of which effect could be accomplished in fact, as there are

no two sides of a fence in connection with the flow of current in an electrical circuit. If there is any basis whatsoever for conceiving a coil in an antenna circuit as one side of a fence and the elevated wire as the other side of a fence, reference to Stone shows that he provided both sides of the fence and introduced the energy into the system on one side of the fence, namely, the coil coupled to the primary circuit, and caused the energy to flow from this one side of the fence to the other side of the fence, namely, the elevated wire, so that the operation was compelled to utilize both sides of the fence in order to function.

On page 1655 Weagant states:

"Marconi drives his antenna circuits in the way in which they want to go, while Stone tries to make them go in some different manner, * * *"

This is not true unless there is read into the Marconi patent the loose coupling so fully and clearly described in Stone. On page 5 of Stone patent 714756, in referring to the mathematical formula. Stone points out that the circuits will not permit of being driven in any one specific way unless there is loose coupling. He also pointed out that he could not expect to obtain selective communication unless he could produce simple harmonic oscillations in his antenna circuit, and for this reason he did not intend to let the circuits choose their own way of oscillating, which would not be simple harmonic if just merely adjusted to have the same time periods, but he would impose upon the operation the requirement that when the oscillations arrived in the antenna circuit they would be simple harmonic in character. The Marconi arrangement falls far short of accomplishing the selective requirements imposed upon it by Marconi in statements of operation desired until it includes the loose coupling not specifically shown.

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[fol. 1741] 32. Question. Please refer to the testimony in answer to question 33, pages 1835 and following, and state whether or not you agree with the statement, giving your reasons.

* * * * * * *

Answer. The testimony in answer to question 23 is that of claimant's witness Hogan as to the Stone-Baker letters, the Stone application for patent as originally filed, and

Stone patent 714756, and my previous testimony concerning the several phases of the present case.

Hogan, like claimant's witness Weagant, endeavors to construe the plain language instructions of Stone in the Stone-to-Baker letters for tuning the antenna to mean a limitation to only a portion of the antenna circuit—that is, the wire above the coil in the antenna circuit—and thus unites with Weagant in contending plain electrical instructions to involve electrical absurdities.

On page 1836 Hogan states in reference to the apparatus illustrated by diagrams on the third page of the Stone-Baker letter of June 30, 1899:

"However, no wiring diagram can show whether or not the various circuits illustrated are tuned to the same or different frequencies; and for information on that important matter we must turn to the text descriptive of the figures."

In other words, Hogan does not contend, like Weagant, that the showing of an antenna circuit including a vertical wire connected to ground through an inductance coil is not means shown for tuning the antenna, but clearly implies that if there are instructions in the descriptive matter for tuning the means illustrated are adequate for carrying out the tuning of the antenna.

Immediately following, on page 1836, the comment just quoted Hogan itemizes features pointed out in the Stone-Baker letters and as item 2 states the following:

"(2) That certain of the circuits illustrated are to be tuned 'one to another and all to the same frequency' (June 30, p. 4.)"

This statement of Hogan is not true to the text of the Stone-Baker letter to which he refers. The text gives no basis for saying that "certain of the circuits illustrated" are the ones referred to by Stone. On page 3 Stone illustrates all of the circuits needed for transmitting and receiving stations, and clearly defines the circuits by reference to the elements in the circuits shown, including the antenna circuits. After so doing he then states: "The tuning of these circuits one to another and all to the same frequency * * *" which is positive language including all of the circuits and excluding none, and therefore is not

subject to the qualification "certain of the circuits" employed by Hogan.

[fol. 1742] At the bottom of page 1836 Hogan admits that these tuning instructions in the Stone-Baker letter, taken alone, include tuning of the antenna system, but adds the contention that other features of the Stone literature lead away from his conclusion to the extent that in Hogan's opinion Stone, in showing and describing four circuits and instructing that *all* of "these circuits" be tuned to one another and the same frequency referred to only two circuits, the lateral circuits, one at the transmitting station and one at the receiving station. The fact is, there is no more reason for Hogan concluding that these definite instructions of Stone for tuning *all* of the circuits referred to the tuning of the lateral circuits only to the exclusion of the antenna circuits than there is for concluding that Stone referred to the tuning of the two antenna circuits only to the exclusion of the lateral circuits.

At the middle of page 1837 Hogan states:

"Stone's theory was evidently that forced oscillations, not utilizing any antenna tuning, were essential for selectivity."

This is an incorrect interpretation of Stone's idea. His idea was clearly the one of requiring "simple harmonic" oscillations in the antenna irrespective of whether or not he employed the matter of adjustment of time periods of the circuits to be the same for resonant or efficient energy transfer. He describes how, with the aid of loose coupling, he can successfully obtain the simple harmonic form of oscillation in the antenna and, in addition, suggests the tuning of the antenna the same as the lateral circuit, which feature he gracefully attributed to Tesla prior to Stone.

In the seventh line of the second paragraph, page 1837, Hogan states as to "forced oscillation":

"At page 10, lines 19-26, Stone emphasizes his intention of using forced oscillation in the antenna 'in lieu of producing natural vibration.'"

Stone made it clear that he did not intend to use or produce natural vibrations generated by a spark gap included within the antenna circuit, but he did not propose to do away with the natural vibrations resulting from a

spark discharge within a circuit, only requiring that the natural vibrations be produced in a circuit so loosely coupled to the antenna circuit that they would be for all practical purposes vibrations *natural* to the circuit in which they were produced, and remain natural after transfer to and arrival in the antenna circuit, Marconi patent 763772 also avoids the production of oscillations natural to the antenna circuit by the use of a spark gap within the antenna circuit, and if Marconi employs a coupling so loose that there is not a double hump, which Marconi advocated in his address of 1912, he produces oscillations natural to the primary circuit and they remain natural after transfer to and arrival in Marconi's antenna circuit.

At the middle of page 1837 Hogan states that a reference inserted in the Stone application by amendment providing for making "the vertical wire" resonant may be taken as a recognition of the kind of tuning included in the Marconi patent. If reference to tuning a vertical *wire* inserted by amendment is the same as the tuning in the Marconi patent, it is not clear on what basis Hogan formulates his contention that the same language in the Stone-Baker letters is limited to tuning only that portion of the wire above the [fol. 1743] coil in Stone's antenna circuit. Hogan points to nothing that transpired between the Stone-Baker letters of 1899 and the 1902 amendment to change the definition of "vertical wire" from wire in only one part of the circuit to all of the wire in the circuit.

In answers to cross-questions 108, 110, and 111, page 1871, Hogan, in further testifying about the Stone system, admits that the system disclosed by Stone is in fundamental components and mechanical arrangement the same as that of Marconi, merely holding out as a difference the tuning of the antenna circuit in the Marconi patent over his alleged tuning of only that portion of the wire above the coil in the Stone patent, so that all that remains is whether or not Stone, in instructing to tune *all* of the circuits to the same frequency and one to another, is to be absurdly construed into an electrical impossibility or is to be given the clear meaning of the plain language employed by Stone in disclosing his system to another, and there is no question that anyone tuning the circuits "empirically," as instructed by Stone, would arrive at tuning the antenna circuit as a whole because it can be done and would not arrive

at tuning that portion of the wire above the coil because this kind of tuning can not be done.

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33. Question. Please refer to the testimony in answer to question 13, page 1917 and following, and state whether or not you agree with the opinions expressed therein, giving your reasons.

* * * * * * *

Answer. The testimony in answer to question 13 is that of claimant's expert Waterman in the matter of the construction and mode of operation of the apparatus described in the Stone-Baker letters and my opening testimony concerning these letters.

Waterman begins his testimony with the statement that he agrees with the statements and opinions of Weagant in his testimony as to these letters, and I therefore understand him to adopt the electrically absurd contention of Weagant that the tuning of the antenna in the Stone-Baker letters is limited to a portion of a circuit which can not by itself be tuned.

At the bottom of page 1917 Waterman states:

"Mr. Loftin, in my opinion, entirely overlooks or ignores the point of view of the art and the meaning of terms. What the art then knew as a wireless telegraph system comprised an elevated wire hung in the air and one terminal connected to earth; there was one such wire at the transmitter and the other at the receiver."

That I do not so boldly and audaciously overlook or ignore the art as does Waterman is readily checked from the remainder of the quoted paragraph in which he makes the charge against me. He unqualifiedly states that all the art knew of wireless telegraphy system at the time of the Stone-Baker letters in 1899 was the simple 1-circuit transmitting system and 1-circuit receiving system of Marconi reissue patent No. 11913. In view of the art having [fol. 1744] dates between the Marconi reissue patent's original date and the Stone-Baker letters that have been introduced in this case contradictory of Waterman no testimony could be bolder and more in disregard of the facts. At the date of writing his first letter to Baker, Stone had available Lodge patent 609154 in suit in which Lodge had employed two circuits at the transmitter and two circuits

at the receiver, thus removing the spark gap from the antenna circuit and the detector from the antenna circuit to make systems substantially removed from that of Marconi reissue patent 11913. In Marconi patent 627650 the detector was removed from the antenna circuit at the receiver and placed in a lateral circuit, and tuning of both circuits provided for, a system entirely removed from that of Marconi reissue patent 11913. It did not include the loose coupling between the two circuits specified by Stone. Reference to my sketch L opposite page 1069 clearly shows that the Lodge system available to Stone was decidedly more than the mere vertical wire system of Marconi reissue patent to which Waterman limited himself. The same is shown as to Marconi patent 627650 in my sketch M opposite page 1071. I have also referred to Tesla patent 645576, which showed the spark gap removed from the antenna circuit at the transmitter, and two circuits at the receiver, and Stone specifically referred to this Tesla system in his letters to Baker, thus showing that Stone knew of features well beyond that of the simple arrangement of Marconi reissue patent 11913, including tuning between the lateral circuit and the antenna circuit. I also referred on page 1076 to British patents Nos. 1862 of 1899 to Braun and 12420 of 1899, showing two circuits at each transmitter and receiver. Thus clearly the art expressed for Stone ideas and points of view well beyond the simple knowledge of Marconi reissue patent 11913 to which Waterman alone pointed.

* * * * * * *

On page 1918 Waterman states that the Stone-Baker letters are mathematical in character and show that what Stone was engaged in was a "mere excursion into mathematical realms." Waterman's attempt to confuse these letters by designating them as "mathematical in character" is apparent from the letters themselves, the fact being that Stone uses no mathematics in either the letter of June 30 or the letter of July 18. In the letter of July 18 Stone uses a well-known expression for wave motions merely to make definite to the usual physicist his conception of the type of oscillation in the old Marconi single-circuit transmitting system. The expression is not used by Stone in any mathematical sense in that he makes no attempt to arrive at any deduction from mathematical operations but merely to portray to one knowing the language of physicists a wave form

visualized by Stone from deductions arrived at by physical conceptions, which he fully expressed in words on page 3 of the letter of July 18 immediately preceding his employment of the expression to sum up the results of his verbally expressed deductions. The letter of June 30 is a complete disclosure by the clear use of fundamental electrical terms [fol. 1745] and language and complete electrical diagrams of the systems and is wholly devoid of any mathematics or the use of any expressions of mathematical form of any kind. The letter of July 18 elaborated the theories around Stone's conception of the system of the letter of June 30 and, except for the one visualizing expression, is devoid of mathematical effort, the theories being expressed in clear, fundamental electrical terms and language.

Immediately following on page 1918 Waterman says that Stone undertook to provide for simplifying the radiation by "avoiding the shock of discharge," discharge referring to the discharge of a spark gap used for aiding in generating oscillations in an electrical circuit. That this is misleading as to what Stone actually did is evident from the fact that Stone did not "avoid" the shock of a discharge, as the letter of June 30 and diagrams on page 3 thereof clearly show that Stone employed the discharge of a spark gap and therefore could not "avoid" its shock. What Stone did was to remove the discharge from the antenna circuit to a lateral circuit and to diminish the effect of the discharge on the antenna circuit as much as possible by the use of loose coupling between the circuits.

Further on on page 1918 Waterman states that Stone expected by his procedure to realize simple oscillation in the antenna circuit which "he thought he had mathematically proven to be represented by the simpler mathematical expression '$A_a \sin pt$.'" That Waterman misrepresents the Stone-Baker letters is evident from the fact that Stone employed no mathematical operations in his letters for proving anything, merely pointing out after clear and intelligently expressed mental deductions that by not trying to generate his oscillations directly in the antenna circuit but in a lateral circuit well removed by loose coupling from the antenna circuit, the harmonic components in the oscillations visualized in the terms in the expression following the first term could be substantially eliminated, thus leaving substantially a simple harmonic oscillation represented by the first term "$A_a \sin pt$."

Immediately following on page 1918 Waterman states:

"Stone's idea was a very natural one. Forced oscillations were well known and according to Stone's mathematics, expressed in the second Baker letter, he should be able to force oscillations on the wire of his mathematically simple form, without regard to the fundamental frequency or wave length of the wire."

It is true that Stone's ideas were natural to the clear-thinking scientist he was. It is not true that "forced oscillations" of the kind with which Stone was dealing were well known. Stone was the first to appreciate that when dealing with "free" oscillations generated in a circuit with the aid of a spark gap it was necessary to employ loose coupling in order to generate the oscillations in simple form, instead of a complex form resulting from reaction of the coupled circuit back onto the generating circuit, and thus to give him a simple oscillation with which he could drive or excite the antenna circuit, for unless he started with a simple oscillation he could have no hope of forcing a simple oscillation upon the antenna circuit. Thus it is clear that Stone did not arrive at success, admitted by Waterman in the quotation above, "according to Stone's mathematics" as inferred by Waterman, but as a result of Stone's intelligent comprehension of the necessity for loose coupling.
[fol. 1746] The latter part of Waterman's quoted statement admits that Stone could produce simple oscillations in the antenna circuit without regard to the tuning of the antenna circuit, which is true, but I do not understand this part of Waterman's testimony to mean that Stone did not intend tuning his antenna, for in the paragraph of Waterman's testimony, page 1918, Waterman states:

"Stone proposed to retain the transmitting wire with its fundamental frequency of oscillation or wave length, * * *" and "he proposed to force thereon 'oscillations from an oscillator, which oscillations shall be of a frequency corresponding to the fundamental of the wire.'"

Analyzing these statements it will be seen that Waterman refers to the fundamental frequency of oscillation of the transmitting wire as the "wave length." Obviously an antenna circuit, including all of the wire in the circuit whether forming elevated wire, wire making up coils, and wire connecting coils to ground, can have but one wave

length, which is the wave length that spreads out into space to travel to distant receiving stations, and Waterman admits that the oscillations coming to the antenna circuit from the primary circuit have this same frequency or wave length, which necessarily implies that the circuit in which the oscillations are generated also has the same frequency of wave length. This reduction of the matter to the expression "wave length" by Waterman emphasizes the absurdity of the contention by claimant's witnesses Waterman, Weagant, and Hogan that the tuning in Stone's antenna circuit referred to that portion of the antenna wire above the coil in the antenna circuit. No one ever succeeded in getting a radio antenna to radiate a "wave length" represented in frequency by only that portion of the antenna circuit above the coil. At the bottom of page 1918 Waterman states:

"Furthermore, Stone's idea was perfectly sound; he could force oscillations on the wire, but the trouble was, and is, that they are of no use, because of their excessive feebleness."

Waterman gives no engineering or physical reasons in support of his condemnation of Stone's system on the grounds of "excessive feebleness" and the fact is that he could not do so because there is no basis whatsoever for the unsupported condemnation. Stone's idea was perfectly sound, as admitted by Waterman, and his system was, as a result, a success.

Waterman next states, at the bottom of page 1918, that Stone's mathematics was defective because of the incompleteness, and without supporting this statement with anything that might be analyzed by a mathematician or physicist he makes the meaningless comment that "nature does not work that way," further adding that the scheme proposed by Stone is "utterly worthless," and again makes no effort to support these sweeping statements with physical considerations that could be analyzed and answered by a qualified respondent. Stone used no mathematical operations in arriving at his deductions, and therefore his deductions could not be defective because of incompleteness of mathematics not used. The expression he did use, quoted on page 1918 by Waterman, to merely portray in the fashion of a physicist some wave forms is more than adequate in

completeness, and deserving of no criticism on the part of Waterman.

[fol. 1747] At the top of page 1919 Waterman states "Stone followed the thought of the art," and immediately following makes it clear that what he means by the expression "thought of the art" is the subject matter contained in Marconi's first patent reissue 11913. Stone did not do any such thing, and it is absurd to imply that Stone had no more before him than the mere one-wire system of the Marconi reissue patent. At the bottom of page 6 of the letter of July 18 to Baker, Stone makes specific reference to his system being the same in substantial respects to that of Tesla, a 2-circuit system well removed from the early Marconi system, and I have heretofore pointed out that between the early Marconi system and the Stone-Baker letters there was much in the way of 2-circuit systems for Stone to consider as advances over the early Marconi system.

In the same paragraph Waterman argues that Marconi's line of thinking differed from that of Stone in that Marconi disregarded his former work, pointing out as a detail of basis of his view as to Marconi that Marconi inserted a coil in the antenna circuit, thereby making the antenna circuit not dependent upon the frequency characteristics of the elevated wire alone but to include the effect of the coil. Why Waterman attributes a new line of thought to Marconi with this as the basis in view of Lodge patent in suit 609154 is not clear, since one of the outstanding features of the Lodge patent in its bearing on the present suit is this matter of the coil in the antenna circuit. He also uses this to differentiate from Stone, who, in practically every figure shown in his letters to Baker and in his patents, included a coil of wire in the antenna circuit.

In the second paragraph, page 1919, Waterman states:

"This is a wholly different concept from that of Stone; Stone's instructions were to erect a wire having a given fundamental wave length, to construct an oscillator that would generate oscillations of that same wave length and to force these oscillations upon the wire."

Stone did not instruct merely "to erect a wire," but clearly showed in his June letter to Baker an antenna circuit having an elevated wire connected to ground through a coil of wire, and on the last page of the letter provided for

tuning this wire, coil, and ground connection as one of the "circuits" of his system to the "same frequency" as all of the other circuits, and thus did not miss Marconi's concept, as alleged by Waterman, but went far beyond it in his further intelligent instructions providing for practical means of securing such loose coupling that the system was effectively operative for carrying out the adjustment of the time periods of the circuit to be the same as an aid to selective communication.

Continuing in the second paragraph on page 1919 Waterman now states that Stone did not obtain the simple oscillations that he expected and, without giving any reasons therefor, states that such oscillations as Stone could have produced would have been more complex than represented by the expression given in the second Stone letter, all of which is directly contradictory of his testimony on the preceding page where he states that Stone's idea was perfectly sound. The truth of the matter is that Stone did approach with the aid of his loose coupling to most practical degree the simple harmonic form of oscillation in the antenna he set out to acquire, and I have previously given in detail the reasons why Stone succeeded in a way readily [fol. 1748] analyzable by the average electrician. I regret Mr. Waterman does not do the same, as I would appreciate knowing the reasons for the unsupported statement contradicting his previous admission of the correctness of Stone's idea.

* * * * * * *

In the third paragraph on page 1919 Waterman charges me with reaching my conclusions as to the Stone-Baker letters by disregarding what Stone says and saying something which he does not state, this without taking up specific instances of my references to pertinent parts of the Stone-Baker letters, which I analyzed in detail, and showing wherein my analysis warrants the sweeping statement of Waterman that I disregarded what was said in the letters. Waterman follows the charge against me by the unexplained statement that Stone throughout deals solely with "the existing concepts of the art" without endeavoring to let one know what comprises the "concepts," or showing any relation of these undefined concepts to his further statement that Stone "undertakes to produce forced oscillations of the frequency of the wire itself." Neither does he under-

take to support his statement at the end of the same paragraph that the idea of forced oscillation was a familiar one to the art by any reference to literature of the art existing at the time of the Stone-Baker letters, and the testimony of Weagant, to which Waterman refers, does not supply any references satisfying Waterman's omission thereof.

In the next paragraph (par. 4) of page 1919 Waterman states that my crediting the Stone-Baker letters with the disclosure of an antenna circuit comprising a wire and a coil proportioned to have the fundamental frequency of the circuit in which the oscillations are generated is not stated or suggested by Stone "either in words or in mathematical symbols, nor is it in any way implied by his diagram." I have previously pointed out in connection with the testimony of Hogan that Hogan admits the Stone-Baker letters to include in diagram all that is necessary for tuning the antenna circuit to the same extent that Marconi's patent 763772 provides for such tuning, Hogan merely pointing out that a diagram of itself can not indicate whether or not there is actual tuning between the primary circuit and the antenna circuit, Hogan adding that the text of the descriptive matter is necessary to determine this point, so that Waterman's objection that the tuning in the Stone-Baker letters is not "implied by his diagram" is not a reasonable one. Waterman's statement that the tuning of the antenna circuit is not stated "in words" does not accord with the facts, for the June letter specifically provides for making the tuning or fundamental of the antenna wire, and Stone shows the wire to include the wire of the coil and the wire of the connection to ground, the same as the frequency of the oscillations generated in the primary circuit, and summarizes these instructions on the last page of his June 30 letter as providing for tuning all of the circuits to one and the same frequency. Statement for tuning with the aid of words could not be more definite and clear. It is true that Stone did not refer to the tuning in "mathematical symbols" expressed in mathematical formulæ, but instructions for tuning all of the circuits to the same frequency on the [fol. 1749] last page of the June 30 letter stated that it could be accomplished mathematically, Stone well knowing that this reference to "mathematically" immediately brought to the mental eye of the type of man to whom he was addressing himself all of the symbols of the then well-known mathematical formulæ given by Stone in the second column

of page 5 of his patent 714756, making a physical display of these symbols unnecessary.

In paragraph 5, page 1919, Waterman states that the July letter makes it clear "mathematically" that Stone regarded it quite immaterial, so far as attaining his results of simple oscillation, whether the oscillator was made to have the frequency of the wire or not. Stone makes no attempt to show any such thing mathematically. As before stated, Stone undertook no mathematical operations, and therefore made no mathematical deductions of any kind. By a well-known shorthand language, so to speak, of physicists he drew by an expression a picture full of meaning to a physicist the result of his mental deductions as to the type of oscillation occurring in the simple system involving a spark gap within an oscillatory circuit, a thing in no way involving the practice of setting up mathematical equations expressive of actions and reactions in electrical systems, and solving these equations to mathematically deduce facts or conclusions. There is not a mathematical equation set up anywhere in the second Stone letter, and without an equation no solution or deduction is possible.

It is true that Stone's second letter does make it clear in words that in so far as the feature of production of simple harmonic oscillations in the antenna circuit is concerned with his system of generating the oscillations in a primary circuit with loose coupling it makes no difference whether the antenna circuit is tuned or not, but Stone nowhere suggests or implies that the statements in his second letter in fuller explanation of his theories as to the system of his first letter are to alter his instructions for construction and use of the system in his first letter. His knowledge that the matter of production of the simple harmonic oscillations he wanted in the antenna circuit is not affected by the state of tune of the antenna circuit he later put to good use in his proposal in patent 714756 for multi-telegraphy from the same antenna circuit having coupled thereto two or more generating systems, so that this additional knowledge of Stone operates to his credit rather than to the discredit that Waterman attempts to impose. Stone was after producing simple harmonic oscillations in an antenna circuit. His letter of June 30 shows that even though Tesla had taken the step of generating the oscillations in a circuit coupled to the antenna circuit and the two circuits adjusted to have the same time period, that Tesla had failed to produce

simple harmonic oscillations in the antenna circuit because Tesla had made no provision for so coupling the two circuits loosely that they would not react upon each other to such extent as to permit the generating circuit to independently determine or set the frequency of the oscillations. Having determined that loose coupling permitted this independency of action of the generating circuit Stone makes the observation in the second letter that the independency persists even though he should depart from the Tesla system to the extent of detuning the antenna, but the observa-[fol. 1750] tion carries no implication that the specifically described tuning of the first letter is to be abandoned.

In my opening testimony as to the Stone-Baker letters I endeavored to support my interpretation of these letters by definite technical considerations and reasoning, and note that Waterman has not attempted to take any one or more features of my technical reasonings and point out errors or fallacies in them, but has in fact dodged the situation by stating at the middle of page 1919 that he does not think it "profitable to consider in detail" my comments, and has accordingly satisfied himself with making sweeping statements that I have disregarded what Stone says, and the like, without pointing out for answer by me wherein any technical considerations disregard Stone's sayings, so that I have been compelled to confine myself to taking up his testimony in detail to point out wherein his sweeping statements are not supported by the facts, and his criticisms of the Stone disclosures are unjustified.

* * * * * * *

34. Question. Please refer to the testimony in answer to question 2, pages 1880 and following, and state if you agree with the statements therein, giving your reasons.

* * * * * * *

Answer. The testimony referred to in the question is that of claimant's expert Waterman as to features of Marconi patent 763772 in suit, and specifically as to the duration of oscillations in the primary circuit at the transmitter and coupling between the primary circuit and the antenna circuit. Also as to the bearing of the Marconi address of April 17, 1912, upon the matter of coupling between the circuits, and also as to features of my first testimony as to Marconi patent 763772.

My disagreements with the statements of Waterman's testimony are numerous and I give my reasons as I consider his statements.

In beginning the third paragraph from the bottom of page 1880 Waterman, without qualification, states that "Mr. Marconi founded a wholly new art." He does not state to what part of Mr. Marconi's work he refers in making this unqualified statement, but since it is clear from this case that Marconi's first radio work was that embodied in reissue patent 11913, it is difficult to reconcile Waterman's sweeping statement with the facts concerning the subject matter of the reissue patent. I have shown that the matter of exciting an elevated wire with alternating currents to cause electrical effects to spread out into space for detection was in existence prior to the Marconi reissue patent, and in fact the transmitting system of the Marconi reissue patent was that of Hertz some 10 years earlier than Marconi. I have also pointed out in detail the existence of features of the Marconi reissue patent receiving station prior to the patent, the coherer used by him being a device of Branly, as well as the tapper on the coherer also being prior to the reissue patent. It doesn't seem reasonable, therefore, to unqualifiedly attribute to one person so much when so much existed prior to him.

[fol. 1751] In the same paragraph Waterman gives to patent 763772 the unqualified position of constituting the "second great step," in such way as to imply that nothing of value happened between the time of the Marconi reissue patent and patent 763772, a period of some four years, which, of course, is not the case. In the meantime Lodge, Tesla, Braun, Stone, and Pupin had taken the spark gap out of the antenna circuit at the transmitter, and the same workers had taken the detector out of the antenna at the receiver, with the addition of Marconi having done so in patent 627650. Tesla and Marconi had provided for tuning the antenna circuit to the lateral circuit and Stone had added to this feature the matter of loose coupling in order to permit of dealing with simple harmonic form of oscillation for a high order of selectivity. Clearly much went on between the Marconi reissue patent and Marconi patent 763772 worthy of admission rather than ignoring as does Waterman.

In the last paragraph, page 1880, Waterman states: "It is necessary to bear in mind the fact that Marconi in his

patent, which is reissue 11913, had disclosed a new phenomenon in the electric arts in general."

Waterman makes no statement as to the nature of this "new phenomenon" attributed to Marconi in reissue 11913, and what it can be is difficult to surmise. If he refers to the production of so-called Hertzian waves he can not attribute this to Marconi as new phenomenon without admitting lack of knowledge of the disclosure in the reissue patent, for on page 1, lines 10-14, Marconi*a* opens up the specification of his reissue patent by conceding this phenomenon to Hertz.

At the end of page 1880 Waterman states:

"In the ordinary practice of the electrical art a path for an electric current had to be closed. Current did not flow in an open circuit."

Unquestionably in referring to an "open circuit" he has reference to the antenna circuit of reissue patent 11913. Hertz used an open circuit, his circuit constituting two simple rods with a spark gap between them, there being no wire or other conductive connection between the outer ends of these two rods to close the circuit, and there is no difference between the open circuit of Figure 9 of reissue patent 11913 and the open circuit of Hertz. I have also referred to open circuits comprising an elevated wire connected to ground in connection with the Edison patent, Dolbear patent and the Tesla-Martin book, all long prior to Marconi reissue patent, and being the grounded elevated wire system of Figure 10 of this patent. Marconi, certainly, is not entitled to any suggestion that he was the first one to cause current to flow in an open circuit.

At the top of page 1881 Waterman refers to Marconi having hung the vertical wire in the air and causing high frequency currents to flow between the top of the wire and the earth. While he does not definitely state that he gives Marconi credit for being the first to do this, it may be intended as a part of his broad statement that Marconi founded the wholly new art. All of Hertz's work was carried out with high frequency currents, and in fact very high frequency currents. He did not hang a wire in the air, but did the equivalent thereof by using rods of length. Tesla, Edison, and Dolbear did hang wires in the air and connected them to earth.

[fol. 1752] In the second paragraph of page 1881 Waterman states:

"This was an amazing phenomenon, and, still more amazing, he found that this wire caused electric waves to be radiated like invisible light from a lighthouse, which followed the surface of the earth."

Thus Waterman attributes to Marconi finding "electric waves," when even to-day there is no accepted theory of the mode of propagation of the energy to a distance from a radio transmitting system. Hertz had already found out and published that the energy of a current flowing in a conductor was transmitted through space, and had investigated many of the properties of this energy transmission some 10 years prior to Marconi, and there was certainly no reason for the effect being newly "amazing" when repeated by Marconi, particularly as many others had understood and repeated the effects following the work of Hertz.

* * * * * * *

In paragraph 7, page 1881, Waterman states that Lodge made the mistake in his Figure 4 of getting a combination which afforded two radiating circuits, and accordingly the arrangement was useless, the statement being made without showing wherein there are two radiating circuits and why, if there were two such circuits, the arrangement would be useless. My sketch L, opposite page 1059, shows in the left hand figure the Lodge transmitter, and it is clear that there is but one elevated wire or radiating circuit, and that the arrangement is substantially the same as the telefunken type transmitter in plaintiff's Exhibit 79, opposite page 180, introduced by claimant as an example of an infringing device rather than a useless system.

In the next paragraph, page 1881, Waterman attributes to the Marconi patent in suit the taking of the spark gap out of the antenna and the detector out of the receiving antenna, though this had already been done by Lodge, Tesla, Braun, Marconi in patent 627650, and Stone.

At the top of page 1882 Waterman classifies the antenna circuit of Marconi's transmitter as a "good radiator," and the lateral circuit as a "persistent oscillator," taking the expressions from the Marconi patent attributing advantages in a radio transmitting system of these types of circuit. Of course, the mere naming of these circuits with the

terms used in the Marconi patent did not give to Marconi any advantage of these kinds of circuits already used by Lodge, Tesla, Stone, Marconi in patent No. 627650, and Braun. In the case of Lodge he provided that the lateral circuit be arranged so that it could not act as a "persistent oscillator," but Tesla, Stone, and Braun did not impose this limitation upon their lateral circuit.

At the end of the second paragraph, page 1882, Waterman states:

"Only by the tuning of the two circuits together in this manner can the energy be transmitted quickly and efficiently from one circuit to the other."

It is not true that this mere tuning of the two circuits or adjusting the time periods to be the same permits of [fol. 1753] efficiency, a matter which is clear from Waterman's own testimony in the first instance in this case, he having stated on page 153, paragraph 1, as follows:

"If the circuits are too closely associated, defects of operation occur as the result of the reaction of the secondary circuit back upon the primary circuit. It will be seen that since two circuits are associated so that energy may be transferred from the non-radiating circuit, to which the charge is initially given over into the radiating circuit it necessarily follows that the oscillations occurring in the secondary circuit would have a tendency to react and produce oscillations in the primary circuit and thus transfer the energy which the antenna circuit has received back into the primary circuit instead of radiating it. If the association of the two circuits is so close that this tendency to the backward transfer of energy is great enough to cause the spark gap in the primary circuit to be broken down, then energy will be retransferred back to the primary, thus wasting it in the spar gap instead of radiating it as an electric wave."

Thus in Waterman's prior testimony loose coupling was an essential feature of efficiency in the transfer of energy from the lateral circuit to the antenna circuit in the system of the Marconi patent.

In the third paragraph, page 1882, Waterman refers to the provision of the local circuit, permitting the use of a large condenser capacity as compared with the relatively

small capacity of the antenna circuit as "the concept, which is fundamental to this invention." If this is so, the fundamental concept did not arise in the Marconi patent. Lodge, Tesla, Stone, and Braun had lateral circuits in which the capacity of the condensers used in these lateral circuits could be chosen large compared to the capacity of the antenna circuit, and thus these prior systems had local circuits which could act as reservoirs and good conservers of energy, attributes given the Marconi arrangement by Waterman.

In the last paragraph but one, page 1882, Waterman states that transformers whose couplings were as low as 85 per cent would have been quite useless except for very special purposes. Why he makes this statement is inconceivable, as couplings of less than 1 per cent are used and have long been used with great utility. As early as 1894, it was proposed to use high-frequency currents in wire communication practice, in systems not involving iron core transformers and accordingly with couplings much less than with the couplings used in transformers for transmission of power by wires. Stone, prior to Marconi, provided for very loose couplings; that is, of the order of 1 per cent, and this loose coupling of Stone has been found useful in many ways.

At the bottom of page 1883 Waterman states that I have based my entire deposition as to Marconi patent 763772 upon the assumption that the expression "a persistent oscillator," used in the patent, is to be understood with a significance that I myself imposed, which is not a fact. The patent not only refers to the lateral circuit as a "persistent oscillator," but adds the instruction that the oscillations in this circuit are to be "maintained for a long time—in the primary circuit," which is not only plain English but has definite technical significance, when taken in conjunction with the complete system described by Marconi. It, in fact, takes the place of the loose coupling definite instructions in the Stone patent and Stone-to-Baker let- [fol. 1754] ters. Marconi shows a system having 4 circuits, 2 at the transmitter and 2 at the receiver, and clearly states that the purpose of this system is to obtain selectivity, adding that all 4 circuits are to be adjusted to have the same time period. If Marconi had started wrong at the transmitting station by transferring the energy too quickly to the antenna circuit, and thus not maintain it for a long-

time in the primary circuit, he would have produced a 2-frequency or double hump form of transmission in the presence of which the tuning of the two circuits at the receiver would have meant nothing, and his selectivity system would have collapsed. It is, therefore, not necessary to rely upon the mere expression "persistent oscillator," for the Marconi patent is replete with information as to why the maintaining of oscillations in the primary circuit for a long time was a real factor of the system.

In the third paragraph of page 1884 Waterman states that he finds the number of oscillations in the primary circuits, when not connected to the antenna, of the tunes of the Marconi system listed on page 4 of the patent, stating these to be 12 oscillations for tune 1, 5 oscillations for tune 2, 15 oscillations for tune 3, and 5 oscillations for tune 4. In arriving at the resistance of the spark gap, he refers to page 185 of the work entitled "Principles of Electric Wave Telegraphy and Telephony," by J. A. Fleming, 1906 edition, claimant's Exhibit 320, taking the resistance he used from the curves shown on said page for "zinc or brass balls," but does not state in figures just what value or values he did take from these curves, but I assume that he took all he could, as we have disputed the value of resistance in a spark gap, my contention having been that 1 ohm used by Waterman in a calculation in his prima facie testimony was too high. I note, using the curve in Fleming, page 185, for the length of spark gap given in the table of Marconi tuning, the resistance would be approximately 1 ohm. However, I note that the data on the curve sheet shows that the resistance measurements of the gap were taken with a capacity equal to 1,070 micro-microfarrads, whereas in the tunes of Marconi to which Waterman referred the smallest capacity is 4,112 micro-microfarrads for tune 3 and the largest is 16,849 micro-microfarrads for tune 4. I note in the text, on page 185 of Fleming accompanying the curves, the statement that the "spark resistance increases with spark length very rapidly for small capacities, but much more slowly for larger capacities." Since the curves were taken with a capacity of about one-fourth the smallest capacity in the Marconi tunes, and about one-fifteenth of the largest capacity of the tunes, evidently they do not represent curves that would have been had with the much larger capacities of Marconi, and the information in the text is that the resistance of the gap would be less for the large

capacities of Marconi, so that I still consider that the one-half ohm I originally gave is more nearly the correct value for practice.

Since the number of oscillations is greater for a small gap resistance, obviously the number of oscillations given by Waterman for each of the tunes is too low because of this one feature.

Again, Waterman states that in arriving at his findings he assumed that the spark gap would cut off the oscillations at 10 per cent, an assumption he was not entitled to make. The fact is that with an open gap the oscillations would [fol. 1755] continue well beyond 10 per cent. Even in a well designed quench gap very special adjustments have to be made in order to reduce the energy to substantially zero in order to get a cut-off, so that properly considering this feature Waterman should add more oscillations than given according to his findings.

It is also noted that the findings are based on the assumption of the primary circuit disconnected from the antenna circuit, which, of course, is not an operating condition and one which does not give all the factors for using the mathematical formula around which calculations of this kind are made. On page 1054 I set up this formula, which shows that the decrement d of a circuit depends upon the ratio of the capacity to the inductance of the circuit, so that the larger the inductance the smaller the decrement, and therefore the more the number of the oscillations. When the lateral circuit is coupled to the antenna circuit, the inductance factor in the formula is increased by the amount of the mutual inductance between the circuits, so that had Waterman assumed the correct operating condition he would have had factors to go into the formula to give a smaller decrement or a still greater number of oscillations.

I therefore find that the findings of Waterman as to the oscillations in the primary circuits of tunes 1, 2, 3, and 4 of the Marconi patent are subject to three additional considerations, each one of which increases the number of oscillations over those given by him.

On page 1885 Waterman states that the number of oscillations required to transfer the energy of the primary circuits to the secondary or antenna may be found with the aid of a formula on page 247 of Morecroft's Principles of

Radio Communication, 1921, claimant's Exhibit 321. The Morecroft formula referred — requires knowing the degree of coupling between the circuits in order to make the required calculation. Waterman states that many years ago he actually measured the couplings of tunes 1, 2, 3, and 4 of the Marconi patent, but is not now able to find his records of these measurements. If Waterman ever attempted to make measurements of the couplings involved in these tunes I do not understand on what basis he can contend that the results of his measurements represent anything disclosed in the Marconi patent, as there is not enough data given in the patent for determining any specific degree of coupling. In the absence of Waterman's notes I have no way of knowing his mode of approach of the problem, but it is certain that no answer having any value could ever be arrived at without knowing all of the features of the transformers employed by Marconi in coupling the primary to the antenna circuit. The table of tunes on page 4 gives the information that Marconi used transformer No. 1 in tunes 1 and 2 and transformer No. 2 in tunes 3 and 4. On page 3 of patent 763772, lines 26 to 40, Marconi gave details of the construction of these transformers, but these details are incomplet so far as they will permit of determining the degree of couplings between the circuits in which they are used. The descriptions refer to Figures 3 and 4 of the drawing, and referring to Figure 4 it will be seen that the turn of wire *d*, which goes into the primary circuit, is spaced from the two turns of wire *d'*, which go in the secondary circuit. The [fol. 1756] degree of spacing between these wires is all vital in the matter of determining the coupling between the circuits, and this spacing is not given, so that Waterman has no right to say that he has constructed tunes 1, 2, 3, and 4 of the Marconi patent in such a way as to arrive at a degree of coupling between the circuits.

I have no objection to the formula of Morecroft used by Waterman, but insist that he has no right to use the formula which depends entirely upon knowing the coupling, without pointing to some more certain way of ascertaining the coupling than his recollection of notes made by him many years ago and since misplaced.

It is particularly odd and interesting to note that Waterman states that he has "a definite independent recollection

of the first and the third tunes," and states his recollection of the first as 10 per cent and of the third as 11 per cent. Reference to the data given by Marconi as to tunes 2 and 4 shows that in one case the antenna coils *g* had 45 turns and in the other case 100 turns, while no turns were used in this coil in tunes 1 and 3. This use of 45 and 100 turns in coil *g* makes it conclusive that if Waterman had been actually able to set up definite systems on definite specifications of Marconi and found couplings of 10 per cent and 11 per cent for tunes 1 and 3, respectively, he would have found that the addition of 45 turns in the case of tune 2 and 100 turns in the case of tune 4 would have reduced the coupling enormously, and, in my opinion, to less than 1 per cent. Stone clearly brings out that a removal of a large part of the inductance of one of the circuits from the transformer used as the coupling element makes the loose coupling Stone pointed out as a part of his system, and Waterman subscribes to this principle on page 1886, near the top, where he states in reference to tune 6:

"The coupling is therefore close, since there is no added inductance in the antenna, and all the inductance of the primary circuit is coupled to the antenna."

In the case of tune 2, there are two turns of wire in the antenna circuit involved in the coupling transformer and 45 turns of wire in coil *g* not involved in the coupling, which difference means a very small coupling—in fact, so much so that it may be that the reason Waterman could not remember these two particular couplings is that they were too small to remember. In any event, there is no basis for Waterman contending that Morecroft's formula shows that the number of oscillations required to transfer all of the energy from the primary to the secondary circuit in tune 1 is 5 and in tune 3 is 2½. Furthermore, if he had applied Morecroft's formula to any reasonable estimate in the case of tunes 2 and 4, which he forgot, he would have found something in the neighborhood of 50 complete oscillations would be required, theoretically, but in fact the oscillations in the primary circuit would have dissipated their energy and extinguished before this number could be reached.

I also again find difficulty with Waterman's mathematics in this matter of oscillations in the circuits, having in my

prima facie testimony shown that in a case where Waterman calculated but 3 oscillations I calculated 24. I now note that with his questionable 10 per cent coupling in tune 1 he finds 5 oscillations by applying the Morecroft formula, and with but 1 per cent difference, or 11 per cent, in tune 3, he finds from Morecroft but 2½ oscillations. My calcula- [fol. 1757] tion from Morecroft's formula for tune 3, using the questionable 11 per cent coupling, gives 4½ oscillations.

I note that the page of the Morecroft book (p. 247) to which Waterman referred for the formula points out that after all of the energy is transferred from the primary to the secondary circuit by a given degree of coupling the energy will then flow back from the antenna circuit to the primary circuit, unless there is something to prevent it from doing so. To accomplish this prevention, Morecroft states: "Such an action is accomplished by a 'quenched' spark gap to be described in detail in Chapter V."

Thus Morecroft brings out that the oscillations in the primary circuit calculable from his formula up to the time all the energy is transferred to the second circuit are not all of the oscillations that will take place in the primary circuit, as the energy will come right back from the antenna circuit and keep up its oscillations in the primary circuit, unless something is inserted in the primary circuit to prevent this, and he states that the "quenched" form of spark gap is the thing that makes such prevention possible. In other words, the subject matter of Morecroft used by Waterman does not apply to the Marconi system, but to the "quenched" gap system which came some 9 or 10 years later.

In the third paragraph, page 1885, Waterman sums up his recollection of the tunes of the Marconi patent to give the range of coupling from 5 to 20 per cent. On pages 1037 and 1038 I calculated the effect of coupling on producing double frequency, taking a specific example, and showed by calculation that with a coupling of 20 per cent the receiving circuits could not be tuned the same as the transmitting circuits with any hope of receiving any one of the two frequencies emitted, and that it was not until the coupling was reduced to the order of 3 per cent would the two humps or frequencies come close enough together for a tuned receiver to be effective. Waterman's questionable range of from 5 per cent to 20 per cent for the Marconi patent

therefore deprives it of being the selective communication system that Marconi so explicitly stated was his purpose, and Marconi's comments in his 1912 address make it clear that he was not then in accord with Waterman's present attempt to make Marconi a tightly coupled system to the extent that tuned receivers can not function with it. On page 1889 Waterman quotes an excerpt from this Marconi address, in which Marconi states that unless weak coupling is employed two frequencies will be created to divide into two waves of different lengths, and further refers to the receiver having to be tuned to but one of these, thus making it clear that Marconi himself admitted that under these conditions his system of tuning all four circuits to the same frequency could not be utilized.

These calculations of mine and the frank admission of Marconi and Waterman's own testimony on pages 152 and 153 makes Waterman's present statement on page 1886, paragraph 3, that "Marconi, of course, was entitled to make the association of the two circuits anything that he pleased" rather strained.

Near the bottom of the same paragraph Waterman states that the word "coupling" in this connection was not known at the date when the patent in suit was written. It may be true that the word itself was not in vogue, but the effect of [fol. 1758] coupling and how to properly use it was decidedly well understood by Stone before the writing of the Marconi patent.

At the bottom of page 1886, Waterman states:

"The matter of coupling is wholly a matter of degree; it expresses the extent to which the local reservoir circuit is loaded by its association with the antenna."

This can not be true with respect to the Marconi patent because Marconi specified that all of the four circuits of the system be adjusted to have the same time periods. If the degree of coupling is exceeded beyond the neighborhood of 3 per cent, the tuning of the receiving circuits in the manner described by Marconi effectively begins to cease having any useful function.

On page 1887, paragraph 1, Waterman states that the coupling used in the transmitter is a matter of choice with the constructor, forgetting that Congress took this matter in hand very early, taking the choice away from the

constructor, placing by law such limits upon him that he could not use degrees of coupling that would interfere with other communication. Keeping within the law required of the constructor some very careful selection of coupling.

The rest of Waterman's testimony on page 1887 infers that the choice as between the open type of gap and the "quenched" type of gap depends upon the amount of power to be handled, which is not the case in practice. Both types of transmitters have been built and used of the same orders of power running from a fraction of a kilowatt to tens of kilowatts, except that when the efficiency of the "quenched" gap type of transmitter was demonstrated, the open gap type fell out of the race, particularly high powers, where efficiency became an economical factor.

In the first paragraph of page 1888 Waterman objects to my reference to "cumulative resonance" in connection with the Marconi patent, stating in effect that the provision in Marconi for adjusting the two circuits to have the same time periods is what Marconi means in his use of the word "resonance." It may be that all Marconi knew of the matter at the time was this one feature of adjusting the two circuits, but the one feature was not sufficient to give the results he sought: that is, such selectivity that the two circuits at the receiving station could also take part in the resonance of being tuned to the same frequency as the transmitting circuits. This could only be carried out by including loose couplings and therefore depending upon "cumulative resonance."

In the third paragraph, page 1888, Waterman states that my pointing out that in the Marconi patent the lateral circuit must produce oscillations which are transferred "without changing characteristics" is a meaningless expression not contained in the Marconi patent. Just because the expression is not contained in the Marconi patent is no basis for it being without meaning. Marconi illustrated an electrical system, and irrespective of what he stated in the patent the system is dominated by the laws of nature. That what I have stated is loaded with [fol. 1759] meaning is clear from the analysis of Prof. J. H. Morecroft of the effects accompanying the transfer of spark generated oscillations from one circuit to another, this analysis being covered in part on pages 238, 239, and 240 of his book entitled "Principles of Radio Communication," published by John Wiley & Sons, New York, copyright

1921. Figure 23 on page 238 shows in the lower half the current i_2 in the secondary circuit when there is a coupling of 42.4 per cent between the circuits. The photographic reproduction is not very clear, but careful inspection brings out that the wave form is badly distorted. The effect is better shown in the more perfect reproduction in Figure 24 on page 239, which illustrates conditions obtained when the coupling was 28.2 per cent. Figures 25 on page 239 and 26 on page 240 show the result when the coupling is 11.4 per cent and 7.07 per cent, respectively. All of these figures are oscillograms or photographs of current movement in the circuits investigated by Morecroft, and clearly show that the characteristics are badly distorted, the distortion being expressed mathematically by Morecroft in equation 73 on page 238. That this distortion of characteristics of the current in the circuit is not meaningless as contended by Waterman is evident from comparing these oscillograms of the coupling effects when tight coupling is used with the oscillogram on page 249 of the same Morecroft book, Figure 37, which shows the current in the secondary circuit in the lower half of the figure when the coupling is "weak," Morecroft's term for "loose coupling." It is seen that this secondary current with loose coupling conditions is substantially pure, and could be expressed in a mathematical equation like that of equation 73 on page 238 of Morecroft by one simple term rather than the complication of terms Morecroft gives for the tightly coupled systems, or in other words the "Asinpt" term of the Stone-Baker letter when Stone wrote to Baker how his system would provide for simple harmonic oscillation in the antenna circuit.

On page 240 and top of page 242 Morecroft gives information why this matter of change of characteristic has most important bearing on the Marconi system. He points out that in the case of two circuits each adjusted for a natural period of 100 cycles, taken alone, but coupled 20 per cent, there results two frequencies upon discharge of the condenser, and he shows his calculation of these frequencies from equations previously given to be 91.2 cycles and the 111.7 cycles, instead of 100 cycles, the time periods of the circuits. He then points out that if a third circuit be loosely coupled to either one of the two circuits of the system and tuned to a natural period of 0.01 second (100 cycles) the current induced in this third circuit so tuned will be much

smaller than if the third circuit was tuned to a natural frequency of either 111.7 or 91.2 cycles. These three circuits of the Morecroft system are the electrical equivalents of the two circuits at the transmitting station and a third circuit at the receiving station of the Marconi system, and Morecroft makes it clear by elaborate scientific analysis that if the transmitting system of Marconi generates two frequencies by employing a tight coupling such as 20 per cent, which tight coupling Waterman erroneously contends he has arrived at from unfounded construction of the several [fol. 1760] tunes given in the Marconi patent, that the circuits at the receiving system can not be adjusted to have the same natural periods as the circuits at the transmitting station, and it is an outstanding feature of the Marconi patent and claims thereof that the circuits at the transmitting station are to have the same time periods as the circuits at the receiving station. Reference again to the figure on page 249, a condition of loose coupling, shows that when the current in a secondary circuit is "without change in characteristics" the circuits throughout can all be tuned alike with real meaning and regard for the laws of nature. Because Waterman gives no analizable support for his sweeping statement that my analysis of the Marconi system is "an entirely meaningless expression" I have gone into the matter somewhat in detail in order to emphasize the extent to which Waterman goes in his testimony without foundation.

In the same paragraph I have just discussed Waterman tries to imply that the persistency of oscillations referred to in the Marconi patent takes its meaning from the mere removal of the spark gap from the antenna circuit to the lateral circuit, coupled with the use of the Lodge coil in the antenna circuit which has the effect of prolonging the circuit oscillations. Since Lodge also removed the spark gap from the antenna circuit as did Tesla, Braun, Pupin, and Stone, Waterman seems to leave little of glory for Marconi in his feature of "persistent oscillation."

In the beginning of paragraph 5, page 1888, Waterman accredits to me the impression that "because the circuits are in resonance, therefore the energy can not be transferred quickly from one circuit to another." I have given no basis for any such impression, but have brought out that because all four circuits of the Marconi system must be tuned to have the same periods it is not possible to combine

with the efficiency of resonant transfer the addition of rapid transfer by tight coupling. I think my testimony is clear that the adjustment of the time periods of the circuits to be the same provides for the most rapid transfer at any given percentage of coupling, but have pointed out that because of the reaction of the secondary circuit onto the first to create distortion of energy transfer the coupling must be kept sufficiently loose that the efficient transfer of resonance must itself be maintained at a low rate of transfer.

Immediately following this paragraph Waterman states that in the Marconi patent the transfer of the energy in the primary circuit takes place in "from 2½ to 10 oscillations." I have previously pointed out that Waterman has no basis for alleging that he could determine any number of oscillations involved in the Marconi patent because of lack of sufficient constructional data from which to do so, and further that this low figure of "2½" he arrived at by a miscalculation in the simplest of mathematical operations, the correct figure from his erroneous assumptions being 4½ oscillations, and that the roughest sort of estimate of tunes 2 and 4 in Marconi patent, which Waterman could not recollect, would give theoretical numbers of oscillations by using the Morecroft formula employed by Waterman in the neighborhood of 50.

At the top of page 1889 Waterman characterizes my statement concerning the Marconi address of 1912 as "nonsense," but as usual avoids any attempt to point out wherein the "nonsense" lies. That neither Marconi nor I dwelt in nonsense is perfectly clear from the review I have [fol. 1761] just made of the scientific analysis by Professor Morecroft of the matter dwelt upon by Marconi in his address. What Marconi said is precisely what Morecroft analyzed on page 240 of his book about a third circuit or receiving system being unable to resonantly receive the emanations from tightly coupled two circuits of a transmitting system. There is positively no "nonsense" associated with these facts of nature.

Waterman goes on to point out that Marconi immediately followed his remarks by reference to development of a spark gap which was capable of opening the primary circuit to thereby prevent any retransfer of energy, also referring to the "Wien spark gap." It is quite natural that Marconi in 1912 should have known about this new form of quenching gap which permitted of overcoming the diffi-

culty of his system he pointed out. Wien's work dated back to 1907 or 1908, and was immediately followed in 1908 or 1909 by valuable improvements of Count Arco and Rendhal and Seibt, German scientists, and by 1912 many quenched-gap systems resulting from the most practical work of these men were in wide use.

Waterman states about the middle of page 1889:

"Mr. Marconi did not state that the circuits were not in resonance if the spark gap did not prevent the retransfer of energy, as Mr. Loftin assumes."

The fact is Marconi did so state. He points out that the tight coupling makes oscillation of two frequencies so that the receiving circuits must be attuned to one or the other of these frequencies, and not adjusted the same as the two circuits at the transmitter. Waterman seems particularly zealous in ignoring the fact that the Marconi system is one of four tuned circuits, rather than one of merely adjusting the time periods of the two circuits of the transmitting station to be the same.

In closing his answer to question 2, on page 1890, Waterman admits that the introduction of a spark gap capable of opening the local circuit at the end of the energy transfer period was an improvement. He does not point out that this new quenched gap permitted of so tightening the coupling that the energy transfer period could be reduced to practically nothing compared to the period of useful oscillation from the antenna at the end of the energy transfer period and that the enormous distortion occurring during the energy transfer period in the characteristics of the energy being transferred would have no great practical effect on the emanations from the antenna, and that the enormous distortion during the energy transfer period precludes any possibility of energy transfer in resonant fashion, thus making the quenched-gap system an entirely different one from the slow feeding, resonant transfer systems of the Marconi patent and Stone.

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35. Question. Please refer to the testimony in answer to question 3, page 1890, and state your opinion of the corrections made by Mr. Waterman of prior testimony of his as to calculations made by him.

* * * * * * *

[fol. 1762] Answer. In Waterman's prima facie testimony he stated that he had calculated the number of oscillations in the primary circuit of tune 1 of the tunes on page 4 of the Marconi patent as 3 oscillations, and because of my practical knowledge of electrical effects I detected a possible gross divergence from the fact immediately upon reading this part of Waterman's testimony, and thereupon made the simple calculation required to verify my doubts, finding 24 oscillations instead of 3, as I had suspected. The calculation is an extremely simple one expected of any schoolboy, being a mere substitution of numerical values in the simple formula I show on page 1054, the operation thereafter being mere arithmetic. I note that Mr. Waterman accounts for his wide divergence from the fact in two steps, the first being that his assumption that he was counting the number of oscillations up to the point of the energy falling to 1 per cent of the original should have been to only 10 per cent of the original, and therefore the 1 per cent is "clearly a typographical error." Why the 1 per cent should be a typographical error is not technically clear, because Waterman was testifying about the point at which oscillations in the primary circuit would cease, and the fact is that once the spark gap breaks down to ionize the gap the oscillations do not cease when the energy has fallen to 10 per cent of the original. Even with a correctly designed quench gap it is necessary to bring the energy through the gap to a substantially zero value at the first beat if oscillation in the primary circuit is to be stopped at this point. It is my opinion that Waterman's 1 per cent in the first instance more nearly accords with the actual operation of the gap.

After changing the point of cut-off all the way from 1 per cent up to 10 per cent Waterman still found that he had 12 oscillations instead of 3, and this he accounts for by a miscalculation in a schoolboy operation in the simple formula on page 1054. It is quite possible that anyone would make a miscalculation now and then, but an engineer can generally be relied upon because of his empirical knowledge of effects not to permit such a gross error to slip by, as the result that Waterman alleges to have obtained (three oscillations) immediately called attention to the possibility of an error.

I have also referred to the fact that Waterman claimed to have calculated the result using a gap resistance of 1

ohm, whereas in my opinion the gap resistance should be of the order of one half ohm, so that in fact there were more than the 24 oscillations I arrived at by calculating with Waterman's 1-ohm assumption.

Noting the freedom with which Waterman has charged me with lack of understanding, nonsense, and the like, he must have found the necessity for using the schoolboy excuses as to the gross divergence of his three oscillations [fol. 1763] from the fact pointed out by me most embarrassing. It is to be noted that Waterman has resorted to numerous unfounded contentions that the number of oscillations in the primary circuit of the Marconi system is low, although Marconi specifically states that the oscillations in the primary circuit are to be maintained for a long time, and the fact is that Marconi is correct in spite of all of Waterman's efforts to the contrary.

* * * * * * *

36. Question. Please refer to the testimony in answer to question 4 on page 1891 and state whether or not you agree therewith, giving your reasons.

* * * * * * *

Answer. This is Waterman's testimony in answer to my criticism of his sketch No. 2, Waterman stating as usual that I am wrong, with which I do not agree. One objection I made to Waterman's sketch No. 2, opposite page 151, and which I repeat in Figure 1 of my sketch K, opposite page 1057, was that Waterman showed the oscillations of the secondary circuit of equal intensity to the oscillations in the primary circuit, and the energy in the secondary circuit greater than the energy in the primary circuit in that the oscillations in the secondary circuit, of equal intensity to those in the primary circuit, endure for a greater length of time.

Waterman now contends that his sketch 2 does not illustrate current flow, but "the charge as determined by voltage across the condenser." Being overanxious to charge me with being wrong, he evidently failed to recollect his own testimony as to this sketch. On page 151 he states as to the sketch:

"I illustrate by Waterman's sketch No. 2 (here produced) the *oscillation of current* in the two circuits of a transmitter,

properly adjusted as described in the specification." (Italic mine.)

If I can not use Waterman's own words for what he shows without being wrong there seems to be little hope of my ever being right. That I am right, however, is clearly shown by actual photographs of the currents in the two circuits on page 249 of Morecroft's book, to which I have previously referred. In Figure 2 of my sketch K I showed my opinion of the way in which Waterman should have made his sketch 2, in order to correctly give an idea of the currents in the two circuits. My sketch is substantially a duplicate of the actual photograph of these currents by Morecroft on page 249.

I also objected to Waterman's sketch 2 on the basis that he showed too few oscillations in his primary circuit just as he calculated too few oscillations. Comparison of Figure 2 of my sketch K with the figure on page 249 of Morecroft, and a like comparison of Morecroft and Waterman, shows again that I was not wrong. It is difficult to keep the facts out of photographs.

At the bottom of page 1891 and top of page 1892 Waterman charges that I apparently do not know that the laws of nature and not my opinion determines the meaning of the language of the Marconi patent. I have formulated my opinions around a very sound foundation for appreciating a great many of the laws of nature, and I think I can safely leave it to Morecroft's photograph, page 249 of his book, [fol. 1764] of the laws of nature in operation in the Marconi circuits as to whether or not my opinion is in accord with the governing laws.

In the first paragraph, page 1892, Waterman states that my amendment to his sketch shows about 14 oscillations in the primary circuit as compared to his 4 oscillations, and that my 14 oscillations are outside of the Marconi patent and his 4 oscillations within the patent. I again refer to the photograph of Morecroft of the laws of nature in operation, page 249 of his book, and find by count that the photograph shows about 14 oscillations in the primary circuit.

In the second and third paragraphs, page 1892, Waterman states that it is immaterial whether or not the spark gap in the primary circuit fails to cut off and permit some retransfer of the energy. In his prima facie testimony, page 153, paragraphs 1 and 2, he states all sorts of defects

of operation when the coupling is so close as to bring about this retransfer, all in accord with Marconi's own statements as to this effect in his 1912 address, and which is in accord with my testimony and the scientific analysis by Morecroft on pages 238, 239, and 240 of his book to which I have referred.

In the fourth paragraph, bottom of page 1892, Waterman states:

"Mr. Loftin has apparently confused the action of a resonant receiving system gradually building up energy received from a far-distant transmitter."

From this I understand Mr. Waterman to mean that there is a transmission in the laws of nature in the matter of transfer of energy somewhere in the range of receiving energy from near by and from a distance, but like many of the other mysteries that have been attributed to radio over general electrical effects, he makes no attempt to point out when or where this transition comes into play. The fact is there is no such transition, and I again refer to the photograph of the laws of nature in operation on page 249 of Morecroft's book, which illustrates energy being transferred from one circuit to a physically closely associated second circuit. It will be noted that the photograph of the secondary current shows it to gradually build up in intensity even though the primary current is initially at a maximum. This gradual building up in the second circuit under a continuous influence from action in the primary circuit is the "cumulative resonance" effect to which I have referred and which Waterman has criticized, and it is well known that it is only by such effect that actual resonant transfer of energy from one circuit to another can be had. For example, I note that Waterman in his answers to cross-question 84, cross-question 86, and cross-question 87, pages 1972-73, was referred to oscillograms or photographs of electrical currents in circuits when coupled, which oscillograms were used by him in his testimony in the case of Radio Corporation of America *v.* Splitdorff Electrical Co., and particularly oscillogram CD120089, shown on printed page 229 of the Splitdorff record. In these oscillograms Waterman shows the currents in two cases of tightly coupled circuits, and it is seen from them that the currents in both circuits are badly distorted as shown by Morecroft for tightly coupled circuits on pages 238, 239, and 240 of his

book to which I have referred. These oscillograms of Waterman clearly show that there is no resonant building up of the oscillations in the secondary circuit in the manner [fol. 1765] shown in the case of the loosely coupled circuits, the currents of which are illustrated on page 249 of Morecroft. In fact, Waterman's photographic investigation of the transfer of energy in the Splitdorff case clearly sustains my contention that where the coupling is tight, as it is in a quenched gap system during the period of charging the antenna before quenching of the gap, there is no such thing present as resonant transfer of energy.

. . . . . .

In the last paragraph but one, page 1892, Waterman states that I am mistaken in my contention that the primary circuit in the Marconi system has much to do with determining the duration of the oscillations, but given no reasons why I am mistaken. The fact is that the patent itself provides that the oscillations be maintained for a long time in the primary circuit, and I have heretofore given many technical reasons that Waterman might have attempted to refute why the patent is correct.

In the first paragraph, page 1893, Waterman charges me with displaying "sheer ignorance" in my contention that in making the oscillations in the two circuits of his sketch 2 of equal intensity illustrates a coupling of the order of 100 per cent, which does not exist, evidently making this statement on his present contention that the intensities represent condenser charges instead of "oscillation of current" as originally stated by him on page 151 to which I have previously referred.

In the next paragraph, page 1893, Waterman states that I am "wrong again," followed by a statement:

"Mr. Loftin seems to have the erroneous impression that the current in a circuit can be going in two directions at once. Mr. Weagant has clearly pointed out Mr. Loftin's error in this regard, as found in Loftin's sketches G and H, defendant's Exhibit O-2 and P-2."

I note that in cross-question 76, page 1970, Waterman was asked to point out where in my testimony I had made any statement to the effect that current can be going in one circuit in two directions at once, and that he failed to do so. The fact is I made no such statement and in no way testi-

fied in a manner to convey this impression. In my sketches G and H, referred to by Waterman as having been criticized by Weagant, I did what is often done in the matter of explaining wave motions; that is, divide the one current of complex wave form into two illustrative components merely for the purpose of clearer analysis and explanation, a practice not unusual in ordinary textbooks involving wave motions of different kinds including electrical currents. For example, on pages 241 and 242 of the Morecroft book to which I have just previously referred he shows three figures in which the "actual current," shown in the wave form of full line, divided into two explanatory components shown in dotted lines in the several figures.

While Waterman was unable to point out where in my testimony I had stated that there were actually two currents flowing at once in any circuit, I note that in his testimony [fol. 1766] in the case of *Radio Corporation of America* v. *Splitdorf Electrical Co.*, quoted to him in cross-question 83, pages 1971 and 1972, he made the statement: "There will be in those circuits as *many currents* as there are circuits" (italics mine), this testimony being in connection with the transfer of energy between coupled circuits. Of course Waterman did not mean in this Splitdorf testimony that there were actually "many currents" flowing in the same circuit at once, but one current having many frequency components, but it emphasizes how loose he may be in his expressions at one time and how unjustly critical he becomes at another time.

In the third paragraph, page 1893, Waterman states that "with a coupling of 8 to 10 per cent there are not necessarily two frequencies," which is not true. I showed on page 1637 of my testimony the mathematical formula for the two frequencies depending upon coupling, the degree of coupling being the term K in this formula. The only way to avoid the two frequencies is to make the value of K zero instead of 10 per cent mentioned by Waterman, and there is no way to couple and operate the circuits to avoid the law of nature expressed mathematically in the formula.

In the last paragraph, page 1893, Waterman states that he fails to see from the point of view of the Marconi invention that there is any consequence whether or not the coupling in the Marconi patent is somewhat tighter than required for best results; thus seeming to forget as always that the Marconi patent is a 4-circuit system and can not

be permitted to emit two frequencies because of the requirement that the circuits at the receiver be adjusted to have the same time periods as the circuits at the transmitter, a feature which was emphasized by Marconi himself in his 1912 address in which he pointed out the necessity for loose coupling.

In the second paragraph, page 1894, Waterman charges me with misquoting him as to the coupling effect in connection with his sketch No. 2, and quotes his testimony verbatim in connection with his charge that I have misquoted him. After going to all of this trouble he does not point out wherein my abbreviated statement of his testimony differs in any way to mislead, and I fail to see any difference.

In the last paragraph, page 1894, Waterman states:

"A qu*e*ched spark gap transmitter, such as he frequently refers to also gives but one frequency and hence, by his own definition, is also 'loosely coupled.'"

I have not contended, nor do I know of anyone who has contended that the quenched gap type of transmitter emits but one frequency. In my sketch O, opposite page 1100, I showed in Figure 6b the type of emission by a quenched gap transmitter, which shows three frequencies, the two small ones in red and green being the coupling frequencies before the gap queneches and the large one in purple being the desired oscillation at the natural period of the antenna circuit after the gap queneches and the coupling relation between the circuit ceases to exist. This same triple frequency of the quenched gap system is shown in Seibt patent, Figure 6, defendant's Exhibit C-3, to which I have referred in my early testimony.

On page 1895 Waterman attributes to the Marconi system all sorts of characteristics only possible in the quenched gap system, and even more, for at the bottom of the page he states:

[fol. 1767] "An effective, that is to say, a spark gap working in the most desirable fashion, will but off by *or before* the time when all the energy has been transferred to the antenna." (Italics mine.)

There is no possible way in the quenched gap system for the gap to cut off before all of the energy in the primary has been transferred to the antenna. In the quenched gap sys-

tem a most careful adjustment is necessary to have the current through the gap at the time of the first beat at substantially zero to get the gap quenched even at this point, which is the point of transfer of all the energy to the antenna, and there is no way to get a quenching in the gap before this point is reached. In the loose coupled Stone and Marconi systems the gap does quench before all of the energy is transferred to the antenna, this because no attempt is made to quickly transfer all of the energy to the antenna and thus arrive at an early first beat when there is still present a large amount of energy in the system. When the oscillations in the primary circuit are long drawn out there is not much energy left in either the antenna or the primary circuit when the gap opens up, so that it just naturally extinguishes from lack of energy anywhere to maintain it in operation.

Waterman follows the quotation above by another as follows:

"The antenna begins to radiate as soon as the spark starts and it continues not only till the spark ends but until long after."

This feature emphasizes one of the outstanding differences between the loosely coupled Stone and Marconi systems and the quenched gap system. In both systems the antenna begins to radiate immediately the spark starts, but in the quenched gap system the radiation that takes place before the gap quenches is useless for communication, and is in fact a defect, as it goes out in two widely separated coupling frequencies as shown in Figure 6-b of my sketch O opposite page 1100. In the Stone and Marconi systems the radiation from the start is at the desired frequency, and thus starts useful communication from the beginning, this as shown in Figure 5-b in my sketch H opposite page 1043.

37. Question. Please refer to the testimony in answer to question 6, page 1896 and following, and state whether or not you agree with the testimony, giving your reasons.

Answer. In my previous testimony I pointed out wherein Waterman in making his sketch No. 3 as an alleged simplification of Figure 2 of Marconi patent 763772 had taken unwarranted liberties in transposition of apparatus not provided for in the patent. Waterman now states in the testimony in answer to question 6 that it was a trivial matter be-

cause the condenser f' which he moved had a large capacity compared to the other condenser h'. I can find no basis in the patent for his present contention that the condenser f' had a large capacity compared to condenser h'. Waterman states that a value of 0.004 "is commonly used," by which I infer that he speaks of the present-day practice in connection with a condenser used in modern circuits, which of course gives him no basis for turning back some 25 years as to what was intended by Marconi, and certainly practical facts are against him. At Marconi's time it was not known how to make up large capacities in small compact forms and a condenser of the capacity now mentioned by Waterman would have been a cumbersome piece of apparatus if made in the fashion of constructing condensers at Marconi's date.

[fol. 1768] 38. Question. Please refer to the testimony in answer to question 7, page 1897 and following, and state whether or not you agree with the statements therein, giving your reasons.

Answer. I do not agree with the statements in many respects. This is Waterman's testimony in answer to my prior testimony concerning Seibt patent 1216615, defendant's Exhibit C-3, which I used to point out the differences between the quenched gap system and the loosely coupled system of Marconi and Stone.

On page 1897 Waterman begins his testimony with the statement that he is compelled to infer that I have never used the transmitters I discussed and "knows little about them." The fact is that the United States Navy has dealt more extensively in quenched gap transmitters than any other one institution, and I was closely associated with this Navy dealing in quenched gap transmitters for some 12 years in many practical ways, including supervising actual installations with calibration and adjustment for use. Waterman's replies to my practical analysis of the quenched gap system compels me to infer that his association with this form of apparatus has been merely that of the professional patent expert rather than as a practical engineer.

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At the top of page 1898 Waterman states that the local circuit of the transmitter of Seibt patent is a "good conserver or persistent oscillator," which is not the case, the reverse being true. The whole purpose of the Seibt patent

is to combine a tight coupling with a quenching gap in such a way as to get the oscillations out of the local circuit quickly and keep them out, and thus avoid any duty of conservation on the part of the local circuit and any possibility of persistent oscillation therein.

In the first paragraph, page 1898, Waterman enumerates the elements in the Seibt transmitter system in a way to point out the elements of the Marconi patent in suit. The same enumeration of elements is possible with respect to the Stone-Baker letters and Stone patent 714756.

In paragraph 2 Waterman states that Weagant has discussed the Seibt patent and its file wrapper, and has pointed out disclosures of Seibt to the effect that these two circuits are in resonance with one another, and Waterman states that he agrees with this testimony of Weagant.

In my testimony on page 1098 I pointed out how Seibt was careful in his patent, page 1, lines 62-70, to make clear that his reference to resonance referred merely to the adjustment of the natural periods of the circuit, and not to the resonant transfer of energy therebetween, and the figures of the drawings of the Seibt patent further emphasize lack of resonant transfer with the tight coupling in view, this being clearly shown in Figures 2 and 3 of the Seibt patent. Weagant takes up a communication between a patent attorney and the Patent Office during the prosecution of the application, page 1633, and tries to use the lack of discrimination of which a non-technical man is capable as evidence [fol. 1769] that the clear discrimination made by Seibt himself in his patent is not to be taken with its full force.

In paragraph 3 of page 1898 Waterman states that the only difference between Seibt and the Marconi patent is that Seibt employed the spark gap of Marconi reissue patent 11913 characterized by a succession of gaps in series. This is not the fact, as the gap of Seibt includes many features other than the mere placement of gaps in series, these being such features as air-tightness, large area, very short gap, and materials of rapid heat conductivity and non-disintegration. No one has succeeded in making a quenching gap out of a mere arrangement of open gaps in series that will function in the Seibt arrangement, that is with the circuits tightly coupled to produce an early first beat at which quenching could take place. The correct type of gap was not shown anywhere until the work of Wein and Arco & Rendhal some 10 years after the Marconi reissue pat-

cut. Marconi required a gap suitable for long drawn out oscillations in the primary circuit, namely an open gap working at rather high temperature, and Seibt a gap to quickly cut off oscillation in the primary circuit, namely, a properly designed quenching gap of rather low temperature.

In the last paragraph but one, page 1899, Waterman states that I ignore the fact that if the circuits did not react on one another they could not act on one another. I have done no such thing. On pages 1037 and 1038 I carefully went into the matter of how much in practice the circuits could act and react on one another without creating frequencies so widely separated as to interfere with tuning of the receiving circuits, and showed that with a coupling of the order of 3½ per cent and below good tuning could be followed throughout the system. A coupling of 3 per cent will resonantly transfer a substantial amount of energy, and the apparatus will be decidedly operative rather than inoperative as suggested by Waterman.

At the top of page 1900 Waterman points out that I have said that the adjusting of the timing periods in the two circuits of the Seibt patent has nothing to do with a resonant transfer of energy between the circuits, and comments that I have given no proof of this statement and that it is wholly incorrect. In my sketch O, opposite page 1100, I show in Figures 6 and 6a how the energy in a quenched-gap system during the transfer period before the quenching oscillates violently at two different frequencies, making a resonant transfer during this period impossible. The main criticism of Waterman of this showing is his foolish suggestion that I have erroneously illustrated two currents flowing in the same circuit at once. He does not take up the actual facts, namely, that the current that does flow has no frequency corresponding to the natural period of the circuits, and therefore is incapable of flowing in them in any manner satisfying the actions and reactions governing resonant flow.

In the first paragraph, page 1900, Waterman states that the figures of the Seibt patent indicate a coupling of about 10 per cent, while the range indicated by Marconi patent is from 5 to 20 per cent. There is no basis for Waterman asserting that the figures of the Seibt patent indicate any specific coupling for a properly designed quench-gap system. Waterman has evidently counted the number of oscillations illustrated by Seibt in Figure 2 up to the Point T_1,

[fol. 1770] and applied this count to the Morecroft formula to estimate coupling. In this figure Seibt is not dealing with the proper operation of a quenched-gap system, but merely illustrating his technical discussion to the effect that with a tightly coupled system the current flow in the circuits waxes and wanes alternately as the energy is transferred from one circuit to the other. The mere use of five oscillations in drawing a diagram of this kind between the state of maximum current and minimum current is not entitled to any significance as to the coupling proposed by Seibt. Seibt makes it clear that the longer the period of time before this point of minimum current at which the gap can quench the less perfect is the result, which in itself is an instruction to make the coupling as tight as possible. As before pointed out Waterman has no basis for saying that the range of couplings in the Marconi patent is from 5 to 20 per cent. It is clear that the two couplings in tunes 2 and 4 which he could not recollect are extremely loose, and well below 5 per cent, and that the Marconi patent does not furnish sufficient data around which to determine any degree of coupling.

Further on page 1906 Waterman objects to my pointing out that the system of Seibt is based on the fundamental principles set up in the Lodge patent, that of quickly transferring the energy from the local circuit to the antenna circuit without regard for resonance, and disconnecting the local circuit from the succeeding action; that is, to leave the antenna circuit free to determine all by itself the frequency of the oscillations with which actual communication could be carried on. In refutation of this Waterman again turns to his ridiculous proposition that Lodge provided two radiating circuits with but one antenna circuit with which to do so, and in answer to which proposition I have pointed to the structure in plaintiff's Exhibits 79, page 180; 91, page 181; and 101, page 190; as systems coupled to the antenna like Lodge's Figure 4, alleged by claimant's witnesses to infringe the Marconi patent in suit.

In the first paragraph, page 1901, Waterman says there is no basis in fact for my contention that the Seibt arrangement is based upon a number of features of Lodge's Figure 4 found in the Marconi patent in suit is also based upon Lodge's Figure 4. I have pointed to a number of features of Lodge's Figure 4 found in the Marconi patent in suit, particularly in pointing to Waterman's attributing to Mar-

coni the use of two circuits at the transmitting station, one open and one closed, and the removal of the spark gap from the open circuit. Lodge has these features. Marconi differs from Lodge in providing for a long drawing out of the oscillations in the closed circuit, and resonant transfer of them to the antenna circuit, which is also a difference between Marconi and Seibt.

In the second paragraph, page 1901, Waterman states that "the sole basis" for my contention that there is not a resonant transfer of energy in the Seibt arrangement is that the number of oscillations during the transfer period is relatively small compared to the number of oscillations from the antenna circuit, which is not the fact. I have pointed out in detail in connection with my sketch O, opposite page 1100, that during this short period of transfer the current flow involves two widely separated frequencies, and therefore can not resonate with the circuit. If during [fol. 1771] this period of transfer it were possible with tight coupling to keep the current from distorting itself into two frequencies, and to cause it to have one frequency, that of the circuits, I would say that in spite of the short duration of the transfer that it is resonant transfer, merely qualifying it as not being sharp or cumulative resonance because of the lack of time for resonant building up. In other words Waterman's reference to "the sole basis" entirely misrepresents my contention as to the operation that takes place.

In the latter half of the second paragraph, page 1901, Waterman outlines the operation of the quench gap system including features wholly inconsistent with fact.

He first says: "The spark gap by discharging sets up oscillations of the desired frequency in the nonradiating circuit." It just can't be done. The tight coupling between the nonradiating circuits and the antenna circuit throws its influence so strongly upon the current movement that an oscillation of two widely separated frequencies persists as long as the gap plays its part in the operation.

He next says: "Associated with this circuit is the open circuit which can, theoretically, be set into oscillation at any frequency, but because its electrical time period has been made the same as that of the spark gap circuit, it offers the lowest possible resistance to being set into oscillation at this frequency to which it is tuned." The only way the circuit could act in the way thus outlined by

Waterman is for it to be a free and independent circuit, and not being so because of a tight coupling to the non-radiating circuit Waterman is wrong. It indulges in a scramble form of oscillation at two widely separated frequencies until the transfer of energy period is over.

Waterman next states: "While it is thus absorbing energy it is also radiating, and it thus is able to radiate more energy * * *." It is true that during the energy transfer period the antenna circuit is radiating, but in no useful way. The radiations are at two widely separated frequencies, so that a distant receiver tuned to the desired frequency gets no benefit out of this radiation occurring during the energy transfer period, shown in detail in Figure 6b of my sketch O, opposite page 1100. On the other hand, the Stone and Marconi systems do usefully radiate throughout the entire transfer period, the coupling being sufficiently loose that the two frequencies do not spread apart any noticeable amount from the point of view of tuning at the receiving station.

At the top of page 1902, Waterman again refers to my analyzing the double frequency current of a tightly coupled energy transfer in my sketches as showing "nothing but Mr. Loftin's ignorance of electrical science," the remembrance of which statement must have embarrassed him considerably, if he is capable of embarrassment, when he was called upon to answer in cross-question 83, pages 1971 and 1972, his quoted testimony in Radio Corporation of America *v.* Splitdorf Electrical Company. At the top of page 1972 his quoted testimony makes the unqualified statement that there are "many currents," and in his answer he transposes this into having said that the current of complex form might be analyzed into the many currents referred to by Stone. In Waterman's conception of my ignorance I pictorially analyze the current just as he, in the last analysis, said he would do. In other words it took Waterman a long time to become as bright as I was in the first instance.

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[fol. 1772] In the first paragraph, page 1902, Waterman says I seem to suggest that the Seibt patent implies that with other forms of spark gap the operation will always be what I illustrated in my sketch G, and adds that he understands the Seibt patent to state quite the opposite. The

fact is that I give no basis for seeming to suggest what Waterman says. On page 1040 I clearly pointed out that Figures 2, 2*a*, and 2*b* illustrate the conditions encountered under tight coupling with a gap that will not quench, and the Seibt patent in referring to Figures 2 and 3 thereof deals with the same composition; that is, the figures do not deal with other forms of gaps merely as suggested by Waterman, but include in a most definite manner the effect of tight coupling on a nonquenching gap system.

Waterman then points out that Seibt discusses a type of gap in which the conductivity is maintained until the energy at the discharge has been entirely dissipated, pointing out that the retention of conductivity by a gap depends upon vaporization of the metal of the electrodes, small heat conductivity and increase of current, features I previously pointed out in connection with the Marconi patent as being helpful in securing long-drawn-out oscillations in the primary circuit specified by Marconi. He then points out that Seibt mentioned that these characteristics for retained conductivity of the gap are never "fully attained" in practice, which is quite true, but in no way warrants the meaning then given by Waterman to this comment, namely, that it would take a very bad spark gap condition, or a very insufficiently loose coupling to bring about the results shown in Seibt's Figure 2 and my sketch G. The fact is the features shown by Seibt and me are precisely the ones referred to by Marconi in his 1912 address when he stated that the open gap had to be used with loose coupling in order to avoid this repeated retransfer of energy. In other words, Marconi knew that the features of prolonged conductivity were sufficiently "fully attained" in his open gap to produce the results shown by Seibt and me.

On page 1903 Waterman discusses the Seibt patent as if it makes no difference at which one of the beats the quenching takes place, which, of course, is absurd. Seibt makes it clear that the whole purpose of his patent is to bring about a quenching at the first beat, and the reason for this is most clear. Seibt shows that he can produce a first beat after a very few oscillations in the primary circuit, for example, four or five, but if the gap fails to quench at this first beat, then the next beat occurs at double the number of oscillations later—that is, around the twelfth to fifteenth—and since the total number of oscillations can not be much greater than this higher number, it is obvious

that if the quenching waited until the second or third beat most of the duration of the entire operation would be taken up by a period of scrambled as to frequency energy transfer without resonant effect, and very little time would be given to final useful oscillation at the desired frequency in the antenna circuit. Every practical engineer knows that when a quench-gap system is not adjusted to quench at the first beat the system is not in fact a quench-gap system. [fol. 1773] On this bogus theory that quenching can take place at any one of the beats Waterman then states that it has been the endeavor from the outset—that is, from the first introduction of the apparatus of the Marconi patent—to provide better and better cooling for the spark gap. The fact is that the matter lay dormant for many years until the disclosure of Wein as to the possibility of the quenched gap effect being used came as a sudden enlightenment of the art, and Wein was so clear in his disclosure that Seibt and the engineers of the Telefunken Co. of Germany almost immediately put the ideas into commercial practice.

At the bottom of page 1903 Waterman states that I "seems to intimate" that Seibt dealt with the operation of an apparatus containing the quench gap in my quotation on page 1099 from the Seibt patent, page 2, lines 74-87, but does not state wherein this seeming to intimate arises. I did not intimate any such thing. Immediately following the quotation I stated on page 1100 that Seibt illustrated in Figure 4 of his patent the quenching of the spark gap at the first beat, thus making it clear that I considered that only Figure 4 of Seibt properly illustrates the quench-gap system. Waterman states that Seibt was talking about the characteristics exhibited by "prior circuits," and that Seibt says that they may act in any of the ways shown in his Figures 2 to 5, inclusive. What Seibt did show was that if anyone attempted to operate the prior circuits with a coupling as tight as that needed for a quench-gap system there would result pandemonium in the oscillation until a quench gap opened up the primary circuit at the very first beat.

At the bottom of page 1904 Waterman limits the Marconi patent to merely calling for an association in a transmitter of a radiating and nonradiating circuit whose electrical time periods are equal, a limitation entirely unfair to Mar-

coni and one which Marconi himself refused to accept in his 1912 address because he knew that his system was a 4-circuit system that would not permit ignoring the tuning of the circuits at the receiving station, so that he specifically made reference to loose coupling as a compulsory feature of his system. However, the patent itself was in effect clear on this point of loose coupling in prescribing that the oscillations in the primary circuit should be maintained for a long time. By ignoring this maintaining of the oscillations for a long time in the primary circuit Waterman states that the instructions of the Marconi patent are "faithfully embodied" in the quenched gap transmitter employed by the Navy. The fact is that the quench-gap system deliberately departs from the Marconi instructions and secures a different mode of operation by so doing.

In the second paragraph of page 1906 Waterman quotes me as making the unqualified statement on page 1117 that Figure 13 of the Lodge patent is a tunable circuit, and follows his unfair method of quoting with the statement that the quotation is decidedly misleading. My testimony at this point was as follows:

"Following such line of argument the secondary circuit of the Lodge receiver, Figure 13, is a tunable circuit if this is what Mr. Waterman means to imply."

This is far from an unqualified statement on my part that the secondary circuit of a receiver of Lodge's Figure [fol. 1774] 13 is a tunable circuit, but a statement placing the burden directly on Waterman. In my testimony immediately preceding I pointed out that Waterman had contended that receivers of defendant not including means for keeping the tuning of the secondary circuits the same as the tuning of the antenna circuit infringe the Marconi patent, and therefore if Waterman's line of argument was acceptable Figure 13 of the Lodge patent was entitled to a like position.

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39. Question. Please refer to the testimony in answer to question 8, page 1907, and state whether you agree with the statements therein giving your reasons.

Answer. In the answer to this question Waterman takes up my prior testimony that the quench-gap transmitters of defendant are based on the fundamental principle of in-

pulse excitation set forth in Lodge's 1898 patent, stating that he does not agree. He gives as his reason that Lodge does not have in his transmitter a local circuit of the non-radiating type and does not have such a circuit associated with an open radiating type, but does not attempt to state that these two circuits are necessarily a part of impulse excitation. The fact is that Lodge does have these two circuits as brought out in my sketch opposite page 1069. He further says that Lodge does not have two circuits whose electrical time periods are equal to one another, again failing to state why it is necessary to have the two circuits so adjusted in order to have impulse excitation, and the fact is that it is not necessary. The Simpson and Thompson transmitters in the Kilbourne and Clark case did not have the two circuits so adjusted, and it is my understanding of the decisions in that case that these transmitters were held to have impulse excitation of the Lodge patent. Waterman further says that the quench-gap transmitters of defendant do not have Lodge's multiplicity of spark gaps. They in fact have a multiplication of the multiplicity of Lodge's gaps, as in general the quench-gap elements in defendant's transmitters employed from 10 to 15 gaps in series, whereas Lodge showed as many as 4, providing for cutting one of these out if desired, the one in the antenna circuit. Waterman also says that defendant's quench-gap types do not have the multiplicity of radiating circuits alleged for Lodge by Waterman in spite of his single-antenna circuit. Just what Waterman means by this multiplicity of radiating circuits in Lodge to the exclusion of other systems has never been clear to me, but if it has anything to do with the ability of Lodge to radiate two frequencies during the period of time before the opening of the gaps, then precisely the same feature is found in defendant's quench-gap systems. They all do it, and Seibt drew a picture of it in Figure 6 of his patent.

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[fol. 1775] 40. Question. Please refer to the testimony in answer to question 9, pages 1907 and following, and state whether you agree with the statements therein, giving your reasons.

Answer. I do not agree with many of the statements in this part of Waterman's testimony which has to do with the matter of resonance, including the question of whether or

not there is a resonant transfer of energy between the primary circuit and the antenna circuit in a quench-gap system during the period before the quenching of the gap. On page 1908 Waterman defines the word "resonance," limiting the definition to application to the Marconi patent, and as used in the art, as "equality of electrical time period," which is not enough. It is true that equality of electrical time period is an essential feature of electrical resonance, but it is also true that resonance can be prevented even where the equality exists. Resonance has to do with response, so that if there is not a definite frequency of electrical activity to which an electrical element can respond there is certainly no possibility of a resonant response taking place, and certainly no electrical circuit or other responding system can at the same time resonantly respond to two different frequencies. The simple physical fact that two coupled electrical circuits produce more than one frequency of noticeable separation with tight coupling makes it impossible to talk in terms of resonance under such conditions, and this was the very purpose of the oscillogram introduced by Waterman in his Splitdorf case identified by him in his answer to cross-question 84, page 1972, this case.

On page 1908 Waterman refers to a quotation from the Navy Manual of 1913, plaintiff's Exhibit No. 78, page 57, and states that this quotation immediately follows the discussion of the quench-gap transmitter in the manual, evidently with the purpose of leaving the impression that the quotation refers to a quench-gap system, but there is no basis for this. The manual takes up on page 55 the discussion of the quench gap under a special heading to this effect, and completes this discussion on page 57 before taking up the matter quoted by Waterman, and gives the new matter a special heading entitled "Methods of Producing Electric Waves." In other words, the treatment had finished with the quench gap and proceeded under another subject. The Figure 29a that is specifically mentioned in the quotation which begins this new subject is shown on page 52, and is an open-gap system under the title of "Slaby Arco," a trade name for wireless systems existing prior to the quench-gap system. The "Arco" part of this name comes from Count Arco, who later associated himself with the Telefunken Co. and developed with Rendhal there the quench-gap system.

On page 1909 Waterman quotes from page 43 of the

same Navy Manual a statement of the writer to the effect that "two circuits" having the same electrical length are said to oscillate in resonance, as being identical with that of the Marconi patent. It is to be noted that the writer specifically limits his statement to "two circuits," and not to a system of coupled circuits. Marconi showed coupled circuits, and for this reason qualified his statement to the effect that the oscillations in the exciting circuit should be maintained for a long time, apparently appreciating that [fol. 1776] with the spark-gap method of producing oscillations he could not maintain them for a long time by tight coupling.

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On page 1908, bottom, Waterman refers to a quotation in his prior testimony from page 162 of the Navy Manual of 1913, plaintiff's Exhibit No. 78, and says that I avoid his quotation of a part of paragraph 224 by saying that it is a very general statement, whereas he points out the matter following the statement makes specific reference to closed and open circuits. It is true that the subject matter following does make reference to what is to be done in using the principles of the general statement when dealing with systems having closed and open circuits, but this is no basis for contending that the general principles can only be applied to such systems. I have not the 1913 edition of the Navy Manual before me, but note that in the 1915 edition, page 163, there is a paragraph 224 corresponding to the 224 paragraph in the 1913 edition. This paragraph 224 of the 1915 edition concludes with the following statement: "After calibration the adjustment of these circuits to the same wave length and to the desired coupling is called tuning."

Waterman has contended throughout that the tuning in the Marconi patent does not involve the matter of coupling, but is simply the adjustment of the lateral circuit and the antenna circuit to have the same time period. This quotation from the Navy Manual makes it obligatory to include the matter of coupling in the adjustment in order for the adjustment to be "called tuning." I note that the 1915 edition of the Navy Manual to which I have referred is claimant's Exhibit No. 78.

On page 1910, (first paragraph, Waterman attempts to draw an inference from my not referring to this quotation

from page 163 of plaintiff's Exhibit No. 78, Navy Manual of 1913. Waterman points out that this portion of the manual is a résumé of matters taken up by the manual prior thereto. Since Waterman had taken up the matters of which this portion was a résumé, and I had answered these, for the sake of brevity in the record I did not deem it necessary to repeat what had gone before as to the résumé. It is noted that the résumé does not differ from the earlier references to the relation between the closed circuit and a radiating circuit, calling for "resonance" between these circuits. The preceding subject matter makes it clear that the tuning for resonance involves not only the adjustment of the time period of the circuits but the coupling between them as well.

At the bottom of page 1910 Waterman takes exception to my testimony that the use of the word "resonance" in the Signal Corps book in referring to the adjustment of the time periods of the closed circuit and the antenna circuit of a quenched-gap system is a loose and incorrect use of the term. In my testimony, page 1515, I pointed out in detail why there could be no resonant transfer of energy during the charging period of the antenna. The 1915 Navy Manual to which I have just referred makes it clear that the matter of coupling is also to be included in an adjustment [fol. 1777] before the adjustment can be called tuning, and it is only an adjustment that includes loose coupling that permits of tuning for resonance.

At the top of page 1911, Waterman states that Figure 56 of the Signal Corps book shows three oscillations in the primary circuit of the quenched gap transmitter the book refers to, and applying Morecroft's rule, this means a coupling of about 16 per cent and one which he alleges is within the range of the examples in the Marconi patent. I have shown that a coupling of 16 per cent will produce two widely separated frequencies which would not permit of tuning receiving circuits to have the same time periods as the transmitting circuit, and Marconi in the 1912 address pointed out that this double frequency condition would not do in his system.

Waterman then refers to a former quotation of his from the Signal Corps Manual which refers to the adjustment of the two circuits of a quench gap system with the term "resonance," and again infers that I overlooked this quotation for a purpose. This quotation was merely a repeti-

tion of like ones pointed out by Waterman in both the Navy Manual and the Signal Corps Manual, and I did not feel called upon to continue the repetition and my comments as to the use of this term under conditions where resonant transfer of energy could not take place.

In the middle of page 1912, Waterman makes a comparison of the amount of energy that could be put into the Marconi system of patent 763772 over the system of his earlier reissue patent. His object in this is not understood because he could have made the same comparison between for the Tesla system, the Stone system and the Lodge system, all of which removed the spark gap to a lateral circuit from the antenna circuit, it being this feature around which Waterman makes the comparison.

Waterman has laid considerable stress on the Navy Manual as to this matter of adjusting the circuits of a quench gap transmitter. One of claimant's witnesses, George H. Clark, is included in the preface of these manuals as a contributor to the compilation of the manual. In question 13, on page 1490, Clark was asked for a statement by him of the method he used in tuning quench gap transmitters, and in answer thereto he set forth the steps in detail. He states that he first separates the secondary coupling coil some distance away from the primary coil; or in other words, starts with very loose coupling. As the next step he states that he adjusts the primary circuit to the wave length desired using a wave meter for the purpose, which is an instrument for determining the time period of a circuit. As the next step he states that he adjusts the antenna circuit to resonance with the primary, it being noted that he does this without changing the loose coupling with which he starts.

If he was adjusting the Marconi system this would be all that he would have to do, as these three steps have provided for making the time periods of the two circuits the same and he would have the loose coupling necessary to prevent the production of two frequencies. In fact, if he did not have the loose coupling he would not be able to know when the antenna circuit is in resonance with the primary by using the indication of maximum current in the antenna ammeter as his guide, as stated by him.

[fol. 1778] He then goes on with additional steps, the first being to move the secondary coil closer to the primary coil to increase the coupling, stating that he continues to do

this until he obtains the maximum antenna radiation consistent with a small decrement of the emitted wave. His looking for this small decrement of the emitted wave means that he sought the point at which quenching took place at an early first beat, for unless this quenching takes places there will be a complex wave form with a large decrement.

He then states that he measured the wave length sent out by the transmitter using a wave meter coupled with the antenna circuit alone, and if not finding the emitted wave length to agree with what he desired he carried out the procedure all over again, the primary wave length being changed to a new value which experience led him to believe would result in the desired wave length, and he continued this repetition several times if necessary.

These additional features of Clark make it clear that the adjustment of the quenched gap system is not a mere matter of adjusting the time periods of the two circuits to be the same. Waterman and Weagant have both testified that because of the spark-gap in the primary circuit of the Marconi system it is not necessary to have the adjustment of the time periods of the two circuits to be precisely the same, and in fact that a discrepancy of 1 or 2 per cent makes no noticeable difference. The wave meter mentioned by Clark as his guide for the adjustment is well capable of measuring practical circuits with an accuracy within 1 per cent, so that if the quench-gap system to which his testimony relates was nothing more than the Marconi system as contended by Waterman, it would be quite sufficient for Clark to measure the wave length of each of the circuits with his wave meter and call his job complete. However, with a quench-gap system it can't be done.

Clark points out that after having adjusted both circuits to have the right time period when loosely coupled he invariably finds on tightening the coupling that the wave length emitted is not the desired one. That he has to start all over again by making a modification in the primary circuit, which of course means detuning, and try all over again by an empirical method of step-by-step trys as taught him by experience. In other words, Clark departs from his wave meter at this point and gropes for that nicety of adjustment obtained by a detuning of the circuits to get that perfect beat so necessary to certain quenching at the first beat of a tightly coupled quench-gap system. Clark, like many other practical handlers of quench-gap systems, prob-

ably never appreciated the reason why the quench-gap system calls for all of this additional effort and therefore could not write it in the book to which Waterman refers.

That Clark did not really understand just what he was doing and why he did it is clear from the awkward procedure he used outlined by him. If he had really understood the fundamentals of the system he would never have commenced by tuning the closed circuit first and thus working from this end. In the quench-gap system the antenna circuit sets the frequency of the desired oscillations after quenching takes place, and when he does this it is entirely free from any coupling to the primary circuit by reason of the opening of the gap. With this knowledge it is obvious that if the start is made with the antenna circuit [fol. 1779] carefully adjusted by a wave meter to have the desired natural period it would not have to be touched again and Clark could then go to the primary circuit starting immediately with a slight detuning of it from the experience he mentions, and thus greatly shorten the adjustment procedure he has outlined.

* * * * * * *

[fol. 1779] 41. Question. Please refer to the testimony in answer to question 11, page 1913, and following and state if you agree therewith giving your reasons.

Answer. The question refers Waterman to my previous testimony concerning Judge Veeder's opinion in the case of the National Electric Signalling Co., in which I quoted a part of Judge Veeder's opinion to the effect that the defendant's apparatus in that case had loose coupling stating: "The loose coupling emits only one wave and admits of electric resonance." Waterman states on page 1914 that the quotation from my testimony indicates that I was again merely hiding behind my unwarranted restriction on the meaning of the word "resonance," which I assume to refer to my contention that resonance in the matter of energy transfer between two circuits can only take place when the coupling is sufficiently loose to in effect permit only one wave to be emitted, and it seems to me that this is precisely what is stressed in the language of Judge Veeder's opinion. At least it is not an "unwarranted restriction" on the meaning of the word resonance, but an essential to giving the word any meaning whatsoever.

* * * * * * *

Cross-examination.

By Mr. Vaill for claimant:

. . . . . .

[fol. 1780] 42. Cross-question. In answer to question 3 on direct examination you criticized Mr. Weagant's use of tubes in the demonstration which he made regarding oscillations and stated that he "departed from the usual tube construction of a globular glass container of proportionally large diameter." You are familiar, are you not, with various forms of vacuum tubes produced for radio purposes which have been put on the market during the last 8 or 10 years?

Answer. Fairly familiar.

43. Cross-question. I show you four tubes which have been obtained by plaintiff as illustrating various forms of tubes which have been on the market for some years. These are respectively indicated or known as the "audiotron," the "diode" of the Electrad Co., a tube having a series of five triangular plates having holes through them and through which the filament passes and known as the "Schickerling" tube, and a tube known as "radiotron UX-199," all of which have cylindrical glass bulbs. You recognize these, do you not, as being tubes which have been for sale on the market for some time during the past 8 or 10 years?

Answer. I know that the UX-199 has been fairly extensively on the market since 1923, the one marked "audiotron" I have seen several samples, the particular construction of the one marked "diode" I do not recall having encountered, and the one referred to by you as the "Schickerling" I do not recall having encountered.

Mr. Vaill. The tubes and base on which the "diode" tube is mounted are offered in evidence, respectively, and it is asked that they be marked as follows by the notary: The "audiotron" tube, claimant's Cross Exhibit No. 352; the "diode" tube, with the base on which it is mounted, as claimant's Cross Exhibit No. 353; the "Schickerling" tube having the triangular plates, as claimant's Cross Exhibit No. 354; and the "radiotron UX-199" tube as claimant's Cross Exhibit No. 355.

44. Cross-question. In answer to questions 14 and 18 you referred to Marconi patent 627650 and stated your

understanding of the operation of the apparatus shown in that patent. Will you please state whether or not you have ever constructed a receiving arrangement or apparatus made strictly in accordance with the directions set forth in said patent and have tested the same in actual reception of signals?

Answer. I have not constructed the precise arrangement of patent 627650 in all of its details, but I have operated its equivalent.

* * * * * * *

45. Cross-question. In answer to question 31 you stated: "Stone wanted only the simple harmonic fundamental in the antenna circuit, * * *" and on page 5 of his alleged letter of July, 1899 (defendant's Exhibit G–3) Stone stated: "The current in the vertical wire in my system may there- [fol. 1781] fore be presented by a simple harmonic $A_2 \sin_2 pt$." This formula represent a pure sine or harmonic wave or oscillation, does it not?

Answer. Yes.

46. Cross-question. On page 9 of the same alleged Stone letter of July, 1899, is a diagram designated as "Figure 2," which apparently indicates a spark gap S and a condenser K in the primary circuit of what is termed "the transmitting circuits" immediately above the diagram. According to your understanding would the arrangement of this Figure 2, when transmitting, produce the usual damped oscillations in the primary circuit containing the spark gap S and the condenser K?

Answer. Yes.

47. Cross-question. Do you mean to contend in your answers on direct examination that such damped oscillations produced in the primary circuit of Figure 2 referred to in the previous question would produce undamped oscillations in the secondary or antenna circuit of said Figure 2?

Answer. No.

48. Cross-question. Are you familiar with the mathematical expression which represents the current flow when a condenser discharges through a spark gap in a circuit containing inductance?

Answer. To what characteristic of current flow does your question refer?

49. Cross-question. My question refers to the same characteristics as indicated by the formula given on page 5 of

the alleged Stone letter of July, 1899, above referred to, except as modified by the action of the spark gap.

Answer. I do not think your question is yet in form that will permit of a definite answer. The expression in the Stone letter to which you refer involves several characteristics of current flow. If you have reference to any particular characteristic and will state it, it may be that I will be enabled to answer.

50. Cross-question. Do you not consider that the following mathematical expression: Ie^{-at} sin pt, is a mathematical expression for a damped electrical oscillation or oscillations in which "e" represents the base of the Naperian system of logarithms, "a" represents the damping factor, and "t" the time as it did in the formula which you have referred to in the alleged Stone letter?

Answer. It is a correct formula to show the first term in the Stone letter in a way to include the damping involved in the fundamental or harmonic frequency of a damped oscillation.

By Mr. Vaill. The title page and pages 2 and 3 of a book by J. A. Fleming entitled "The Principles of Electric Wave Telegraphy and Telephony," 1919 edition, in the form of photostat copies of said pages, are introduced in evidence as one exhibit and it is requested that the same be marked as claimant Cross Exhibit 356 (the formula included in the last question being found on page 3 of the said exhibit).

51. Cross-question. Do you consider that Stone has illustrated or described in his alleged letters of June and July, 1899, (defendant's Exhibits F-3 and G-3) any means by which he could produce a pure sine wave in any of the circuits illustrated or described by him in the letters referred to in the transmitting antenna?

[fol. 1782] Answer. If you use the term "pure" in the absolute my answer is no, and I think my testimony has been clear to the effect that absolute purity can not be expected.

52. Cross-question. In answer to Question 34, you stated that Mr. Waterman assumed that the spark gap would cut off the oscillations at 10 per cent, and as being an assumption he was not entitled to make. According to your experience, at what per cent would the spark gap cut off under the conditions which you had in mind in making that statement?

Answer. The conditions I had in mind in making the statement of course included a well designed open gap operating with as low resistance throughout the entire wave train as practical construction would permit, this low resistance operation being an obviously desirable factor to any constructor. I am unable to state any definite percentage of the total energy at which the gap will extinguish, but in view of the difficulty in extinguishing quenching gaps with almost a perfect beat condition or no energy through the gap, I have no hesitation in saying that the open gap will not cease its operation until below 10 per cent if the gap is a proper one.

53. Cross-question. Have you ever personally made any tests or experiments to determine at what percentage a spark gap, whether an open gap or quenched gap, would cut off?

Answer. Yes; in adjusting the quenched gap I have found that the adjustment must be such that the energy is substantially zero in order to get a cut off; that is, in the neighborhood — 1 per cent and fractions thereof.

54. Cross-question. I believe you stated on your direct examination that you appreciated that Mr. Waterman finds that the number of oscillations in the primary circuit were when the primary circuit was not connected with the antenna, but you have apparently referred to a complete quenched gap transmitting system in your last answer. I therefore ask you whether, under the conditions stated by Mr. Waterman, and which you considered and criticized in your answer on direct examination, you have ever made any tests to determine the cut off percentage in an oscillating circuit containing a spark gap of the kind referred to by Mr. Waterman.

Answer. Your question indicates, in referring to my testimony, that you have not grasped the purport of my criticism of the numerical values given by Mr. Waterman as the number of oscillations in the circuits of the tunes of the Marconi patent. I think if you will study my testimony you will find that I objected to Waterman using in the formula merely the constants in the primary circuit to arrive at the oscillations that would occur in the primary circuit when the primary circuit was coupled to another circuit, which coupling alters the constants affecting the oscillations in the primary circuit. As to measuring the

precise point of cut-off of an open spark gap, I do not know of any way of carrying out such an experiment with precision, and have not attempted to do it myself.

* * * * * * *

[fol. 1783] 55. Cross-question. In answer to question 34 on direct examination you commented upon the number of oscillations which Mr. Waterman had found in connection with the four "tunes" of the Marconi patent 763772. I will ask you if you have ever constructed and operated the tunes according to the apparatus exactly as described by Marconi in his patent?

Answer. You ask if I have constructed the apparatus "exactly" as described by Marconi. I do not find in the Marconi patent specifications that will permit of any construction that is entitled to the qualification "exact," and accordingly I have never made any construction that satisfies the terms of your question.

* * * * * * *

56. Cross-question. In view of your criticism of the details of the construction of the apparatus of the Marconi patent 763772, both in your last answer and in your answer to question 34 of your direct examination regarding the question of coupling, I invite your attention to page 3 of Marconi patent No. 763772, lines 26–35, where he gives detail directions as to the construction of the transformer shown in Figures 3 and 4 of that patent. He says: The transformer is made on a block or core or insulating material which is 0.17 meters wide, and that the primary coil *d* is 0.946 meters in length, the core being of one turn. Dividing the latter number by 4 would indicate that the block is approximately 0.236 meters square. In other words, the block would be 17 centimeters wide and 23.6 centimeters square. The description also states that the insulation of both primary and secondary consists of 1.25 millimeters of rubber and 1 millimeter of jute, making the total thickness of the insulation 2.25 millimeters. With these facts in mind and with the spacing indicated in Figure 4 as related to the surface of the block, when taken in connection with the detailed description of the coil *d* in the transmitting circuit, is it not possible to tell very closely the amount of coupling between the primary and secondary or antenna circuit of the apparatus as illustrated in Figure 1?

Answer. I can't understand how you arrive at the information given in your question from the information given in the patent at the part to which you have referred.

* * * * * * *

57. Cross-question. In answer to question 34 you stated that——

"When the lateral circuit is coupled to the antenna circuit, the inductance factor in the formula is increased by the amount of the mutual inductance between the circuits, so that had Waterman assumed the correct operating condition he would have had factors go into the formula to give a smaller definite or a still greater number of oscillations."

Can you produce or refer to a formula which justifies your statement that the inductance factor in the formula is increased by the mutual inductance?

Answer. Yes. One of Newton's laws of motion, the second, as I recall it, clearly provides for this. The law simply says that for every action there must be equal and [fol.1784] opposite reaction. The current flowing in the primary circuit encounters not only the reactions of the elements in the primary circuit itself, but the reactions of associated elements through the coupling responsible for the association. In the coupling of two circuits through inductance elements there is a mutual inductance involved that must be taken into consideration to satisfy Newton's law.

* * * * * * *

58. Cross-question. Is your last answer the best you can do as an answer to my previous question?

Answer. I do not find in your question any incentive for finding a better authority than Newton. So far as my experience goes his laws have not been questioned.

* * * * * * *

59. Cross-question. In order to save you the trouble of having any greater incentive to answer my question I show you a formula on page 100 of a book entitled "Wireless Telegraphy and Telephony," by W. H. Eccles, which I believe has been referred to by you in your previous testimony as instanced on page 1130, although possibly of a different edition, and ask you if you do not find on page

100 the formula under the heading "With load on secondary" which is as follows:

$$X'_1 = X_1 - \frac{M^2 w^2}{Z_2^2} X_2$$

in which the letter M is stated in the book to represent the mutual inductance between the primary and secondary and letter X'_1 represents the total primary reactance. This equation indicates, does it not, that the total inductance factor or reactance of the primary circuit is reduced by the presence of mutual inductance rather than being increased?

Answer. Your question seems to imply that you have the impression that what you refer to as "the total inductance factor" and what you refer to as "reactance" are one and the same thing, which is not necessarily true. Reactance may be either inductive of capacitive, depending upon whether the inductive reactions in the circuit predominate, or the capacitive reactions predominate when an alternating current flows in a circuit at a frequency out of step with the natural period of the circuit. You therefore can not say that a generic reference to the term "reactance" means an inductive reaction. The equation to which you refer me refers generically to reactance and does not discriminate as between inductive reactance and capacitive reactance. I refer you to an equation on page 82 of Morecroft's "Principles of Radio Communication," 1921 edition, to which I have previously referred, equation 59, which distinguishes between capacitive and inductive reactions in a circuit. You will note in this equation that the reaction of the current I_1 through the mutual inductance M is added to the reaction of the current I_1 through the inductance L_1.

* * * * * * *

(Photostat copy of page 100 of the 1915 edition of "Wireless Telegraphy and Telephony" by W. H. Eccles, which by comparison appears to be the same as that of the 1918 edition from which defendant's Exhibit E–5 was taken, is offered in evidence as claimant's Cross Exhibit No. 357.)

[fol. 1785] 60. Cross-question. In your last answer you referred to equation "59" on page 82 of Morecroft's book. I note that this equation applies, according to the text, to

the diagram of Figure 72 on page 79 of the same book in which the primary and secondary circuits are apparently directly coupled through the same coil M which represents the inductance of the coupling coil. Inasmuch as we are referring to inductive coupled circuits such as you referred to in your testimony quoted in my cross-question 57 and you referred to the formula given on page 1037 of your first deposition, I will ask you if Morecroft's formula on the same page to which you referred, to wit:

$$wL_2I_1 - \frac{I_1}{wC_1} - wMI_2 = 0 \qquad (61)$$

does not represent the mathematical expression for inductively coupled circuits such as shown in Figure 73 on page 79 of the same book, and the letter M represents the mutual inductance between the two coupled coils L_2 and L_1?

Answer. Mr. Waterman and I have fully agreed in this case that there is no difference between the inductive or indirect type of coupling and the direct type of coupling, the former being that of Figure 73 and the latter being that of Figure 72. The Morecroft equation 59 on page 82 is correct for either form of coupling and that it is so is shown by Morecroft in equations 63 and 65 just below the 61 to which your question refers me. Morecroft apparently made equation 61 incomplete, and says that equation 61 becomes equations 63 and 65 by giving his terms values to indicate inductance in the circuit and the mutual inductance in the circuit. In equation 63 as well as equation 65 it is seen that the reaction of the current I_1 flowing through the mutual inductance M is added to the reaction of the current I_2 flowing through the inductance L_2.

Mr. Vaill. Photostat copies of pages 79 and 82 of Morecroft's book entitled "Principles of Radio Communication," 1921 edition, are offered in evidence and it is requested that the same be marked "Claimant's Cross Exhibit No. 358."

61. Cross-question. Are you prepared to deny that the mutual inductance between two inductively coupled circuits to which you are apparently referring in the quotation from your testimony made as part of cross-question 57 decreases the inductance factor or decreases the total inductance of the lateral circuit as referred to in said quotation?

Answer. The matter of denying or affirming the effect as one of personal investigation I am not prepared to do. I have accepted it as a matter of course that the formulae evolved to cover the actions and reactions of this kind, based on Newton's laws of motion, have been sufficiently developed by others over a long period of time to be acceptable to me.

[fol. 1786] 62. Cross-question. You are willing to agree with me, are you not, that if in the quotation from your testimony which I made as a part of cross-question 57, the word "decreased" was used in the place of "increased," the consequence of this would be that the factors which go into the formula would give a smaller number of oscillations instead of a larger number?

Answer. Yes, but not any greater amount of change in the result, as the coupling is loose and the degree of change depends upon the degree of coupling.

63. Cross-question. In further answer to question 34 on direct examination you stated that you had calculated the effect of coupling on producing double frequency, using the formula on page 1037 of your previous deposition (defendant's Exhibit N-2). I invite your attention to that formula and ask you if you appreciated at the time you made your calculation that section 59 on page 88 of Zenneck's book from which the formula was taken related to "primary circuit without spark gaps," whereas in the tunes referred to by Mr. Waterman the spark gap was included.

Answer. I note that Zenneck also states that the relations of the formula also apply to a primary circuit with spark gap. I believe I took into consideration what Zenneck had to say about the formula.

64. Cross-question. In answer to question 37 and other places in your direct examination you referred to your understanding of the operation of the apparatus illustrated in Figure 4 of Lodge patent No. 609154. Have you ever constructed and operated apparatus made strictly in accordance with the description and drawing of Figure 4 of said Lodge patent?

Answer. No.

* * * * * * *

MR. EDWARD H. LOFTIN, being recalled as a witness on behalf of the defendant, testifies in answer to interrogatories by Mr. Edwards, as follows:

Direct examination.

By Mr. Edwards:

1. Question. I show you a copy of defendant's Exhibit B-7, being a copy of an agreement dated November 26, 1918, between the Marconi Wireless Telegraph Co. of America and the United States. Please say whether or not this agreement or a copy thereof was before or known to the radio patents board of which you were chairman at any time prior to the rendition of the report of that board in or about 1921.

Answer. To the best of my present recollection it was not.

Cross-examination.

By Mr. Vaill:

2. Cross-question. Did the interdepartmental radio board make its investigation and awards without any search or [fol. 1787] study as to whether or not the United States had any rights from the owners of patents which might cover any of the apparatus on which the board's awards were based?

Answer. Efforts were made to find rights flowing to the Government as offsets against claims made. For example, particular attention was given to following up purchase contacts as to source in order that a claimant should not be given credit for apparatus furnished by the claimant.

3. Cross-question. Did you know prior to the time the interdepartmental radio board made its award to the claimant in this case that the defendant had purchased the stations referred to in the agreement of November 26, 1918, upon which the direct question is based?

Answer. The board merely made a recommendation for an award to this claimant. I seem to recall that I did know as a matter of general information in the Bureau of Engineering that the Navy had taken over the ship and coastal radio stations of the claimant company, though it is a fact that the transaction was completed some months prior to my taking up my duties in the Bureau of Engineering.

4. Cross-question. Prior to the interdepartmental radio board's award to the claimant, do you know whether or not Captain Hooper had knowledge of the agreement of November 26, 1918, between the United States and the Marconi Wireless Telegraph Co. of America covering the sale of the latter's stations to the United States?

Answer. As a matter of definite recollection or personal knowledge of the matter set forth in the question, the answer is "No." However, it is a type of matter that would ordinarily be intimately handled by the officer holding the office held by Captain Hooper at the time.

5. Cross-question. Were you present during the hearings held in December, 1918, before the congressional Committee on the Merchant Marine and Fisheries of the House of Representatives with reference to the bill to regulate radio communication known as H. R. 13159?

Answer. No.

6. Cross-question. After the hearings took place as mentioned in the previous questions or at the time of the same, did you discuss with Commander Hooper, now Captain Hooper, the subject matter of the hearings and his testimony given before the committee?

Answer. I have no recollection of having discussed these specific matters including in the question, though I was first assistant to Commander Hooper and naturally much that occupied him did reach me as matters came up. However, I did not commence my duties until some months after the hearings referred to, and it is quite likely there was no occasion for taking up the matters of the hearings with me.

7. Cross-question. In your last answer, what do you mean by "my duties"?

Answer. My duties in the Bureau of Engineering (Radio Division), Navy Department.

8. Cross-question. Were you not ordered to the Bureau of Engineering, Navy Department, immediately after the signing of the armistice in November, 1918?

[fol. 1788] Answer. I was, but was in France at the time, so that following a leave of absence it was not until the latter part of January that I assumed my duties in the Bureau of Engineering.

9. Cross-question. About what date did you return from France?

Answer. As I now recall it, shortly before Christmas, 1918.

10. Cross-question. Have you ever examined the printed copy of the report of the hearings before the Committee on Merchant Marine and Fisheries in the House of Representatives, previously referred to in my questions, and in order to have you answer specifically, I now hand you a printed copy of the report of the hearings of that committee.

Answer. I do not recall having done so, though, of course, I have been required to follow up many documents of this kind, so that I can not be positive. I see nothing in the contents that attracts my attention as having been something specifically followed up.

11. Cross-question. I will ask you to refer to pages 18 and 19 of the report of the hearings for the Committee on the Merchant Marine and Fisheries which you have just examined as a whole, pages 18 and 19, for convenience, being copied below, and to state whether you discussed with Commander Hooper the subject matter of the statements made by Commander Hooper on those pages.

"Commander Hooper. May I say a word at this point, Mr. Secretary?

"The Secretary. Yes; certainly.

"Commander Hooper. If we had not purchased those sets for the Shipping Board we would have had to pay $1,000 a year on the apparatus for those remaining ships and as they intend to be in business, I understand, for about five years—or at least that seems to be the general opinion—that would have made $5,000 a set that we would have had to pay as rental.

"Mr. Edmonds. Is that with an operator or without an operator?

"Commander Hooper. They have to pay extra for the operator; the operator is paid for in addition.

"Now, those sets cost only about half of that amount, so it was a very good business proposition for the Shipping Board for us to buy those sets; and they asked us to buy them; and we had to take the shore stations in order to get them; and we are saving money for the Government by taking the whole business; and we would have been foolish not to have them throw the shore stations in if the Marconi Co. did not want them.

"Mr. Hardy. As I understand, you mean that if you were only using them temporarily you would still be effecting an economy by purchasing them with the shore stations?

"Commander Hooper. That is it exactly; that is the whole thing; we would have had to pay too high a rental.

"Mr. Humphreys. How much rental would you have had to pay?

"Commander Hooper. $1,000 a year for those sets.

"Mr. Humphreys. And how much did you pay?

"Commander Hooper. Well, we paid for the apparatus $1,200 for some sets and $2,500 for others.

"Mr. Edmonds. The companies kept them in repair on the ships, did they not?

"Commander Hooper. Yes; but that did not cost over $50 a year.

[fol. 1789] "Mr. Edmonds: That would depend on the age of the material, would it not, just like it would cost more to keep an old automobile in repair?

"Commander Hooper: Well, we counted on an average of $75 a year, putting it at the top figure.

"Mr. Edmonds: Does that include the overhead expenses, or just the cost of the actual physical repairs?

"Commander Hooper: That is, as we estimate, a fair price for everything. And Mr. Marconi told me that his average price was about $50 a year. Our relations have been very cordial and agreeable on the whole matter; there is no diversity of opinion between the Marconi Co., who made this deal, and the department as to the propriety of this deal. They did not want to keep the coastal stations, I believe, because they saw there would be no business for them; and it was a good business deal for them to sell just as it was a good business deal for the Government to buy them and save the Shipping Board all of that money.

"But the interest of those companies in fighting this bill is not on account of those coastal stations that you gentlemen are asking about. The opponents of this bill are fighting it on the high-power stations, which we have not bought; and that is the question that all of the arguments are coming up about; the matter of the coastal stations is something that they are satisfied with, and the Navy Department is satisfied with.

"Mr. Edmonds: Would they not sell you those sets without the coastal stations?

"Commander Hooper: No; that is the reason we had to buy them.

"Mr. Edmonds: Well, were you not buying sets on ships?

"Commander Hooper: We were buying sets of our own.

but the Marconi Co. had contracted with those shipowners of the ships that were requisitioned by the Shipping Board, which bound them to keep the sets that the Marconi Co. owned, and to pay that rental of $1,000 a year; and they wanted to get rid of that, so as to get it on the same basis as all the rest of the Shipping Board's ships.

"Mr. Edmonds: I do not suppose that any committee of Congress appreciates any more than this one the kindness of the Navy Department, in endeavoring to save the Shipping Board a few cents—certainly somebody ought to be able to do that for them. [Laughter.]

"Commander Hooper: Yes. Well, I think we hand-ed all of that business well, and I think the Shipping Board handled that business well; we saved them money; they wanted us to handle it all for them; and we made a good deal which nobody in the radio world objects to; we got what we wanted; the Shipping Board got what they wanted; and the Government made money on the whole business.

"Mr. Edmonds: Well, I suppose that the Shipping Board has spent that money that you saved by this time. [Laughter.]

"Mr. White: What did those sales include? Did they include any patent rights, or just the physical properties?

"Commander Hooper: They include the patent rights on the apparatus that we purchased—absolutely, clearly, and for all time. But not for any other apparatus except what we purchased; but as to the apparatus we purchased it is specifically stated in the contract that the patent rights are clear."

[fols. 1790-1797] Answer. I have no recollection whatsoever of having ever gone into the set of details set forth in the two pages to which the question refers me with anyone.

12. Cross-question. Commander Stanford C. Hooper was a member of the interdepartmental radio board in 1919, was he not?

Answer. A member in name, but not greatly active in the details of the functioning of the board.

13. Cross-question. Was the United States Navy or the Navy Department doing any commercial wireless communication business subsequent to June, 1910?

Answer. Yes, some commercial traffic was handled.

14. Cross-question. And the Navy made regular toll charges for such commercial business during the period that is was conducting such business, did it not?

Answer. Yes.

15. Cross-question. Can you tell over what period or periods the Navy carried on commercial wireless communication business for which it charged toll?

Answer. My information as to traffic operations in the Navy is not very reliable, as I mainly occupied myself with the engineering features of radio. I can not answer the question with any definiteness.

16. Cross-question. As regards such commercial toll business carried on by the Navy Department, you were aware, were you not, that it included the transmission and reception of communications between shore stations and ship stations at points on the Atlantic and Pacific coasts and the island possessions of the United States?

Answer. I know that the Navy handled commercial traffic and covered it by regular commercial traffic accounting, but just what regions were involved I never had occasion to consider.

17. Cross-question. Such commercial traffic as you referred to in your last answer was within the territory of the United States, was it not?

Answer. It was.

18. Cross-question. The United States Navy was engaged in commercial wireless communication traffic up to the time of the World War, was it not?

Answer. Yes.

(Claimant's counsel, with the consent of defendant's counsel, offers in evidence photostat copies of the title page and pages 18 and 19 of the Hearings before the Committee on Merchant Marine and Fisheries, etc., referred to by the witness, and the same is marked "Claimant's Exhibit No. 365."

Defendant's counsel offers in evidence the oscillogram CD120089 marked for identification at page 1406, and the same is marked "Defendant's Exhibit X-6"; defendant's counsel also offers in evidence plaintiff's Exhibit No. 22 and defendant's Exhibit 11-A in the Splitdorf case referred to on page 1406, and these are marked "Defendant's Exhibit Y-6 and Z-6," respectively.)

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[fol. 1798] GEORGE H. CLARK

(Tr. 2)

GEORGE H. CLARK, a witness produced on behalf of the claimant, having been first duly sworn by said Commissioner, was examined, and in answer to interrogatories testified as follows:

Direct examination.

By Mr. Blackmar:

Q. 1. Will you please state your name, age, residence and occupation?

A. George H. Clark; age 57; residence, 1055 Summit Avenue, New York; occupation, with the Department of Information, Radio Corporation of America, New York.

* * * * * * *

(Tr. 3)

Q. 4. Will you state briefly what you had to do with the design of radio apparatus and particularly radio receivers purchased by the defendant for the United States Navy from July, 1910, to 1919, when you left the Navy Department.

A. I compiled all specifications for all these receivers, and also served as the electrical expert for the Navy Department and more particularly for the Washington Navy Yard on receivers and detectors, since that yard had been given the duty of being the official yard for those factors of a radio set. In that capacity I assisted in the design of many of the receivers and also assisted in the design of these receivers by a firm in Washington, the National Electrical Supply Company, which furnished a great many receivers to us. In my official trips to various other concerns my specialty was to keep in touch with them and helped them where I could on receivers and detectors.

[fol. 1799] (Tr. 126)

Q. 280. Mr. Clark, are you personally familiar with the type CN 208 receiver?

A. Yes, sir.

Q. 281. Were you familiar, at the time of the CN 208 receiver, with the instruction book of which Plaintiff's Exhibit No. 409 is a copy?

A. Yes, sir.

Q. 282. Will you please explain the antenna circuit of the CX 208 receiver, using the diagram appearing on the first page of Plaintiff's Exhibit No. 409, and also the photograph annexed thereto?

A. The antenna circuit passed from the binding post for the antenna to a variable condenser in series; from that point to a primary load coil, and from that point to another primary load coil marked as adjustable; from there to a primary coupling coil, and thence to ground.

Q. 283. At what points in that circuit were connections run to binding posts on the face of the panel of the receiver?

A. On the face of the panel there were binding posts for the antenna and for the ground, these being placed close to each other so that a protective sparking-gap could be mounted between the two in case of sparking or other high power; on top of the panel were two binding posts situated close to each other, and normally they are connected by a [fol. 1800] metal strap. If this strap were removed, an external loading coil could be connected across these posts, and it was so marked as a primary load coil.

Q. 284. Have you made a sketch of the antenna circuit shown schematically, and also shown with the binding posts as they existed in this type CX 208 Receiver?

A. Yes.

Q. 285. Will you state, please, what is also shown on that sketch, in general terms?

A. Fig. 1 shows the schematic circuit as it exists in the instruction book of CX 208. Fig. 2 is the same schematic diagram with the binding posts added and with the strap normally on the circuit, and the words primary load coil also added. In these two figures the connection is the series connection. Fig. 1a is still the series connection and shows the same binding posts as Fig. 2, excepting they are placed as they normally appear on the face of the panel. And Fig. 2a shows how, by change of connections on the exterior of the panel, the normal series condenser may be placed in shunt with the entire primary inductance.

Q. 286. Does this particular instruction book, Plaintiff's Exhibit No. 409, say anything, so far as you can find, with respect to the connections which result in the antenna condenser being connected in parallel with the antenna tuning inductance (handing exhibit to witness)?

[fol. 1801] A. No.

Q. 287. Were there other receivers purchased by the Navy which had the same arrangement of antenna circuit and binding posts as the type CN 208?

A. Yes, a great number.

* * * * * * *

(Tr. 129)

Q. 289. Did you have anything to do with the design of the SE 95 or the SE 143?

A. Yes; I had much to do with the design of both.

Q. 290. What?

A. I had to do with the general electrical arrangement of the set and the actual building of some of the models both at the Navy Yard and by contractors, and had to do with certain specific arrangements of circuits which were novel in these receivers. These specific changes were originated by me and placed in here according to my ideas.

Q. 291. What do you mean by "placed in here"?

A. Placed in the design, I mean.

Q. 292. Did these designs differ as to the antenna circuit and particularly as to the location and connection of the antenna condenser from prior Navy types of receiver?

A. Yes; It was that change to which I referred as the change which I had placed in the design.

Q. 293. In what respect did these types differ from the earlier types?

[fol. 1802] A. In that the primary variable condenser was placed in the antenna side of the circuit rather than in the ground side, as had been done in all previous receivers.

Q. 294. What was accomplished, as a practical matter, by that arrangement?

A. The only reason for doing it was that by so placing the condenser it was placed across two binding posts which appeared on the face of the receiver, and that therefore any change such as the parallel change I referred to could be made without getting inside of the receiver and unsoldering leads. That was not the case when the condenser was in the ground circuit, as in that case one terminal of the condenser would be connected to the lower end of the coupling coil, and that had no binding post connected to it.

Q. 295. At the time of designing these receivers, had you had any practical experience covering a comparison of the desirability or efficiency of the series connection of the

antenna tuning condenser as compared to the parallel connection?

A. Yes. I have specialized in receivers from my first work in radio, and had found in a very great number of experiments that the parallel connection was better in certain conditions, and the series connection in other cases was better.

[fol. 1803] Q. 296. What were those cases; what was the difference between the two?

A. I found by many experiments that on long-waves signals were materially louder where the primary circuit contained the parallel connection, and found later that on shorter waves the series connection gave the louder signals.

Q. 297. Have you any particular instances of tests in mind, Mr. Clark?

A. I recall making such tests in 1903, when I first went into radio, and that was one of the first tests I made,—tests between Cambridge, Mass., and Lynn, Mass.

Q. 298. For whom were you working at that time?

A. For the Stone Telephone and Telegraph Company of Boston. I recall making a test on the U. S. S. Arkansas in 1912, between Key West and the Panama Canal Zone, and my log book record shows that the signals were three times as loud with the shunt connection and a long wave from the transmitter than the series connection gave.

Q. 299. What vessel were you on, Mr. Clark?

A. On the U. S. S. Arkansas, and the receiver used was the one to which I have already testified in this case, the E5. A third test, I recall clearly now, was the test made on the U. S. S. Salem in the so-called Arlington tests, when the transmitter at Arlington, then under construction, was being tested for acceptance, and the receiver on the Salem [fol. 1804] was being tested in receiving long waves from the temporary arc transmitter at Arlington, in 1913. On this cruise I tried both series and parallel connections, and I have examined my records and find that the parallel connection gave louder signals materially than the series connection.

Q. 300. In what ratio, do you know, Mr. Clark?

A. Two or three to one.

Q. 301. In favor of which one?

A. In favor of the parallel connection.

Mr. Blackmar: I offer in evidence the sketch which the witness has made and produced and which he has referred to in connection with the type CX 208 receiver as Plaintiff's Exhibit No. 410.

The Commissioner: So accepted.

(Said sketch was by the reporter marked as indicated, of this date.)

Q. 302. Mr. Clark, referring to your sketch, Plaintiff's Exhibit No. 410, just what would an operator have to do to arrive at the arrangement of your Fig. 2a?

A. The operator had to remove the lead from the antenna from its normal binding-post position A and change it over to the lefthand binding-post of the primary load system. I say the lefthand binding-post because if any load [fol. 1805] coil were in place, such load coil would not be shunted by the condenser, and that was the practice we adopted. The other change would be to connect this now open binding-post A to the binding-post G for ground, directly, beneath, by short wire. Those two changes were all that were required if it were done by wire connections.

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(Tr. 133)

Q. 303. Under what circumstances and in what conditions, met with in Navy practice, was it desirable to make the arrangements of Fig. 2a rather than that of Fig. 1a?

A. In two cases it became necessary on account of certain naval procedure which had just come into use. The two circumstances were these: The parallel connection would [fol. 1806] enable the receiver to be used with a smaller, shorter antenna than that for which it was normally designed. The receivers were always designed with the primary and secondary roughly of the same range of wave-length, but since the primary circuit contained the antenna this meant that the receiver primary coil was designed for a certain definite antenna, which was given to the contractor in electrical terms when the order was granted. If the antenna were smaller than this standard form, the capacity would be less and the wave-length range with the series connection would not correspond in the primary to that of the secondary. This could be obviated by putting the condenser in parallel for the longer wave-lengths.

By the Commissioner:

Q. 304. May I interrupt to ask if it was not also obviated by the use of the loading coil?

A. It could have been so done. It was not the practice.

By Mr. Blackmar:

Q. 305. What would the comparative effect be of using the loading coil and using the parallel connection of the condenser?

A. The loading coil would have given an increase of wave-length, but at a loss of efficiency.

Q. 306. Continue your answer?

[fol. 1807] A. (continued:) The smaller antenna was brought into the picture just about the time of the design of this first receiver, SE 95, by reason of the fact that the Navy for the first time used its outside antenna in which a low, single wire receiving antenna was placed below the deck of the ship on spars extending from the deck, so that it could not be shot away easily in action. That type of antenna had a very small capacity compared to the standard antenna for which the receivers were designed.

Q. 307. Before recess you were explaining the circumstances under which the parallel connection of the condenser would be desirable, and, I think, had explained one circumstance, namely, where a smaller antenna than the standard antenna was used. Continue your answer?

A. The second major importance of using the parallel condenser arrangement in the primary was in the case where a receiver to be used had a greater wave-length than the maximum for which it was designed. This feature was very prominent in the Navy after 1915 when arc transmitters were coming into play. These are transmitters used wave-lengths much longer than the previous spark sets, but in the case of a number of vessels there were not enough receivers available to give them one for the spark and one for the arc.

[fol. 1808] By the Commissioner:

Q. 308. What date was this?

A. About 1917.

By Mr. Blackmar:

Q. 309. Continue with your answer.

A. (continued:) Therefore, temporarily arrangements had to be made to receive the arc transmitter beyond this

range. This was done by placing a loading coil in the secondary circuit for which binding posts and a short-circuiting link were provided; this could have been in the primary, but for greater efficiency the primary condenser was placed in parallel with the inductance instead of adding the loading coil. This use was very common in the majority of ships in the Navy around 1915, and the condition was removed possibly two or three years later by a greater supply of long-wave receivers which could be given to the ships for use exclusively on arc-reception.

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(Tr. 146)

Mr. Blackmar: I offer in evidence as Plaintiff's Exhibit No. 413A the copy of the Instruction Book of the type SE 143 receiver.

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(Tr. 181)

Q. 438. Will you please produce the simplified diagram of SE 950 receiver, and briefly explain what is shown thereon, referring to Sheet 8 of Plaintiff's Exhibit No. 416A?

[fol. 1809] A. Fig. 1 of my abstract is taken directly from the picture of the cam and its switches on Sheet 8 of Plaintiff's Exhibit No. 416A. Fig. 1A shows the schematic diagram, including all of these springs which are in operation for series connection, and including the antenna and ground and inductances, which are in series. These latter are taken directly from Sheet 8 of Plaintiff's Exhibit 416A.

Q. 439. What do the letters and numbers on those diagrams refer to, Mr. Clark?

A. The letters were taken from sheet 8 of the exhibit. The numbers I placed in myself so that we could identify it from the springs themselves, as the working drawing to the schematic diagram, Fig. 2 shows the cam in the position when it is rotated to the opposite position as shown in Plaintiff's Exhibit No. 416A; that is to say, the switch arm is no longer on contact A for the shortest wave, but is on contact G for the longest wave. In this position, as I have testified from the instruction book, the receiver has parallel condenser connection in the primary automatically provided by switching mechanism. The switches shown in Fig.

2 are the same as those in Fig. 1, excepting for the new position of the cam. Fig. 2A shows the schematic diagram of the shunt connection making use of the figures on the springs of Fig. 2 and the electrical data in Sheet 8 of the instruction book.

Mr. Blackmar: I offer in evidence as Plaintiff's Exhibit No. 419, the sketch prepared by the witness, and which [fol. 1810] has just been described.

The Commissioner: So accepted.

(The sketch was by the reporter marked as indicated, of this date).

Q. 440. Will you please produce your diagram with respect to the type SE 1012 receiver, and explain it in connection with the diagram on page 12 of Plaintiff's Exhibit No. 417, and also in connection with the change or correction in that diagram, as to which you testified yesterday?

A. In the simplified drawing which I have made for SE 1012, Fig. 1 shows the cam and the switches in their position as shown on Sheet 12 of the instruction book. The numbers which I have on my sheet for the terminals of the springs are the same as on Sheet 12. As I said in my testimony yesterday, the diagram is incorrect, in that springs 5 and 38 remain closed, no matter what is done with the cam switch. I, therefore, have re-drawn the cam switch and its springs in Fig. 1A, which shows spring 5 extending beyond spring 4, with an insulated section between the two and a bend on the end of spring 4, so that, under certain conditions, spring 5 and spring 4 can make contact. As they are shown in Fig. 1A, in the parallel connection, they are insulated. Fig. 1 and Fig. 1A show the inductance switch in the parallel position, that is to say for the longest wave range of the set; and Fig. 2 shows the cam turned to the shortest wave length. In the first case the connection is the parallel connection of condenser. In the second, it [fol. 1811] is the series connection. Taking the same numbers for the switch terminals, and also the numbers given on page 12 of the schematic drawing, I have shown in Fig. 1B the complete connection for the shunt arrangement, which obviously shows on the face of it that it does have the condenser 6, 7 in parallel with all of the inductances then in use on that step. Fig. 2A shows clearly that the condenser 6, 7 is in series with the inductance.

Q. 441. Referring to your Fig. 1A, is the change made therein, as compared to Fig. 1, in accordance with the construction diagram which you testified that you examined in the Navy Department files?

A. Yes, it is.

By the Commissioner:

Q. 442. Is it in accordance with the actual construction of these sets?

A. The construction diagram of the sets, sir. I looked that up in the Official files of the Navy Yard. I did not look up the set.

Q. 443. I take it you are more or less familiar with these sets, having used them?

A. I can say this, sir. It certainly worked correctly, as if the switches were correct. And they were correct in operation.

By Mr. Blackmar:

Q. 444. And if the arrangement were in accordance with Fig. 1, would it have so worked?

[fol. 1812] A. No, sir, it could not have worked at all.

Q. 445. Is there another position of this inductance switch which will give the parallel arrangement of the condenser more or less as shown in your Fig. 1B?

A. Yes. I have shown it on the eighth or last step. And the same is true on the seventh or next to the last step. All of the others are in series.

Q. 446. In general, what would be the difference between the next to the last step and the last step?

A. None whatever, excepting that the switch, 37, in Fig. 1B would go to a different point on the inductance, namely, instead of going to point 30 it would go to point 35.

Q. 447. Is point 35 shown on Fig. 1B?

A. No. It is shown in page 8 of the instruction book, however.

Q. 448. Approximately where is it on Fig. 1B?

A. It forms a considerably less portion of the antenna inductance than when the coil is tapped at point 30, as in position 8. That is so that overlapping will be obtained between the two positions.

Q. 449. That is to say, it is another tap on the same coil that 30 is a tap on?

A. Yes, it is.

Mr. Blackmar: I offer in evidence as Plaintiff's Exhibit No. 420 the sketch referred to by the witness, with respect to the receiver type SE 1012.

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[fol. 1813] Q. 464. What would have to be done to that receiver to connect the antenna tuning condenser in parallel with the primary inductance?

A. The antenna would have to be placed on the left-hand binding post of the primary load coil and the antenna binding post would have to be connected to the ground binding post, and thence to ground.

By the Commissioner:

Q. 465. If that were done, what effect would that have on the primary circuit with respect to the wave-length range?

A. If the anenna being used at the time on the ship was less in capacity than the one for which the set was designed, it would tend to bring the wave-length range of the primary up toward its normal range for which it was designed. It might do that, or it might not, depending on the antenna. If the antenna for which the set were designed were in use, the effect would be to increase materially the wave-length range of the primary circuit over that of the normal range of the secondary. The latter could be brought into the same relation by adding a loading coil.

Q. 466. There would be two different purposes achieved?

A. Those are the two standard emergency purposes, yes, sir.

[fol. 1814] Q. 774. Mr. Clark, in the cases of the CN 208, CN 239, CN 240 and SE 95, I note that the instruction books refer to the nominal wave-length range of the secondary circuit and also to the actual range, the actual range in every case being greater than the nominal range. Do you know what was meant by actual range and nominal range?

Mr. Edwards: I object to his stating what was meant by it. He is in no position to state what they meant. All of us can read English.

The Commissioner: Ask the witness what it means to him.

Q. 775. In view of your familiarity with the radio art and these receivers, Mr. Clark, what do "nominal range" and "actual range" of secondary circuits mean to you?

A. In cases where the range of the primary circuit and the range of the secondary circuit are indicated as different, the nominal range of the secondary would be that range which agreed with the primary and, therefore, the range to which the whole receiver would operate. The actual range means the total maximum wave-length to which the secondary circuit could be tuned which would be greater than the nominal range.

Q. 776. In the case of the actual range, did that include the use of an external loading coil in addition to the coil in [fol. 1815] the receiver?

A. No. The reference was to the constants of the receiver within the panel.

Q. 777. By what means could these receivers be used in the actual range of the secondary where this actual range was of a longer wave-length than the nominal range and longer wave-length than the given range of the primary circuit?

A. Assuming that the antenna used was that for which the primary was designed, the range of the primary could be increased to agree with the actual range of the secondary either by placing a loading coil in the primary or placing the normal series primary condenser in parallel with the primary inductance, or by a combination of both.

Q. 778. Referring to your sketch, Plaintiff's Exhibit 410, does that apply to the Type SE 952 or SE 952A receiver in the same way that you applied it to the CX 208 receiver as appears in your answer to Q. 285 at page 128 of the record?

A. Yes, it does.

Q. 779. Does it also apply in the same way to the SE 899 and SE 998, the SE 1220 and the SE 95?

A. Yes.

. . . . . .

[fol. 1816]

(Tr. 306)

Q. 782. You have explained at least one of the circumstances where the parallel connection of the antenna tuning condenser was used in Group III receivers, namely, where the antenna was smaller than the antenna for which the set was designed and where it was desired to increase the normal range of the primary circuit where a standard antenna was used. What was the importance of the first circum-

stance, the smaller antenna, with respect to short wave receivers as compared to the long wave?

A. It applied about equally to each case.

Q. 783. Referring to the second circumstance, increase in the range of the primary circuit, what was the comparative importance or utility of the parallel condenser arrangement as applied to short wave receivers compared to applying it to long wave receivers?

A. It was of much greater importance in the case of the short wave receivers.

Q. 784. From your personal experience, with which type of receiver was the parallel arrangement more used?

A. It was used more often, considerably, with the short wave type of receiver.

Q. 785. Can you explain the electrical reasons for that?

A. Yes. From actual tests and experience I know that in using a long wave receiver when we had to go to a longer [fol. 1817] wave still, the increase in the new wave would not be very much greater than the original range of the receiver; it was already a long wave receiver. But if we wished to go to the new long wave from a short one, using a short wave receiver, it would have required a great change in the constants of the receiver. Had that change been made, as we sometimes tried, by putting loading coils in both circuits, there would have been no coupling left between the two circuits on account of the fact that all the inductance was in the loading coils.

Q. 786. You are speaking of the short wave receiver?

A. Yes. It was much more efficient to cut out your loading coil in the primary as much as possible by putting the condenser in parallel. That has been supported by many tests and experiments. I am not explaining it by theory but by actual tests I made.

Q. 787. Then, for example, where you had a long wave receiver, such as many of these are, with a maximum nominal range of 10,000 meters, and you wanted to receive a 14,000 meter wave, what was the usual practice?

A. It was more likely that a loading coil would be placed in both circuits.

Q. 788. And was that also true on the short wave receiver?

A. The usual practice was to use a load coil in the secondary and to make use of the parallel condenser in the primary, and, if necessary, add a small coil in the primary

to bring up the wave length if that was not already done by the condenser.

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[fol. 1818] (Tr. 321)

Q. 821. Can you state from your knowledge, Mr. Clark, whether any of the wireless receivers which have been covered in this proceeding were designed by men actually in the employ of the Navy Department?

A. All the types which begin with the letters "SE" were so designed, and the greater part of the design of the receivers beginning with other letters was also done by Navy personnel.

Q. 822. What does "SE" in the Navy Type Number Book mean?

A. Designed by employees of the Bureau of Steam Engineering at the Bureau or any of the yards.

Q. 823. In Navy type numbers what does the letter "C" following by another letter such as "N" and preceding the type number mean?

A. "C" means the design was made in a commercial factory, and the letter "N" following it in this particular case identifies the National Electrical Supply Company of Washington, as they are a commercial concern.

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[fol. 1819] By Mr. Blackmar: (Tr. 322)

I offer in evidence as Plaintiff's Exhibit 430 photostats of the following pages of Navy specifications RE 13A 242B, of which, I understand, a copy is also on file in the Court of Claims in response to Schedule F of plaintiff's call on the Navy Department. It is understood that the photostats to be submitted are subject to verification and correction from the copy on file in Washington: The cover which is marked Sheet 1, and pages 3B, 4A, 5B, 9A, 10A, 12A, 13A, 14A and 15A, and drawing RW 46A 417A annexed to the specifications.

* * * * * * *

Q. 824. Mr. Clark, from your experience with Navy types of receivers, is there any practical advantage in locating the antenna tuning condenser on the ground side of the antenna inductance rather than on the antenna side?

A. Other things being equal, yes, there is.

[fol. 1820] Q. 824a. What is it?

A. The connection of one side of the condenser to the ground means that when the operator brings his hand up to the knob of the condenser to tune it he does not introduce a false capacity which is removed when he takes his hand away and therefore leaves the circuit slightly mistuned.

Q. 825. And that spurious effect is present under which circumstances?

A. That would be present if the primary tuning condenser is placed in any other part of the primary circuit other than with one side of it grounded.

Q. 826. And when it is connected on the antenna side of the inductance coil, is either connection of the condenser grounded?

A. No.

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(Tr. 388)

Q. 990. Will you please refer to Plaintiff's Exhibit 430, sheet RW 46A 417A thereof, and describe the operation of the device marked "Antenna inductance switch"?

A. This switch cut in various sections of the primary coupling coil and the antenna inductance or loading coil, and simultaneously therewith placed the antenna tuning condenser either in series with the total primary inductance on the shorter wave lengths or in parallel with this total inductance on the longer wave length.

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(Tr. 580)

[fol. 1821] GREENLEAF WHITTIER PICKARD

GREENLEAF WHITTIER PICKARD, a witness produced on behalf of the plaintiff, having been first duly sworn by the Commissioner, was examined, and in answer to interrogatories testified as follows:

Direct examination.

By Mr. Blackmar:

Q. 1. Please state your name and residence.

A. Greenleaf Whittier Pickard, Seabrook Beach, New Hampshire.

Q. 2. Will you state your occupation?
A. Consulting electrical engineer.

* * * * * * *

Q. 4. Will you please state your education and experience in the radio field, and particularly in the commercial and manufacturing side of that field?

A. My academic education was at Harvard College and Massachusetts Institute of Technology; but in as much as I was then in training for the field of chemistry I think my principal qualification is my professional record.

I entered the field of radio while still in college, as summer work, during 1898 and since then, and down to the present time I have been continuously engaged in the field of radio communication. From 1907 to 1931 I was consulting engineer, for the entire period mentioned, and an officer and director for the major part of this period, of the Wireless Specialty Apparatus Company and its successor, the RCA-Victor Company of Massachusetts. My work for this company involved not only research work in the field of [fol. 1822] radio communication but the designing and, to a very considerable extent, the development of production and final forms of apparatus for manufacture.

I have been, through this entire period, quite familiar with manufacturing costs, this coming in the line of duty as an officer of a manufacturing company.

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(Tr. 581)

Q. 5. Did you state what the business of the Wireless Specialty Apparatus Company was, Mr. Pickard?

A. The Wireless Specialty Apparatus Company was during its entire existence a manufacturer of radio apparatus, starting with receiving apparatus in the first few years of its existence, and finally both receivers and transmitters.

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[fol. 1823]

(Tr. 677)

Q. 46. Referring to the Marconi patent No. 763,772, the Court of Claims, as you know, has held Claim 16 of that patent covers a new and useful invention, but that the remaining claims thereof, which were in issue in the case, are invalid in view of prior art and certain prior disclosures. Will you first, please describe the subject matter of Claim

16, as distinguished from the other claims of that patent?

A. Claim 16 of the Marconi patent relates only to a receiver, whereas the other claims or certain of the other claims of the patent relate to transmitters and to combinations of transmitters and receivers.

Q. 47. What is the difference between the subject matter of claim 16 and that of the other receiver claims of the patent?

A. The distinction is that in the antenna circuit described by Claim 16 the tuning element in the form of an adjustable condenser is placed in a shunt connection around the transformer coil; that is, around a portion of the inductance in the antenna circuit.

Q. 48. And are the other elements of that claim common to other claims in the patent?

A. Yes, the are.

Q. 49. Is the arrangement of that claim illustrated in any figures of the patent?

[fol. 1824] A. Yes. Figure 2 of the patent. All of the elements of claim 16 are shown including an antenna circuit, f' A, g', j', E, and the shunt condenser h; also the secondary circuit called for in Claim 16 is shown in Figure 2, consisting of the coils j^2, g^2, the condenser h' and the detector T, with its associated indicating circuit C'-B-R-C^2.

Q. 50. I believe that the record herein shows that in certain of defendant's receivers the antenna circuit differs from that shown in Figure 2 of the Marconi patent, in that the shunt condenser in the receivers is connected not only around the primary coil of the transformer but also around a loading coil. Do you know of any of the exhibits on the main case—exhibits on the main case referred to by the Court of Claims in its findings and opinions—showing the arrangement of the defendant's receivers that we have been speaking of?

A. As I recall the exhibits, in all cases the shunt condenser h of Figure 2 of the Marconi patent is placed around both the primary of the oscillation transformer j'—referring again to Figure 2 of the Marconi patent—and the loading inductance g'. I do not offhand recall any exception to that.

Q. 51. Will you please look at Plaintiff's Exhibit 79, which is printed opposite page 180 of the original record in this case, and tell me whether that arrangement is the arrange-

[fol. 1825] ment of Figure 2 of the patent?

A. That is the arrangement of Figure 2 of the patent, even to the lettering, so far as the lettered elements are the same. However, in Exhibit 79 there is no separate loading coil, g', such as appears in Figure 2 of the Marconi patent.

Q. 52. Yes. And in comparing it you are referring only to the antenna circuit, I take it?

A. Yes, that is correct.

Q. 53. You are not trying to compare the other details of Figure 2 with the apparatus; is that correct?

A. That is correct.

Q. 54. Will you also please look at Plaintiff's Exhibit 95, which appears opposite page 183 of the main record, and tell the Commissioner how that compares with Figure 2 of patent, so far as the antenna circuit is concerned?

A. Briefly, it differs only from Figure 2 of the Marconi patent in that the condenser h is placed in shunt or parallel connection around both the primary of the oscillation transformer and the exterior loading inductance, whereas in the Marconi patent the condenser h is only shown as connected around the primary of the oscillation transformer.

Q. 55. In other words, is there a coil in the antenna circuit of Exhibit 95, referring to the receiver that corresponds to the coil g' of Figure 2 of the patent?

[fol. 1826] A. Yes. It not only corresponds, but in the Figure 2 of Exhibit 95 the coil is lettered g' as it is in the patent.

Q. 56. The antenna tuning condenser when connected in parallel arrangement in Figure 95 extends around both the primary of the coupling coil and the coil corresponding to g' of the patent. Is that right?

A. That is correct. I omitted to state that in Exhibit 95 the condenser is actually shown in two positions. It is shown in dotted or broken line also with the same letter h, in a series connection in the antenna circuit, but I omitted mention of that because in reading a diagram one customarily refers to only that portion shown in the full line, that being the convention or the operating connection shown.

Mr. Blackmar: I call the Commissioner's attention to the fact that the Court of Claims in Finding LXIII held that the receiving apparatus of the Kilbourne & Clarke Company shown in Exhibit 95, which is the one which the wit-

ness has just been referring to and the receiver made by the Telefunken Company, illustrated in Exhibit 79, which is the one previously referred to by the witness, each has apparatus coming within the terminology of Claim 16.

Q. 57. Mr. Pickard, referring to the subject matter of Claim 16 of the Marconi patent, will you please state [fol. 1827] what, if any, advantages there are in connecting an antenna tuning condenser in parallel with the antenna inductance coil or coils as compared either to connecting such condenser in series with those coils, or omitting such condenser, and in your answer will you briefly explain the reason for each advantage?

A. There are several advantages: first, with a given set of coils—that is, with a given oscillation transformer and a given loading coil, such as those shown in Figure 2 of the Marconi patent as j' g' the range in wave length tuning of the antenna circuit is multiplied some two- or more -fold as compared with the range which would result if the condenser were either omitted or were used in a series connection in the antenna circuit. Secondly, there is a very practical advantage.

Q. 58. Will you briefly explain the reason for the first advantage, please?

A. The reason, briefly, is that: when the condenser is in a series position in the antenna circuit, the range of tuning is limited. For example: taking any particular value for [fol. 1828] the antenna capacity and any particular value or values for the maximum and minimum capacity of the tuning condenser in the series connection, the two capacities—the antenna capacity and the tuning capacity—are in series, so that a resonant circuit is formed, in which, disregarding the inductance of the antenna itself, there is lumped inductance corresponding to the primary of the oscillation transformer and the loading coil, which may be considered as one inductance for this purpose paralleled by the antenna capacity in series with the tuning or primary condenser capacity. The sum of the capacities in a series circuit is given by an exceedingly simple formula which is that the capacity of two condensers in series is equal to the reciprocal of the sum of the reciprocals of the two capacities. To get this into the record numerically, or, rather, algebraically, if the two condensers have capaci-

ties of a and b, respectively, for the antenna and for the tuning capacity, the value of their sum in the series relation is

$$\frac{1}{\frac{1}{a}+\frac{1}{b}}$$

It is very rarely indeed that a ratio of more than ten to one between maximum and minimum is found in the type of variable air condenser used during the period in which we are interested, in radio receivers. If the tuning condenser were the only capacity in the circuit, then the range of capacity variation would be ten to one, and the [fol. 1829] range in wave length variation would be three to one. That is the square root of the capacity variation. But when the condenser is in series with the antenna capacity, the range is much less, so that only a comparatively small variation in wave length range can be obtained by the series connection. Where the condenser is placed in parallel, the capacity in the circuit available for tuning the circuit is simply the sum of the two capacities; that is, the antenna capacity and the shunt capacity. And with the condensers of the type ordinarily used at that time, as, for example, in the SE 143 receiver, the capacity ranged from a minimum value of about .0008 microfarad to approximately .0045 microfarad, and the antenna which was specified for use with the SE 143 had a capacity of .0008 microfarad. Under those conditions, and in view of the fact that the maximum capacity of the condenser, the primary tuning condenser, was some five- to six fold that of the antenna capacity, the actual range of capacity available for tuning in the parallel position was from .0016 microfarad to .0053 microfarad. That is a range of between three- and four-fold in capacity and a range of something under two-fold in wave length. In the series position with the same values a smaller range of tuning was all that could be obtained, owing to the fact that when the capacity of the series condenser became materially larger than the capacity of the antenna, the capacity of the antenna be- [fol. 1830] came the conrtolling capacity in the circuit, and further increase in the capacity of the primary condenser only brought about a small increase in the wave length of the tuning.

* * * * * * *

A. Continuing my answer to your last question, a second advantage of the parallel antenna circuit tuning of the Marconi patent has to do with selectivity; that is, the ability of the circuit to accept or reject desired or undesired frequencies. While this, if one goes into all its ramifications, is an exceedingly complex matter, I think I can briefly explain it in this manner: referring now to Figure 2 of the Marconi patent, and considering that the condenser h is actually placed in a shunt or parallel circuit with that of the lumped inductance of the antenna circuit, electrically we have three elements in parallel: first the inductance; second the tuning condenser, and third the antenna view as a capacity.

When, as, for example, in the SE 143 receiver, the capacity of the tuning condenser is greater than that of the antenna, then the current flowing into the third branch of the circuit to which I have referred as a three-element circuit, is small as compared with the current flowing in either the condenser h or the inductance g', j'. In consequence, the losses in that part of the antenna circuit exterior to the receiver are minimized.

For example: a frequent source of loss or high resistance in an antenna circuit lies in the ground connection, and [fol. 1831] this loss is an ohmic loss; that is, it is a real resistance which can be measured in ohms. The loss of energy in such a resistance is proportional to the square of the current flowing through such a resistance, and if the current flow in that part of the circuit can be minimized, the loss can also be minimized, and when we consider the selectivity as shown, for example, by the resonance curve of the circuit the thing that determines the breadth or narrowness of the curve—that is, the question of whether it is a highly selective or a poorly selective circuit—is nothing more or less than whether or not there is small or great loss; that is, high or low resistance in the circuit. So it has been found as a practical matter. I have repeatedly made measurements on different antenna systems such as are customarily found at stations and with the parallel connection, of course, with the longer wave lengths, the energy losses due to resistance in the antenna system are minimized and the sharpness of tuning is accentuated, increased, as compared with a simple series tuned circuit—that is, a circuit in which the antenna capacity, the tuning condenser and the inductance are all

in a single series circuit, and it follows also that anything which increases the selectivity of a circuit, just because whatever increases the selectivity does it by lowering the resistance or decreasing the losses, makes the circuit more efficient.

[fol. 1832] In other words, the weaker the field, the weaker signal field from a transmitter would give a useful signal in the detector circuit; whereas with high losses in the circuit no useful signal would result, and, finally, from both the manufacturing and the operator's viewpoint, the use of the parallel condenser simplifies the operation of the receiver. One building a receiver only has to use one-quarter or less of the inductance in the anteana circuit required to cover a given wave le gth range which would be needed if parallel tuning were not employed. The inductance coils can, therefore, be made smaller. That is to say, more cheaply, and, to some extent, more efficient. From the operating standpoint, either by the throw of a switch or as in some receivers during the period with which we are concerned, done automatically, the receiver can pass from series to parallel tuning without any loss of time. Those three advantages that I have just mentioned are, as I see them, the principal advantages of pa llel tuning, such as is shown in the Marconi patent.

Q. 60. And are there also any advantages, comparing a receiver that has both series and parallel connection available with one that has only the series connection or no antenna condenser?

A. Yes, there are quite marked advantages. In the first place, if the receiver is restricted to merely series tuning, the coil system will have to be rather largely increased in [fol. 1833] magnitude, and, what is perhaps even more important, additional switch points will have to be provided, so that the inductance can be more accurately controlled; and that brings to my mind one other advantage; the subdividing of inductance by bringing out leads to a switch is always a source of loss, principally because the leads coming out from the coil to the switch are of different radio frequency potentials and there is a considerable dielectric loss in the panel holding the switch and in the leads coming out to the switch. It is an advantage, therefore, to have as few loss points as possible; and in the absence of parallel tuning, in order to cover any extended range, it is necessary to subdivide the inductance in the antenna cir-

cuit into quite a large number of steps, and that is not good practice. It introduces, as I have just said, losses. Also, if we are restricted to merely a series condenser, the selectivity of a circuit will be lessened, particularly on the longer wave lengths, so that from both the manufacturing standpoint and an operating viewpoint the receiver is less efficient.

Q. 61. Is there any advantage in the parallel connection over the series connection with respect to transfer of energy into the secondary circuit from the primary?

A. Yes, there is this advantage: that the parallel circuit with respect to the source of electromotive force, which, of course, is the antenna itself, is a divided circuit which is [fol. 1834] tuned to resonance. The current in each branch of such a circuit is considerably greater than the current flowing in the antenna, because, to put it mathematically, the current in the antenna is the vector sum of the two currents in the loading inductance, and the parallel condenser, and as these two currents, or the vectors which represent them are only 180 degrees apart in angle, the impedance of the circuit formed by the parallel condenser and the loading coil is high, as viewed from the antenna and ground connections, so that the current, being high in this circuit, a comparatively small coupling coil is all that is required for the maximum useful coupling into the secondary circuit; so there is potentiality, at least, of better transfer of energy into the secondary circuit when using parallel tuning than when using series tuning. Of course, one could get equivalent coupling transfer of energy into the secondary circuit with series tuning by increasing the dimensions—that is, the inductance in primary of the oscillation transformer.

Q. 62. Is the use of the parallel connection of the antenna tuning condenser particularly advantageous for any one range of wave length as compared to any other range of wave length?

A. Yes, it is peculiarly advantageous for the longer wave lengths.

[fol. 1835] Q. 63. Will you briefly state why it is advantageous?

A. It is advantageous for the reason that in parallel tuning the capacity of the primary condenser is arithmetically added to the capacity of the antenna, so that the sum of these capacities, being large, for a given coil system,

the resonant period is long—that is, the system is tuned to a long wave length, as compared, for example, with the same coil system with the series condenser, where the capacities are in series, and therefore their sum, which is the reciprocal of the reciprocals of the capacities, is smaller than either one.

Q. 64. You have referred to an advantageous selectivity with the parallel connection. Is that advantage more or less noticeable on the longer wave lengths as compared to the shorter wave lengths?

A. It is more noticeable on the longer wave lengths. There are several reasons for that. One of them has to do with what we call dielectric loss—that is, the loss of energy at radio frequency or in radio frequency fields of all dielectrics traversed by these fields, such, for example, as the insulation on coils, the imperfect dielectrics surrounding or near the antenna itself, which may not be only insulators supporting the antenna but structures which support the antenna system itself. These dielectric losses vary directly with wave lengths. The longer the wave the greater the dielectric loss in any ordinary dielectric, so [fol. 1836] that the selectivity of the system, which depends primarily upon the amount of the losses, is greatest when the currents and therefore the voltages in the antenna system are kept at a minimum; so the selectivity, other things being equal, is greater at the lower frequencies; that is, greater at the lower frequencies when parallel tuning is used. If series tuning were used at the lower frequencies—that is, the longer waves, the loss in the coil system due to radio frequency voltages producing fields through the coil insulation would be greatly increased, because there would be many more turns on the coils and many more chances for loss, and the same thing, of course, holds on the various losses in the antenna system itself.

Q. 65. Is there any relation between the number of communication channels available on the longer wave lengths and selectivity?

A. Yes, there is. The number of communication channels is a matter of frequency, rather than wave length. We have, of course, two systems, the earliest of which was to express things in terms of wave length. Nowadays we generally speak in terms of frequency, so many kilocycles per circuit, and the width of a communication channel, whether it be used for radio, telegraph, or for voice or

music or what-not, is a definite number of cycles or kilocycles. The lower frequencies—that is, the longer wave lengths, have, therefore, comparatively few channels, and [fol. 1837] in order to fully utilize these longer waves it is necessary to space or allocate station frequencies rather closely together. If that were not done, there would be very few channels available between, say, 19,000 and 20,000 meters. So it is increasingly important as we go up in wave length to get high selectivity.

Q. 66. Has the decrement at the transmitter anything to do with this or was that covered in your discussion as to dielectric losses?

A. No, that was not covered, and it has a very important bearing indeed, because if the transmitter were one of high decrement, that is, short train of waves emitted regardless then of the selectivity available at the receiver very little discrimination could be made between stations on closely adjacent wave lengths. The way in which we look at that matter today is simply this: that a station of high decrement occupies a wide band. It is the equivalent of a transmitter radiating at a number of different frequencies simultaneously. As the wave train lengthens, that is, as the number of useful oscillations in the wave train increase, the transmitter approaches more and more nearly to a single radiated frequency, at which, of course, the selectivity of the receiver is at a maximum. So with high decrement transmitters there would be no particular purpose in using very selective receivers. No advantage would be obtained.

Q. 67. How far, if at all, do these various advantages of the parallel connection, which you have discussed, apply [fol. 1838] to the various types of receivers purchased by the defendant as set forth in the record?

A. They apply in somewhat varying degree, because these receivers have been divided already into classes in which the change from series to parallel tuning is accomplished automatically by a switch connected with the inductance varying switch and another class in which a double pole double throw switch, for example, is mounted outside the receiver but still practically instantly available to the operator, and a third class in which there is no switch available but one can change by change of connections. From an operating standpoint the first two classes that I have

mentioned are the best, because no time is lost in making the change.

Q. 68. You stated that the advantages apply in varying amounts to the various receivers. Do they apply to all of the receivers to some greater or lesser extent?

A. I only discussed in my last answer the advantages from an operating standpoint. All three classes of receivers have electrically the same advantage; that is, they have the possibility of change from parallel to series tunings. They differ only in the ease with which that can be accomplished, but when it is accomplished the advantages are the same for all.

Q. 69. Have you prepared a chart showing the effects of the series and parallel connections with the type SE 143 [fol. 1839] receiver, as that receiver is described in the instruction book, Plaintiff's Exhibit 413-B?

A. I have done so, and I hand you the chart.

Mr. Blackmar: I ask that this be marked for identification as Plaintiff's Exhibit 440.

(The paper just offered was by the reporter marked as indicated, together with his name and the date.)

Q. 70. Mr. Pickard, will you kindly explain that chart and also what it shows? In the first place, state what constants you have used and the origin of the constants.

A. I have used in making this chart the constants given in the instruction book of the SE 143, these constants being an antenna capacity of .0008 microfarad, a primary or antenna tuning condenser having a capacity range of from .0008 to .0045 microfarad and a total antenna inductance—that is, the sum of the coupling or oscillation transformer primary inductance and antenna load coil inductance of from 81 microhenries to 4220 microhenries.

The four curves shown in this chart are, proceeding from the bottom to the top, the series connection of the antenna condenser with the minimum value 81 microhenries of inductance, and there the tuning range runs from 340 meters to 442 meters. Owing to the scale of ordinates required to show all of the ranges this lowest curve is rather flat in appearance. The abscissa of this chart are degrees on the [fol. 1840] condenser scale—that is, assuming a condenser having 180 degrees of rotation from maxima to minima and the ordinates are wave lengths in meters. The second curve

going up from the bottom is for the parallel connection of the antenna condenser with the minimum inductance, 81 microhenries and there the range is from 677 meters to 1236 meters. The third curve is a series connection with the entire antenna and oscillation transformer primary inductance in circuit and there the range is from 2450 to 3187 meters, and finally the topmost——

Q. 71. Before you take the next one, that accords substantially, does it not, with the maximum range of the primary circuit as indicated in the instruction book (handing book to the witness)?

A. Yes, that is correct, it does; and finally the fourth and upper curve is for the parallel connection with primary condenser with the maximum value of inductance, and there the wave length range is from 4900 to 8717 meters. I may say, in connection with this chart that it must not be taken too exactly at the lower end of all of these curves—that is, where the wave length is at a minimum and the capacity of the tuning condenser whether series or parallel is at a minimum. The reason for that is that the antenna characteristics other than its capacity come into the picture there. So, for example, on the lower curve, which, considering the antenna as a pure capacity without any induct- [fol. 1841] ance, runs from 340 to 442 meters, the lower end of that might easily be a number of meters higher or lower, depending upon the length of the antenna, and therefore on its distributed constants, particularly its inductance, as we progress to longer and longer wave lengths, the antenna behaves more and more like a pure capacity, and the two upper curves, for example, except perhaps for the first few degrees of the condenser scale, may be considered as quite closely correct.

Q. 72. In preparing that chart did you make any assumption as to the form of plates of the variable condensers?

A. Yes; I assumed the then ordinary semi-circular plates and I assumed a calibration curve for this condenser in which for the first few, the first first five or six degrees and the last five or six degrees of the condenser scale—that is, for the portions of the curve near the minimum and near the maximum—that the calibration curve would round over and would be approximately horizontal, but for the major part of the condenser scale the calibration would be linear—that is, the capacity would vary directly as the movement.

That I know from many, many laboratory measurements on such condensers as the fact with all of these condensers, and if you wish I will produce the calibration curve which I actually used.

Mr. Blackmar: I ask that it be marked for identification as Plaintiff's Exhibit 441.

(The paper just offered was by the reporter marked as [fol. 1842] indicated, together with his name and the date.)

Q. 73. Mr. Pickard, if your assumption as to the form of calibration curve of the condenser were incorrect, what effect would that have on the curves of Exhibit 440 for Identification?

A. It would have this effect: it would change the shape of the curve but it would not change the wave length range—that is, the values given at the top and the bottom of these curves on the exhibit are fixed by the maximum and minimum values, and those in turn are taken from the SE 143 instructions, and regardless of the shape taken by the plates, whether they are semicircular, logarithmic, or otherwise, the range covered by any one of the connections and any particular set of inductance values would be the same as I have shown in my chart. The only thing that would be affected would be the shape of the curve lying in between the maximum and minimum values.

By the Commissioner:

Q. 74. In other words, it might change the characteristics of the curve but not its end points?

A. Not its end points and not its range, its ratio from maximum to minimum.

By Mr. Blackmar:

Q. 75. Referring also to plaintiff's Exhibit 440 for identification, it might appear that there was a gap be-
[fol. 1843] tween something over 1,000 meters and something near 2,500 meters that is not covered by the receiver. Would you explain that, please?

A. Yes. For simplicity I have simply taken maximum and minimum values of the inductances actually in the SE 143. The inductance values are controlled through the use of switches so that there are a number of inductance values lying between the maximum and minimum values which I have assumed. I did not for two reasons use the

intermediate values. In the first place, I did not know them. The instruction book does not give the intermediate values. I would have had to make some rather inaccurate assumptions on the subdivisoin of the inductance by the switch connections, but had I known the inductance values for each switch point I could have easily made the chart a rather large family of curves, one curve corresponding to each subdivision of the inductance then it could be seen that there was no gap; in fact, there would be a considerable overlappping; for example: starting from the bottom up, that the first or series connection with the minimum inductance of 81 microhenries, which runs only to 422 meters, would overlap by quite a number of meters the next highest point—that is, the next switch point, giving a higher value than 81 microhenries, and so on up the scale. Actually, the overlappping would amount to probably 20 degrees on the condenser scale—that is, the wave length [fol. 1844] obtained at, say, 150 or 160 degrees on the condenser scale on one inductance point setting would be the minimum wave length obtained from a zero setting on the condenser on the next inductance setting and so on.

Q. 76. Then may this exhibit be interpreted to mean that with the series connection the range of the receiver is from somewhere around 200 meters?

A. 340, let us say.

Q. 77. Is that the minimum?

A. That is the minimum.

Q. 78. 340 meters up to slightly over 3,000 meters?

A Yes, that is correct.

Q. 79. With the parallel connection the range of the receiver is from 700 or 800 meters, in that neighborhood?

A. 677.

Q. 80. Up to about 8700 meters?

A. Yes, that is correct.

Q. 81. And that in both instances that range can be continuously covered from one end to the other?

A. Yes.

Mr. Black: I offer in evidence Plaintiff's Exhibits 440 and 441 for Identification. (Received and marked.)

* * * * * * *

Q. 82. What other paper have you there?

A. I have here available my work sheet—that is, my computations based on the assumed calibration curve of

the condenser and the SE 143 instruction book values for inductance and antenna.

[fol. 1845] Q. 83. And that is available to defendant's counsel?

A. That is available to anyone.

Q. 84. In Plaintiff's Exhibit 413-B, which is the instruction book for the SE 143 receiver, I note the following statement with reference to connecting the primary variable condenser in parallel with the primary inductance, namely "This combination is very efficient on waves longer than 3,000 meters. On short waves it is not as efficient as the series capacity." Do you agree with that statement? Do you wish to see the statement?

A. With certain reservations, yes. That is, as a general matter, I think I have already said that this matter of efficiency is a complex one. It depends upon a great many factors, both in and outside the receiver, which vary in different installations. But in general I agree with that statement given in the instruction book.

Q. 85. Bearing in mind that the statement was made with respect to the SE 143, are you in a position to agree or not to agree with it?

A. So far as anything in the receiver is concerned, yes. The only reservation which I would have would be with respect to the characteristics of the antenna, which, of course, are not specified, other than by way of capacity.

Q. 86. Noting that the instruction book for that receiver states that the secondary circuit has a wave length range from 250 to 6800 meters, does Plaintiff's Exhibit 440 indicate that the parallel connection is available to cover [fol. 1846] the same range as the secondary covers?

A. It certainly shows this: that in the absence of the parallel connection the wave length range of the secondary as specified could not be covered. That is, with series connection alone you would fall far short of covering the secondary range. So if the receiver were to be used for wave lengths over the entire secondary range it would be necessary to use parallel tuning as well as series tuning.

* * * * * * *

[fol. 1847]

(Tr. 702)

Q. 87. Referring to Plaintiff's Exhibit 411, which is the instruction book for the type CN 239 receiver, I note that it states that "the secondary circuit has nominal wave

length range of 1,000 to 10,000 meters. The actual range is from about 1,000 to 15,000 meters." Were you familiar with this and similar types of receivers?

A. Yes. And also familiar with that use of nominal and actual wave length range.

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Q. 90. The instruction book just referred to also states that the antenna circuit has a wave length range of from 1,000 to 10,000 meters when used with an antenna of a certain capacity. How can the full actual range of the secondary circuit of that type of receiver be utilized?

A. Either by adding to the antenna capacity with a parallel connection of an antenna condenser or alternatively by adding loading coils to the antenna circuit.

Q. 91. Which arrangement would be preferable from an operating point of view?

A. From an operating point of view the parallel connection with the condenser would be preferable.

Q. 92. And from the point of view of efficiency and selectivity of the receiver which would be preferable?

A. The parallel connection would be in general always preferable. Higher selectivity would be obtained in practically all cases.

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(Tr. 705)

[fol. 1848] Q. 98. One of the advantages of the parallel condenser to which you have referred is the ability to receive long waves under certain conditions. During the period in which we are interested, 1910 to 1919, were there considered to be advantages in the use of long wave for communication as distinguished from the use of short waves?

A. Very distinctly so. This period was before the appreciation and use of short waves for long distance communication. It was a time when this art of radio communication was absolutely dominated by the laws laid down by Marconi, Austen, Cohen, and Alexanderson, which were to the effect that the greater the distance of communication the longer the wave length that should be used. The Austen-Cohen transmission formula was accepted in this period as gospel by all of the radio world so far as I know, and it showed very definitely indeed that if you wished to

[fol. 1849] work over distances of several thousand miles you had to use for optimum transmission wave lengths of the order of 10,000 meters or even more, and that is true today. That is, these laws were not superseded in any way by the introduction of short waves, merely that the short waves were not amenable to the laws of Marconi, Austen, Cohen and others. The laws themselves, however, held for the wave lengths then used.

Q. 99. Lest we get into any misunderstanding as to what "short waves" means, I think you have used it in the sense meaning well below 200 meters, haven't you, in this answer?

A. Yes. That is the division line which I have used through the years.

Q. 100. There are short wave receivers in this case which apparently go down to only about 300 meters. That is the distinction I want you to be sure to bear in mind.

A. In the modern sense, wave lengths of 200 meters or less are short wave lengths, and anything over that is not considered short today. In the period that we have been considering, however, wave lengths of 300, 400, 500 meters were considered short.

Q. 101. I think I interrupted your answer, Mr. Pickard.

A. Well, the laws which I have mentioned being universally accepted at that time and the facts so far as they [fol. 1850] were then known for wave lengths from, say, 300 or 400 meters up to 25,000 meters obeying these laws so far as our measurements showed, it came about as a matter of course that the longer waves were used for the longer distances. Both theory and practice seemed to be in full agreement. Furthermore, the longer waves at that time provided, from an engineering standpoint, an easier application of power. We did not know in the early days how to get any large amount of power into a radio circuit of any sort or how to get it out as radiation at the higher frequency or shorter wave lengths, and certain types of transmitters were actually limited in their performance to the longer waves where any considerable amount of power was required.

The arc transmitter was in that class, invented by Poulson in 1903 or thereabouts.

It was soon found in practice that the amount of power, or better, perhaps, the efficiency of the arc, rapidly fell off as the wave length became shortened. So the arc fell into a division in the transition period between spark and con-

tinuous wave, in which certain transmitters operated from a few hundred meters up to approximately 3,000 meters and arc transmitters took over the work from 3,000 meters up to in some cases 25,000 meters, and all of the transmissions over the longer distances, such, for example, as over the North Atlantic between this country and Europe, was delegated to wave lengths of well over 3,000 meters, and most [fol. 1851] of it was accomplished by arc transmitters.

Q. 102. And as far as regular communication at transatlantic distances was concerned, approximately what wave lengths were in use?

A. Wave lengths in order of 10,000 meters; and when I say "in order of 10,000 meters" I mean waves ranging from something under 10,000 meters to 15,000 or in some cases 20,000 meters.

I recall very clearly indeed, because I made frequent measurements of wave lengths of transmitters in this country and abroad in this period, that the wave lengths in use were such as I have just stated. Nauen, for example, one of the stations that was frequently received in this country and used by us as a sort of test station in this period, operated with approximately 12,000 meters. Other stations in France operated at around 10,000 meters, and the Lafayette station at, I think, approximately 20,000 meters.

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(Tr. 906)

Cross-examination.

By Mr. Edwards:

X Q. 381. As I recall your testimony, it was to the effect that the essential feature of novelty of Claim 16 is the parallel variable condenser and primary coil of the coupling transformer. Am I correct in that?

A. That is correct. That is, the novelty is the use of [fol. 1852] a parallel capacity or condenser across a portion—or, as it has been interpreted later, all of the primary or antenna circuit inductance.

X Q. 382. And it is upon that basis that your estimate of the value to be attributed to Claim 16 is based, is it not?

A. Yes.

X Q. 383. To be somewhat more specific, would you agree that the essential feature of novelty is making the parallel condenser a variable condenser as distinguished from having a condenser in parallel with the coil?

A. No. I should say that the question of variability was not primarily concerned for the reason that tuning could be accomplished by varying the inductance and leaving the condenser fixed.

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(Tr. 911)

A. As a matter of fact, when the number of turns in the coils are changed, the distributed capacity is not in general changed. If I might make that clear, and briefly, what we have in a coil is a distributed capacity consisting of a series of capacities or small condensers existing between adjacent turns. If the coil has 100 turns, there are therefore 100 turning capacities in series between the whole 100 turns in the coil. If now, by switch or other arrangement, we cut down the number to, say, 50, we have changed the series of small condensers to one-half the former value and we [fol. 1853] have increased that part of the capacity two-fold. We have also changed the distributed capacity due to the condensers by the capacity not merely from turn to turn but from turns that are separated by several turns from each other. It is really a very complicated matter, and it often, as a matter of measurement, comes down to this: that the distributed capacity of a coil remains approximately the same with a considerable change in the number of turns, although the general effect is to increase the distributed capacity when we decrease the number of turns.

X Q. 393. Let us, for simplicity, assume that the coil is a fixed coil. Do you agree that one skilled in the art could adjust the coil so as to have the proper number of turns and proper distributed capacity so as to tune the antenna to any given frequency?

The Commissioner: One skilled in the art as of what time?

Mr. Edwards: As of 1910.

A. Yes. As of 1910 one skilled in the art would know and would be able to adjust the inductance of the coil by changing the number of turns or in other ways, and he would also

have known that he was changing, to some extent, the distributed capacity of the coil.

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[fol. 1854] (Tr. 912)

X Q. 394. And as a result he would be able to tune the antenna to any given frequency?

A. As the result principally of the change of inductance of the coil, yes. Within the limits of the inductance range of the coil and the capacity of the antenna and secondarily the distributed capacity of the coil, he would be able to change within those limits the tune of the circuit.

X Q. 395. And one skilled in the art at that date could have devised a series of coils which could be used one at a time to give a selected frequency, a selected number of frequencies to which the antenna would be tuned, could he not?

A. Yes, that is quite correct.

X Q. 396. If he did use such a fixed coil he would of necessity have a capacity in parallel with the primary coil of the coupling transformer, would he not?

A. He would have such a capacity—that is, distributed capacity of the coil.

X Q. 397. And that would be in parallel with the inductance, would it not?

A. In a general sense, yes; bearing in mind, however, that distributed capacity differs materially from a lumped capacity such as is given by a condenser for the very reason that it is distributed over the entire coil, and not concen-[fol. 1855] trated across the terminals of the coil. There is quite a difference there.

X Q. 398. But would it not be the fact that the designer would have tuned his antenna to a given frequency by the use of a capacity in parallel with the primary of his coupling transformer?

A. Theoretically, yes; practically, no; because the distributed capacity is in general very, very small as compared with the capacity of any antenna which would be used.

X Q. 399. In point of fact, such coils were used to tune the antenna, were they not?

A. Principally through their inductance they were used to tune. I do not know of any deliberate use that was made of the distributed capacity of the coil.

By the Commissioner:

X Q. 400. How were the usual tuning inductance coils made at that time?

A. The usual type of coil was a single-layer coil for the shorter wave lengths; and referring now to such a receiver as the IP 76 and considering the coupling coil—that is, in Exhibit 87 the coil marked J'—that consisted of a single layer of 100 turns of wire wound on a form approximately 3½ or 4 inches in diameter and about the same length.

[fol. 1856] X Q. 401. Were the turns spaced or close together?

A. The turns were slightly spaced apart. The forms were generally threaded—that is, a worm screw thread was cut in the hard rubber and later bakelite and the wire wound in that. Actually, the turns were separated by something less than the wire diameter, and in all cases the turns were separated by the thickness of the insulation—or, rather, by the thickness of the insulation on a single conductor. That would be regardless of whether the form were threaded or not.

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[fol. 1857] (Tr. 916)

X Q. 404. So it was advantageous, then, to space the coils?

A. Yes.

X Q. 405. In order to decrease the distributed capacity?

A. Yes. There were really three reasons for it. First, the uniformity of inductance of a series of coils made up for different receivers; second, the matter of losses, which were due to the matter of spacing. The closer the spacing the greater the loss.

By Mr. Edwards:

X Q. 406. Is it not true that the bringing of coils closer together reduced the capacity area of the coil and spreading it apart tended to increase the area, up to a certain limit?

A. No. The capacity between any pair of conductors is a simple function of the area exposed by each conductor to the other and the separation—that is, if we have two conductors which may be wire turns 1/100th of an inch apart, the capacity may be one-tenth of a microfarad. If we double that spacing and place them two one-hundredths

of an inch apart, approximately, the capacity between those two wires has been cut in half. I say "approximately" because there are fringe or edge effects which are not amenable to a simple formula.

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[fol. 1858] (Tr. 920)

By the Commissioner:

X Q. 421. Let us assume a primary circuit comprising an antenna and a tuning inductance inserted between the antenna and ground. Let us now make a hypothetical assumption, which I understand can be only one—namely, that the tuning inductance has no distributed capacity whatever but is still capable of inductive adjustment or change of inductance. Would that be capable of tuning to different frequencies?

A. Yes, your Honor; that would be capable of tuning to different frequencies, and would be, as a matter of fact, the ideal case, the one toward which every constructor has striven, but not quite attained.

X Q. 422. And that would have both capacity and the inductance?

A. Yes. It would have the capacity of the antenna and the pure inductance without any distributed capacity of the coil, and it would be capable of tuning to any desired wave length within the range of the inductance variation given by the coil.

X Q. 423. Let us assume a second primary receiving circuit also having an antenna connected through ground by means of a tuning inductance but this time the tuning inductance possessing its distributed capacity. That is, as I understand it, also capable of being tuned to different [fol. 1859] frequencies?

A. Yes. That is the actual case. That is the practical case, because, of course, all coils have some distributed capacity.

X Q. 424. I think you have already answered the third question in my mind; but for the sake of the record I will ask it: which of those two systems, the first or second one, which I referred to, is the more efficient?

A. The first is the more efficient, your Honor, for the reason that distributed capacity in the coil, just because it is distributed, increases the losses in the coil, and there-

fore impairs the efficiency, and, therefore, the selectivity, of the system. It is, however, a secondary effect, and I would hate to leave this matter without just one sentence on the magnitude of the effect. We have seen in some of the exhibits in this case, such as the instruction book for one of the receivers, SE 143, a specified capacity for an antenna, namely, .0008 microfarad. The distributed capacity of the coil on an ordinary receiver primary is less than one-hundredth of that value. Its effect, therefore, is very secondary, although it is present, and does have an effect.

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[fol. 1860] By the Commissioner: (Tr. 925)

X Q. 437. Did you know at that time, in 1910, whether distributed capacity in an inductance coil was a detriment or a benefit?

A. I knew, your Honor, very definitely, from measurements, that it was a detriment, and that was the subject of frequent discussion among engineers at that time. It abundantly appears in lectures on the art as of 1910-1914, particularly.

By Mr. Edwards:

X Q. 438. The detriment was in what respect?

A. Efficiency; because the effect of the distributed capacity, just because it is distributed, lowered efficiency. It introduced additional loss in the circuit and so affected not only the transfer of energy from coil to coil or from antenna system to space, but also, of course, the selectivity or the sharpness of tuning which could be accomplished.

X Q. 439. In view of your statement, would you now agree with the basis upon which value should be attributed to Claim 16 of the Marconi patent as the basis of distributed capacity as against a lump capacity or a variable capacity as against a fixed capacity?

A. I do not know that the matter of distributed capacity had entered my mind before in this connection, but I should say that the value of the apparatus and [fol. 1861] arrangement described and covered by Claim 16 of the Marconi patent lay primarily in parallel capacity tuning of a circuit and was in part independent of whether or no- that capacity were variable; but admitting that variability of the condenser is a distinct advantage, that, of

course, makes the apparatus more valuable. I should have difficulty in answering the question as a whole, taking into account distributed capacity, because I am not aware of any system of radio telegraphy in which distributed capacity was used as a method of tuning.

[fol. 1862] By the Commissioner: (Tr. 929)

X Q. 441. Every antenna circuit or every primary circuit which has an antenna and a tuning inductance in connection to ground possesses inductance and possesses capacity, and that capacity is of two kinds or characteristics: first, the capacity of the antenna with respect to ground, and, second, the distributed capacity of the inductance coil; is that correct?

A. That is correct, your Honor.

X Q. 442. Second: am I correct in understanding that any distributed capacity whatsoever in the coil, in the inductance coil, is a detriment?

A. That is also correct, so far as it has an effect; and I mention that because its magnitude is so small as compared with the average antenna that for many purposes it can be neglected. So far as it is present at all, its effect is always detrimental. I know of no exception to that.

[fol. 1863] PICKARD—REDIRECT (Tr. 941)

R. D. Q. 471. Will you please look at the Marconi patent 763772 and point out whether or not it discloses that the parallel condenser h of Figure 2 is a variable condenser?

A. I find that the parallel condenser h is described on page 2, lines 83 to 86, as "preferably similar in construction and operation to the condenser e," and referring to the description of condenser e, which appears on page 1, lines 88 to 92, I find that this condenser e is "preferably one provided with two telescoping metallic tubes separated by a dielectric and arranged to readily vary the capacity by being slid upon each other." So as the condenser h is described by the Marconi patent as being similar in construction to the condenser e, it is a variable condenser.

R. D. Q. 472. Have you in mind what we have referred to as Groups I and II of the defendant's receivers in this case?

A. Yes.

R. D. Q. 473. And I believe that you have testified to familiarity with at least a number of types of those receivers?

A. Yes.

R. D. Q. 474. In so far as you are familiar with them are there wave length ranges within the stated ranges of those receivers that could be covered only by the parallel condenser connection?

[fol. 1864] A. That is correct. The secondary tuning range in those receivers is such that with the coils supplied in the primary circuit tuning over the entire range could be accomplished only by the use of parallel tuning.

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R. D. Q. 476. To one skilled in the art as of 1910 or thereabouts, did the term "condenser" mean distributed capacity as well as capacity lumped in a piece of apparatus?

A. No. The term "condenser" as of that time meant a discrete piece of apparatus,—that is, a lumped capacity. Whenever we referred to other capacities, such as those existing in coils and in various systems of wiring, we did not use the word "condenser," but referred to them as "distributed capacity."

R. D. Q. 477. You have spoken of the distributed capacity in parallel with the coil,—that is, the distributed capacity of the coil,—as decreasing efficiency; is that correct?

A. That is correct.

R. D. Q. 478. Does a condenser connected in parallel with the coil also decrease efficiency?

A. No, it does not.

[fol. 1865] R. D. Q. 479. Will you please explain that?

A. There are two reasons: one reason is that distributed capacity is not a capacity connected across the terminals of the coil. It corresponds really to an infinite series of small condensers connected across various and all portions of the coil; secondly, the dielectric involved in distributed capacity effects is, of course, the insulation, whatever it might be, of the coil itself. In the case of a receiving coil, this insulation is a more or less imperfect dielectric, such, for example, as silk or cotton impregnated, very often, with shellac or a similar material; whereas in the case of the normally used variable condenser, the dielectric is air, a very perfect dielectric, in which there

is no loss at ordinary receiving circuit potentials; so for two reasons the loss is much greater in the case of the distributed capacity than it is in the case of a lumped capacity connected across the coil. I might add to that that any ordinary variable air condenser of practically any period in the art was a far better device from the standpoint of losses than any form of coil which could be devised. The condenser first and last was a very efficient piece of apparatus, the coil relatively much less efficient.

[fol. 1866] R. D. Q. 480. So within your knowledge has the coil or coils of an antenna circuit been designed for the purpose of tuning that circuit by means of the distributed capacity of the coil?

A. No, I know of no case in which that has been done.

R. D. Q. 481. From your experience would it be practical to do that?

A. No, because it would be physically impossible to cover the normal desired wave length ranges, owing to the small amount of capacity existing as distributed capacity in any practicable size of coil. It is very, very small as compared with the antenna capacity, generally of the order of less than one per cent. of the antenna capacity.

R. D. Q. 482. I do not know whether this question is too speculative or not, but, if so, you can tell me: if an antenna circuit were designed to be tuned with a series of coils having the same inductance but different capacities and those coils were of reasonable size, how broad a range could be covered?

A. The size of the coil, as I think I have indicated before, is rather definitely limited. We cannot have indefinitely large coils, and therefore indefinitely large distributed capacities; because finally the coil shrinks to a single turn of wire if it gets large enough, and then, when that turn [fol. 1867] attains a sufficient diameter, the inductance increases beyond the desired value.

Within any practical range of coils—and by that I mean coils ranging, say, from an inch or two in diameter up to a foot or two in diameter, or something of that sort, in which the cubic contents or volume increased over quite a large range indeed, the distributed capacities would range from a few millionths of a microfarad—one or two millionths of a microfarad, for the smaller coils,—up to perhaps three, four, or even five times that value, and the effect upon wave length tuning of any circuit would be quite

closely the square root of that. That is at the most; and assuming, as I have assumed several times before, an antenna capacity of .0008 microfarad, or, in the more frequently used units (micro-microfarads, or millionths of a microfarad) of 800 micro-microfarads, we would then have a circuit capacity ranging from, say, 803 micro-microfarads to, say, 815 micro-microfarads, and that is a change in capacity of 12 parts in 800, and that is one and one-half per cent. The change in wave length would be quite closely the square root of the capacity change, or approximately .75 per cent.; that is, less than one per cent.

For example, if with the smallest coil the circuit was tuned to 3,000 meters, it could be changed by going through the larger coil to not over 3030 meters.

[fol. 1868] R. D. Q. 483. In one question on cross-examination there was reference to the difference between a condenser and distributed capacity as depending upon the structure of the condenser and the structure of the coil.

In a practical receiver, and referring to the antenna circuit, still, are there differences in results between utilizing a condenser for tuning and utilizing a distributed capacity for tuning?

A. Yes. Entirely aside from the very considerable difference in range or wave length range which might be accomplished by the two methods, there is a difference in efficiency. The efficiency—that is, the selectivity of the circuit—would be greater with the condenser than with the use, so far as it could be made to function, of the distributed capacity as a tuning element.

R. D. Q. 484. In the receivers of those periods it was not unusual, was it, to provide different coils for tuning purposes?

A. Yes; either different coils or coils with taps of one form or another, which is more or less the same thing.

R. D. Q. 485. And what was the electrical purpose of providing either one of those arrangements?

A. To subdivide the inductance into steps so that by the use of some other variable element, such, for example, as [fol. 1869] a variable condenser in series or in parallel with the circuit, one could continuously vary the tune of the circuit—that is, by infinitely small steps over an appreciable range. Then the number of steps would be so proportioned that a slightly overlapping series of wave ranges would be

obtained. That was the object of the subdivision. In some special cases, the inductances were subdivided quite finely as particularly in the IP 76 receivers.

R. D. Q. 486. What was the effect on the constants of the circuits of changing coils or changing connection to coils? What constant was affected primarily?

A. Primarily the inductance.

R. D. Q. 487. A change in the inductance had some effect on changes in the wave length, did it not?

A. Yes. The wave length was directly related to the change of inductance; or, rather, related as the square root of the change of inductance. It was still a direct relation, though.

R. D. Q. 488. And in any normal antenna circuit was the larger portion of the inductance of that circuit embodied in the coil?

A. Yes; with the exception of a very long wire antenna and a very small antenna loading inductance such as might be used at the very bottom of the wave length range of a receiver. In that case there would be an appreciable amount [fol. 1870] of the inductance in the circuit of the antenna. Usually by far the greater part of the inductance was concentrated in the inductance of the receiver.

[fol. 1871] LESTER L. JONES (Tr. 1264)

LESTER L. JONES, a witness produced on behalf of the defendant, having been first duly sworn by said Commissioner, was examined, and in answer to interrogatories, testified as follows:

Direct examination.

By Mr. Houghton:

Q. 1. Mr. Jones, will you state your full name, age, residence and occupation?

A. Lester L. Jones, 455 Summit Avenue, Oradell, New Jersey; age, 47; engineer and executive.

Q. 2. Were you ever in the United States Navy?

A. I was in the navy as a civilian employee.

Q. 3. When did this employment begin?

A. I first started to work in the Brooklyn Navy Yard in December, 1913, and continued at the Brooklyn Navy

Yard until the end of February, 1917, at which time I was transferred to the Washington Navy Yard, and I continued there until March or April, 1918.

Q. 4. During this entire period of employment by the navy, were you employed under your present name or under a former name, prior to its judicial change?

A. Yes, I was employed under the name of Lester L. Israel.

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[fol. 1872] (Tr. 1270

Q. 19. Were you the Lester L. Israel whose name appeared on the instruction book prepared for the SE 143?

A. Yes, sir.

Q. 20. Were you in any way connected with the preparation of that book, other than signing it?

A. My best recollection now is that I wrote at least portions of the book. I may have written it all. I cannot remember definitely. I certainly read and checked everything before I signed my name to it. I remember that I had quite full discussions with everybody available as to what should go in and what should be left out.

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(Tr. 1274)

Q. 28. Referring again to the SE 143 and the statement in the instruction book regarding the possibility of placing the primary condenser parallel with the primary coil, what condition would this change meet, or what change of condition would this change of position meet?

A. That would be for an unusual or extraordinary use of the receiver. It would not be an arrangement for regular use of the receiver, because I clearly recollect that we put into the receiver everything that was required for the regular and ordinary use. I also recollect that the statements in the instruction book relating to the outside connections of switching apparatus for arranging the antenna [fol. 1873] tuning condenser in parallel with the coil were desired by Lieut.-Commander Eaton as being desirable for two purposes. More specifically, in the case of regular antennae, where it had been shot away, and it was necessary to operate with a single short wire. In this latter

case, the wave-length range of the receiver would have been seriously diminished, and it was desirable to have the operators know that it could be extended to a longer wave-length range on any kind of antenna, by using the parallel connection.

There is a statement there that this form of connection is not as efficient, and this was intended to discourage the use of such a connection in regular operation.

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(Tr. 1277)

Q. 32. Referring to Plaintiff's Exhibit 413-B in the instruction book for the SE 143, sheet 1, first paragraph below the figure 1, it states:

"This places the primary variable condenser in parallel with the primary inductance. This combination is very efficient on waves longer than 3000 meters; on short waves it is not as efficient as the series capacitive."

Do you agree with that statement?

A. Yes.

Q. 33. Will you explain why you agree with that statement?

[fol. 1874] (Tr. 1278

A. Yes. I agree with the statement for these reasons on the long waves, the paralleling of the condenser forms an efficient arrangement, because the radiation resistance, or total resistance, of the antenna on ships is usually very small. The distributed inductance of the antenna is also negligible. The coils of this receiver were of stranded wire, and were very efficient; that is, they had low resistance values on the long waves.

In consequence of all these things, the primary circuit with the tuning condenser arranged in parallel, would oscillate as a single resonance circuit, having low damping; and such a system would be easier to manipulate than a system in which the loading effect were obtained by a separate loading coil inserted in series with the antenna and the tuning condenser.

On the shorter wave-lengths, the parallel tuning arrangement would be less efficient and generally undesirable, for these reasons: the antenna system on short waves generally

has a high resistance. The parallel condenser arrangement would minimize the inductance necessary for tuning, and would give to the antenna a broad resonance curve, and make it less selective.

And also the usual long lengths of antenna lead-in wires, and the long antennae themselves, would have considerable distributed inductance, so that the parallel arrangement would create a set of coupled circuits in the antenna, which [fol. 1875] would not resonate to a single frequency at any one setting and would give rise to additional interference, due to coupling waves being generated in the antenna system.

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[fol. 1876] Jennings B. Dow (Lieut.-Commander, U. S. Navy, Washington, D. C.) a witness produced on behalf of the defendant, having been first duly sworn by said Commissioner, was examined, and in answer to interrogatories testified as follows:

Direct examination.

By Mr. Edwards:

Q. 1. You reside where?

A. I reside in Washington, D. C.

Q. 2. Will you state what training and experience you have had in the line of radio engineering?

A. I graduated from the U. S. Naval Academy early in June, 1919. From there I was ordered to sea duty as radio officer of the U. S. S. Montana, and in 1920 I was ordered to duty as Assistant Radio Officer of the U. S. S. Texas. In or about 1921 I was ordered to duty as radio officer of the U. S. S. California; and about 1923 I was ordered to duty on the staff of Vice-Admiral Wiley as a communications and radio officer.

During the above period, subsequent to my graduation from the Naval Academy, my duties involved the supervision of operation and maintenance of radio installations of the vessels which I mentioned; and, during the period of my office on the staff of the Vice-Admiral, Wiley, I was charged, in addition, with the supervision of the operation and maintenance of the radio installations of all battleships of the battle fleet.

[fol. 1877] Q. 2a. What types or classes of vessels were the Montana, the Texas, and the California?

A. The Montana was an armored cruiser. The Texas was a battleship, and the California was a battleship.

Q. 3. Now will you continue your answer?

A. About 1924 I was ordered to duty at the Post Graduate School at Annapolis for post graduate training in communications engineering. I devoted a year to this work and the following year I continued my duties in the graduate School of Engineering at Harvard University.

I hold the degrees of Bachelor of Science and Master of Science and Communications Engineering. Upon the completion of my studies at Harvard——

Q. 4. What year?

A. In the summer of 1926, I was ordered to duty on the staff of Admiral Williams, who was Commander-in-Chief of the Asiatic Fleet, where I served during the tenure of his office, as radio officer in the Asiatic Fleet, for a period serving both as communications and radio officer of the Asiatic Fleet.

Upon the detachment of Admiral Williams, I was ordered to duty as radio material officer of the Sixteenth Naval District, with headquarters at the Navy Yard Cavite, Philippine Islands.

[fol. 1878] Q. 5. When was that?

A. I completed eighteen months of duty as radio material officer at that station; and, in the summer of 1929, I was ordered back to the United States for duty in the Research and Design section of the Radio Division of the Bureau of Engineering, during which duty I was charged with the preparation of specifications for Navy radio equipment and with the administration of research and development problems at the Naval Research Laboratory.

I was detached from the Bureau of Engineering in the spring of 1932, and was ordered to duty as radio officer of the Radio Control Battleship Utah, as I had followed the development and design of the equipment for that vessel, as a part of my duty in the Bureau.

I served on the Utah in the capacity of radio officer until the fall of 1934, when I was ordered again to duty as assistant to the officer in charge of the Radio Division, Bureau of Engineering.

In June, 1938 I relieved the officer in charge of the Radio Division of the Bureau of Engineering, and I have served in that capacity up to the present time.

The Radio Division of the Bureau of Engineering, of which I am the head, is charged with the design, development, procurement, testing, and installation of all radio equipment used by the Naval Service, including equipment for ships, shore radio stations, and air-craft.

[fol. 1879] Q. 6. Have you read Patent No. 763,772, of June 28, 1904, to G. Marconi?

A. I have.

Q. 7. And do you believe that you understand the description of the construction and operation of the device therein shown?

A. I do.

Q. 8. I call your attention to Figure 2 of the patent and to the condenser marked "h" in that figure. This condenser, you will note, is in shunt with the primary coil J' of the coupling transformer. Will you state if you find anything in the specification directing the reader to any special function of that condenser, and whether or not you find any such direction in the specification, will you explain how that condenser operates?

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(Tr. 1351)

A. Oscillations transmitted by the equipment of Figure 1 are intercepted by the antenna F' of Figure 2, and, as stated, beginning with line 118 on page 2 of the specifications, the open circuit of the receiver of Figure 2, comprising the antenna F', the loading coil G', the condenser h, and the coil J', are tuned so as to be responsive to the wave signal energy.

[fol. 1880] By the arrangement shown in Figure 2, energy is coupled from the primary coil J' to the secondary coil J'' and causes the secondary circuit, including the detector, to respond to the received signal in such a way that it can be detected.

I have analyzed the specification and the various figures of the drawing and have come to the conclusion, based upon facts which I will mention, that the condenser h acts as a series condenser in the open circuit or antenna circuit of the receiver, and that the coil J' is in fact a coupling coil. By that I mean that, from the matter which is disclosed

in the specification, the condenser H and the coil J' are not made resonant to the received signal.

The Commissioner: By that do you mean that the condenser h does not have any function in tuning?

The Witness: The condenser h serves to tune the open circuit to the wavelength of the incoming signal. That is, the condenser h, in combination with the loading coil G' and the capacity F' of the antenna—that is, the capacity between the antenna and ground—is adjusted to resonate at the wavelength of the incoming signal.

When that adjustment is made, a maximum voltage exists across the condenser h, which causes the current to flow in the coil j' and this is coupled to the secondary coil J'', [fol. 1881] so that the received signals can be detected.

In answering your question more completely, your Honor, I refer you to the tables on page 4 of the specification. The upper table discloses the adjustments of the equipment at the transmitting station for various tunes, which are labeled in the left-hand column.

[fol. 1882] Similarly, the table captioned "Receiving Station" shows various adjustments of the receiving system for the various tunes labeled in the left-hand column.

The tunes under the receiving station column correspond to those under the transmitting station column. It is possible to compare these tables readily, where only one variable is involved. That is, it would be difficult to compare tunes wherein two adjustments were changed.

However, referring to the table headed "Receiving Station" and to tunes 3 and 4, under column "h" is shown the value of the capacity h for tunes 3 and 4.

You will note that the condenser h was not changed in shifting from tune 3 to tune 4. It is important to note that tunes 3 to 4 have, point for point, widely-separated wave lengths; since, in the column g' of the lower table, you will note that only 21 turns of inductions were used in the loading coil G' of the receiver for tune 3; whereas 100 turns were used for tune 4.

It is important to note at this time that the transformer, or that the primary coil J' of the transformer, comprising this coil and the secondary coil J'', was not changed. And, since neither the capacity of the condenser h nor the in- [fol. 1883] ductances of the primary coil J' were changed, the circuit consisting of the condenser H and the primary coil J', even if it were resonant, for example, to tune 3, could

not be resonant to tune 4, since the wave length was changed and yet the adjustments of this circuit were not changed.

That there is a material difference in the wave length for tunes 3 and 4 is also borne out by the fact that, in the table headed "Transmitting Station," for these tunes, Transformer D-D′ was the same in both cases; that is, the primary coil D of Figure 1 had the same inductance for both of these tunes.

However, the capacity of the condenser e in the case of tune 3 was 0.004112 microfarads. In the case of tune No. 4 it was over four times as great.

As the inductance was the same in both cases, and the capacity was four times as great in tune 4 as it was in tune 3, and since the wavelength varies as the square root of the product of the inductance times the capacity, then the wavelength in the case of tune No. 4 must have been substantially twice as great as in the case of tune No. 3.

The Commissioner: Looking at it from the practical point of view entirely, would you not have to adjust the condenser h in Figure 2 to receive the two different waves? [fol. 1884] The Witness: That is not necessary, your Honor. In a resonance circuit which may be adjusted, from which it is desired to adjust to several wavelengths, either the capacitance or the inductance or both may be varied to change the resonant wavelength.

Marconi varies his resonance wavelength by changing his loading coil G′ rather than the condenser h. And this is borne out by one or more parts of the specification which I will read. Beginning with line 56 on page 1 of the specification, I quote the following:

[fol. 1885] "The system also requires, as essential elements thereof, the inclusion in the lines (at both stations) from the aerial conductor to the earth of variable inductances, and the use at both stations of means for varying or adjusting the inductance of the two circuits at each station to accord with each other. By this arrangement of apparatus, I am able to secure a perfect 'tuning' of the apparatus at a transmitting station and at one or more of a number of receiving stations."

That is, Marconi prefers to accomplish this result by the adjustment of his loading inductance G′ in his receiver of Figure 2.

The Commissioner: And he did not need to make the condenser h adjustable, then.

By Mr. Edwards:

Q. 9. Whether he did or not, will you look at the table on page 4 and say whether, as between tune- 3 and 4, there is any indication of variation of the condenser for those tunes.

A. In the lower table on page 4, you will note that tunes 3 and 4 which operated at wavelengths varying in the ratio of substantially 2 to 1, the condenser h was identical in both cases.

Q. 10. Had the same value?

A. Yes, had the same value—namely, 0.0046 microfarads in both cases.

[fol. 1886] In reading the specification, I find the statement, beginning with line 83 on page 2 of the specification:

"In a shunt around said primary J', I usually place a condenser h, preferably similar in construction and operation to the condenser e."

Now, he indicates that that condenser might be variable; but I can find, in no place in the specification, anything to indicate that he actually used that, that he actually varied that to change his tunes.

The Commissioner: What would you consider as his preferred form with respect to condenser h—a variable or non-variable condenser?

Q. 11. Do you find anything in the specification indicating that?

A. Yes. It is very difficult to look at this circuit now, in the light of what we have learned over the past forty years. For another reason, which I will explain, he had no reason for varying the value of condenser h in making the circuit operate as he described it.

The Commissioner: I do not believe that quite answers my question. I will ask the reporter to read it to you.

(The last question of the Commissioner was read by the reporter as above recorded.)

[fol. 1887] The Witness: I would say that the preferred form would be the variable condenser.

Q. 12. Do you find any reference in the specification to the condenser h or its functions, other than the matter on page 2, lines 83 to 86, and in the table on page 4?

The Witness: Will you read that to me, please?

(Q. 12 was read by the reporter as above recorded.)

A. I find no other reference to the condenser h. However, beginning with line 12 on page 3 of the specification, the following statement appears:

"The adjustment of the self-induction and capacity of any or all of the four circuits can be made in any convenient manner and employing various arrangements of apparatus, those shown and described herein being preferred."

By the Commissioner:

Q. 13. Does the sentence beginning on page 1, line 88, help you in any way in your answer?

A. In the beginning of line 88 appears a statement describing the condenser e, which reads:

"A condenser e, preferably one provided with two telescoping metallic tubes separated by a dielectric and arranged to readily vary the capacity by being slid upon each other, is included in one connection from the induction coil to the transformer winding d."

[fol. 1888] That, when used in conjunction with his statement beginning with line 83 on page 2 of the specification, namely, "In a shunt around said primary j', I usually place a condenser h, preferably similar in construction and operation to the condenser e," indicates a construction of the condenser h, although the references to the tuning of the circuit indicate that the actual tuning adjustment was made by the coil g' of the receiver.

Q. 14. I wonder why Marconi wanted an adjustable condenser there, then?

A. I can readily understand why he might want an adjustable condenser there, if he tuned his circuit, consisting of the condenser h and the coil j' to the resonant wavelength; but, for the reason which I pointed out, using the table on page 4, he does not appear to tune that circuit.

Now, in going over this patent, that fact was also confirmed from another angle, which I can go into at this time if you desire.

By Mr. Edwards:

Q. 15. Suppose, before you do go into that, that you let me ask you again: do you find any statement anywhere in the patent as to any specific function that the condenser h is to perform.

A. Only by implication from the matter appearing in lines 84 to 86 of page 2, and the matter beginning with lines 88 to 92 on page 1.

[fol. 1889] Now, if he uses his condenser for tuning, as suggested, in the manner—

Q. 16. Now, before you go into that, I would like an answer to my question: do you find any specific statement in the patent that that condenser performs any specific function?

A. I do not.

Q. 17. Now, then, it is a fact or not that what ever function may be performed by the condenser would depend upon the value of the condenser in any particular circuit?

A. That is correct.

Q. 18. Is it or is it not true that it is purely a matter of speculation at the present time as to what particular function may have been intended by that condenser?

A. It is. However, from studying this specification in particular in connection with what I pointed out in connection with the tables on page 4, and in looking at it also from another angle based upon what appears in the specification, I conclude that the condenser h was used as a part of the resonant system, consisting of the antenna f', the coil g', the condenser h, and the ground, as the open circuit of the receiver.

Q. 19. Yes. Now, will you explain in what manner you find confirmation of that belief?

A. I will try to make this as—since it involves consideration of several parts of the specification, I shall have to go slowly in covering this.

[fol. 1890] Q. 20. Yes. Well, take it slowly, step by step, in order to enable the Court to follow your line of reasoning.

A. Beginning with line 118 on page 2, Marconi states that:

"The capacity and self-induction of the four circuits—i. e., the primary and secondary circuits at the transmitting station and the primary and secondary circuits at any one of the receiving stations in a communicating system—are each and all to be so independently adjusted as to make the product of the self-induction multiples by the capacity the same in each case or multiplies of each other—that is to say, the electrical time periods of the four circuits are to be the same or octaves of each other."

This means, as I have stated before, that the primary circuit of the transmitter, the secondary or open circuit of the transmitter, the primary or open circuit of the receiver, and the secondary or closed circuit of the receiver, are all adjusted substantially to the same wave length.

If we examine the values of the condenser e, the primary coil d, in Figure 1, we can obtain certain information which can be used for comparison purposes, to determine the relative values of wave length to which these circuits are adjusted in both transmitter and receiver. [fol. 1891] We have a further means of comparing the wave-lengths by the table on page 4. In order to be specific, I would like to compare the transmitting tune No. 3 with the adjustment or with the resonant wavelength to which the circuit h-j' in Figure 2 is adjusted.

Tune 3 in the upper table corresponds to tune 3 in the lower table, and it will be noted that the capacity of condenser e in figure 1 was 0.004112 microfarads. This is substantially the same capacity as that of condenser h in figure 2, which, as listed opposite tune No. 3 in the receiving station table, is 0.0046 microfarads.

The primary coil d of Figure 1, which, in conjunction with the condenser e, determines the resonance wavelength of the primary circuit, and, accordingly, the transmitted wavelength, is described beginning with line 36 on page 3, which states:

"A transformer in all essential respects similar to 1, but with a primary of 1.93 meters, and the core or block on which both primary and secondary are wound, is .3048 meters wide."

It will be noted at this time that the three transformers corresponding to those listed in column d-d' of the trans-

mitting station table, are described beginning with line 26 on page 3, through line 46.

The coil d thus consists of a piece of wire 1.93 meters in [fol. 1892] length, wound on a core block .3048 meters wide. This would represent roughly one and one-half turns of wire.

We have now a description of the primary coil d. We also know that the condensers e and h are of substantially the same capacity.

If we now can determine a relative value of the coil j' in Figure 2, we can get a pretty good picture of the resonance wavelength of the two circuits, namely, the primary circuit in the transmitter, which determines the wavelength of the communication and the value of the resonant wavelength of circuit h-j'.

Four different kinds of induction coils or transformers were used or are described by Marconi for use in the receiver. The description of these begins with line 59 on page 3 of the specification and continues through line 127 on page 3.

Four different types of induction coils corresponding to the four different types listed in the second column from the left of the table on page 4, under receiving station, are described. His induction coil No. 2 which was used in tu[illegible] No. 3 is described beginning with line 85 on page 3.

[fol. 1893] This description states:

"The form of induction coil shown in Figure 6 has a primary of 100 turns of copper wire .037 centimeters in diameter, wound on a core j (2.9 centimeters in diameter).

It will be noted that the diameter of the core is 2.9 centimeters, so that the circumference of the length of one turn would be approximately 10 centimeters. A hundred turns of this wire would be 1,000 centimeters, or 10 meters. That is, the length of the wire used in the coil j' is 10 meters, in contrast with 1.93 meters of wire used in coil d of the transmitter.

The inductance of coil j' of the receiver can be said to be several times greater than that of the coil d in the transmitter; and, since the condensers e and h are substantially the same, what I have said is further proof that the circuit in the receiver, consisting of the coil h and the in-

ductance j' was not tuned to the wavelength of the received signal.

This confirms the matter which I mentioned some time ago, this morning, in connection with tunes 3 and 4, wherein the wavelength of the transmitted signal was changed; yet neither condenser h nor the coil j' were changed to make the circuit h-j' resonant.

[fol. 1894] This, all of which I have said, leads me to conclude that the condenser h was in fact used merely as a series capacity in the antenna or open circuit of the receiver, and that the coil j' is merely a coupling coil by which energy can be conducted from the primary or open circuit of the receiver to the second circuit.

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(Tr. 1368)

Q. 28. Is it true or not that, in effect, the total distributive capacity is in series with the inductance of the various antenna and coils?

A. That is correct. I think perhaps your Honor's suggestion off the record that we take a recess was a good one. I see further complications ahead.

* * * * * * *

A. (Continuing:) In answering the previous question, in showing the operation of a circuit consisting of a condenser h, a coil such as j', I would like to simplify the apparatus under consideration, to the extent of providing an antenna connected to a parallel circuit consisting of a condenser and an inductance coil, the other side of which circuit is connected to the earth.

I have sketched such a circuit, and will assume that the wave length of the transmitter wave is such that the condenser, when it is in its mid-position, would resonate the coil to the transmitted wavelength.

[fol. 1895] Under these conditions, and starting out with the condenser in its zero position——

The Commissioner: Can I interrupt you to ask what you mean by "resonate the coil"?

The Witness: By that I mean: when the capacity reactance of the condenser plus certain distributive capacities which may be lumped with that condenser, is equal to the inductive reactance of the coil, the circuit is said to be in resonance.

Starting out with the condenser in the zero position, the circuit would consist merely of the antenna, having in series connection with it to the earth the induction coil.

Q. 29. That is the coil j'?

A. The coil j'.

Q. 30. Would you not make your circuit more complete by putting in there your loading coil and your antenna?

Mr. Blackmar: As I understand it, the witness just said he simplified the circuit by omitting them.

The Commissioner: I think that is correct. The witness, Mr. Edwards, started to simplify the circuit, omitting the loading coil.

Mr. Edwards: Oh, yes; that is all right.

A. The circuit—since we assumed that the resonant wavelength corresponded to that of the circuit h-j', when [fol. 1896] the condenser was in its mid-position, very little current would go through the coil j'. However, all of the current which would be induced into the antenna system by the transmitting station would flow through the coil j'.

The Commissioner: That is, with the condenser at zero position?

The Witness: That is correct. And, the coil j' would present an inductive reactance to the incoming signal or to currents of the incoming signal wavelength. Now, as we begin to increase the capacity of the condenser h, the inductive reactance of the coil begins to be neutralized. At the same time, more and more current begins to flow through the condenser h. As the resonant wavelength of the transmitting station is approached, when the condenser is in the mid-position, the same current flows in the condenser as in the coil; and, when the coil and condenser reactances neutralize one another, the reactance of the circuit between the antenna and the ground becomes resistive, rather than capacitive or inductive.

At the resonant wave length, the maximum current possible under the conditions will flow in the circuit, consisting of the condenser h and the coil j'.

Mr. Edwards: Will you read that last sentence to me please?

(Portion of testimony read as above recorded.)

[fol. 1897] The Witness: As the capacity of the condenser is further increased beyond this resonance point, the current in the circuit, consisting of condenser h and capacity j' decreases. However, more of the current flowing in the antenna circuit will divide to the capacity branch of the circuit; so that, when the capacity is at an infinite value, if we desire to go that far, none of the current in the antenna circuit would flow through the coil j'.

By the Commissioner:

Q. 31. Could you plot some kind of a rough curve showing what you have just stated, with respect to the current flowing in the coil, flowing current from the coil against the condenser position?

A. I think I can plot that; but two curves should be plotted, in order to illustrate what I have said. One of these currents should be the current which flows in the circuit, consisting of the condenser h, parallel with the coil j'; and the other current should be that which flows in the antenna lead or in the ground lead, which is the same thing. (The witness makes another drawing on the same sheet of paper.)

I have here a curve which shows the relative values of the currents in the antenna lead and in the resonant circuit h-j', under the assumed conditions. The ordinates repre-[fol. 1898] sent current and the abscissas the condenser setting. 50 degrees condenser setting is assumed to be the mid-position or the resonance position of the condenser.

As the condenser is increased in setting from zero, the current in the circuit h-j' rises with increasing rapidity, as the resonance position is reached, reaching a maximum value when the inductive reactance of the circuit is near to the capacity of reactance.

Mr. Blackmar: May I interrupt a moment? When you say the current is a maximum in the circuit, you mean the circulatory current in that circuit?

The Witness: Yes, that is right.

A. (Continuing:) Then, as the capacity of the condenser is increased beyond the resonant point, the current in the circuit h-j' rapidly decreases.

With reference to the current flowing in the antenna lead, owing to the poor match of impedances between the antenna circuit and the circuit h-j', the maximum value of current in the antenna lead will be considerably less than the maximum value of current in the circuit h-j'.

This current will be a minimum at the resonance frequency; and, at this point, the circuit consisting of the condenser h and the inductance j' offers the maximum parallel impedance.

[fol. 1899] The Commissioner: What you mean by this is that, at that resonant point, the voltage was the maximum across the coil j'?

The Witness: That is correct. I would like to point out at this time, in order that there can be no misunderstanding, that what I have just stated in connection with the circuit which I have drawn is not the condition which exists in the corresponding circuit h-j' of Figure 2 in the drawing, for the reason that the resonant frequency of the circuit h-j' was, according to the specification, for the two reasons which I pointed out, much lower than the transmitting frequency. That is, the resonant wavelength of the circuit h-j' was much greater than that of the primary circuit of the transmitter, consisting of the capacity e and inductance d, as this capacity and inductance determines the wave-length.

Mr. Edwards: I will offer in evidence the sketch, consisting of two figures made by the witness, and ask that it be marked Defendant's Exhibit JJ.

The Commissioner: It is so received.

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Q. 32. Can you make a corresponding sketch or sketches which will include the induction coil g' in the antenna, and explain the action with that coil included, as shown in Figure 2 of the Marconi patent?

[fol. 1900] A. Under the particular conditions which were assumed, namely, that the condenser h and the coil j' were resonant, the condenser h in its mid-position, there would be no substantial difference in the curves. That is, we are assuming, in connection with the question which was asked, that the circuit h-j' was actually resonant to the transmitting frequency when the condenser was in its mid-position.

Q. 33. In this case how does the coil g' affect the operation (indicating Fig. 2 of the Marconi patent)?

A. The circuit of Figure 2, from the facts pointed out in connection with the tables on page 4 and in connection with the deduction which was readily made in connection with the condensers e and h, and the coils d and j', operates in an entirely different manner from the circuit which was made the subject of the previous question.

As explained, the condenser h of Figure 2 is used as a part of the resonant system, consisting of the antenna f', the coil g', the condenser h, and the earth. When this circuit is resonant to the incoming frequency, the maximum voltage exists across the condenser h.

The Commissioner: You are now talking about the disclosure of the patent?

The Witness: Oh, yes.

[fol. 1901] A. (Continuing:) The maximum voltage exists across the condenser h, and a maximum of current flows through the coil j'. However, the current which flows through the coil j' under these conditions is not nearly as great as would be the case where the condenser h and the coil j' were adjusted so as to provide a circuit which was resonant to the received frequency or wavelength.

Q. 34. Assuming that the values of g' and h in Figure 2 are so adjusted as to make the natural frequency of circuit f', g' and h and e resonant to the incoming frequency, what, then, would be the frequency of the circuit h-j'?

A. As I pointed out previously this morning, from the information contained in the specification, the condenser e and the condenser h are substantially of the same value for tune No. 3. However, the coil j' has a much greater inductance than the coil d, so that the resonant frequency of the circuit h-j' is much lower than the resonant frequency of the circuit consisting of the condenser e and the coil d.

Therefore, considering the circuit between the tap on the coil g' and the earth—that is, just the impedance of that branch of the circuit, the reactance would be capacitive, even in the presence of the coil j'.

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[fol. 1902] Q. 35. From the values of the coils as given in the specification, can you say approximately how much

lower the frequency in the circuit h-j' would be than the frequency in the circuit f'-g'-h and a ground?

A. Because of the fact that the coils d and j' are of different diameters, this comparison can be only approximate. That is, if these coils were of the same size, the same diameter, it would be possible to pretty closely approximate the ratio of inductance, from the fact that the inductance varies approximately directly as the square of the number of turns; that is, if these coils were of the same diameter, the coil d having one and a half turns, the square of that would be 2.25; and if the coil in j' would have a hundred turns, the square of that would be 10,000. Under these conditions, the ratio of inductances would be as 10,000 is to 2.25.

However, no such ratio as that exists, since the coil d is probably larger than the coil j'.

Now, on the basis of the length of wire, a comparison can be made. The coil d contains 1.93 meters of wire. The coil j' contains 10 meters of wire.

If this wire were laid out straight, the inductance would be approximately in the ratio of length of the two wires, namely, about 5 to 1.

[fol. 1903] However, when a wire is coiled, provided it is not coiled back upon itself but wound in the form of a helix, the inductance is enormously increased, so that I would say that the ratio of the inductance of coil j' to coil d would be at least 5 to 1—probably 10 to 1.

Since the condenser e and the condenser h, are for tune 3, of substantially the same capacity, and since the resonant wavelength of the circuit consisting of inductance capacity in parallel varies as the square of the product of the inductance and capacity; then, assuming that the minimum ratio of inductances which was deduced above—the resonant wavelength of the circuit h-j' and the circuit e-d' would be at least as the square root of 5 is to 1, and probably much greater, because of the fact that the coil j' is a coil rather than a straight piece of wire.

By the Commissioner:

Q. 36. What spacing of turns are you making in your assumption?

A. The assumption which I made assumed merely that the wire was straight, laid out as a straight piece, and

that there were no turns, which is the most unfavorable condition in so far as the ratio of inductances is concerned.

[fol. 1904] By Mr. Edwards:

Q. 37. Unfavorable in just what respect?

A. Unfavorable in the point of obtaining a high ratio; that is, it is the condition under which the lowest ratio of inductances exists.

By the Commissioner:

Q. 38. I was just thinking—correct me if I am wrong—that, where you took a piece of wire and wound it in a helix—by the way, is that not what Marconi intended to do?

A. Yes.

Q. 39. Well, then, when it is wound in a helix, does not the spacing of the turns have a great deal to do with the induction?

A. Yes, it does. The closer the turns are together, the greater will be the inductance. However, it is difficult to compare the coil d with that of coil j, in so far as determining an accurate value of inductance ratio is concerned. My comparison gives the lowest ratio of those inductances which could exist, namely, I assumed, in determining that ratio of the square root of 5 to 1, that the coils j' and d were merely straight pieces of wire.

By Mr. Edwards:

Q. 40. When you say "the ratio of inductances," do you refer to the ratio of performance as between the two circuits?

[fol. 1905] A. No. Going back over what I said, I pointed out that there was approximately 2 meters of wire in the coil d and 10 meters of wire in the coil j'. If this wire were laid out straight and the inductance were measured, the ratio of inductance would be roughly 5 to 1. If these same straight pieces of wire were associated with two identical condensers, or two similar condensers, such as e and h, then the resonant wavelength would vary as the square root of the ratio of the inductances, namely, as the square root of 5 is to 1.

Q. 41. I do not think you have left it quite clear. When you speak of the ratio of inductances, is that equivalent

to saying the ratio between the frequencies of these two circuits?

A. No. I tried to bring that out in my last statement: that the ratio of inductances is as 5 is to 1, but the ratio of wavelength is as the square root of 5 is to 1, and the ratio of frequencies would be inversely proportional to the ratio of wavelengths.

Q. 42. I understand that your calculations were based upon wire not wound into coils.

A. That is correct.

Q. 43. And upon that basis what, approximately, is your understanding of the frequency of the circuit h-j' as compared with the circuit f' g' e' under the condition that the circuit f' g' h' E is tuned to the resonance of the incoming frequency?

[fol. 1906] A. Since we have been speaking of resonance wavelength, I will answer the question first in terms of ratio of wavelengths. The circuit f' g' h E is tuned to a wavelength which bears the ratio indicated above of one to the square root of 5, with respect to the wavelength to which the circuit h-j' is resonant. In terms of frequency, the circuit f' g' hE would be resonant to a frequency which bears the ratio with respect to the resonant frequency of the circuit h j', which is approximately as the square root of 5 is to one.

By the Commissioner:

Q. 44. Now, as I understand it, your whole answer is based upon the fundamental assumption that these coils are formed in straight lines and not in coils.

A. That is correct. Now, if the assumption is made that these lengths of wire are wound in the form of coils, then the ratio which I have indicated would be much larger.

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[fol. 1907] (Tr. 1381)

Q. 45. Commander Dow, referring to Figure 2 of the Marconi patent, am I right in understanding that, if the wavelength of the antenna circuit f' g' h and E is in resonance with the circuit e, d, and C of Figure 1, that the wavelength of the circuit h j' in Figure 2 will be longer than that of the circuit f' g' h E?

A. That is correct, and that is borne out by the analysis which I made this morning in comparing the coils j' and g

when used in conjunction with the two condensers e and h which had substantially the same capacity as is indicated in the table on page 4 for tune 3, and that is also borne out by the places in this table where it is possible to compare the condition of adjustment of the circuits for two different tunes, such as tunes 3 and 4. My estimate, based upon the analysis which I made, is that the resonant wavelength of the circuit h j' is at least the square root of 5 times the resonant wavelength of the circuit e g C of Figure 1. The square root of 5 is something over 2.

Q. 46. Does the same ratio obtain if the circuit h j' is tuned to a wavelength corresponding to the wavelength of circuit e g C of Figure 1?

A. If the circuit h j' was tuned to the same wavelength, it would be possible to select a value of g' which would make the theoretical resonant wavelength of the antenna circuit, consisting of f' g' h and E resonant to the same [fol. 1908] frequency as the circuit h j'. However, in doing that, the circuit h j' would, in effect, introduce extremely high impedance, which would be in the nature of a resistance, because of the resonant condition, into the circuit between the antenna and the ground. Whether such a circuit could ever be made resonant, I do not know. I would have to investigate that.

Q. 47. Yes. Now, as I understand it, your basis of comparison was that the length of wire in the respective coils was a straight wire and not a coiled wire. Am I right in that?

A. That is correct.

Q. 48. Now, if you had used a coiled wire, what would have been the difference with regard to the ratio between the wavelengths of circuit h j' and f' g' hE?

A. The ratio of the wavelength between h j' and that of f' g' hE would be much greater. That is, the wavelength of the circuit h j', instead of being roughly twice that of the circuit f' g' hE would be three, four, or perhaps five times as great.

By the Commissioner:

Q. 49. Is this last assumption of yours based on uniform spacing of the turns, or uniform diameter of the turns, or what?

[fol. 1909] A. Assuming, for instance, that the coil D is about one meter around—that is, it takes one meter of wire

to make one turn. That would mean that the wire on the coil j', if wound into a coil of the same diameter, would make about three turns to one in coil D, or to one-half in coil D, if the turns were spaced the same distance. Then the ratio of the inductance in coil j' to that in coil D would be approximately as 9 is to 2.25, or four times as great.

Now, the coil j' is wound into a much smaller space—that is, the wire of coil j' is wound in a much smaller space than that, so the ratio would be even greater than 4 to one.

I might amplify that a little for the purposes of clarification by stating that, if you have a piece of wire and wind it into a coil, the smaller you make the turns without approaching infinites/imal dimensions and the more turns you have in a given space, the greater will be the inductance for a given length of wire; provided, of course, that the wire is not wound in such a way that one turn cancels the other one, as by winding the wire back on itself.

Mr. Edwards: I will offer in evidence at this time copy of Patent No. 640,516, granted January 2, 1900, to M. I. Pupin, upon application filed May 28, 1895, as Defendant's Exhibit KK.

[fol. 1910] Mr. Blackmar: May I ask the purpose of that, Mr. Edwards?

Mr. Edwards: The purpose of this offer is to show the function of the condenser h in the Marconi patent, and the difference between that function and mode of operation and the function and mode of operation of corresponding condensers in the prior art and in the defendant's device.

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(Tr. 1387)

The Commissioner: Obviously, as I understand the offer of this patent of Pupin, it does not in any way attack the validity of Claim 16 of the Marconi patent in suit. As you state, Mr. Blackmar, that has been decided by the Court, and I do not recall just now what procedure was followed after the decision and prior to this accounting proceeding; but the defendant had at that time opportunity for a motion for a new trial and presentation of newly-discovered evidence and all those matters.

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The Commissioner: Oh, yes. They had all the customary opportunities of complete review of all the questions of infringement and also validity.

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[fol. 1911] (Tr. 1388)

The Commissioner: I do not believe that defendant's counsel at this late date could presume to introduce any prior art to go to the validity of Claim 16.

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I take the offer just as he stated it, that the Pupin patent is offered for the sole purpose of aiding the witness and the Commissioner and the Court in an understanding of how the condenser in the Marconi patent operates. That is my interpretation of this offer.

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(Tr. 1391)

The Commissioner: I will take it in evidence, in accordance with the understanding which I expressed for the record a few moments ago.

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Q. 50. Have you read the Pupin patent, 640,516?

A. I have.

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[fol. 1912] (Tr. 1392)

Q. 52. Will you refer to the matter on page 1 of the Pupin specification, especially beginning at line 9 and running down to line 20, and explain what that operation is; and, in doing so, you might refer to Figure 2 of the drawing of the Pupin patent.

A. Figure 2 of the Pupin patent shows a system that is responsive to alternating currents which are impressed at the point x.

Q. 53. If you will permit the interruption, you might refer to Figure 1 first, because that leads up to the other figures.

A. Pupin states broadly, beginning with line 9, that, if a condenser and a self-induction coil are connected in shunt, and an alternating current is impressed across such a circuit, the current in the shunt circuit flowing around the shunt circuit will be greater under certain conditions than

in the line itself. Such a circuit was illustrated in the sketch which I drew this morning, and curves were shown to indicate the conditions under which this phenomenon existed.

That is, when the frequency of the alternating current corresponded to that resonant frequency in which the shunt circuit is tuned, then the circulating current of the shunt circuit will be a maximum; and, concurrently and coinci- [fol. 1913] dentally, the current in the line feeding the shunt circuit will be considerably less. In fact, it is usually at the minimum value at that point.

By the Commissioner:

Q. 54. In your discussion this morning in connection with the circuit, and the curves which you drew, Defendant's Exhibit JJ, did you have anything in mind in connection with your testimony, other than what is termed by those skilled in the art as radio frequency?

A. That phenomenon is found regardless of the frequencies. It applies to all alternating currents.

Q. 55. It applies to what?

A. It applies to alternating currents of any frequencies.

Q. 56. Then your discussion this morning is not limited to phenomena such as are referred to as involving currents of radio frequency?

A. No, sir. It refers to any frequency.

Mr. Blackmar: I might point out to your Honor that antennas are involved in those circuits.

The Commissioner: That is a point I had in mind, that the sketch should involve antenna.

The Witness: Well, but the curves are applicable to the same circuit, whether a low frequency is impressed on the antenna or a high frequency.

[fol. 1914] A. (continued): Pupin further states, beginning with line 33, as one of the conditions to be met with in the adjustment of the circuit, that the capacity of the condenser and the self-induction of the shunt coil must be so related as to bring the shunt circuit in resonance with the line current; and, beginning with line 68, he states:

"By a 'resonance circuit' is meant one which has self-induction and capacity and therefore a natural period. When the self-induction and capacity are properly adjusted

so as to give it the period of the impressed electromotive force, the resonance circuit becomes resonant to this electromotive force."

Q. 57. In connection with Figure 2, Pupin states, beginning with line 89 on page 2:

"Referring now more particularly to Fig. 2 which represents the receiving end of the line and can be hitched onto the transmitting end shown in Fig. 1 instead of the receiving end shown in that figure, I show a resonance circuit H I and K L."

These are two resonance circuits in series, between the point x and the earth connection.

"The condensers H and K, as in Fig. 1, are in series in the line; but I control the frequency of H I by means of a circuit H' I' I", which contains the secondary coil of the induction coil I I' and the supplemental condenser H' and a self-induction coil I'."

[fol. 1915] He adjusts this condenser h, or selects the condenser h, and inductance I of the primary coil of his transformer to be resonant to frequencies that he is interested in transferring to the secondary circuit.

He also adjusts the secondary circuit consisting of I' and inductance I" and the inductance of the solenoid of his responsive device, to neutralize the capacity of his condenser h', so that the secondary circuit is also resonant.

By the Commissioner:

Q. 58. What is the character of the current impressed on x?

A. An alternating current. He does not state the frequency, as I recall; but, presumably, it is a relatively low frequency. That is, as far as I can gather from his disclosure. Perhaps it is some frequency between 25 cycles and 2,000 cycles per second.

Q. 59. Continuous?

A. No. He interrupts his current with a key. If you will refer to the left-hand part of Figure 1, which shows his alternators which generate the frequency, you will see that he has one alternator A and the other one B. And, in those circuits, he has a key; so that if, for example, alternator A has a frequency of say 100 cycles per second.

he impresses that on the line x g' and, for the resonant frequencies, the circuit consisting of condenser h and the coil I is adjusted to resonate at this frequency of 100 cycles [fol. 1916] per second; and then the maximum current possible will flow in the primary coil of his transformer I-I'.

If he at the same time adjusts the inductance I'-I", plus that of the solenoid in the responsive device M, so that the value of that capacity of the circuit is neutralized, so that that circuit also is resonant, then he will get a maximum transfer of current or of voltage to the secondary circuit.

Q. 60. What I had in mind when I made my inquiry with reference to the word "continuous," was the generators A and B themselves in Fig. 1, rather than a key. In other words, my inquiry went to what kind of current these generators produce.

A. I would say probably current in the nature of simple alternating current, very much as you would have—except with much lower frequencies—the same as you would have with a modern C W radio transmitter.

Q. 61. A continuous current?

A. Continuous current.

• • • • • • •

By Mr. Edwards:

Q. 63. I believe you mentioned that Pupin might or would operate with frequencies up to in the neighborhood of 2000. Did you have in mind at that time the fact that Pupin mentions a frequency of 250 in the circuit, for example on page 2, about line 86, and perhaps in other places?

[fol. 1917] A. I did not at the time I made that statement, although I can see no difference in the operation of the circuits of Figure 1 and Figure 2, whether the frequency was 100 or 250 or 2000 cycles per second. Those are all within the range of audibility in which his responsive device M was undoubtedly operative.

Q. 64. What would be your opinion of a range of frequencies up into the neighborhood of 2,000?

A. Those are all audio frequencies, but could be used in such a system as that shown in Figures 1 and 2.

• • • • • • •

(Tr. 1398)

Q. 66. What instruction does Pupin give in regard to securing the stated desired object of having greater current in the coil than in the condenser path?

A. I think I quoted from the specification beginning about line 33 on page 1, that the capacity of the condenser and the self-induction of the shunt coil must be so related as to bring the shunt circuit in resonance with the line current.

Q. 67. And the wavelength of the line current in this case would be that of the wire from the generator?

A. That is right. The wavelength would b equal to the velocity of light divided by the frequency. That would be the wavelength along the wire.

[fol. 1918] Q. 68. Well, from the fact that he mentions that it is in the multiplex telegraphy system, is it or is it not a fair inference that the frequency of the current is transmitted by wire from the wire x at the transmitter to the wire x at the receiver?

A. That is correct.

* * * * * * *

Mr. Edwards:

I will offer in evidence a copy of the Fessenden patent No. 706,735, granted August 12, 1902, upon application filed December 15, 1899. I may say that this patent is already in evidence as one of the plaintiff's exhibits. It is part of Complainant's Exhibit 171, and appears on pages 90 to 97 of that exhibit.

* * * * * * *

(Tr. 1401)

It is offered in justification of what the defendant has been doing. I am offering it at this time as a matter of convenience, in order to have in this record on accounting the prior art, such as Pupin and Fessenden, together.

* * * * * * *

But here I offer it, not to show invalidity but as showing justification for the defendant's use.

I ask that this be marked Defendant's Exhibit LL.

* * * * * * *

[fol. 1919] (Tr. 1406)

By Mr. Edwards:

Q. 69. Commander Dow, will you look at Fessenden Patent 706,735 and explain the operation of that device, particularly with reference to the function of the condenser 19 in Figure 1 of the patent?

A. Fessenden shows, in the right-hand sketch of Figure 1, a transmitting station comprising antenna conductor 5 and 5-A, a ground connection down in the lower right-hand corner of the figure, which is not marked, an induction coil 1, a primary which is connected through battery 2 to the key 3 for interrupting the flow of current; a spark gap, 4-4, and a condenser 18 across the spark gap.

In the left-hand figure he shows a receiving system for an aerial conductor 6, which is connected through a shunt circuit consisting of the inductance 7, which consists of two coils with a galvanometer and a condenser 19.

He states in his specification, as shown in Figure 1, beginning with line 101 on page 2 of the specification:

"As shown in Fig. 1, a condenser 19 may be connected in shunt with the field coil or coils 7 for the purpose of obtaining as large a current as possible in the field coil 7, as this increase in current will give a greater torque to the ring 8."

He further states, in continuation, beginning with line 25 on page 3 of the specification:

[fol. 1920] "This shunt circuit must be tuned to the receiving conductor; otherwise, the oscillations produced by it will have no action upon the wave-responsive device at the receiving station. This shunt circuit, by virtue of its capacity, stores up an additional amount of energy, and, when a spark passes across the gap, since the sending conductor can radiate energy at a given rate, it must continue to radiate for a longer time, in order to dissipate this additional stored-up energy."

In the matter between the two quoted portions that I read, he explains, among other things, how, when this shunt circuit is made resonant to the incoming frequency, the current flowing around the shunt circuit is greater than in

the antenna, just as I explained in connection with the sketch which I drew this morning.

* * * * * * *

(Tr. 1408)

Q. 72. How does the transmitter portion of Figure 1 of the Fessenden patent compare with the transmitter Figure 1 of the Marconi patent in its function and mode of operation?

A. Marconi employs two circuits in his transmitter, with a rather loose coupling between them. The transmitter of Fessenden is what may be called a direct-coupled or very closely-coupled system, in that his primary circuit or oscillation-generating circuit is directly connected to the aerial conductor or antenna. Marconi also has the coil g' [fol. 1921] in his antenna, whereas Fessenden has not. Marconi uses a loading coil. The wave emitted by the circuit shown by Fessenden would, according to all experience that I have had with spark transmitters, be a highly damped one. The wave emitted by the Marconi circuit would be classed as a damped wave, but would not be nearly so highly damped. In so far as frequency is concerned, they might have the same frequency. Both would be approximately radio frequencies. Both Fessenden and Marconi receivers would be receiving the radio waves.

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(Tr. 1410)

By the Commissioner:

Q. 78. Let us go back to radio waves in connection with Fessenden. You say that Fessenden would transmit waves that would be highly damped. What do you mean by that?

A. I mean by that that the individual wave trains which were caused by the discharge of the condenser 18 would have—or would die out in the course of a few, a very few, high-frequency cycles.

Q. 79. Would that have any effect on resonance?

A. It would, to this extent: that the waves generated by Fessenden's apparatus would take up a wider band of frequencies in the spectrum than would be taken up by Marconi's apparatus. This Marconi apparatus was more selective.

* * * * * * *

[fol. 1922] The Commissioner: Perhaps we can save some time there, if the witness will tell us whether the Marconi transmitter is what has been referred to here as a tuned transmitter.

A. Marconi's system, comprising his transmitter and receiver, is capable of much sharper tuning than that of Fessenden.

By the Commissioner:

Q. 81. Would you call Marconi's transmitter a tuned transmitter?

A. Both Marconi's and Fessenden's are tuned transmitters.

. . . . . .

(Tr. 1415)

By Mr. Edwards:

Q. 97. Now come to the receiver portion of the Fessenden patent. How does the coil 8, which you term the galvanometer coil, compare, in its function and operation, with the secondary circuit shown in Figure 2 of the Marconi patent?

A. The coil 8 of the Fessenden patent is not tuned by a secondary condenser, as in the case of the coils j'' of Figure 2 of the Marconi patent. Had Fessenden tuned this coil 8 in the manner taught by Pupin, he probably would have gotten a greater effect than he did with the arrangement shown by Fessenden.

[fol. 1923] Q. 98. Now, tell us what happens when current is induced in the coil 8 of the Fessenden receiver.

A. Well, due to the magnetic field set up by the primary coil and the magnetic field set up by the induced current in the secondary coil, the coil 8, a torque is produced, and the coil 8 tends to turn, giving an indication of the incoming signal.

Q. 99. How does that operation compare with Marconi's Figure 2, so far as detection goes?

A. Well, Marconi employed another form of detector. Marconi used an entirely different form of wave responsive device. He used a detector and a receiver. His detector in Figure 2 is the item indicated by T.

. . . . . .

(Tr. 1418)

Q. 104. Yesterday, Commander Dow, you were referring to the comparative operation of the Fessenden and Marconi transmitters. Can you make a simple sketch showing the form of wave trains created in the charging circuit, and the form as emitted from the antenna in each of the transmitters?

A. I have drawn such a sketch.

In the circuit of Fessenden, the right-hand circuit in Figure 1 of the drawings, the antenna is directly connected to the charging circuit; so that the wave trains in the antenna would be the same as those in the charging circuit. [fol. 1924] By "charging circuit" I mean the circuit of the spark gap and the condenser 18. In the circuit of Marconi, Figure 1, where a loose coupled arrangement is used rather than a direct coupling arrangement as in the case of Fessenden, the closed circuit is as I have indicated in my sketch.

When the spark gap breaks down, by virtue of the coupling between Marconi's coil d–d', the currents are induced in the open circuit, and very shortly following the instant of the breaking down of the gap, the current begins to build up in the open circuit of Marconi and reaches a maximum; and then, during the series of oscillations, which are in general of the same character as those of Fessenden, the oscillations continue in the open circuit, even for a short period of time after the oscillations die out in the closed circuit.

From the sketch I have drawn, showing the action in Fessenden and that for Marconi, the general character of the oscillations in the two circuits or in the circuits of Fessenden and Marconi, are very much the same.

* * * * * * *

(Tr. 1421-2)

Q. 112-3 Is it now and has it always been necessary to employ some device for the purpose of translating these electromagnetic or electrostatic waves into sound waves?

A. It is and has.

[fol. 1925] Q. 114. What is such a device usually known as?

A. Such a device is usually known as a detector.

* * * * * * *

The device shown in the Fessenden Patent 706,735 is only for translating the electromagnetic waves into the movement of a mirror which can be seen or sensed visually rather than orally.

Q. 116. Now, specifically, just how is that done in the device shown in the receiver of Figure 1?

A. As I explained yesterday in my testimony, the electromagnetic waves propagated from the transmitting station set up a flow of current between the antenna 6 and the earth connection, which is shown but not identified by a reference character.

Between the earth connection and the antenna 6 is a resonance circuit consisting of the condenser 19 and two coils 7. This circuit is made resonant to the radio frequency of the incoming signal. Interposed between the two coils 7 is a secondary coil 8, which is suspended by a string; the current flowing from the coils 7 sets up by induction a flow of current in the coil 8.

As a result of the magnetic fields due to the currents in the coils 7 and the coil 8, the ring 8 is caused to turn, which causes the mirror 9 to move, and causes a light beam to move on the scale shown.

[fol. 1926] Q. 117. What was the function and mode of operation of the condenser 19 in this receiver shown in Figure 1?

A. The condenser 19 is employed to cause the circuit, including the coil 7 and the condenser 19, to be resonant to the frequency of the incoming oscillations.

Q. 118. Then, when it is resonant, what happens?

A. When it is resonant, the maximum current flows in the coils 7 and the maximum effect upon the secondary coil 8 is produced. When this condition exists, as explained in Fessenden, with the matter beginning with line 102 on page 2 and continuing through to line 13 on page 3, the current in the resonance circuit is much greater than the current in the antenna circuit.

Q. 119. To what wave length is the circuit 19–7 made resonant?

A. That is, as I explained, made resonant to the radio frequency of the incoming signal.

* * * * * * *

(Tr. 1425)

Mr. Edwards: I will offer in evidence the sketch made by the witness, shewing the wave trains of the transmitters.

according to the disclosure of Marconi, and I will ask that this be marked Defendant's Exhibit MM.

* * * * * * *

(Tr. 1494)

Q. 271. If the loading coil corresponding to the wavelength of both the normal and highest wavelength of one of these instruments, as given in the instruction books, but lower than the highest assigned wavelength of the secondary [fol. 1927] of the instrument, were used, what would be the relative advantages or disadvantages of using such a coil, as compared with placing the condenser in shunt with the primary of the inductances in the circuit?

A. To answer that question from an engineering point of view would require a knowledge of the detailed construction of the receiver and the coils—that is, the resistances of the coils enter into it. However, the fact that it became unconventional to connect the primary condenser in parallel with the primary inductance in receivers of this general design which followed the period under consideration, leads me to believe that it was at least as efficient, if not more efficient, to employ the external loading coil, instead of connecting the primary condenser in parallel.

This is also confirmed, in a measure, by the fact that if it were more efficient to have a primary condenser connected across the antenna inductance system, it would have been used, not only in the last two positions of the switch of some of these receivers, but in the other positions also.

Q. 272. Take the SE 143, for example. If the proper-sized loading coil were substituted to give a wavelength range up to, say, 6,800 meters, which, as I recall it, is the wavelength range for the secondary in that instrument, [fol. 1928] what would be the relative advantages of the load coil and the parallel connection, with respect to selectivity or efficiency?

* * * * * * *

A. I am unable to answer that question without going into the actual design of the receivers, since so many factors are involved in determining the answer to such a question. I might add that the fact that external binding posts were provided for a loading coil, would indicate to me that the use of an external loading coil was the preferred arrangement, and, possibly, the more efficient one.

Q. 273. Why would it be the preferred arrangement from the standpoint of operative advantage or increasing the efficiency or other qualities of the instrument?

A. If it had been intended by the designers of the receivers that the primary condenser be used, in preference to an external load coil for extending the frequency range or extending the wavelength range of the receiver, the designers would have provided two or more conveniently-arranged binding posts with suitable arrangements for rapidly making the connections of the condenser.

Q. 274. Granting all that, would the load coil serve just as well as the condenser in parallel, or would it have advantages, or disadvantages?

[fol. 1929] A. It is my opinion that the load coil would have been the much preferred arrangement.

Q. 275. For what reasons?

A. Because by the use of a loading coil the entire antenna circuit is made resonant. By that I mean that all of the capacity and inductance in the antenna circuit as a whole, including that in the antenna as well as in the coils and condensers of the circuit, are resonated to form a simple resonant circuit. Where a condenser is connected across a coil which provides only a part of the total inductance that is in the circuit, the resulting electrical structure is much more complex.

. . . . . .

A. (continued). In order to provide for an efficient transfer of energy from one point of the circuit to another part, there must be a proper match of impedances. The impedance of a circuit, consisting of a condenser and inductance in parallel—the impedance of a parallel resonant circuit consisting of an inductance and condenser in parallel, is very high. To properly and efficiently transfer energy to such a circuit, requires that the generator impedance be high also. By this I mean that if the impedance of the antenna circuit measured between the point of connection of the antenna to such a parallel circuit and the ground connection to such a parallel circuit is not high, the transfer of energy would be inefficient. It is like attempting [fol. 1930] to transfer energy from a storage battery, a high capacity storage battery, to a high resistance. To provide for a transfer of maximum power or energy from such a storage battery to a resistance would require that the re-

sistance of the battery be made substantially equal to that of the resistance.

* * * * * * *

By the Commissioner:

Q. 277. I am afraid your answer is rather long, and I would think a little complex, myself. Let me see if I get the gist of your answer. As I understand it, it covers two basic things: first, am I correct in assuming that you stated that the electrical circuit involved in the parallel connection of the condenser was much more "complex" than the series connection?

A. Much more complex electrically.

Q. 278. Not physically?

A. Just electrically.

* * * * * * *

By Mr. Edwards:

Q. 280. Could you make a diagram explaining that operation?

The Commissioner: Before you make a diagram, let us look at the physical question. It is no more complex physically, as far as elements are concerned?

The Witness: No.

[fol. 1931] By the Commissioner:

Q. 281. It costs no more to manufacture?

A. No. However, from the point of view of efficiency, determining the efficiency, it is much more complex in the case of the parallel circuit. I have prepared a sketch to indicate and or to show a comparison between a circuit in which all of the elements are in series, as in the case where a loading coil is used, and a circuit in which the parallel condenser is used.

Where a number of capacities and inductances are in series the circuit can be readily reduced to a simple one, consisting of a single inductance and a single capacity.

By Mr. Edwards:

Q. 282. Would you mind saying as shown in each one of your figures?

A. As shown in the right-hand upper figure labeled "Equivalent Simple Circuit." The capacity in this case is equal to the product of the two capacities, divided by their sum. The inductance is merely the sum of the several inductances, including that of the loading coils, coupling coils, and the antenna. Where an antenna is connected, or where a parallel resonant circuit is connected between an antenna and ground the case is not nearly so simple electrically and consists of two coupled circuits.
[fol. 1932] To determine the best values of inductance and capacity for the several portions of the circuit in order to permit the most efficient transfer of energy from one through the other, presents a rather complex electrical problem, but one which is amenable to solution.

By the Commissioner:

Q. 283. Before you go into all the detailed solution of this problem, is it a fact that, in your opinion, the parallel connection of the condenser is more complex electrically than the series connection?

A. That is correct.

Q. 284. And all of these sets involved in this accounting proceeding in which you are now testifying as an expert witness, called by the defendant, did use that parallel connection, did they not, even though it was more complex electrically?

. . . . . .

A. I know only that in the case of certain receivers switches were provided in the design of the receiver for employing a parallel connection of the condenser. In certain portions of the wavelength band in other receivers, no switches were provided, but mention was made in the instruction book that the condenser could be connected in parallel by making certain external connections, and in other receivers no mention was made in the instruction book regarding this use.
[fol. 1933] In all of these receivers, except those which I understand are grouped in Class I, external binding posts were provided for the specific purpose of inserting a loading coil for increasing the frequency range or increasing the wavelength range.

Q. 285. Then do I take your answer to mean that you do not really know whether these were used? I suppose

you really do not know whether the parallel connection was used. I believe that is the interpretation I have put on it. So suppose I reframe my question and ask you if in some of these receivers, at least, the sets were not capable of such parallel operation. Take the ones with the switch. What was the switch for?

A. In that case the switch was for the purpose of connecting the condenser in parallel.

Q. 286. Even though it possessed the more complex electrical characteristics?

A. That is correct.

Mr. Edwards: That would be true of Groups I and II. The switch was there and we did use it.

Q. 287. Somebody thought that was a good thing to have on those sets, didn't he?

A. It was, mechanically and electrically, a convenient arrangement, although, from the point of view of electrical efficiency of the circuit, it may not have been the most desirable one.

Q. 288. Why was it put on the sets?

A. Because of its mechanical and electrical convenience, probably.

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[fol. 1934] (Tr. 1502)

Mr. Edwards: I offer in evidence the sketch made by the witness, as Defendant's Exhibit PP.

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Dow—Cross

(Tr. 1550)

X Q. 452. That was my question, I think. Now I wish to refer you to Plaintiff's Exhibit 413-A. It is one of the instruction books for the SE 143 receiver. On sheet 2-A thereof this statement appears in reference to Figure 1: "This places the primary variable condenser in parallel with the primary inductance. This combination is very efficient on waves longer than 3,000 meters; on short waves, it is not as efficient as the series capacity." Do you agree with that statement?

A. I would take that statement as being correct, since the efficiency of the circuit is dependent upon the ratio,

or is dependent upon the design, which involves the ratio of capacity to inductance. For any given frequency, an optimum ratio of capacity to inductance exists.

X Q. 453. In view of that statement, may I ask the basis for a statement which you made in your direct examination today, namely, that the use of a loading coil was—and I think I am quoting you—"the much preferred arrangement" in the SE 143?

[fol. 1935] A. I think that the statement I made should be quoted more completely.

X Q. 454. Do you now think that the use of a loading coil in the primary circuit of the SE-143 was much preferred to the use of the parallel connection for an increase in the range of the primary circuit?

A. The use of a loading coil with an antenna series condenser would permit of an impedance match between the antenna and earth connections and the coupling circuit of the receiver. Where a parallel resonant circuit is used at resonance the impedance is extremely high, reaching a value of many thousands of ohms, ordinarily. Normally, the impedance of short antennas—that is, antennas that do not approach a quarter of a wavelength in length,—is relatively low, compared with that; therefore, if an antenna were connected to a parallel resonant circuit, there would be a mismatch of impedances. For that reason I would say that the use of a loading coil would be the more efficient arrangement.

X Q. 455. You think the use of a loading coil would be better in the SE 143 than the parallel connection for the purpose of extending the range of the primary circuit so that it would cover the same range as the secondary circuit; is that correct?

[fol. 1936] A. I can foresee engineering points involved, in an answer to that question in the manner in which it is framed.

• • • • • • •

X Q. 457. What is the difficulty with the way it is framed?

A. In that the question refers specifically to the SE 143 receiver; and I am not familiar in detail, as I mentioned this morning, with the actual ratio of capacity to inductance, and the resistance of the coils of that receiver.

• • • • • • •

(Tr. 1554)

X Q. 461. Let us get back to the question of which is the preferred arrangement, or which is the better. With respect to the SE 143, are you prepared to say which would be better, the use of the parallel connection of the antenna condenser, or the use of the loading coil?

A. Why, it would certainly be more convenient.

X Q. 462. I did not ask you that.

A. I should like to ask if your question is directed to a matter of efficiency, or convenience?

X Q. 463. Efficiency.

A. Then it would be necessary, to answer the question, to consider the circuit design.

X Q. 464. You cannot answer that with your present knowledge of the SE 143; is that correct?

A. That is correct.

[fol. 1937]

(Tr. 1555)

X Q. 467. Perhaps it is a little involved. I will split it into two questions: does your statement that you cannot say which would be the more efficient,—the use of a loading coil or the use of the parallel condenser with the SE 143, because you are not sufficiently familiar with the circuit characteristics,—apply to the other receivers of Group III?

A. Yes. In amplification of that, I should like to say that for the reasons given above an impedance match does not exist when the parallel connection is used, which would favor using a loading coil, provided the proper ratio of inductance to capacity could be maintained. To answer the question completely, and based upon an engineering study of it, would require a detailed examination of the electrical constants of the resulting circuits.

* * * * * * *

X Q. 468. Then I take it from what you have been saying that the design of a receiver is something that requires real engineering knowledge and skill?

A. That is correct.

X Q. 469. And to determine what arrangement of circuits may be most efficient with any particular receiver, requires either a comparatively complete knowledge of the constants of that receiver, or actual test of the receiver, does it not?

[fol. 1938] A. That is correct. For example, in the light

of existing knowledge all of these receivers that we are now considering would be classed as very poor receivers, for many reasons.

X Q. 470. That was not true in 1917, 1918, and 1919, was it?

A. That is correct.

X Q. 471. That is, they were high-class receivers, in those days?

A. That is correct.

X Q. 472. And for example with these various types of receivers it is possible to tune the primary circuit to a particular wavelength with various combinations of inductance and capacity. Isn't that ordinarily so?

A. That is correct.

X Q. 473. That is, you would increase the inductance and decrease the capacity and tune it the same way, wouldn't you?

A. That is correct. However, an optimum ratio of capacity to inductance exists for the most efficient operation.

X Q. 474. That is what I was coming to. Of those various arrangements, one is best, normally?

A. That is correct.

X Q. 475. And likewise when you increase the range of the primary circuit beyond its normal range with the series connection, whether it is better to do that by a loading [fol. 1939] coil or by a parallel condenser, depends on the constants of the receiver and the way it is constructed, doesn't it?

A. That is correct.

* * * * * * *

[fol. 1940] (Tr. 1560)

X Q. 478. I show you a sketch. Does that fairly indicate the primary circuit of the SE 143, with a loading coil used to increase the range of that circuit, the sketch indicating in the dotted line the antenna capacity?

A. Yes; except that the antenna capacity you have placed in the ground lead rather than in the antenna lead.

X Q. 479. Yes, I see. I will correct that. Is the antenna condenser on the antenna side of the loading coil that we have spoken of?

A. It is.

X Q. 480. Now, does the corrected sketch that I show you, then, correctly represent the circuit that I have discussed?

A. Yes, it does. I might add that you have shown the antenna capacity in dotted lines, or you have shown the equivalent circuit of the antenna in dotted lines represented by a capacity only. That is satisfactory in this case, since the inductance of the antenna would be quite negligible compared to the other inductances in series.

X Q. 481. Would you mind drawing, to the right of that sketch, the equivalent circuit?

A. I will draw it.

X Q. 482. In the left-hand sketch, I will mark the——

A. I would like to add, here, that it is assumed that we are considering the operation of this circuit at a given frequency, and that the capacity of the antenna is assumed to be the effective capacity at that particular frequency.

[fol. 1941] X Q. 483. I will accept those assumptions. Now, I will mark on the left-hand sketch referened characters for the various reactances: C for the antenna tuning condenser; L_1 for the loading coil; L_R for the loading coil embodied in the receiver; L_C for the coupling coil; C_A for the antenna capacity. Will you please indicate on your sketch of the equivalent circuit at the right, the corresponding elements?

A. I am assuming further that the consideration of the—or the extent to which this circuit is to be considered, permits the ignoring of the resistances in the circuit.

X Q. 484. Have you marked your sketch as I requested?

A. I have.

X Q. 485. You stated that there was no series parallel switch on the diagram SE 143 that you have before you. Are you familiar with the method of connecting the antenna tuning condenser in parallel with the coils, as indicated in the beginning of the instruction book?

A. I am. The condenser is merely connected by a rearrangement of the circuits outside the front panel, to put the condenser in parallel with the inductances.

X Q. 486. Now, I have drawn on the same sheet at the lower left-hand corner another circuit diagram. Does that properly represent the primary circuit of the SE 143 re-
[fol. 1942] ceiver when the antenna condenser is connected in parallel, as described in the instruction book? The sketch also indicating, in dotted lines, the capacity of the antenna.

A. This diagram shows the proper connection of the condenser across the inductance coils. However, in this case, the inductance of the antenna is not in series with

an inductance which would make the antenna inductance negligible at all frequencies. It would be more accurate, in making an analysis of such a circuit as this, to show in series with the effective antenna capacity an inductance representative of the antenna inductance.

X Q. 487. Can you state at what frequencies relative to the fundamental of the antenna itself, the inductance of the antenna would be negligible?

A. I cannot state that offhand. As I pointed out in connection with my sketch yesterday, it is very difficult to compare a relatively simple electrical circuit with one which can be shown analytically to be quite complex, without knowing the various electrical constants of the circuit.

X Q. 488. In your sketch at the right of the top which you have already made, you have neglected the distributive capacity of the coils, have you not?

A. Yes; also the resistance of the circuit is neglected.

[fol. 1943] X Q. 489. Does the resistance have any effect on the tuned frequency of the circuit?

A. Only a very slight effect, which can be considered negligible, I think for present purposes.

X Q. 490. Now, the distributive capacity of the coils extends, does it not, not only from each turn to each adjacent turn, but also from each turn to other turns in the same coil?

A. Yes, that is correct. But, in treating analytically circuits having coils with distributive capacities, it is the custom to consider the distributive capacity of the coil to be represented by a small capacity in parallel with the coil.

The actual value of the distributive capacity will vary with the wavelength or frequency used, just as the effective capacity of the antenna varies with the wavelength or frequency used.

However, if the conditions that were assumed at the beginning of this discussion are made, namely, that we are considering the operation of these circuits at a given frequency, it is sufficient to consider a capacity as a given value for such a frequency.

X Q. 491. That is a convenience, rather than an accurate mathematical assumption, is it not?

[fol. 1944] A. No. It is accurate to consider the effective value of a capacity as an accurate value for any particular frequency.

X Q. 492. For any particular frequency, yes.

A. Yes.

X Q. 493. Supposing the frequency is changed. Then that capacity is changed, too, is it not?

A. Yes. It is accurate to substitute in this formula the actual value of the capacity.

X Q. 494. Then, as to the inductance of the antenna itself, does that increase or decrease as the wavelength increases?

A. I have not reviewed that particular thing for some years; but I am quite sure that the inductance of the antenna can be considered as constant for any particular frequency. That is, when the capacity changes, when the effective value of the capacity changes, that change is due to the change in the inductance of the antenna.

X Q. 495. As the wavelength which you are considering increases, is it not true that the inductance of the antenna becomes of less and less importance, due to the fact that the other inductances in the circuit are increasing?

A. That is correct.

X Q. 496. Now, the parallel connection in the antenna is used on the longer wavelengths, is it not, normally, rather than the shorter?

[fol. 1945] A. Yes, that is correct.

X Q. 497. For any particular receiver?

A. That is correct. That is, as it was used in these receivers that are under discussion.

X Q. 498. That is all I am interested in for the moment. In those cases it was on the longer wavelengths that the parallel connection was used?

A. Yes, that is right.

X Q. 499. And, on those wavelengths, the antenna inductance was smaller in comparison with the other inductances in the receiver than on the shorter wavelengths, was it not?

A. That is correct.

X Q. 500. Have you any idea of what the magnitude of the antenna inductance might be, for antennas such as the SE 143's were used with?

A. I cannot, offhand, indicate the value of that. It is quite small.

X Q. 501. Quite small?

A. Yes.

X Q. 502. It does not amount, for example, to as much as the inductance of the coupling coil which I have denominated L_c in the antenna circuit, does it?

A. I would say that it should be somewhat smaller than that.

[fol. 1946] X Q. 503. And, considering the reactance of the antenna at the longer wavelengths, it would be capacitive, would it not?

A. Yes, it would.

X Q. 504. Now, will you draw, at the lower right of the figure, please, the equivalent circuit of the lower left-hand figure, and mark the element with reference characters corresponding to those in the left-hand figure, please?

A. I have so drawn the circuit.

X Q. 505. I think you have added an additional reference character there which does not appear in the left-hand circuit. What is that?

A. I have added a small inductance, representative of the inductance of the antenna.

X Q. 506. And how have you marked it?

A. I have marked that L_a.

X Q. 507. Now, I will ask you to disregard the inductance of the antenna and draw an equivalent circuit, disregarding that—whether or not you agree that it should be disregarded. Have you done so?

A. I have.

X Q. 508. Will you add to it the reference characters I applied to the lower left-hand figure?

A. I have.

Mr. Edwards: Read that question.

[fol. 1947] (X Q. 508 was read by the reporter as above recorded.)

Mr. Edwards: I suggest that you make some indication to show that that is not one that follows the rest of the drawings; so, that, later on, we will not be offering this sketch as something with which the witness agrees.

Mr. Blackmar: Yes. I will now mark the five sketches on this paper as follows:

Figure I being the primary circuit of the SE 143 receiver, using a loading coil to increase the range of the circuit.

Figure II being the equivalent circuit thereof, as drawn by the witness.

Figure III is the circuit diagram of the primary circuit of the SE 143 receiver, with a condenser connected in parallel to increase the range of the circuit.

Figure IV is the equivalent circuit thereof, as just drawn by the witness.

Figure V is the equivalent circuit thereof, as drawn by the witness at my request, disregarding the antenna inductance.

* * * * * * *

[fol. 1948] (Tr. 1571)

Mr. Blackmar: I ask that the sheet of sketches be marked as Plaintiff's Exhibit 453 for Indentification.

(The paper just offered was by the reporter marked as indicated, together with his name and the date.)

* * * * * * *

(Tr. 1573)

Q. 513. Does what you have just said or should what you have just said been taken to mean that, in your opinion, in the SE 143 receiver, the parallel connection of the antenna condenser is not so good a way of increasing the wavelength range of the antenna circuit as the use of a loading coil?

A. I am unable to answer that question, as I have explained, for the reasons, as I have explained several times previously—without knowing the electrical constants of the circuit of the antenna, without knowing the frequency under consideration, it is not possible to answer such a question; and, to answer it even with a knowledge of those constants, would require an extended analysis.

X Q. 514. I just want to make sure that what you said before would not be misunderstood also—what you said particularly as to the different impedances of the antenna and parallel circuits.

[fol. 1949] We are not to draw the inference, from what you said as to that, that the parallel connection would not be as good in the SE 143 receiver as the loading coil, are we?

A. No.

* * * * * * *

(Tr. 1584)

X Q. 553. Have you a copy of the Marconi patent?

A. I have.

X Q. 554. That is Patent No. 763,772?

A. Yes.

* * * * * * *

(Tr. 1585)

X Q. 557. What is it in the antenna circuit that is tuned to the received wavelength?

A. The antenna f, the coil g', the condenser h, and the earth capacity e. The coil j' would obviously have some effect on the actual adjustment of that circuit.

X Q. 558. I am not sure, then, that that answers my question, in view of that last reservation and modification. Is there anything in the antenna circuit, or any part of the antenna circuit, that is tuned to the received wavelength? [fol. 1950] A. The circuit as a whole, in whatever complexity it exists, is adjusted presumably so that a resonant condition exists. Now, that resonant condition is affected mainly by certain structural parts of the circuit; and, of course, it is also affected by anything that is coupled to or attached to the circuit, to a greater or lesser degree.

X Q. 559. Do you mean that the circuit as a whole is tuned to the received wavelength?

A. Broadly, I think that is a re-sonable answer to make, since anything which is attached to or coupled to the circuit enters into the adjustment or tune for the resonant condition.

X Q. 560. In other words, then, as I understand you, it is the circuit made up of the antenna f', the loading coil g', the condenser h, and the coil j', and the earth connection?

A. Plus——

X Q. 561. Plus any effects that may be brought into that circuit from the secondary circuit?

A. That is correct.

X Q. 562. That, as a whole, is tuned to the received wavelength?

A. That is correct.

[fol. 1951] X Q. 563. Then, if I understood your direct testimony to be to the effect that it was the circuit f' g', h,

and e, that was tuned to the received wavelength, I misunderstood you. Is that so?

A. There is a question of degree there—that is, the elements that you have just recited mainly determine the resonant condition. Now, there are contributing causes which alter that resonant condition, to a greater or less degree.

X Q. 564. Then, to repeat, if I understood you to say that the circuit which was tuned to the received wavelength was solely determined by f', g', h and e, I misunderstood you?

A. You did. I made no such statement.

X Q. 565. And you do not want your testimony interpreted as meaning that, do you?

A. That is correct.

X Q. 566. What is correct, that you do not want it so interpreted?

A. That is correct.

X Q. 567. In other words, if the value of j' is changed and the circuit is not changed, there will have to be a readjustment of the circuit?

A. Slightly.

[fol. 1952] X Q. 568. Depending upon the amount of change in j'?

A. Yes. The answer to that question should not be misunderstood, in as much as, from the analysis which I made of that circuit, in the light of what is stated in the specification, the effect of j' to me, from those analyses, appears to be only a very slight one—that is, the inductance j' could be increased enormously without seriously affecting the resonant condition. However, if it was materially reduced, it might affect the resonant condition very much.

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(Tr. 1589)

X Q. 572. In other words, to analyze a circuit of this kind, as well as to analyze the antenna circuits of receivers like the SE 143, you really have to know the constants of the individual elements of the circuits, do you not?

A. That is correct.

X Q. 573. Did you ever attempt to duplicate Figure 2 of the Marconi patent, in so far, at least, as the primary cir-

cuit is concerned, for any of the tunes mentioned in the tables on page 4 of the patent?

A. Well, I have not, no.

(Tr. 1597)

[fol. 1953] X Q. 596. Now, if the condenser h, in figure 2 of the patent, is variable, then is it not correct to say that a variation of the capacity of that condenser enables the electrical periodicity of tuning of the open circuit of the receiver to be altered?

A. That is correct.

X Q. 597. I hand you Defendant's Exhibit JJ, comprising sketches made by you in the course of your direct examination; I think you made some assumption as to the relation between the position of the condenser plates and the resonance with the incoming signal; is that correct?

. . . . . .

A. Yes, the assumption was made that the condenser was about in its mid position.

X Q. 598. That the condenser was in its mid position?

A. The circuit was resonant.

X Q. 599. And that was what circuit?

A. The circuit consisting of the condenser h and the coil j' was resonant.

X Q. 600. Regardless of the value of the antenna capacity?

A. Yes. This curve was drawn to show the relation of the current in the closed circuit to that in the antenna circuit. And, since the antenna circuit is a very high impedance circuit, as compared to the series impedence of the [fol. 1954] condenser h, and the coils j', the current in the circuit, consisting of the condenser h and the coils j', would be much greater than that in the antenna.

X Q. 601. And that sketch shows, does it not, the greatest current in the coil j' when the circuit composed of the condenser h and the coil j' is tuned to the received wavelength?

A. That is correct.

X Q. 602. In using such a circuit in a receiving antenna, where would the condenser be set to secure the loudest signal in an associated circuit with a detector in it?

A. That would be set—it would have to be adjusted by some meter or by the ear to such a position that the largest measured current or voltage is in that coil.

X Q. 603. Supposing that an adjustment would be made by ear, which is the usual way, is it not, in a receiver?

A. Yes.

X Q. 604. Would not the condenser be set midway to receive the loudest signal.

A. It would be. Well, of course, the assumption was made that, at that particular point, the largest current was flowing in that circuit. That was the basis for drawing the curve.

[fol. 1955] X Q. 605. Although the assumption was that, at that point, the circuit composed of h and j', in and of itself, was tuned to the received wavelength?

A. The actual resonant frequency to which the condenser in the mid-position would respond, would be influenced by the antenna.

X Q. 606. Then, may I repeat the question: if the operator tunes that circuit, considering that as the primary circuit of the receiver, to receive the loudest signal, would the condenser be set at the mid-point?

A. I think we are thinking about two different things here.

X Q. 607. I would be glad to know what the trouble is.

A. This curve was drawn under the assumption that, for the condenser in the mid-position, the maximum circulating current or voltage in that circuit——

* * * * * * *

X Q. 609. First tell us what the assumption is, Commander Dow.

A. The assumption is made that the circuit as a whole, including the effect of the antenna capacity, is adjusted so that the greatest current will circulate in the circuit h-j', when the condenser is in the mid-position. And this curve was drawn merely to show that the relation between the current of the antenna and the current in the wheel circuit h-j'—that is, that the current in the wheel circuit was [fol. 1956] much larger than the current in the antenna lead.

Now, this condenser h and the coil j'—are any condenser h and any coil j', provided this adjustment is made. And the result is based upon making the adjustment under the assumed condition.

* * * * * * *

This is the resonant condition of the circuit as a whole.

X Q. 610. Then the circuit h-j', of itself, and without considering the effect of the antenna, is not resonant to the received wavelength?

A. That is correct.

X Q. 611. Then I take it that your statement, which appears at page 1370 of the record, that "We assume that the resonant wavelength corresponded to that of the circuit h-j', when the condenser was in its mid-position," must be qualified, to a certain extent?

* * * * * * *

A. I do not understand why.

X Q. 612. Because, as I understand you now, the resonant wavelength corresponds to that of the entire antenna circuit, when the condenser is in its mid-position?

[fol. 1957] A. Well, here we go into that question of the relative constants; or, rather, the relative value of various constants. If you will be explicit, and tell me what the capacity of the antenna is, what the inductance of the antenna is, what the capacity of condenser h is, and what the value of the inductance of coil j' is, I think I can more readily answer. I may answer this question in terms of the picture that is in my mind, as to the relative values of things.

X Q. 613. What is that picture?

A. That the antenna has some effect on the resonance frequency; but that it is principally determined by the value of the condenser h and the coil j'.

X Q. 614. But, nevertheless, it does have some effect?

A. Yes, that is true.

X Q. 615. And, to that extent, the assumption, as I read it to you from the record, must be qualified?

A. Yes, to that extent.

X Q. 616. To that extent?

A. I do not recall at this time exactly what led up in the direct testimony to this figure, and I do not like to say something, make answers to present questions, on the basis of those questions as I hear them and attempt to read them in the light of something that was said before, with which I am not familiar. I have not even read the record in this case.

[fol. 1958] X Q. 617. Then the entire circuit shown in Ex-

hibit JJ is resonant to the received wavelength, with the condenser at its mid-point; is that right?

A. Yes.

X Q. 618. And it is at that point where the maximum current flows in the coil j'?

A. Yes, that is correct.

X Q. 619. Can we generalize that statement and say that, in a receiver having a primary and secondary circuit, to secure the best signal, the antenna circuit as a whole should be tuned to the received wavelength?

A. Under this condition here, the maximum current——

X Q. 620. And "this condition here" is what? The record does not show.

A. Assuming this structure shown in the antenna circuit of Figure 2 of the Marconi patent. When the antenna circuit as a whole is tuned to the resonant frequency, the maximum current will flow in the coil j'.

However, that is not the maximum that is obtainable, if certain elements of the circuit are—or if the tune of certain elements of the circuit are modified, as, for example, by adjusting the capacity of the condenser h and the coil j' to have a broader value. I do not know whether that is clear or not.

[fol. 1959] X Q. 621. Well, even then, the antenna circuit as a whole would still be tuned to the received wavelength, would it not?

A. Yes, that is correct.

X Q. 622. I think my general statement, then, applies to that, does it not?

A. The maximum current, but not a max-max current.

X Q. 623. When the maximum current is received, then the antenna circuit as a whole is in tune with the received wavelength, is it not?

A. That is right. But that is not the maximum current that is obtainable by better adjustment of the circuit.

X Q. 624. Yes; but even a better adjustment would still leave the antenna circuit as a whole tuned to the received wavelength?

A. Yes, that is correct.

X Q. 625. So that I still think my statement is correct.

A. I think so.

[fol. 1960] (Tr. 1605)

X Q. 628. I may have misquoted your testimony slightly. What you said, according to the record, at page 1372, is that: "As the condenser is increased in setting, from zero, the current in the circuit hj' rises with increasing rapidity as the resonance position is reached, reaching a maximum value when the inductive reactance of same is equal to the capacitive reactance."

A. Yes.

X Q. 629. Is not the reason that the current in the coil j' is smaller when the condenser is nearer zero because the antenna under those conditions is de-tuned—that the circuit as a whole under those conditions is detuned?

A. Yes, that is correct.

X Q. 630. And, likewise, the reason why the current in the coil j' again decreases after the mid-point is passed, is because the antenna circuit as a whole is de-tuned, is it not?

A. Yes, that is correct.

(Tr. 1607)

[fol. 1961] X Q. 631. Commander Dow, will you refer again to Defendant's Exhibit JJ; have you that before you?

A. I have that before me.

X Q. 632. I think you testified, in connection with that exhibit that, if a loading coil such as g' were added to that circuit, the action of the circuit would be substantially the same; is that correct?

A. Yes.

X Q. 633. And adding the loading coil would involve a change of the position of the condenser, in order to secure the maximum current in coil j', would it not, assuming that the wavelength was unchanged?

A. It would involve changing the tuning of the condenser h, to some extent, the amount of which would have to be determined by the relative value of the various capacities and of the inductances in the circuit.

X Q. 634. Including that the coil g'?

A. That is correct.

[fol. 1962] (Tr. 1613)

X Q. 664. Have you a copy of the Pupin patent, Defendant's Exhibit KK?

A. I have a copy of the Pupin patent, 640,516.

* * * * * * *

X Q. 665. Commander Dow, what is the highest frequency mentioned in this Pupin patent?

A. 250 cycles is the highest frequency that I find specifically mentioned in the specification.

X Q. 666. Is that considered a radio frequency?

* * * * * * *

The Witness: Such frequencies are not ordinarily considered in the category of radio frequencies, however.

X Q. 667. Did you ever see a radio transmitter designed to transmit frequencies of 250 cycles?

A. I never have.

X Q. 668. Did you ever see a radio receiver designed to receive frequencies of 250 cycles?

* * * * * * *

The Witness: Not a conventional type of radio receiver.

X Q. 669. Why do you use the word "conventional" in that answer?

A. Because there are in use at the present time—or there is in use at the present time, receiving apparatus for receiving frequencies of the order of 500 cycles.

[fol. 1963] X Q. 670. The question was with respect to 250 cycles.

A. With respect to 250 cycles, I have not.

X Q. 671. What wavelength corresponds to 250 cycles?

* * * * * * *

A. It would be 1,200,000 meters wavelength.

X Q. 673. Now, I presume, in studying the Pupin patent, that you notice that on page 1, line 37, and following, he says that iron should be avoided in the coils of this circuit. Have you ever constructed a coil which, with a suitable condenser, would resonate at a frequency of 250 cycles.

A. I have never actually determined or made such a determination. However, I have constructed many coils which, with a suitable condenser, would resonate at such frequencies, coils without the use of an iron core. Coils used in the SE 1000 amplifiers, by a relatively small condenser connected across their terminals, would be resonant at such a frequency.

X Q. 674. Those have iron in the core?

A. Those are air-core.

X Q. 675. Air-core?

A. Air-core. They were computed at 1,000 cycles, without the use of a condenser.

[fol. 1964] X Q. 676. Referring to Figure 1 of the Pupin patent, what are the elements of his resonance circuits at the receiving end?

A. The condenser h, the coil j, and the inductance of a solenoid which forms a part of the responsive device M; also the condenser K, the inductance L, and the solenoid which forms a part of the responsive device N.

X Q. 677. What are the devices M and N?

A. They are electrodynamic devices, which contain a magnet and an armature, which is constrained in its motion by what appears to be a spring.

X Q. 678. Similar to a telegraph sounder?

A. Of that order, yes.

X Q. 679. Would the presence of the coil of these devices M and N have any effect upon the resonance curve of the circuits in which they are connected?

A. Yes, I would say that they would have an effect upon it.

X Q. 680. With normal devices of that character, would they have any effect on the sharpness of tuning of the circuit?

A. Yes, they are inductance coils, and all inductance coils introduce a certain amount of resistance into the circuit, so that, depending upon the amount of resistance introduced into the circuit by their presence they would have an [fol. 1965] effect upon the resonance curve of the circuit.

X Q. 681. Does that mean that, the greater the resistance of those coils, the less sharply resonant the circuit would be made?

A. That is correct.

X Q. 682. Does such a coil normally have an iron core?

A. From the nature of the nomenclature—or, rather, from the nature of the structure shown, I would assume that these coils had an iron core.

X Q. 683. And the reference to them at line 123 on page 2 of the patent as "Electromagnets" tends to bear that out, does it not?

A. Yes, that is correct.

X Q. 684. And is it not true that, with a coil of that type, the resistance would normally be considerably higher than with an air-core coil?

A. Yes. There is nothing here to indicate the relative values of resistance of the solenoid plates, and the resistance of the inductances I and L. At these frequencies, it is quite possible that the resistances of the inductances I and L were fairly high.

X Q. 685. And that, again, would tend to reduce the sharpness of the tuning of the circuit, would it not?

A. Yes, that is correct.

[fol. 1966] X Q. 686. Can you state whether or not, as of either 1895 or 1900, there would have been any problems involved in designing the circuit H-I-M, so that it would have a sharp resonance characteristic?

A. I cannot state. I cannot give a very specific reply to that question, because I am not entirely familiar with the literature on the particular subject under discussion at this time, which existed at the time in question However, I note, beginning with line 97 on page 1 of the specification, the statement: "Electromotive forces of different frequencies, say of 150 and 250 vibrations per second." That is a 2-to-1 ratio in wavelength. If those frequencies were used, the resonance characteristics of the circuits might not have been so bad.

X Q. 687. Now, will you r 'er to Figure 2 of the Pupin patent. As I understand it, there are primary and secondary circuits there; is that correct?

A. That is my understanding.

X Q. 688. Which is the primary circuit of the left-hand of the two groups of circuits?

A. The circuits H-I I understand to be the primary circuit.

[fol. 1967] X Q. 689. How is that circuit tuned?

A. That circuit is tuned substantially to resonance, according to my understanding of this patent.

X Q. 690. By means of what element or elements?

A. Capacity H is made resonant with the inductance of the coil I, plus the reflected inductances of the secondary circuit.

X Q. 691. Now, will you please look at page 2 of the patent, and particularly lines 95 to 100, and state whether that induces you to change your answer in any way.

A. It does not lead me to change my answer.

X Q. 692. Does not the patent there say that he tunes the circuit H-I by means of the circuit H'-I'-I?

A. That is correct. However, he states, beginning with line 94: "Referring now more particularly to Fig. 2, which represents the receiving end of the line and can be hitched onto the transmitting end shown in Fig. 1, instead of the receiving end shown in that figure, I show a resonance circuit H-I and K-L", which I mentioned.

He states further: "But I control the frequency of H-I by means of a circuit H'-I'-I".

In giving my answer, I stated that the capacity H was made resonant with the inductance I, plus the reflected inductances of the secondary circuit.

[fol. 1968] X Q. 693. And, according to the patentee, it is the reflected inductance, or whatever may be reflected from the secondary circuit, that tunes the primary circuit, is it not?

A. That is correct.

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(Tr. 1629)

X Q. 694. Have you got a copy of the Fessenden patent before you?

A. I have.

X Q. 695. I think you referred in your direct examination primarily to Figure 1; is that correct?

A. That is correct.

X Q. 696. You said that the antenna circuit of the transmitter of that patent was tuned. What are the tuning elements of the transmitter antenna circuit?

A. He has a capacity body, 5-A, a conducter 5, a condenser 18, and the ground lead, which is not identified by reference character. That I interpret to be or understand to be the tuned element or tuned system.

X Q. 697. Is there any lumped inductance in that antenna circuit?

A. There is none.

[fol. 1969] (Tr. 1630)

X Q. 704. Well, as compared with Figure 1 of the Marconi patent, the spark would be much sharper under the Marconi patent, would it not?

A. That is correct.

X Q. 705. In the receiver, Figure 1, of the Fessenden patent, how many tuned circuits are there?

A. Well, he shows a resonant circuit, consisting of the condenser 19 and the two coils 7. Now, the inductance of the

antenna and the capacity of the antenna are lumped into that and form a part of the whole resonant system that he has.

X Q. 706. That is, in your opinion, the antenna circuit is a tuned circuit; is that correct?

A. Yes. I would place that as a tuned circuit.

X Q. 707. Is there any other tuned circuit in the receiver?

A. There is none.

[fol. 1970] (Tr. 1631)

X Q. 709. Now, I understood you to testify that there was tuning in the receiver circuit. To what is that circuit made resonant?

A. The circuit—I understand the specification to disclose that the condenser 19 is selected to be of such value that the maximum current flows in the inductances 7.

X Q. 710. The maximum current at some particular wavelength?

A. Yes; at the wavelength of the transmitting station.

X Q. 711. That is, the wavelength as determined by the capacity of area of 5-A, wire 5, and the condenser 19 and the ground connection?

A. That is correct.

X Q. 712. Now, I notice that Fessenden says, on page 3, at line 25, that the shunt circuit of the transmitter must be tuned to the receiving conductor. In the first place, what is the shunt circuit of the transmitter?

A. I will now read out of the specification something that I have not observed before, in that apparently the wavelength of the oscillations generated in Fessenden's transmitter is determined to a substantial extent by the inductance of the secondary coil of his transformer and the condenser 18. He states: "It is preferred to place a shunt [fol. 1971] circuit containing a condenser across the terminals of the induction coil at the sending station, for the purpose of maintaining sustained radiation. This shunt circuit must be tuned to the receiving conductor."

X Q. 713. What kind of an instrument is that which is marked "1" in Figure 1?

A. An induction coil. This would indicate to me that he was using relatively long wavelengths, since the inductance of the secondary of his coil must have been very great.

X Q. 714. What do you mean by "relatively long", in this instance?

A. Well, as distinguished from waves of the order of 100 to 200 meters that we have assumed he was using, from the structure of his circuit, which consisted merely of the vertical conductor of the capacity 5-A and the condenser 18, in series to ground.

X Q. 715. An induction coil is normally a pretty large coil, is it not?

A. Yes.

X Q. 716. Would it not, in practice, be so large that it probably would not act as an inductance at all on a transmitter frequency?

A. I do not know that I would say that. I do not have any justification for saying that.

[fol. 1972] By the Commissioner:

X Q. 717. Has that an iron core?

A. Yes.

X Q. 718. Would it not act more as a choke-winding, than anything else?

A. Well, that would depend largely upon the construction, the exact construction, of such a secondary coil, whether it was close to the iron core or whether it was quite some distance away from it. It would depend upon the size of the wire.

By Mr. Blackmar:

X Q. 719. Are there any instructions in the patent as to how that coil should be constructed?

A. It states that the apparatus employed at the sending station may be similar to that now in use for the generation of electromagnetic waves and consists of an induction coil 1, having its primary coil in circuit with a generator 2, said circuit having a make and break mechanism 3 included therein.

X Q. 720. Would you know what kind of coil would be "similar to that now in use for the generation of electromagnetic waves"?

A. Well, I have used induction coils of various sizes and designs. I have no information at hand to indicate the exact construction of the coils which he used.

[fol. 1973] By the Commissioner:

X Q. 721. The coil that he uses here might be termed the conventional spark coil, might it not?

A. It might, yes, sir.

X Q. 722. Are you sufficiently familiar with radio of the early days to give an estimate of the length of spark that would be necessary to the practice of the Fessenden invention here?

A. I would say that the Fessenden spark, with a length from an eighth of an inch to half an inch or one inch, was probably used. At least, I would not expect him to use a longer spark than that, with the condenser across the secondary.

X Q. 723. Well, without the condenser across the secondary, the free length of a spark obtained from the secondary terminals would be much longer?

A. Yes.

X Q. 724. On that assumption, how long a spark would you think would be employed? What I am getting at is this—correct me if I am wrong—the spark coils of these early times were rated as a one-half inch spark, or one-inch spark, or 2-inch spark, and so forth.

A. Well, I used a spark coil for radio, about 1910, that had a spark length of about an inch and a half on the open circuit and about a quarter of an inch when the condenser [fol. 1974] was connected across it. I have also seen spark coils at around that time that were able to break down gaps up to—used for radio—that were able to break down gaps up to 4 or 5 inches, when the condenser was not across the secondary; and something in the order of about a quarter of an inch to an inch when the condenser was used.

X Q. 725. Have you any idea of the number of turns on the secondary winding for an inch length of spark on convential equipment?

A. That is ordinarily very great.

X Q. 726. Would 50,000 turns be about right for each inch of spark? Now, do not take my statement as correct. I may be wrong. But that is an impression that I had. That figure comes to my mind because, in those early days, I built some spark coils myself. It is a good many years ago, however.

A. If he had 100 turns on his primary coil and used 50 volts for his battery and had 50,000 turns on the secondary coil, he would get something of the order—and I am using transformer theory on this—something of the order of 25,000 volts, between spheres of a centimeter in diameter.

That would be equivalent to a spark gap of about a centimeter.

[fol. 1975] X Q. 727. My estimate, if anything, then, is perhaps conservative?

A. Yes. Of course, it is very difficult to look at a sketch of this kind and say exactly what goes on in the circuit. Now, with these 50,000 turns in the secondary, or whatever he had, there was an enormous distributive capacity, which always enters into the picture, and concerning which I have no knowledge. I can only take this statement which Mr. Blackmar pointed out, to indicate that the secondary induction coil did play a part in determining the wavelength of his circuit.

By Mr. Blackmar:

X Q. 728. Of course, there is a possibility that his theory of how it operated was incorrect?

A. That is correct; as I understand sometimes is the case.

X Q. 729. And, from your examination of Figure 1, and your general familiarity with induction coils, as they were used to generate radio frequency, do you not think that probably your first answer as to what determined the frequency of that circuit, was more correct than Fessenden's theory of what determined that circuit?

A. Well, that is a little difficult to answer, because Fessenden worked on those, and I have not.

[fol. 1976] X Q. 730. You assume that he worked on it, but you do not know. Many patent applications are drawn on paper, as I think you know, without having them tried out. But, leaving aside what you think Fessenden may have found: if a circuit, such as the transmitter in Figure 1 of that patent, was utilized with an induction coil of an ordinary type, what would determine the transmitted frequency or transmitted waves?

A. Well, upon this statement that you have pointed out——

X Q. 731. I am asking you from your own experience.

A. From my own experience, it would be determined very little by the secondary of the induction coil, and principally by the elements which I have pointed out.

X Q. 732. That is, by 5, 5-A, and 18, and the ground connection?

A. That is correct.

X Q. 733. And, on that basis, would it be fair to say that you are doubtful as to the accuracy of Fessenden's statement as to what determined the wavelength of the signal?

A. Well, as I said before, I am not familiar with the detailed construction of his coil. He may have had an induction coil there that had very few turns on his primary. He may have been using very high primary current. He could maintain a fairly high ratio of turns without, perhaps, as [fol. 1977] many secondary turns as was conventional on coils with which I am familiar.

By the Commissioner:

X Q. 734. In the absence of any specific specifications by Fessenden of the type or character of coil to be used, can you answer the question with reference to what you would consider as the conventional spark coil, as of that time?

A. I would say that, from what I understand of the conventional spark coils of the period between—the period proceding 1910—that a wavelength would be determined by the elements which I detailed before Mr. Blackmar pointed out this statement of Fessenden.

By Mr. Blackmar:

X Q. 735. Rather than by what Fessenden determines the shunt circuit to be?

A. Yes.

X Q. 736. Now, he says at the same place that the shunt circuit must be tuned to the receiving conductor. What do you understand he means by "the receiving conductor"?

A. Well, I understand that he means the receiving system as a whole.

X Q. 737. As a whole?

A. Yes; that is, he sent out waves, transmitted waves, of such a length that his receiving system responded best to it. [fol. 1978] X Q. 738. And he meant, did he not, the receiving system as a whole, rather than the circuit made up of the coils 7 and 7 and the condenser 19?

A. Yes, the receiving system as a whole includes those elements.

X Q. 739. I understand your direct testimony to be that it was the secondary 7 and 7 and 19 and the wires 6——

A. I think you will find, if you will refer back to my direct testimony, that I stated that the capacity of the element 6,

which is the receiving conductor, was considered, in that answer, to be lumped with the capacity 19.

X Q. 740. So that what is tuned to the received wavelength, if anything, is not only the circuit 7-7-19, but anything associated with it.

A. Yes.

X Q. 741. That might affect the tuned frequency?

A. That is correct.

X Q. 742. Now, will you please point out where, in the patent, Fessenden says that the receiving conductor as a circuit or receiving conductor, as he calls it, is tuned to the received wavelength? I would like you to be specific, because I will be interested to see whether that statement is in the application as filed.

[fol. 1979] A. Fessenden states, beginning with line 101 on page 2 of the specification: "As shown in Fig. 1, a condenser 19 may be connected in shunt with the field coil or coils 7, for the purpose of obtaining as large a current as possible, in the field coil 7, as this increase in current will give a greater torque to the ring 8."

X Q. 743. Does that, to you, of itself, direct you to tune the receiving conductor?

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(Tr. 1641)

The Witness: I interpret that to mean that he selected such a value of capacity there that his receiving system as a whole was resonant to the wave that he was interested in.

X Q. 745. Now you may complete your answer to the previous question.

A. Fessenden continues, beginning with line 106, in a rather long explanation, showing the results which he got, indicating a phenomenon similar to that which I pointed out in one of my sketches of yesterday, wherein the current in the antenna circuit was larger than the current in the receiving conductor.

[fol. 1980] X Q. 746. Is there anywhere in that rather long explanation where there is a specific direction to tune the receiving conductor?

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A. No specific mention is made of it. However, all the explanation which he gives is that which would apply to a resonant circuit, or a shunt circuit connected to the terminals of a generator or source of alternating electromotive force.

X Q. 747. That is, according to your opinion, he describes the results which would be obtained by tuning; is that what you mean?

A. Yes, that is correct. That is, by having a resonant circuit which is responsive to the incoming oscillations.

X Q. 748. In the receiver of Fig. 1, as I understand it, there is no tuned secondary circuit, is there?

A. There is not.

X Q. 749. Will you refer to Figure 2 of the patent, please? Is a secondary circuit shown there?

A. I find no tuned circuit in Figure 2.

X Q. 750. Is there a secondary circuit, however?

A. Oh, yes, there is a secondary circuit.

[fol. 1981] X Q. 751. But there is no shunt condenser there in the primary or secondary circuit, either, is there?

A. No, there is not.

X Q. 752. In fact, in that figure, no means are shown for varying or tuning either of the circuits?

A. There are none shown. And I find no mention of such a structure in that portion of the specification relating to Figure 2.

X Q. 753. In any other figures of the specification of the Fessenden patent, do you find a secondary circuit? That is, in Figures 3, 4, or 5?

A. I interpret Figures 3, 4, and 5 as showing various arrangements for transforming electromagnetic waves into recordable action.

X Q. 754. Do you find any secondary circuits in any of them?

A. I do not.

[fol. 1982] (Tr. 1647)

X Q. 769. I understood you to say that the circuits of a receiver constructed according to the Marconi patent would be more selective than a receiver made in accordance with Figure 1 of the Fessenden patent?

A. I would say so, yes.

X Q. 770. And that would be also true of the defendant's receivers, would it not—that they were more selective than the receivers shown in the Fessenden patent?

A. That is true.

[fol. 1983] (Tr. 1650)

Mr. Blackmar: I think possibly if he hears them he will bear them in mind.

My first question is the one just asked—what is there which is common to the Pupin patent and to the defendant's receivers which is not also present in the circuit of plaintiff's Exhibit 454 for Identification?

The second question will be: What is there that is common to the Fessenden patent and the defendant's receivers which you do not find in Plaintiff's Exhibit 454 for Identification?

And the third question will be: what is there that is common to the Pupin patent and to the defendant's receivers which you do not find in Plaintiff's Exhibit 455 for Identification.

The fourth question is: What is there that is common to the Fessenden patent and to the defendant's receivers which you do not find in Plaintiff's Exhibit 455 for Identification.

[fol. 1984] (Tr. 1652)

X Q. 781. I believe there are four questions on the record.

(The first question referred to, as recorded on page 1650, minutes of July 18, was read by the reporter).

A. My answer to this question applies to those of defendant's structures in which a condenser is shown connected in parallel with the primary inductance system. With respect to what appears in the Pupin patent and defendant's structures which does not appear in the sketch marked Plaintiff's Exhibit 454 for Identification, I find no detector in the sketch.

X Q. 782. Then, am I correct in understanding that, in so far as radio frequency circuits are concerned, there is nothing which is common to Pupin and to the defendant's receivers which you have mentioned, that is not also present in Plaintiff's Exhibit 454 for Identification?

A. That is correct.

X Q. 783. Now, will you listen to the second question which I put on the record yesterday afternoon.

(The second question referred to, as recorded on page 1650, minutes of July 18, was read by the reporter.)

A. My answer to this question applies also only to those of defendant's structures in which the condenser is shown in parallel with the primary inductance system. I find no [fol. 1985] detector in the sketch marked Plaintiff's Exhibit 454 for Identification.

X Q. 784. Then am I correct in understanding that, if the question had been confined to the radio frequency circuits, your answer would have been that you find nothing else common to Fessenden and to the defendant's receiver that you described, which is not also in Plaintiff's Exhibit 454 for Identification?

A. That is correct.

X Q. 785. Now will you listen to the third question, please?

(The third question referred to, as recorded on pages 1650 and 1651, minutes of July 18, was read by the reporter.)

A. My answer to this question also applies to those of defendant's structures in which a condenser is shown in parallel with the primary inductance system. I find no detector in the sketch marked Plaintiff's Exhibit 455 for Identification.

X Q. 786. Then am I correct in understanding that, if the question had been limited to radio frequency circuits, you would find nothing which is common to Pupin and to the defendant's receivers which you have mentioned, which is not also in Plaintiff's Exhibit 455 for Identification.

A. That is correct.

[fol. 1986] X Q. 787. Now, will you listen to question No. 4 which I asked yesterday afternoon.

(The fourth question referred to, as recorded on page 1651, minutes of July 18, was read by the reporter.)

A. My answer to this question applies to those of defendant's structure in which a condenser is shown in parallel with the primary inductance system. I find no detector in the sketch marked Plaintiff's Exhibit 455 for Identification.

X Q. 788. And again am I correct in understanding that,

if the question had been limited to the radio frequency circuits, you find nothing which is common to the Fessenden and to the defendant's receiver, which you have mentioned, which is not also in Plaintiff's Exhibit 45 for Identification?

A. That is correct.

X Q. 789. Now, in limiting your answers to the defendant's receivers in which the parallel connection is shown, would your answer be the same if they also applied to the so-called Group III type receivers, when the connections were so made at the time that the antenna condenser was connected in parallel?

A. The answers would reply.

[fol. 1987] (Tr. 1665)

X Q. 824. Now, in connection with Defendant's Exhibits NN and OO, and referring to the figures showing the parallel connection with the antenna condenser, you pointed out, as I understood it, a similarity between those circuits and the receiver circuit of Figure 1 of the Fessenden patent, in that, in all cases, there was more than one coil in parallel with the condenser. Do you remember so testifying?

A. I do.

X Q. 825. Why, in your opinion, did Fessenden show two coils marked 7 in Figure 1?

A. These coils 7 are on either side of his secondary coil 8, and he desired to place his secondary coil at a point in the field of maximum electromagnetic intensity.

X Q. 826. Is there any such function in the use of two or more coils in any of the receivers of the type of SE 950 or SE 1012?

A. No. Fessenden's detector device was incorporated as a part of his coil system, and there was no need to provide such an arrangement in connection with the use of the detectors which are employed in the receivers under consideration.

[fol. 1988] X Q. 827. Then, when you referred to this similarity, it was merely a similarity in that each used more than one coil; is that correct?

A. That is correct.

X Q. 828. Not a functional similarity?

A. You are correct.

* * * * * * *

(Tr. 1668)

X Q. 841. Now, is it not correct that an inductance coil in a radio circuit may act either as an inductance or as a capacity, depending upon the wavelength applied to it?

A. That is correct; depending upon the design of the coil and the wavelength.

X Q. 842. And the same is true of the condenser, is it not?

A. At frequencies corresponding to wavelengths of one meter, certain capacities might act as inductances.

X Q. 843. And, in analyzing a radio frequency circuit to determine the effect of the elements on the current in the circuit, that is ordinarily done by considering the reactance of it, is it not?

A. The reactance or resistance.

X Q. 844. And if you know the reactance it does not make any particular difference whether the instrument is a coil or a condenser, does it, as far as analyzing the operation of the circuit is concerned?

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A. That is correct.

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[fol. 1989] (Tr. 1673)

Mr. Blackmar: With Mr. Edwards's permission I offer in evidence as Plaintiff's Exhibit 453 the sheet of sketches which has been marked Plaintiff's Exhibit 453 for Identification.

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(Tr. 1674)

[fol. 1990] Mr. Blackmar: I also offer in evidence as Plaintiff's Exhibit 454 a diagram which has previously been marked Plaintiff's Exhibit 454 for Identification; and I call the Commissioner's attention to the fact that it is a partial copy of Plaintiff's Exhibit 79, showing the Telefunken type of receiver, which the Court of Claims held infringes Claim 16 of the Marconi patent, which appears opposite page 180, of Volume 1, of the printed record in the main case.

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Mr. Blackmar: I also offer in evidence as Plaintiff's Exhibit 455 the diagram which has heretofore been marked

Plaintiff's Exhibit 455 for Identification, and I call the Commissioner's attention to the fact that it is a partial copy of Plaintiff's Exhibit 95, appearing opposite page 183 of Volume I of the printed record herein, which is representative of the Kilbourne and Clark types of apparatus, which the Court of Claims also held infringed Claim 16 of the Marconi patent.

GEORGE H. CLARK

(Tr. 1930)

[fol. 1991] 147 Q. With this receiver did you ever compare its operation, utilizing the series position of the condenser, with its position utilizing the parallel connection of that condenser?

A. Yes, I have made a test many times.

148. Q. Have you any contemporaneous records of such tests?

A. Yes.

149. Q. Will you describe briefly what the records are, not their contents, but what they are?

A. The record that I have with me is a record of tests made during a trip which I made on the U. S. S. Arkansas in December of 1912 from Key West to Colon. The tests were made either on the ship at Key West or en route to Colon.

150. Q. Have you a record of the test made by you December 19, 1912?

A. Yes, I have. I have the original log and I have the general report covering the whole test.

151. Q. Referring to the original log, where was that test made?

A. This was made with the receiver at the naval station at Key West, Fla., on December 19, 1912.

152. Q. What is the original document that you have before you?

A. This is the original log that I made at the time of the test.

153. Q. And the test to which you have referred appears on page what of the log?

[fol. 1992] A. It appears on page 12 of the log, the page which is numbered 12.

154. Q. Have you any independent recollection of that test?

A. Yes, I have. I have a memory clearly.

155. Q. What was the result of the test?

A. I found that with the shunt connection the signals were approximately 5 times as loud as with the series connection on the primary condenser.

156. Q. What type signals were you receiving and from where?

A. Arc signals from the transmitter at Arlington.

157. Q. And this page 12 is a contemporaneous record of that test, is that right?

A. Yes, made at the time.

158. Q. Now, referring to that, will you please point out what that shows with respect to a comparison?

A. The circuit of each test is shown schematically at the left.

On the first test and second test I used the parallel condenser in the primary, No. 1 test having two coils in the loading coils and No. 2 test having three coils. I obtained a shunt across the telephone for a unit signal of 15 ohms in the first test and a unit signal of 7 ohms in the second test, the second one being approximately twice as loud as the first and being the better of the two for the shunt connection. I have a star and arrow marked on the side of the diagram which means I called attention to that one as it would be the one which I would select in making a later [fol. 1993] report. It was the one of the two to be considered as standard.

159 Q. When were the star and arrow put there?

A. At the time or shortly before my report was written.

The third was with the series condenser. There I obtained a shunt of 50 ohms across the telephone for unit audibility. So with a shunt of 7 ohms for the parallel connection in the condenser as against 50 ohms for the series connection in the condenser it shows that the signals were approximately 5 times as loud for the parallel connection.

Mr. Blackmar: I offer in evidence a photostat copy of page 12 of the log book, which is the page to which the witness has just been referring, defendant making no objection to the use of the photostat copy, as I understand it.

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(Tr. 1933)

Mr. Blackmar: I ask that it be marked Plaintiff's Exhibit No. 462.

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(Tr. 1934)

162. Q. You said something about taking that receiver on a trip with you from Key West.

A. Yes.

[fol. 1994] 163 Q. What ship?

A. On the U. S. S. Arkansas.

164 Q. Did you use that receiver and test it while you were on shipboard?

A. My orders were to compare the arc and spark transmitters at Arlington at the same time, during day and night, for strength of signal from each.

165 Q. Did you subsequently make a report of your observations?

A. Yes, I did. I have a copy here dated December 29, 1912.

166 Q. What did you do with the original?

A. The original was turned into the Navy Department as my report.

167 Q. Does that report contain any direct comparison between the use of the series and the use of the parallel connections?

A. Yes, it does.

168 Q. Where in the report?

A. Paragraph 2 on page 1. The first statement is made that it was the Federal Telegraph receiver and that said receiver had variable and fixed condensers in both primary and secondary circuits, and that the primary capacity was capable of use either in series or in parallel with the primary inductance.

On page 2, halfway down the page, is the following: [fol. 1995] "In general, signals were best obtained with the entire primary inductance, (3 coils), no loading coil, parallel connected primary condenser, No. 2 coil secondary inductance, and the maximum obtainable stopping condenser."

[fol. 1996] LYNDE PHELPS WHEELER produced, sworn, and examined as a witness on behalf of the defendant.

(Tr. 2102)

1 Q. Will you please state your full name, age, residence, and occupation.

A. My name is Lynde Phelps Wheeler. I live in 2317 20th Street, N. W., Washington, and I am Chief of the Technical Information Division of the Engineering Department of the Federal Communications Commission.

2 Q. And your age, Doctor Wheeler.

A. I have got to stop and calculate. I am 65 years old.

3 Q. Do you have any personal interest in the outcome of this suit, Doctor Wheeler?

A. No, none whatever.

4 Q. Will you briefly outline your education and experience in connection with radio matters.

A. I received my bachelor's and doctor's degrees at Yale University, the first, in 1894, the second, in 1902. From the time of my graduation in '94 until 1926, I taught electrical engineering subjects and mostly physics, at Yale University. In 1926, I went to the Naval Research Laboratory, here in the District, as assistant superintendent of the radio division and superintendent of the consulting division where I stayed until 1933. For the next three years, I was a consulting physicist in private practice, and in 1936 I went to my present position. During my teaching at Yale I initiated and organized the instruction in high-frequency phenomena and in vacuum-tube theory. In 1917, I was one of [fol. 1997] the organizers of the Signal Corps School for training officer candidates, which was established at Yale, and I taught in that school. From 1919 to 1926, I was in charge of a considerable portion of the work of instruction with the officers of the Army and Navy who were sent to Yale University for post-graduate work in communication engineering. I have taught courses in radio engineering at the Bureau of Standards and at the graduate school of the Department of Agriculture. At the Naval Research Laboratory, my duties were largely directing research on various phases of the radio art. While in the naval service and also since I have been with the Commission, I have been active in the preparatory work of this Government for international conventions on radio and communication sub-

jects. I am a fellow of the American Physical Society and of the Institute of Radio Engineers. I have served on several committees of the Institute, and I am at present the chairman of the standards committee of the Institute, and also a member of the board of editors of the proceedings of the Institute.

5 Q. In the course of your experience, have you had extensive practice in the making of mathematical calculations concerning radio parts and circuits?

A. I have done a fair amount of that sort of work.

6 Q. Are you familiar with the Marconi patent No. 763,772, involved in this suit?

A. I have read it a number of times with considerable care. I think I can say I am familiar with it.

[fol. 1998] 7 Q. With reference to Fig. 2 of the patent, can you state, briefly, whether the specification of the Marconi patent discloses data necessary to enable calculations to determine with good accuracy the resonance frequencies of the receiver tunes which are summarized in the tables on page 4 of the patent specification?

A. As I read the specification, there is sufficient data for getting approximate values, with one exception: There is not sufficient data given to determine coefficient of coupling between the primary and the secondary circuits; otherwise, there is sufficient data.

8 Q. With reference to the secondary circuit of Fig. 2, do you find that that circuit is a circuit of high impedance or a circuit of low impedance?

A. A circuit of high impedance.

9 Q. Does that have any bearing on the answer you gave to the last question?

A. It justifies the assumption that the coupling is very loose between the two circuits, in which case the higher powers of the coefficient of coupling which occur in the general theory of coupled circuits, which is here applicable, can be made, and very approximate calculations as to the resonance frequency of the primary circuit can be determined.

10 Q. In connection with your study of this Marconi patent, have you calculated the value of the effective inductance of the antenna of Fig. 2 for tunes 1, 2, 3, and 4?

A. I have.

[fol. 1999] 11 Q. And the capacity of the antenna of Fig. 2 for the same tunes?

A. I have.

12 Q. And have you calculated the inductance of the loading coil g' for tunes 1, 2, 3, and 4?

A. I have.

13 Q. And the inductance of the coupling coil j'?

A. I have.

14 Q. Did you find the data given sufficient to give close results in the calculations of these circuit constants or circuit values?

A. Depending on the meaning of the word "close", yes.

By Commissioner Gordon:

15 Q. Suppose you define that, so that this question may not be left open.

A. That, as to the coils, is sufficient to determine their inductances. The data with respect to the antenna are, I should say, insufficient for very accurate determination of the antenna constants, but sufficient to give an approximation which will be valid for practical purposes.

By Mr. Houghton:

16 Q. And from the calculations which you have just mentioned, have you determined the values of resonance frequency or wave-length indicated for the antenna circuit of Fig. 2?

A. I have.

[fol. 2000] 17 Q. For each of the conditions of the receiver, under tunes Nos. 1, 2, 3, and 4, in the table on page 4?

A. I have.

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(Tr. 2106)

18 Q. Will you briefly explain what your determinations are with respect to the operation of Fig. 2 for the respective tunes indicated in the table on page 4.

Mr. Blackmar: Operation in what respect, Mr. Houghton?

The Witness: You took the question out of my mouth.

By Mr. Houghton:

19 Q. Operation with respect to resonance frequencies of response of the overall antenna circuit and any subsidiary

elements of the circuit which you have found it desirable to consider.

A. That is rather a large question. I think I may answer it best by explaining the method by which I arrived at my results. I first determined the equivalent inductance and capacity of the antenna as given from the specifications, by formulae as given in the circular, 74, of the Bureau of Standards, pages 73 and 75.

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[fol. 2001]

(Tr. 2107)

22 Q. Now, will you continue with your explanation.

A. After determining the approximate antenna constants from the height and diameter of the antenna wire as given in the specification, and having computed, as previously testified, the inductances of the coils, I applied the general theory of coupled circuits, assuming that the coupling is so small that its square can be neglected in determining the values of the resonant frequencies or wave-lengths of the primary circuit. Do you wish me to give the values that I found for that, or any more detail as to the method of calculation?

23 Q. I believe it will be instructive to continue, and give the values as you think necessary to explain the determination of the resonance frequencies of response of the antenna circuit in the several tunes.

A. Corresponding to the tune labeled "No. 1", under "Receiving-Station", in the table on page 4, I find that the wave-length response is approximately 206 meters; that corresponding to tune No. 2, approximately 303 meters; that corresponding to tune No. 3, approximately 199 meters; and that corresponding to tune No. 4, 364 meters. I calculated, in addition, since, in this patent for tune No. 3, the table reads, "up to 21 turns".

24 Q. Of what coil?

A. Of the coil g'; two additional values, one where there were no turns in g', and one where there were 10 turns [fol. 2002] in g'. Where there were no turns, the resonant wave-length turns out to be 142, approximately; for 10 turns, 166, approximately.

25 Q. Of the tunes Nos. 1 to 6, set forth in the table for the receiving station, on page 4 of the Marconi patent, the table states that condenser h is omitted in tunes 1, 2, 5,

and 6. Under those conditions, what type of circuit is the antenna circuit, for tunes 1, 2, 5, and 6?

A. It is a series-tuned circuit, tuned by varying the inductance g'.

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(Tr. 2109)

27 Q. What sort of resonance determines the resonant wavelength of response of the antenna circuit in tunes 1, 2, 5, and 6, where condenser h is omitted?

A. It is a case of what is technically known as "series resonance".

28 Q. With reference to tunes 3 and 4 of the receiving-station table, on page 4 of the patent, did you make calculations to determine what sort of resonance affects the tuning of the antenna circuit of Fig. 2 for those tunes?

A. As previously testified, I calculated the resonant wave-lengths or frequencies for cases 3 and 4. I then calculated the resonance frequencies having simple series circuit con-[fol. 2003] sisting of the antenna, coil g', and the condenser h, alone; that is, omitting the primary of the transformer j'. These wave-lengths thus calculated I find to be substantially the same as those previously calculated with j' in the circuit; and hence I draw the conclusion that the tuning of the antenna circuit with j' in the circuit is essentially simple series tuning.

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(Tr. 2110)

A. (Continuing:) Just in the calculations with j' in the circuit, to which I testified some moments ago, I think it should be pointed out that there are, as it is a simple coupled circuit, two resonant frequencies of response, as there always are in a case of coupled circuits. I have read into the record only one of those two frequencies for tunes 3 and 4. The second frequency, which is essentially that of the circuit including j' and h alone, remains constant, for all of the tunes which I have calculated, to within 13 parts in 1,600, at a value of about 1,640 meters. This wave-length or frequency is not the frequency to which the whole antenna is tuned, and signals arriving of that frequency, 1,640 meters, or at that wave-length, would not be readily passed on to the detector, because of the relatively high

impedance of the primary circuit for that frequency; whereas signals arriving of the frequencies previously testified to would be so passed on.

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[fol. 2004] (Tr. 2111)

30 Q. I will ask the witness if I am not correct in assuming that, if the coil j′ is omitted from this circuit, there is no coupling existing to the closed receiving circuit. In other words, would not this answer of necessity assume an inoperative circuit?

A. If the coil j′ is physically omitted from the circuit, of course there is no coupling shown between primary and secondary of the oscillation transformer.

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(Tr. 2112)

31 Q. Doctor Wheeler, you have just testified that with the coil j′ connected in the circuit, the resonance frequency of tuning of the overall antenna circuit is substantially the same as the resonance frequency of the series circuit comprising the antenna, the loading coil g′, the condenser h, and the earth connection E. Will you explain why this is so.

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(Tr. 2113)

A. There are, as I see it, two reasons: one, the looseness of the coupling between the primary and secondary circuits; and, two, the relatively large value of the inductance of the primary of the transformer j′.

[fol. 2005] By Commissioner Gordon:

32 Q. Can you indicate, for the purpose of the record, upon what you base your "loose coupling"?

A. The reasons for the loose coupling, assuming a loose coupling?

33 Q. You did assume a loose coupling, I take it.

A. That there was loose coupling, yes. I have stated in evidence before that the coupling was so loose that the square of the value of the coefficient of the coupling was negligible. The reasons for assuming loose coupling here are, first, that the secondary circuit has a relatively high

resistance detector in series in it; second, that the reactance of the secondary coil j^2 is also high, the whole thing resulting in an impedance of the secondary which is very high. Now, the coefficient of coupling depends inversely upon the impedance, as it is taught in all the theory of coupled circuits; and hence, if that impedance is high, the coupling is small. From the data given, it is impossible to calculate the coefficient of coupling with any accuracy, but those considerations which I have just mentioned seem to me conclusive that the coupling must be very loose.

34 Q. Did Marconi suggest that coils j^2 be wound directly over the coils j'?

A. He shows four different forms, in Figs. 5, 6, 7, and 8, of that transformer. In three of them, viz., Figs. 5, 6, and 8, the secondary is wound over the primary. That in Fig. 7 [fol. 2006] shows the primary wound over the secondary.

35 Q. How about the magnetic lines of force in that type of winding?

A. Where the primary is wound over the secondary?

36 Q. No, where the two coils are, of the primary and the secondary, coincidental?

A. They are wound, one over the other. They are not actually coincidental in space. If they are right close, there, why, in the absence of magnetic materials in the coil, there is a considerable leakage of lines of force, to use a technical bit of slang. That is, all of those which originate in the primary do not cut through the secondary, so that the coupling is necessarily what is called "loose". A tight coupling would correspond to the majority of the lines of force from the primary, threading the secondary, much more than the majority.

37 Q. I do not know whether I understand your last answer. Do you mean that a tight coupling is exemplified by the fact that the primary and secondary circuits have in common a majority of the lines of force, and that a loose coupling does not have the majority but has a considerable leakage? Is that the sum and substance of your last answer?

A. Well, of course, coupling in any case is affected by the one coil, to be in the field of another coil. Now, you can put two coils far apart, and relatively few of the number of lines of force from the primary will go through the secondary.

[fol. 2007] 38 Q. And that is "loose coupling"?

A. That is "loose coupling".

39 Q. Now, if you have the two coils wound right over each other, can you get them any closer together, winding one coil directly over the other?

A. There is the thickness of the insulation between the two. It is difficult to get them actually in contact, of course.

40 Q. Oh, I know that.

A. Yes.

41 Q. You have got to follow the practical considerations, such as insulation, and something to wind them on; but I am just asking as a matter of curiosity if you can get coils, the primary and secondary coils, any closer together, or any tighter coupling, by winding one over the other.

A. Yes, it would be possible.

42 Q. How would you do that?

A. By interleaving the windings for the primary and the secondary, on the same form, winding the two together simultaneously.

43 Q. And that would be a tight coupling, in your opinion?

A. Not all of the lines would go through, in that case, even, unless we put some magnetic material in to concentrate the lines of force.

44 Q. I am trying to find out what you mean by a "tight coupling". You have exemplified what you mean by a "loose coupling"; that is, where the coils were separated; [fol. 2008] and in giving your answer, you held your hands wide apart. I think that is a good example of loose coupling. Now, I am trying to find what your opinion is of a tight coupling. I always thought that a tight coupling was where the coils were wound directly over each other, or coincidentally with each other.

A. Not necessarily so.

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(Tr. 2117)

45 Q. Will you please explain how a loose coupling occurs in spite of the coils being wound with the secondary directly superimposed physically on the primary.

A. The matter of the coupling is a matter of the concentration of the lines of force in the magnetic field of a coil through another coil. Now, the lines of magnetic induction or magnetic force are closed lines; they run around.

That is, if you have a coil with current running in this direction, the lines of force are running actually through, this way, and around, and out through space, and back. Now, even if one is wound over another, there will be a considerable number of these lines of force wihch do not traverse the secondary, at all, but go out through space and come back, at the primary, around in that way; whereas, if we put magnetic material (iron) in the core, more of them are concentrated down in the space. The question of the degree of coupling is a matter which involves quantitatively the geometry and the nature of the materials in the neighborhood, both.

[fol. 2009] 46 Q. Do the impedance of the coils themselves and the impedance of the external circuits connected to the coils affect the coupling?

A. Yes.

47 Q. Will you please explain in what manner the presence of a high impedance in the secondary or closed circuit may affect the coupling between that circuit and the antenna circuit in Fig. 2.

A. In general, the effect on the impedance of a primary circuit, of the presence of the secondary, is to make it apparently have a higher resistance and a lower reactance, and the amount of that increase in resistance or decrease in reactance depends upon what is known as the "coefficient of coupling" between the two circuits. If that coefficient is small, the change in the apparent resistance and reactance of the primary is small. If the coefficient of coupling is large, the changes may be relatively large; and the measure of that change depends directly upon the frequency, directly upon the mutual inductance, and inversely upon the impedance of the secondary.

Commissioner Gordon: I do not believe you have answered the question. As I understood the question, it called for the effect of an impedance on the coupling; and in your answer, as I understand it, you have given the effect of coupling upon impedance. Suppose you read the question to the witness again, and let him answer it.

(47 Q. was read by the reporter.)

[fol. 2010] A. I think the last portion of my answer was relevant to that; that is, the coupling depends directly upon

the mutual inductance, directly upon the frequency, and inversely as the impedance of the secondary; so that if the secondary impedance is high, the coupling is low; and *vice versa.*

By Commissioner Gordon:

48 Q. In the last portion of your answer you used the word "coupling" in the ordinary sense of magnetic coupling of two circuits?

A. I have a little difficulty understanding just what you mean by the "ordinary sense of the word". "Coupling" is used in several senses.

49 Q. I am trying to find out in what sense you are using it. Suppose you define it.

A. As defined by the equation which I stated, in words?

50 Q. Oh, can you not define it more simply than by referring to a mathematical equation? It is a familiar term that is used again and again in radio. I do not believe it requires a mathematical formula to define it. However, if you feel that it does, why, all right.

A. I think it does, to be precise, quantitative about it.

[fol. 2011] 51 Q. Considering the antenna circuit shown in Fig. 2 of the Marconi patent, for tunes 3 and 4, on page 4 of the patent, how does the current in the circuit f'-g' divide bewteen the path through condenser h, and the path through coil j', for tunes 3 and 4?

A. They divide inversely as the impedances of the two branches.

52 Q. With an incoming signal of the resonant wavelength approximately 199 meters which you have determined for tune 3, would a large part or a small part of the antenna current pass by way of the coil j', or the condenser h?

[fol. 2012] A. If you want a quantitative answer, I would have to figure the two impedances.

53 Q. Speak qualitatively, if you can.

A. In general, the impedance of the condenser h at that frequency is less than that of the coil j', and therefore the greater current will flow through h.

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(Tr. 2122)

55 Q. Now, Doctor Wheeler, referring to your calculations concerning the Marconi circuit of Fig. 2, will you

please explain the behavior of the antenna circuit of Marconi, Fig. 2, in tunes 3 and 4, assuming the values for the elements making up the circuit, which you have calculated.

A. From the calculations which I have made and my study of the circuit of Fig. 21, I am of the opinion that the antenna circuit behaves as a simple series tuned circuit, the primary coil j functioning simply as a coupling element and not as a tuning element; that is, the coil j' is the element for the transfer of the energy from the primary to the secondary, and does not figure appreciably in determining the resonant response of the primary to a received signal.

By Commissioner Gordon:

56 Q. I take it, however, that you do not mean that the antenna current, a portion of it, flows through j'?

A. A portion of it does, yes; a small portion.

[fol. 2013] 57 Q. What proportion?

A. I haven't the figures here. I could figure it out, in a little time.

58 Q. You must have figured it out beforehand, when you say "a small proportion". I am just trying to find out what you mean by that.

A. I was judging by the ratio of the reactances of the coil and the condenser at a given figure.

59 Q. Is it 50 per cent, or 25 per cent, or 30 per cent? What is it?

A. I cannot answer that quantitatively, immediately. I [fol. 2014] can answer it, in about five minutes, if I can take that time.

60 Q. No, I take it that you based your present answer to me on something that you had in mind. Now, what was that? You said, a small proportion. What do you mean by "a small proportion"?

A. I have not figured out what proportion.

61 Q. Then you did not know?

A. I can figure it, in five minutes' time.

62 Q. I am not asking you to figure it. I want to know what you meant when you gave in your answer the phraseology "a small proportion". I do not ask you to figure anything. I just want to know what your mental idea was of "a small proportion". You must have had something in mind, otherwise you could not have made that statement. Now, what was it that you had in mind?

A. I had no exact figures in mind, only I know it must be very much less.

63 Q. Less than what?

A. In the j' than in h, the current in the two.

64 Q. But you cannot tell us what it is, without figuring?

A. Not without figuring; no: not exactly.

Commissioner Gordon: All right, next question.

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[fol. 2015] (Tr. 2124)

66 Q. You stated that the coil j' acts as a means or coupling element for transferring the energy from the primary to the secondary circuit.

A. Yes.

67 Q. What is that energy? Is it potential across, an element of the primary circuit?

A. Energy is not potential, and I do not quite understand what you mean by that question. All of the energy that gets into the secondary gets into it by virtue of the action of the coil j'.

68 Q. Just how does that coil j' couple energy into the secondary—by what sort of coupling?

A. A very complicated sort of coupling, partially a coupling in the magnetic field, partially a coupling of the electrostatic field. I should judge that the electrostatic coupling was predominant over that of the magnetic field.

69 Q. Is there another name frequently applied to this electrostatic coupling?

A. It is sometimes called "capacity coupling".

70 Q. You stated that the antenna circuit of Fig. 2 for tune 3 of the Marconi patent and tune 4 behaves as a simple series tuned circuit, with j' functioning simply as a coupling element and not as a tuning element. Will you explain that in a little more detail.

A. The resonant frequency which I have calculated was [fol. 2016] on the basis of the ordinary coupled circuit theory, the resonance of the primary of the coupled circuit, frequencies to which it will respond in the presence of the secondary. Then, I also found that these frequencies, or rather, one of those frequencies, was substantially the same as for the simple series circuit, consisting of the antenna, coil g', and the condenser h, to ground; and hence, it seems to me conclusive that the resonance of that primary circuit

is accomplished without any substantial contribution from the coil j'. For instance, in the case of tune 3, with 21 turns in the coil g', the resonant frequency of the primary or resonant wave-length of the primary came out 199.2, and, with the same value of g' in the simple series circuit, came out 199.3 meters—substantially the same frequency; and hence I conclude that the coil j' affects the tuning of the primary circuit in only a very secondary degree.

By Commissioner Gordon:

71 Q. Is that true for all wave-lengths?

A. For the wave-lengths which I have computed, which vary from 142 to 364; not for all wave-lengths, no.

By Mr. Houghton:

72 Q. What values determined your making of calculations which led to these wave-length ranges, 142.3 meters to 364.1 meters?

A. The values of what?

73 Q. What values of elements of the circuit derived from the patent.

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[fol. 2017] (Tr. 2126)

A. I do not think I have testified to the actual values, numerical values, of the inductances. For the coil g' with the 21 turns, my computed inductance is 24 microHenrys. The computed value of the coil j' came out to be 154.7 microHenrys. That is, being computed by the formula given in circular 74 of the Bureau of Standards, page 252. The value of the condenser h is given in the tune, 4,600 micromicrofarads. The equivalent antenna inductance was computed to be 25 microHenrys, and the equivalent capacity of the antenna, 240 micromicrofarads.

By Mr. Houghton:

74 Q. Does the patent state any limit in number of turns for coil g'?

A. It says "up to 21 turns".

75 Q. That is for which tune?

A. That is for tune No. 3, receiver.

76 Q. Now, with respect to tune No. 4, does it state?

A. It specifies 100 turns for the coil g'.

77 Q. What is the total possible range, then, of turns for the coil g', as disclosed by the patent?

A. From zero to 100.

78 Q. Do the wave-length ranges which you have calculated from 142.3 up to 364.1 bear any relation to the possible range of number of turns of the coil g'?

A. The values which resulted in the wave-length 142.3 assumes g' zero; the values which resulted in 166.4 were for g' having 10 turns; that resulting in 199.3 were, for g', 21 turns; and that which resulted in the value 364.1, were for g' having 100 turns.

[fol. 2018] 79 Q. Then the maxima and minima of the wave-length range to which you have just testified corresponds, does it not, to the maxima and minima number of turns of the coil g', as disclosed in the patent?

A. It does, with this proviso—that h remains at 4,600 micromicrofarads.

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(Tr. 2128)

81 Q. If the condenser h for tunes 3 and 4 is to be given a value of 4,600 micromicrofarads, what utility is there in having the condenser constructed to be adjustable?

A. In so far as the operation of the equipment as specified in the table on page 4 goes, I can see no particular advantage in having the condenser h adjustable except for the purpose of attaining that particular value, 4,600 micro microfarads at all of the receiving stations. The question is possibly a bit difficult because one has to project himself back to some 30 or 40 years in the art to understand just what was intended in the specification and table.

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(Tr. 2129)

A. (Continuing:) At the present day, one would certainly not put in a variable condenser and then leave it fixed in only one value, but, at the time referred to, and with [fol. 2019] the type of construction of the condenser, making it adjustable for the purpose of getting one particular value might be the better way of obtaining that value than to attempt to make all condensers of a fixed value, questions of manufacturing tolerance, and so on, coming in. Of course, I cannot say that that was the reason, because I do not know; but, as far as the operation, as disclosed in those

tables, goes, there is no reason why that condenser h should not have been a fixed condenser.

By Mr. Houghton:

82 Q. Earlier in your testimony today, you stated that you assumed the coupling between the primary and the secondary to be so small that its square could be neglected. Did you make any computations to check the validity of such an assumption?

A. Yes.

83 Q. Will you briefly summarize what sort of calculation this was, and how it indicates the validity of the assumption.

A. I computed the inductance of the secondary, approximately—quite approximately—as disclosed in Fig. 8 of the patent, as being the form most amenable to calculation. This calculation, while it admittedly is not so accurate as those connected with the determination of the tuning, showed that the inductance was of the order of 1300 to 1400 microHenrys. From the number of turns in the construction given for the secondary used in tune 3, namely, that of Fig. 6, I judged that the inductance would be considerably greater than that shown in Fig. 8. Now, for the coil, as I figured it from Fig. 8, the inductive reactance of [fol. 2020] that coil would vary over the range of frequencies or wave-lengths 142 to 364 from 18,000 to 7,000 ohms, which is a tolerably high reactance. Consequently, this coupling coefficient for the alteration of the primary circuit resistance and reactance is bound to be small, because that coupling coefficient varies inversely as the impedance of the secondary. It having a high reactance in the coil j^2 and a relatively high resistance in the detector T, the two together will insure a very small coupling coefficient—coupling coefficient, Your Honor, for the transfer, not of energy but of apparent reactance and resistance from the secondary to the primary.

Commissioner Gordon: I do not understand what you mean by that last statement. I always thought that the coupling was for the transfer of energy.

The Witness: Your Honor, I probably owe you an apology for the form in which I have presented this. As you say, the ordinary meaning of the coupling coefficient is simply the ratio of the reactance which is common to the two circuits to the product of the reactances of the same nature in the primary and the secondary separately, the

square root of those. That is the ordinary one. Now then, any transformer behaves as if its resistance and reactance were different from the values that they would have if they were separated entirely. That is, if you measure the resistance and reactance of the primary of the transformer with the secondary taken over to China or anywhere else out of the way, you get certain values. You bring them together [fol. 2021] and measure again by identical methods the resistance and reactance of the primary, and you find them different: you will find the resistance increased and the reactance decreased by a certain fraction of the resistance and reactance of the secondary circuit. Now, I probably should not, in this company at least, have called this a "coupling coefficient", but what I meant by the coupling coefficient, in that sense, is the factor that determines what fraction of the secondary resistance and reactance is effectively transferred to the primary so as to alter its value, to what is found when they are together. It is a thing you find in all text books, and so on; and that factor, that transfer factor, varies directly as the "ordinary coefficient of coupling" if you want, and the frequency, and inversely as the impedance of the secondary.

By Commissioner Gordon:

84 Q. Does not your statement, after all, mean that the impedance of the primary and the secondary windings varies in accordance with the tightness or looseness of the coupling?

A. The amount of the change will be much less dependent on the tightness or looseness of the coupling than it is dependent upon the impedance of the secondary. The amount of the alteration of the constants of the primary coil, that is, the resistance and reactance, is much less dependent upon the coefficient of the coupling than it is upon the value of the impedance to the secondary when that impedance is large.

By Mr. Houghton:

85 Q. By the "coefficient of coupling" in that last sent- [fol. 2022] ence, did you mean the same thing that you meant when you used——

A. (Interposing:) Let us call them "coefficient of coupling, No. 1," and "coefficient of coupling, No. 2." No. 1

is the ordinary definition of coefficient of coupling. No. 2 is a coupling of the two circuits with respect to the alteration in the values of resistance and reactance which results from the juxtaposition of the two circuits.

By Commissioner Gordon:

86 Q. Or which result from the tightness or looseness of the coupling?

A. Well, no, not exactly, because this coefficient of coupling No. 2 is, as I have stated, less dependent upon coefficient of coupling, No. 1, than it is upon the magnitude of the secondary impedance.

87 Q. I am perfectly frank to say that I do not follow the use of two different terms or definitions of coefficient of coupling.

A. It may be inadvisable to have two terms, and call this second "baby" by another name than "coefficient of coupling." I think it would have been advisable. I regret somewhat that I introduced it. It is one of those things that is very simple to explain as an equation in mathematics and very difficult to put into words.

88 Q. Let us see if I understand this. Let us come down to what you referred to as a conventional coefficient of coupling. Just in the last few answers, you used the term "jux- [fol. 2023] taposition of the primary and the secondary". When the primary and secondary are as closely related to each other as possible, isn't that known as a "tight" coupling?

A. You mean physically?

89 Q. Yes.

A. No, it may be, or it may not be.

90 Q. Then I wish you would define for me again what is meant by the conventional term as it is used, "loose coupling", and "tight coupling"; in other words, what those conventional terms mean as they are ordinarily used, and in simple language. The ordinary radio operator uses those terms, does he not?

A. Yes.

91 Q. And he does not possess any great wealth of mathematical knowledge, does he?

A. He may not, and usually does not.

92 Q. Then what do those terms mean to the ordinary radio man, not the highly skilled mathematician?

Mr. Houghton: In that connection, I believe it might be helpful, Doctor Wheeler, if you would enumerate the ways in which a coupling may be made looser or tighter, and then from that, explain the answer, requested by the Commissioner.

Commissioner Gordon: I suggest that he first give us definitions of these two phrases, "tight coupling" and "loose coupling", in the ordinary usage of the radio art, and then he can elucidate as to the various ways in which "tight coupling" and "loose coupling" are obtained.

A. Of course, tight coupling and loose coupling are two [fol. 2024] extreme cases of the coupling, and there are various types of coupling. The tight coupling will be one where the number that expresses it is of the order of five tenths or greater.

By Commissioner Gordon:

93 Q. Five tenths of what?

A. A pure number. Coefficient of coupling is a pure number.

94 Q. I did not ask you to define "coefficient of coupling".

A. That is, we will say, the mathematician's way of looking at it.

95 Q. I did not ask you for the mathematician's way of looking at it. I asked you for the ordinary, conventional use of that term, as used by the radio man and not by the mathematician.

A. Well, he means, probably, that he brings the primary and the secondary into close juxtaposition for tight coupling.

96 Q. That is "tight coupling" in the ordinary sense?

A. In his sense of the word; yes.

97 Q. What is "loose coupling"?

A. When he separates the coils, primary and secondary, to considerable distance.

By Mr. Houghton:

98 Q. What is the functional difference between such tight coupling and a loose coupling?

A. There is more than one difference. It affects the [fol. 2025] transfer of energy from one circuit to the other, and it also affects the apparent electrical constants, the resistance and reactance, of the circuits. In the case of the

loose coupling, there is less energy transferred and less effect of the primary upon the secondary, or vice versa. In the case of tight coupling, there is more energy transferred, and the apparent resistance and reactance of the two circuits are altered more.

By Commissioner Gordon:

99 Q. Then as I understand it, that energy is transferred electromagnetically and electrostatically?

A. Yes.

100 Q. And is it proper to say that that transfer*ance* is a maximum when a tight coupling exists, or, not a maximum, but it approaches maximum?

A. There is a certain critical value of the coupling, known as "sufficient coupling", or, rather, there is a critical value above which the coupling is called "sufficient" and below which it is called "deficient" coupling, where the behavior of the two circuits is quite different with respect to energy transfer. As you increase the coupling beyond this critical dividing point into the region where the coupling is called "sufficient", you will increase the energy transfer according to one law, and where you are below that, the law of transfer is different.

101 Q. But, after all, if I have a primary coil in my right hand a secondary coil in my left hand, and my arms are [fol. 2026] extended as far as they can be apart, it would be proper to say that that would represent a very loose coupling with a minimum transfer of energy, would it not?

A. Yes.

102 Q. And then, as I brought my two hands together and as they approached each other, would it be proper to say that I was increasing the coupling and also increasing the transfer of energy?

A. In a general sense; yes.

103 Q. And, finally, when my two hands met, providing the coils were of the same diameter, and I could not get them any closer together than the meeting of my hands, in that case I would have the maximum coupling and the maximum transfer of energy, would I not?

A. The closest coupling that you could obtain without the use of magnetic material in the cores of the coils.

104 Q. That would be about the closest I could get, under those circumstances?

A. Yes.

105 Q. Now, if the coil in my left hand were smaller than the one in my right, so I could slip it inside, would that give me a still closer or a tighter coupling?

A. Yes.

106 Q. And that, then, would represent, under those conditions, with two concentric coils, the tightest coupling that I could get without the use of magnetic material?

[fol. 2027] A. Yes, and without actual interleaving of the two on the same coil form.

By Mr. Houghton:

107 Q. Doctor Wheeler, you have indicated by your last answers that one manner of obtaining tightness or looseness of coupling is by the physical space of separation of a primary and secondary coil. Are there other ways in which tightness or looseness of coupling of two coils may be controlled?

A. Do you mean between two coils already existent or in the design of coils to produce the greatest possible degree?

108 Q. I mean between two coils already existent, and physically close together, bearing in mind that you have said looseness or tightness of coupling had reference to the transfer of energy from one coil to the other.

A. You could effect it by putting magnetic material inside the core. You could change the coupling that way, and increase it.

109 Q. That would increase the coupling? Suppose a high impedance is inserted into the circuit of one of the coils; a high impedance of the same nature as the impedance in the coil itself; does that affect the energy transfer between the two coils, which may otherwise be termed the closeness of coupling?

Commissioner Gordon: It rather seems to me that defendant's counsel has not only asked a question but has made a statement. The question, because of that statement, is dual.

[fol. 2028] Mr. Houghton: I will withdraw the "which may otherwise be termed", and so forth, for the present. Will you read the question as revised.

Commissioner Gordon: Rephrase the question, so that the witness has the question in its rephrased form.

(109 Q., minus the final clause, was read by the reporter.)

Commissioner Gordon: I suppose the question contemplates both electromagnetic and electrostatic transfer of energy, does it not?

Mr. Houghton: Impedance of the same nature as the impedance of the coil would be inductive impedance.

A. Yes; it would affect the transfer.

By Mr. Houghton:

110 Q. Is it correct to say that the transfer of energy between the two coils is an indication of the looseness or tightness of coupling between them?

A. In a very general sense, yes.

111 Q. It appears to me that the Commissioner is troubled by the fact that these coils, j' and J^2, are physically very closely juxtaposed; and yet you indicate that for the coupling between the primary and secondary of Fig. 2, the coupling coefficient is small, and the coupling is therefore what might be termed "loose". Can you explain how the loose coupling exists, in Fig. 2, notwithstanding the close physical justaposition of coils j' and j^2?

[fol. 2029] A. It would be very easy to do it mathematically. The reason is that the coefficient of coupling for all quantitative purposes is defined as the ratio of the reactance which is common to the primary and secondary to the square root of the product of the reactances of the same kind in the primary and the secondary; therefore, if the reactance of the primary or secondary, one or both, is high, that ratio is low, independently of the physical juxtaposition or physical positions of the primary and secondary; because it is a matter of definition of what we mean by the coefficient of the coupling. That is the definition, as I quoted it, as it is given in the books.

By Commissioner Gordon:

112 Q. But you still maintain, do you not, that when two coils, the primary coil and the secondary coil, are juxtaposed, the electromagnetic transfer of energy and the electrostatic transfer of energy are maximum, which can only be exceeded when the coils themselves are interwoven or interlaced or something, that is correct?

A. That is about correct, sir; yes.

By Mr. Houghton:

113 Q. Is it correct to say that introduction of high impedance into the secondary circuit of Fig. 2 produces the same electrical effect between coils j' and j^2 that would be produced by the physical separation of coils j' and j^2?

A. Yes, sir; that is so.

[fol. 2030] 114 Q. In other words, either physical separation or the introduction of high impedance values into the secondary are alternative ways of loosening the coupling, is that correct?

A. That is correct.

By Commissioner Gordon:

115 Q. Both electrostatically and electromagnetically, is that true?

A. The electrostatic—remember, in the definition, that is taken care of by specifying the kinds of reactance. You have got to have the reactance which is common, too, to the two circuits of the same kind as the reactance in each circuit, when you calculate your coefficient of coupling.

Commissioner Gordon: I think that can be almost answered Yes or No.

A. It is a little more complicated than that, Your Honor, I think, because the definition of the coefficient of coupling changes with the character of the transfer, whether it is electromagnetic or electrostatic.

By Commissioner Gordon:

116 Q. Tell me, then, Doctor Wheeler, when we have two coils in juxtaposition, and we do not move them apart, or we do not separate them, but we merely change the reactance or resistance, or something, in one of those lines, would there be the same exact number of lines of magnetic force transferred from the primary to the secondary, as before?

[fol. 2031] A. No, because the current is changed.

117 Q. I am talking about the current in the primary.

A. No. I say, the current is changed by that fact, so that there is not the same number of lines of force in the two cases.

118 Q. There is not the same number of interlinking lines of force?

A. No.

119 Q. Now, how about the electrostatic effect which is set up in the primary and affects the secondary? Is that the same, where we change the resistance or reactance of the secondary?

A. If the reactance that we change is inductive reactance, the number of lines of force will remain the same, but if it is capacity reactance in the secondary you could not say; we change, and it will make a difference.

120 Q. And by this last answer, you mean the electrostatic, is that right?

A. Of course, the use of the word "electrostatic" is somewhat a misnomer any way, because in this case we are dealing with changing charges, moving charges, all the time, and there is nothing static about it.

121 Q. It is a term that you have used?

A. Yes, it is used. I admit that scientists are not impeccable in their choice of language, always, it is true. The [fol. 2032] actual coupling in this case is a complicated thing, terribly complicated, and so far as I have been using it for these calculations it is not for a question of determining the energy transfer, at all, but only for determining the change produced in the electrical characteristics of the primary.

122 Q. Back in 1900, when Marconi applied for this patent, was he not more interested in the energy exchange than anything else?

A. I presume so. He was interested in that, and in tuning. According to this patent, one of the main features is to be able to tune the circuits so that only designated receiving stations can get the signal. And it is with respect to the tuning only that my calculations have been directed.

123 Q. Doctor Wheeler, before the noon recess, you stated that you could calculate the distribution or approximate distribution of currents in the antenna circuit of tune 3, as between the coil j' and the condenser h. Have you now made such a calculation?

A. I have.

124 Q. And what does the calculation show with respect to the current distribution?

A. Assuming that the currents are inversely proportional to the reactances, the current in the coil j' will be between one and two percent of that in the condenser h. This calculation is not exact, in that the true ratio of the

currents is the inverse ratio of the impedances. However, there is no data immediately available for determining the impedances, which means that I have neglected the resist- [fol. 2033] ances in each branch. Inclusion of the resistance of the coil j' would tend to decrease the ratio of the current in j' to that in h; and hence this ratio of one to two percent is in the nature of an upper limit to the ratio of the currents.

By Commissioner Gordon:

125 Q. Is that figure which you have given a figure which is just for the one wave-length or one set of wave-lengths, or does it apply generally?

A. No, only for the wave-length, 200 meters. It will change. I have not had time to figure it out for the whole range. I will change, but not enormously. It won't change enormously. I should guess it might go up to 10 percent at one extreme, as an outside. That is a guess.

By Mr. Houghton:

126 Q. When you were asked your opinion as to the relative value of the current distribution between the coil j' [fol. 2034] and the condenser h, you stated that a much smaller amount of current would pass through the coil than through the condenser for tunes 3 and 4. Now, can you state without reference to the calculation which you have just made what theoretical basis you had for your previous statement with respect to the approximate distribution?

A. My knowledge that at these frequencies the capacity reactance of the condenser, as large as 4,600 micro-microfarads, would be very much less than the inductive reactance of a coil of inductance of approximately 150 microhenries. Without having calculated it out, I know it must be so, simply from experience, if you want to, with condensers and coils.

127 Q. Can you explain a little more in detail why you know it must be so?

A. I know that the capacity reactance is inversely proportional to the product of the capacity and the angular frequency, whereas the inductive reactance is proportional directly to the product of the inductance and the angular frequency, and with the magnitudes of the capacity and the inductance involved, I know that capacity reactance must

be much less than that of the inductive reactance. You may take it that the feel for the magnitudes of those things gets to be more or less instinctive after one has figured such things a good many times.

128 Q. Bearing in mind the current distribution in the primary circuit between the coil j' and h, will the coupling [fol. 2035] of the secondary circuit of Fig. 2 to the coil j' affect materially the current distribution to which you testified?

A. It would affect it somewhat, but not materially.

129 Q. You have testified that the secondary, j'', of the transformer of Fig. 6 would have a very high inductive impedance. With that secondary coupled to the primary j', does that impedance enable you to judge about what effect if any the coupling of that secondary would have on the distribution of current bewteen coil j' and the condenser h?

A. Again, it is a matter of our old friend, the "coefficient of coupling", and that means in general that since, owing to the construction of the coil of Fig. 6, the coupling would probably be somewhat looser than in the case of that of Fig. 8, the effect of the reactance of the coil of Fig. 6 in changing the current distribution between the j' and h would be less than in the case of the Fig. 8 transformer.

By Mr. Blackmar:

130 X Q. May I interrupt to ask which coefficient of coupling you were talking about, then?

A. As a matter of fact, it would be both that would be loosened, I believe.

[fol. 2036] By Mr. Houghton:

131 Q. Doctor Wheeler, do you have a tabulation of the resonance frequencies of the Marconi tunes as calculated by you in accordance with your previous testimony?

A. I have.

132 Q. Is this the tabulation?

A. That is.

Mr. Houghton: I ask that the tabulation be marked defendant's exhibit BBB, and offer it in evidence.

* * * * * * *

(Tr. 2147)

133 Q. You have just indicated a correction in a legend on the copy of this tabulation. What was that? Will you

indicate it on the record, and also mark it on the tabulation.

A. Change the subheading of the column, numbered 4, by striking out the words "if" and "j' omitted", and substituting "of series circuit f'g'hE alone"; so that the caption reads: "W/L (wave-length) of series circuit f'g'hE alone."

* * * * * * *

(Tr. 2149)

134 Q. Referring to the tabulation, defendant's exhibit BBB for identification, please refer to the first and third [fol. 2037] columns, the third column being headed "Overall W/L", meaning "overall wave-length". Will you please state if the values in the third column are those determined by your calculations for the respective tunes of the Marconi table on page 4 of the patent, as previously testified.

A. They are.

135 Q. And with respect to the fourth column, headed "Wave-length of series circuit f'g'hE, alone", are the values set forth opposite the three cases of tune 3 and tune 4 the values calculated for that series circuit by you, as previously testified to?

A. They are.

136 Q. And with respect to tunes 3 and 4, what do the figures set forth in the fifth column of the tabulation represent?

A. The wave-lengths of the second response point of the coupled circuit, consisting of the primary and secondary, as shown in Fig. 2.

137 Q. Are those the figures calculated by you for the three cases of tune 3 and the case of tune 4?

A. They are.

138 Q. And what do the figures set opposite them in the last column of the tabulation represent?

A. The resonant frequency of the circuit hj' by itself.

139 Q. Is there any statement in the patent with respect [fol. 2038] to the relation of the transmitter frequencies for the respective tunes, to the receiver resonance frequencies for those tunes?

A. The statement on page 4, immediately beneath the two tabulations, the one you refer to.

* * * * * * *

141 X Q. At what lines of that page?

A. At line 6 of page 4; and also in specification on page 2, beginning, line 118.

142 X Q. How about page 4, line 1?

A. For completeness, it might be well to make it "page 4, line 1".

* * * * * * *

By Mr. Houghton:

143 Q. Referring to the tabulation, defendant's exhibit BBB for identification, will you explain what the several columns of figures on the tabulation mean, with respect to the tuning of the Marconi receiver antenna circuit?

A. You wish me to take the columns in order?

144 Q. Either taking the columns in order, or comparing the columns, with more particular reference to tunes 3 and 4.

A. In column 3 are given the computations of the resonant frequency of the primary circuit of Fig. 2 of the Marconi patent, from the data available in the patent specification as given in the tabulations on page 4, and the data as to coils, on page 3 of the patent. Column 4 gives the resonant [fol. 2039] wave-length of a simple series circuit consisting of the antenna, the loading coil, condenser, ground connection, with the values of the loading coil and the condenser as given for the corresponding cases of the Marconi primary circuit, Fig. 2

145 Q. The same antenna, also?

A. With the same antenna.

146 Q. What does the comparison of those columns show?

A. A comparison of those columns seems to me to afford the definite conclusion that the primary circuit of the Fig. 2 of the Marconi patent is essentially the same as that of a simple series inductance capacity circuit. Do you wish me to go on with the columns?

147 Q. Please.

A. In column 5 are given the values of the second resonant frequency of the primary circuit of the Marconi Fig. 2, which occurs in tunes 3 and 4, only, as only in those two cases will the transformer possess two frequencies. In the sixth column is given for comparison the wave-length of the circuit, consisting of the condenser h and the coil j', by itself, and the comparison of those last two columns

shows that the second coupling frequencies are substantially those of the circuit hj' by itself.

148 Q What does the fifth column show with respect to the effect on this second frequency of material changes in the number of turns of load coil g' included in the circuit?

[fol. 2040] A. It shows that the change, the effect, is very small.

149 Q. Doctor Wheeler, do you have all of the calculations, made to determine the results tabulated on defendant's exhibit BBB for identification, here and available for inspection by opposing counsel?

A. I have, with the exception of the figures in column 2.

150 Q. Are the figures in column 2 dictated by the statements referred to by you in the Marconi patent specification with respect to the relation between transmitter and receiver wave-lengths?

A. Yes, they are.

Mr. Houghton: I offer in evidence, as defendant's exhibit BBB, the tabulation just referred to by the witness, and entitled "Marconi Antenna Circuit Tunes".

* * * * * * *

By Mr. Blackmar:

151 X Q. I would like to understand your answer with respect to column 2, which you said was dictated by something in the specification.

A. That all the circuits should have approximately the same tune, the four circuits.

152 X Q. In other words, the figures in column 2 were taken from column 3 rather than from anything directly in the patent, is that what you mean?

[fol. 2041] A. Except as given in the patent by the two quotations that I cited from it.

153 X Q. Well, those quotations are the ones which indicate that tune 1, for example, of the receiver, is to be of the same wave-length as the tune 1 of the transmitter?

A. Yes.

154 X Q. In other words, then, column 2 is arrived at by taking approximately the figures which appear in column 3?

A. Yes.

155 X Q. Rather than by independent calculation?

A. Yes, sir; that is correct.

156 X Q. Now, may I ask what the statements opposite the numbers 5 and 6 in column 1 mean.

A. In 5 and 6, the significant difference is in the form of the antenna, which has the zinc cylinder at the top, the different distance above the ground—not a difference, but a height—three meters, approximately, above the ground, in there. In that circuit it is. Otherwise, No. 5 is identical with No. 1, except for that antenna difference, and No. 6 is also identical with No. 1, and, as No. 1 is a simple series circuit, so also are tunes 5 and 6, with the exception that in 5 and 6 the condenser h is not included. The notations there are very compressed; there really should be a comma after the series.

[fol. 2042] Mr. Blackmar: I have no objection to your putting that in if you wish to, in the original.

The Witness: That is, it is a series tuning arrangement in those cases, as in tune 1. It differs from tune 1 in having H omitted.

By Mr. Blackmar:

157 X Q. Is h present in tune 1?

A. No. Oh, no, that's right. How did that get that way? The comma should be after the "only". If there is no objection, I would like to alter the thing, to put a comma after "only" in both those.

Mr. Blackmar: I have no objection, if you wish to do so in the original exhibit, if you think it will clarify it.

(The witness makes the correction or change referred to.)

* * * * * * *

(Tr. 2159)

(The tabulation referred to, marked Defendant's Exhibit BBB, and entitled "Marconi Antenna Circuit Tunes", is filed in connection with this case.)

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(Tr. 2164)

164 Q. In your testimony yesterday with reference to tune 3 of the Marconi patent you indicated the general distribution of current of the antenna circuit between the coil j' and the condenser h. With that current distribution, is the cur-

rent in the coil j' or the condenser h in such a condition that it could be said the current in each of those elements is considerably greater than the current flowing in the antenna? [fol. 2043] A. If the received signal is in tune with the natural resonance frequency of the coil j' together with the condenser h, then the circulating current in that circuit may be much greater than that outside.

165 Q. Referring to your tabulation, defendant's exhibit BBB, with what is the received wave-length in resonance, in Fig. 2?

A. With the overall antenna resonance frequency, which is very different from that of the natural resonance frequency of the coil j' with the condenser h.

166 Q. In using the arrangement of Fig. 2 of the Marconi patent in accordance with tunes 3 and 4 of the table appearing on page 4 of the patent, is the antenna current of the received signal substantially equal to the current in the condenser h, or is the current in the condenser h much greater than the antenna current?

A. The antenna current will be very nearly equal to that in the condenser h.

167 Q. Referring again to the table, defendant's exhibit BBB, and to the disclosure of the Marconi patent, would you say that the transmitted and received wave-lengths of the Marconi disclosure are long wave-lengths or relatively short wave-lengths, speaking as of the period prior to 1919?

A. For the tunes calculated, they are relatively short wave-lengths. On the present international system of classifying, I think they would be called the "medium long", though my recollection is not exact on the frequency limits, under the present convention.

[fol. 2044] 168. Q. Do you find any disclosure in the Marconi patent comprising any teaching of the desirability of using a parallel resonant circuit for receiving wave-lengths longer than 3,000 meters?

A. I have not calculated all the possible tunes disclosed with the apparatus in the specifications; however, as far as I have gone, the answer to your question is No.

169 Q. Do you have the calculations here with respect to the results obtained contrary to those obtained by Mr. Picard with respect to the tuning range of the condenser of the SE-143 primary circuit?

A. I have.

170 Q. And they are available for inspection by opposing counsel?

A. They are.

Mr. Houghton: That is all. Direct examination closed.

Cross-examination.

By Mr. Blackmar:

171 X Q. You referred to not having calculated all the possible tunes of the Marconi patent. How many possible tunes do you consider that there are?

A. I haven't figured that out.

* * * * * * *

173 X Q. Isn't it true that in your opinion, within the disclosure of that patent, there might be an infinite number of tunes?

[fol. 2045] A. It depends upon the method of selecting turns in the load coil.

174 X Q. Do you understand that there is anything in the patent limiting it for example to the six so-called tunes of page 4?

A. No, not as the specification reads. In tune 3, on the "receiving-station", it is up to 21 turns, can be used. That would mean that you might have from zero to 21 turns, and if he can select one turn for a tune, that would make 21 tunes possible for the tune numbered "No. 3".

175 X Q. I think, Doctor Wheeler, my question was a little broader than that. In your opinion is there anything in the Marconi patent limiting it to the six tunes of page 4, including in those tunes any of the variations of tune 3 of the receiver?

A. The thing that will limit the ranges that you can get, of course, is the values of the coils and the condensers, and the particular way in which they are connected.

176 X Q. In your opinion, is the disclosure of the patent limited to the coils and condensers that are specifically described in the patent?

A. Of course, the statement is general that these things that are described in the specification are preferred forms.

[fol. 2046] 177 X Q. And that is also true, is it not, with respect to the tunes given in the tables on page 4?

A. I should judge so, in general.

178 X Q. They are referred to as "preferred adjustments", are they not?

A. I should think so, as a layman. I do not know. There may be some legal question of interpretation of the exact meaning of those phrases that I am not familiar with.

179 X Q. May I say this, Doctor Wheeler, that a patent is not addressed to a patent attorney, but to the man skilled in the art. In that sense I do not think you are a layman. Therefore, in construing the patent, it should be looked at by you as one skilled in the art; and from that point of view, would you in reading the disclosure of the patent consider that the only things contemplated by Marconi were those described by him?

* * * * * * *

[fol. 2047] (Tr. 2168)

A. The answer is No, that portions of the apparatus such as coils and condensers having equivalent electrical properties could be substituted for the actual elements as he specifies them.

By Mr. Blackmar:

180 X Q. What do you mean by "equivalent electrical properties"?

A. Similar inductances, self and mutual; similar capacities, and similar arrangement of those elements in the circuit.

181 X Q. Similar in value, you mean?

A. Similar arrangement of the elements; similar in value, yes.

182 X Q. Then as I understand your testimony, if a transmitter and receiver were utilized, even though they embodied the circuits shown in the patent, and the wave-length employed was say 3,000 meters, and that wave-length is not described in any of the tunes, then you would not be utilizing the disclosure of the patent; is that correct?

A. Strictly, I think that is what I would say now. I would not like to commit myself absolutely definitely on that point.

183 X Q. In 1904 were you familiar with radio phenomena?

A. Radio phenomena? Yes.

[fol. 2048] 184 X Q. If the Marconi patent had been brought to your attention in 1904, which is the year in which

it issued, and if you had read and studied the patent, am I to understand that the only thing that you would have been taught by it would be the use of the circuits shown in figures 1 and 2 for the wave-lengths covered by the various tunes on page 4?

A. That is all that I would definitely have been taught. I might have attempted, if I were curious at that time, to extend the same methods to other wave-length ranges, either longer or shorter.

185 X Q. And I assume then that you would have considered that a contribution by you to the radio art, is that right?

A. No.

186 X Q. Would you consider it based on Marconi's disclosure?

A. Yes.

187 X Q. And I also call your attention to paragraph on page 3, starting at line 12. Would that have suggested to you in 1904, if the patent had been shown to you, that variations or modifications could have been made in the arrangement shown in figures 1 and 2? And in the same connection, you might read the paragraph commencing on line 19 of page 4.

A. Yes.

188 X Q. Now, referring to your calculations which are embodied in defendant's exhibit BBB and in your testi- [fol. 2049] mony, will you please point out in the patent where you find the description of the receiving antenna, the constants of which you calculated.

A. I find on page 3, line 19, that the aerial conductors at all stations were of a given diameter, 7-strand copper wire. The transmitting conductor, the aerial conductor, is given for the transmitting station, the length of it is 36.576.

189 X Q. That is for the transmitting station?

A. For the transmitting station.

By Commissioner Gordon:

190 - Q. Where in the patent is this given?

A. On page 4, the second column of the "transmitting-station" table—36.576 meters of cable; and that is repeated all the way through.

By Mr. Blackmar:

191 X Q. With the exception of tunes 5 and 6?

A. Yes, which had a different kind, what we would call now "top loading" of particular kind. At the present moment I presume I may be accused of assuming that the antennas were the same at receiving and transmitting stations. I do not see any definite statement as to the receiving antenna.

192 X Q. In approaching your calculations and considering the patent did you consider the coil *j'* as fixed or as variable?

A. As a fixed coil which had different values in different tunes.

[fol. 2050] 193 X Q. But as far as each individual tune was concerned you considered it as a fixed coil?

A. I did.

194 X Q. Incidentally, did you have available in 1904 formulas or information from which you could have made the calculations that resulted in the figures of defendant's exhibit BBB?

A. I do not know whether the formulae which I used this week in making the calculations existed in 1904, but formulae of some kind did exist at that time, and much previously.

195 X Q. That is, for computing the inductance of a multiple-layer coil, and things of that kind?

A. Yes, sir.

196 X Q. Were they more or less accurate than the formulas which you employed?

A. I used no formulae for multiple-layer coil.

197 X Q. In general were the formulas for calculating inductance that were available in 1904 more accurate or less accurate than those employed by you?

A. I do not know, without looking them up.

198 X Q. Then you are not sure whether you used the most accurate formulas now available in making your calculations, is that right?

A. No, I used formulas now available which I consider as good as any.

[fol. 2051] 199 X Q. I take it from a recent answer that you have not made calculations as to the wave-length of the secondary circuit of Fig. 2, is that correct?

A. Wave-length of the secondary circuit? No, I have not.

200 X Q. In Fig. 2 is the condenser h in shunt or parallel relation with the coil j'?

A. It is.

201 X Q. Do you consider the secondary circuit of Fig. 2 a series circuit or a parallel circuit?

A. As shown, the condenser h' is in parallel with coil j^2, or as pictured, in parallel with the coils j^2 and portions of the two g^2's.

202 X Q. In the first place, I think that the tables, page 4, will show that the condenser h' is not embodied in the arrangements of tunes 3 and 4; is that not correct?

A. That is correct.

203 X Q. My question was, as to whether you considered the circuit a parallel or a series circuit. I do not think that question has been answered. Will you please answer it.

A. With the condenser h' out of the circuit, the secondary circuit is a series circuit, including coil j^2, condenser j^3, portions of the coils g^2, and the detector.

204 X Q. And what type of detector is that?

A. According to the specification it may be a number of different types. From the drawing, I would say that a coherer is indicated.

[fol. 2052] 205 X Q. When you considered the impedance of the secondary circuit, you considered that a coherer was present, did you not?

A. I did.

206 X Q. What is the resistance of a coherer, roughly?

A. I do not know what it is, in magnitude. Before the particles cohere, it is some thousands of ohms. After it coheres, during that time, depending upon how many of the contacts do cohere, the resistance falls quite appreciably.

207 X Q. When you referred to high impedance in the secondary circuit, were you considering the coherer as decohered, or as cohered?

A. As cohered.

208 X Q. And can you give us any idea as to the resistance of the coherer in that condition, other than to say that it is less, or considerably less, than in the other condition?

A. I am trying to recall some experiments I made on that in 1897 or '8, and my recollection is not any too good as to exact values. I do recollect that the cohered resistance might vary over a very considerable range, from some hundreds to some thousands of ohms, the decohered resist-

ance being say of the order of—well, I cannot remember exactly, but say, the order of from 10,000 up to infinity.

209 X Q. I thought you gave us the figure of 3,000, a few minutes ago.

A. No, "a few thousand", I meant to say, some thousands—I do not know.

[fol. 2053] 210 X Q. If you followed the instructions of the Marconi patent and set up a transmitter and receiver in accordance with tune 4, for example, would you expect to have had the apparatus precisely in tune, if you had been building it say in 1904 and 1905?

A. You mean the transmitter and the receiver exactly in tune?

211 X Q. And each of the two circuits, in each of them.

A. I would have considered myself very lucky if they were.

212 X Q. Would there have been present in the apparatus means for bringing them into tune with each other?

A. Yes.

213 X Q. Now, taking the receiver, the condenser h could have been used for that purpose, could it not?

A. Yes; to a certain extent, yes.

214 X Q. h is a variable condenser, is it not?

A. It is an "adjustable" condenser, as he—well, from the point of view of 1904, yes.

215 X Q. Incidentally, in giving the constants which you had calculated, you did not mention the values of inductance for the coil g' when it had 10 turns, or 45 turns, or 100 turns. Can you give us that information?

A. I can. This coil g', I find for 10 turns the inductance to be 9.18 microHenrys; for 45 turns, 57.4 microHenrys; for 100 turns, 139 microHenrys. It is understood, of course [fol. 2054] that those values are not exact, to an indefinite number of decimal places. In general, I think they are correct to the last figure given from the formula. They are correct as far as the formula is concerned, to the last figure.

216 X Q. I am not sure what you mean by "as far as the formula is concerned."

A. That is, the formula, if you put the values of the radius, number of turns, and length of the coil, into the formula, the formula gives you a result which is good to that last place. The determination of the radius depends upon the thickness of any insulation as well as the diameter of the wire. The diameters of the wire are given appar-

ently from the values quoted in the specification, to the old British wire gauge, which is not our standard gauge, and therefore there is some uncertainty as to how thick their silk insulation, which he specifies, was, compared with modern silk insulation. I have taken the values from tables for the thickness of insulation available to me at the present time, so there are certain uncertainties in the data which went into the formula.

217 X Q. I notice the patentee specifies an interval of 2.28 millimeters between adjacent turns, on page 3, line 53. Did you take that as between insulation, or as between the wires?

A. Between the centers of the turns, the centers of the wire. Oh, wait a minute; I will have to correct that, I think. In the case referred to in line 53, page 3, there was no insulation.

[fol. 2055] 218 X Q. I thought you referred to silk insulation.

A. That would be for the coil j', but as to the inductance coils g and g', the diameter of the wire is given, the cylinder upon which they are wound, the coil form diameter is given, and in that case the 2.28 was taken as the distance between the outside of the wire's adjacent turns. There was no question of silk insulation in that coil g'.

219 X Q. I think you said a few minutes ago that if you built up the receiver of tune 4, for example, a final adjustment could be made with the condenser h to bring that into tune with the transmitter.

A. Yes.

220 X Q. Now, according to my notes you said yesterday that in so far as the operation of the receiver as specified in the table of tunes goes, you could see no particular advantage in adjusting h, except to attain the particular value specified in the table.

A. Yes.

221 X Q. Have you not now pointed out an advantage beyond that?

A. I have pointed out the same advantage.

222 X Q. In other words, to arrive at tune 4, you construe that as requiring exactly 4,600 micromicrofarads of capacity in the condenser h, is that what you mean?

A. If the antenna is as I have assumed in my calculations.

[fol. 2056] 223 X Q. You then do not take the figures

given in the tables, as guides, but as specific requirements, is that it?

A. As approximate specific requirements, yes.

224 X Q. Suppose you built the arrangement of tune 4; first, as I understand you, the coil j' in that case and the coil g' would each have a definite number of turns, is that right?

A. Yes.

225 X Q. And I think you said you would consider yourself very fortunate if you hit the right wave-length by constructing the circuit following the specific instructions of the patent, that is true, is it not?

A. Hit the exact wave-length? I would expect to hit somewhere near it.

226 X Q. What variable element or elements are there in the antenna circuit of the receiver of tune 4?

A. The coil g', the condenser h, the two coils g^2 in the secondary.

227 X Q. I was speaking of the antenna circuit.

A. Of the antenna circuit, alone? We have coil g' and the condenser h.

228 X Q. If the coil g' were kept at 100 turns, then the only variable element would be the condenser h, is that right?

A. Correct.

[fol. 2957] 229 X Q. If you wished to have the circuit respond to the exact wave-length, would you expect to have to use exactly 0.0046 microfarads for the condenser h?

A. If the received wave-length were exactly 364.6 meters, you would have to be very close to .0046.

230 X Q. If you were also constructing a transmitter at the same time for tune 4, would you expect to have the transmitter and the antenna circuit of the receiver exactly in tune with each other, to start with?

A. No, not exactly in tune.

231 X Q. To tune them, you would have to make some adjustments in one or the other, would you not, probably?

A. I would.—That last?

232 X Q. "Probably" is the last word.

A. Probably, yes.

233 X Q. And as far as the receiver is concerned, that adjustment could be made by the condenser h, could it not?

A. It could.

234 X Q. And the condenser h would have utility for that purpose, would it not?

A. It would.

235 X Q. And the resultant capacity of condenser h would not, under those circumstances, necessarily be .0046 microfarads, would it?

A. Not exactly, no. It could however be exactly that if you adjusted the capacity E of the transmitter.

[fol. 2058] 236 X Q. And if you adjusted the capacity E of the transmitter, it might very well not amount to 16,849 micromicrofarads, might it?

A. Not exactly.

237 X Q. In other words, I think the probabilities would be, and I think you will agree with me, that when transmitter and receiver were in tune, either the condenser E or the condenser h would not have the exact value of table 4?

A. Might not.

238 X Q. And if the final adjustment were made at the receiver, then it might well be that the capacity of the condenser h would not be .0046 microfarads?

A. No, it would not be exactly that, though it would not be very far from it.

239 X Q. And then I repeat, is there not an advantage in being able to adjust the condenser h beyond the possibility of adjusting it to the exact value of tune 4?

A. The value of adjustment for condenser h is to adjust it to the exact value of the received wave-length, which may not be exactly .0046.

240 X Q. In making the calculations upon which the results of defendant's exhibit BBB are based, did you or did you not consider the distributed capacity of the various coils?

A. I did not.

241 X Q. And that would affect in one way or another the resultant wave-length, would it not?

[fol. 2059] A. It would have affected it, to a certain extent, yes.

242 X Q. Or, if the wave-length were not affected, it would affect the value to which the condenser h would be set, would it not?

A. It would.

243 X Q. As I understand you, the secondary circuit of Fig. 2 of the Marconi patent, when h' was omitted, is a series circuit, is that right?

A. A circuit made up of the elements which I enumerated before, in series, yes.

244 X Q. And, as I also understand you from your direct testimony, that is a high-impedance circuit, is that right?

A. A relatively high impedance circuit, yes.

245 X Q. And is that so, whether or not that circuit is tuned to the same frequency as the primary circuit?

A. The impedance in the secondary will be different, depending upon whether it is tuned exactly or not.

246 X Q. The impedance of a series circuit varies with the impressed wave-length, does it not?

A. Yes, it does.

247 X Q. At what wave-length, as compared to the resonant wave-length, is the impedance lowest in a series circuit?

A. The impedance is lowest in a series circuit at the point of resonance.

[fol. 2060] 248 X Q. And when the secondary circuit of Fig. 2 is tuned to the same frequency as the primary circuit, and that is the received frequency or wave-length, then the impedance of the secondary circuit is at its lowest point, is it not?

A. It is.

249 X Q. What are the elements that give the secondary circuit the high impedance that you spoke of?

A. The resistance of the coil j^2. You are speaking now of tune 4?

250 X Q. Tune 3 or tune 4, yes.

A. And in the case of tune 4, the resistance of the two coils g^2, the resistance of the capacity j^3, the resistance of the detector T, the reactance of all of the coils mentioned, and the reactance of the condenser. There is one further factor that is relatively negligible, and that is the parallel circuit with the chokes c' and c^2, battery to the recorder or whatever it is that is indicated by "R" in the diagram.

251 X Q. Can you give me any idea of the magnitude of the reactive impedance of the elements, assuming as we are assuming that the circuit is tuned to the received wave-length—that is, the total reactive impedance? Doctor Wheeler, I am informed that I can make the question a little simpler by saying "reactance" instead of "reactive impedance", and that is what I mean.

A. I wasn't worrying about that; I knew what you meant. As I testified yesterday, the approximate, very approxi-

[fol. 2061] mate inductance of the coil j^2 in the construction disclosed in Fig. 8 is somewhere between 1300 and 1400 ohms, microHenrys. Its reactance would therefore be two times pi times the frequency times that value, which is somewhere between 13 and 14 hundred. The reactance of the condenser j^3 I can tell you nothing about, because the capacity of that condenser is not disclosed, as far as I have observed.

252 X Q. Maybe I can make a short-cut, Doctor Wheeler. At the resonance frequency, do not all of the reactances in the circuit cancel out in their net result?

A. The reactances cancel out at the resonance frequency, the sum of the reactances.

253 X Q. And therefore the algebraic sum of the reactances in that circuit is zero, is that right?

A. That is right. The impedance, however, does not vanish. You have still the resistive component.

254 X Q. Now, according to my notes, you stated yesterday that there were two reasons why you considered the antenna circuit in tunes 3 and 4 as a series circuit, and the first reason was, because of the looseness of coupling between the primary and secondary circuits. Do you remember so testifying?

A. Yes.

255 X Q. I would like you to explain that, please—that is, why the looseness of coupling between the two circuits leads you to consider the antenna circuit as a series circuit. [fol. 2062] A. Because the looseness of the coupling reduces the reaction of the secondary upon the primary, and because the value of the primary inductance is such that it passes a very small amount of the total current; that is, expressed in a different manner, the computation of the resonant frequency of the antenna circuit as a whole, with the loose coupling, shows that the resulting resonant frequency is substantially the same as that of the series circuit at f'Ag'hE.

256 X Q. And that is your explanation, as I understand it, of why the looseness of coupling between the primary and secondary circuits leads you to consider the antenna circuit as a series circuit, is that correct?

A. That is correct.

257 X Q. And does it follow that, if the coupling were closer, you would not consider the antenna circuit as a series circuit?

A. If the coupling were close enough, and if the impedance of the secondary at resonance were low enough, then you could not consider the antenna circuit as equivalent to a simple series circuit. I should add also that the value of the inductance of the coil j' affects the question of whether the antenna circuit can be considered as a simple series circuit.

258 X Q. That was the second reason you gave yesterday, I believe, the size of the coil j'?

A. Yes.

[fol. 2063] 259 X Q. And with the close coupling, would that be closer than the critical value, or can you not tell that?

A. I cannot answer that question quantitatively.

260 X Q. And if the coupling were close enough so that the antenna circuit is not a simple series circuit, what would it be—a parallel circuit?

A. No. The antenna circuit would be a circuit having a series element in series with a parallel element.

261 X Q. The overall antenna circuit would still be a series circuit, would it not?

A. In that sense of the word, yes.

262 X Q. In the arrangement of Fig. 2 of the patent, as I understand it, the antenna current divides between the condenser h and the coil j' as it passes from antenna to ground, does it not?

A. That component of the antenna current which is of the frequency of the received signal, yes.

263 X Q. And that means that h and j' are in parallel in the antenna circuit, does it not?

A. Yes.

264 X Q. The circuit of Fig. 2 of the Marconi patent for tunes 3 and 4, referring to the antenna circuit, as I understand you, is also resonant at the wave-length given in column 5 of the defendant's exhibit BBB, is it not?

A. Correct.

[fol. 2064] 265 X Q. That is, it has two resonance points?

A. Yes.

266 X Q. —namely, the wave-lengths given in the column 3?

A. Yes.

267 X Q. —and also those given in column 5?

A. Yes, that is correct.

268 X Q. Now, did I understand you to say that if the wave-lengths set forth in column 5 ,which are in the neighborhood of 1630 or 1640 meters were applied to the antenna circuit, that circuit would not respond well to that wave-length?

A. The primary circuit?

269 X Q. Yes.

A. No, the primary circuit would respond to that.

270 X Q. Then, if the secondary circuit were readjusted or rebuilt to respond to the same frequency, the receiver would be an operative receiver at those wave-lengths, would it not?

A. At the 1630-40?

271 X Q. Yes.

A. Yes, but not if the receiver were tuned to the 200-400.

272 X Q. That is, the secondary of the receiver?

A. If the secondary were tuned to this 200-400, it would not respond to the 1630-40.

273 X Q. And if you wanted to receive the 1630-40, the patent instructs you, does it not, to tune the secondary cir-[fol. 2065] cuit to that wave-length?

A. You would have to tune it to that, yes.

274 X Q. And that is taught in the patent, is it not? I refer you to line 118, at page 2 and following.

A. Yes, I guess that is a fair conclusion from that.

275 X Q. And under those circumstances, what type of antenna circuit would it be? Would it be a simple series circuit?

A. I have not figured that case, owing to lack of time, and I would prefer not to express an opinion until I had had opportunity to do that.

276 X Q. Wherein lies the difficulty there, Doctor Wheeler?

A. There is no difficulty.

227 X Q. Well, why are you unwilling to express an opinion? That is what I mean.

A. But I am loath to express an opinion where I have not figured out quantitatively the result.

278 X Q. In that arrangement, namely, receiving in the neighborhood of 1630 meters, with both primary and secondary tuned to that wave-length, can the effects of the coil

j' be disregarded, as you testified that they could be, for the wave-lengths, column 3 of the exhibit?

A. I cannot answer that definitely without carrying out the calculations.

279 X Q. Now, am I correct in understanding defendant's exhibit BBB to mean, as to column 3, that the wave-[fol. 2066] lengths given there are the resonant wave-lengths of the antenna circuit as a whole?

A. Yes.

280 X Q. And is the same true for column 5?

A. Yes.

281 X Q. That is, it has taken all elements of the antenna and associated elements into consideration?

A. What do you mean by "associated elements"?

282 X Q. Whatever elements might have any effect on that wave-length, or on the resonant wave-length of the antenna.

A. The answer is Yes.

283 X Q. Would relative positions of parts of the primary and secondary circuits have any effect?

A. Certainly.

284 X Q. And did you assume certain relative positions in making these calculations?

A. I assumed the position of the primary and secondary of the transformer j', j^2, as given in the specification. I assumed where the two coils g^2 were included in the secondary that they were so placed as to have no effect upon the primary circuit, and I assumed that the antenna structure was erected in position such that its constants were not affected by neighboring objects.

285 X Q. In your discussion of coupling coefficients and coupling effects between the primary and secondary cir-[fol. 2067] cuits, were you considering only the magnetic coupling, or both the magnetic and capacitive coupling?

A. I was considering both, though in neither case could I get a quantitative estimate as to the amount of the coupling from the disclosures in the patent.

286 X Q. Does the Bureau of Standards bulletin No. 74, to which I think you referred, give the formula or formulas for the coefficient of coupling, using that term in the sense which I think you called "unconventional", and in which you used it in your direct-examination?

A. I cannot answer off-hand. I do not remember. My impression is that it does not.

287 X Q. Does it, so far as you know, give any formulas that show that changes of the impedance of the secondary circuit have a greater effect on reflection of reactance and resistance into the primary than changes in the coupling have?

A. It gives formulas from which such a conclusion could be deduced.

288 X Q. Will you refer to them, please.

A. Page 49, the equation which is not numbered but is in the fourth line from the bottom of the page. I should amend that reply to say that that equation referred to is only one of the factors in this that I called yesterday the second kind of coefficient of coupling.

289 X Q. Do I understand you to mean that the formula [fol. 2068] to which you have referred shows that the changes in the impedance in the secondary circuit have a greater effect on reflection of reactance and resistance into the primary than changes in coupling have?

A. Not necessarily.

290 X Q. You mean I am not to understand that necessarily, or what does your answer mean?

A. That with proper values in that formula you can deduce a value for this coupling coefficient of which that formula is an expression, which will show a greater effect of the secondary reactance, of changes in the secondary reactance, than of changes in the mutual inductance between the two circuits.

291 X Q. The mutual inductance is not the only thing that enters into a coupling coefficient in the usual sense, is it?

A. No.

292 X Q. The inductance of each circuit enters into it, does it not?

A. If it is a case of magnetic coupling, yes.

293 X Q. Incidentally, are the primary and secondary circuits of Fig. 2 directly coupled?

A. Not what is known as "direct"—well, they are coupled by their magnetic field.

294 X Q. Yes, but is that what is ordinarily known as "direct coupling"?

[fol. 2069] A. It is so specified in the figure on that page.

295 X Q. Which figure?

A. Figure B on page 49.

296 X Q. And what does the legend under the figure show, with respect to figure B?

X. Oh, yes—"inductive coupling" they call it. That is my mistake, I beg pardon. "A" shows the direct coupling.

297 X Q. There is a figure there, showing direct coupling, is there not?

A. There is a figure. Figure A shows direct coupling, figure B, inductive coupling, and figure C, capacity coupling. I was misled for a moment, for the words "inductive coupling" were right under the figure as printed.

298 X Q. That is, you looked upon figure B as direct coupling for a moment, is that it?

A. Figure B was "direct coupling", as I read it for the moment, yes.

299 X Q. And you were willing to take that statement that it was a direct coupling?

A. No, I was not willing to take it. I simply said that this was what it said on that page, and I expected to clear it up in further answers by saying it was not what I understood by "direct coupling".

300 X Q. Is the coupling between the primary and secondary circuits of Fig. 2 of the Marconi patent what you [fol. 2070] understand by "direct coupling"?

A. No.

301 X Q. Which type of coupling is that?

A. Inductive coupling—what they call here "inductive coupling".

302 X Q. There is capacitive coupling present, is there not?

A. There is capacitive coupling present, and, in certain circumstances of the disclosure, that, I think will probably be the controlling coupling.

303 X Q. I think you said yesterday it was predominant under certain circumstances.

A. Yes.

304 X Q. I think you also said that capacitive coupling effects are quite complex, is that true?

A. That is correct.

305 X Q. Those capacity couplings between the circuits do enter into the coefficient of coupling between the circuits?

A. They do.

306 X Q. And they enter into both the conventional and the unconventional type of coefficient of coupling, as you have used those terms?

A. Yes.

307 X Q. Incidentally, the formula to which you referred, on page 49, is a formula relating to direct coupling, is it not?

A. Yes.

[fol. 2071] 308 X Q. The capacity coupling between the primary and the secondary circuits is directly affected by relative positions of elements in those circuits, is it not?

A. It is.

309 X Q. And in order to determine the actual capacity coupling between the circuits, you would have to know the relative positions of the parts, would you not?

A. I would.

310 X Q. As I understand your testimony with respect to the operation of the circuits of the Marconi patent, that is all based on calculations, is it not?

A. Yes.

311 X Q. That is, you have not set up the arrangement of Fig. 2, or any of the arrangements of Fig. 2, and observed their operation?

A. I have not done it, personally.

312 X Q. Referring to tune 3 of the tables of the patent, suppose that that circuit were set up with 21 turns in g', and otherwise as described except that the capacity of the condenser h were in the neighborhood of 50 micromicrofarads; can you say whether or not the antenna circuit then would be a simple series circuit, or not?

A. It would be impossible to obtain a capacity of 50 micromicrofarads from the condenser as specified.

313 X Q. Supposing you used another condenser, then, [fol. 2072] and attained that capacity; on that basis, can you answer my question?

A. A condenser with the sam maximum value?

314 X Q. I do not see that that makes any difference, in view of the fact that, as such, it has a capacity of 50 micromicrofarads. You may take any maximum value you want.

A. If you take a small enough value of h, leaving j' the same, g' the same, there will be more difference between the resonance frequency as computed by the method of column 3 from that computed by the method for column 4, than in the cases of the tunes shown.

315 X Q. My question was, whether with a capacity for h of approximately 50 micromicrofarads, would the antenna circuit be a simple series circuit.

A. It would not show the same resonant frequency, exactly, as a simple series circuit, consisting of the antenna, the coil g', and the small condenser h.

316 X Q. Does that mean that it is not a simple series circuit?

A. It is a matter of definition.

317 X Q. You have used the term, Doctor Wheeler. You must have had some definition in mind.

A. I say that this circuit, whatever you want to call it, which is a circuit consisting of a series element in series with a parallel, would not behave quite so closely, as far [fol. 2073] as the resonant frequency goes, to that of a simple series circuit, as if the condenser h were large.

318 X Q. Then I take it the border line between a simple series circuit and one which is not a simple series circuit is not a fixed or a definable border line, is that right?

A. Yes, it is a series circuit with respect to the resonant frequencies that it will exhibit, is what I have meant by saying the circuit is a simple series circuit.

319 X Q. Then let us go a little further and reduce the capacity of condenser h to zero: is it a simple series circuit, or not?

A. You mean, by reducing the capacity to zero, for practical purposes you remove the condenser h from the circuit?

320 X Q. Is that the electrical equivalent of reducing the capacity to zero?

A. Yes; then it would leave the series circuit, consisting of the antenna capacity in series with the coil g' and j' in series.

321 X Q. Is that a simple series circuit?

A. That would be a simple series circuit.

322 X Q. With respect to reflection of reactance or resistance effects from the secondary into the primary circuit, am I to understand that where the secondary circuit is a series circuit and the detector is a high-resistance detector, that fact alone means that there is necessarily loose [fol. 2074] coupling between the primary and the secondary circuits, regardless of other conditions?

A. No, it means there is loose coupling of the unconventional second kind that I mentioned.

323 X Q. There is loose coupling of the unconventional kind or the "new baby" type I think you called it yesterday?

A. Yes.

324 X Q. Regardless of the coefficient of coupling between the circuits, using that term in the conventional sense?

A. Yes.

325 X Q. That is, even if the primary and secondary circuits are very closely coupled, in the usual sense of that term?

A. A high-resistance secondary will then make the unconventional coupling coefficient relatively small.

326 X Q. In defendant's exhibit BBB, was there any reason for omitting the wave-lengths in column 2 for the first two arrangements of tune 3?

A. No reason that I recall at the present moment.

327 X Q. Did you calculate the transmitter wave-lengths on the basis of the transmitter circuits as described in the patent?

A. No, I did not.

328 X Q. That is, the approximate wave-lengths of the transmitters as set forth in column 2 of that exhibit are [fol. 2075] merely restatements of what appears in column 3, is that right?

A. Approximately so; yes.

329 X Q. And there is no other basis or source for the figures in column 2?

A. Well, with some rather wild guesses at the oscillation transformer dd', I would expect wave-lengths of the same order of magnitude at least as those given for the more accurately calculable resonance frequencies of the primary of the receiver.

330 X Q. As far as specific figures in column 2 are concerned, there is no basis for them except what appears in column 3, is that right?

A. Practically so.

331 X Q. I do not know what "practically so" means.

A. As I say, I was influenced from the general consideration that all of the circuits must be in tune according to the specification, and what rough guesses I could make about the primary circuit, that it seemed reasonable to suppose that the frequencies would be about there, but, perfectly true, there are no definite calculations back of those figures in column 2 that I have made.

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[fol. 2076] By Mr. Blackmar: (Tr. 2198)

332 X Q. Doctor Wheeler, you spoke of a simple series circuit, I think. You used that term?

A. I did.

333 X Q. What were you distinguishing from in that term?

A. A circuit in which the frequency-determining elements are in parallel with each other, with respect to the applied electromotive force.

334 X Q. Would that be a complex series circuit, or a parallel circuit, or what?

A. Would which be a complex?

335 X Q. The thing from which you were distinguishing.

A. I would make the distinction between a simple series and a simple parallel circuit; between a simple series circuit and the complex series circuit.

336 X Q. Now, referring to open antennas and radio receivers, 2-circuit receivers such as shown in the Marconi patent, do you ever have a simple parallel circuit in the antenna?

A. Not including the antenna itself.

337 X Q. I am talking of the whole circuit.

A. No.

338 X Q. Then it is either a simple series circuit or a complex series circuit, is that right?

A. Yes, that is right.

339 X Q. Referring to defendant's exhibit BBB, what is the nature of the antenna circuit of column 5? Is that a simple series circuit or a complex series circuit?

[fol. 2077] A. Complex.

340 X Q. And what is it that makes it so?

A. The presence of the simple series element, consisting of the antenna and loading coil in series with the parallel element, consisting of the coil j', condenser h.

341 X Q. The coil j' and condenser h taken alons, as I understand it, have a slightly longer resonant wavelength than the antenna circuit taken as a whole, is that correct—at least as to the cases of tune 3?

A. Yes, as respects tune 3, it has.

342 X Q. And in that case, for the wavelength of the entire antenna circuit, can the parallel circuit hj' be considered to act either as an inductance alone or as a capacity alone?

A. For tune 3?

343 X Q. Referring to tune 3, yes, and also referring, still, to columns 5 and 6 of the exhibit.

A. As far as a received frequency of approximately 200 meters goes——

344 X Q. (Interposing:) No, I think that is not what I was referring to. Assuming the received wave-length is that shown in column 5.

A. (Cont'd.:) If the received wave-length is approximately 1630-40), the resonant frequency of the antenna circuit would be the same to within a fraction of one percent, as with a simple series circuit consisting of the antenna, the coil g′, and the condenser h, to ground. The frequency [fol. 2078] is very nearly the same as that of the parallel combination of hj′, but the action of the circuit as a whole is barely distinguishable from that of the simple series circuit mentioned.

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346 X Q. I am not sure whether that answers my question. I will put it in a different way, Doctor Wheeler. The resonant wave-length of hj′ taken alone is 1640 meters, is that right?

A. That is correct.

347 X Q. Now, assume that that is in a circuit; let hj′ constitute one element of a circuit, and the wave-length of 1628 meters, to take case 1 of tune 3, is applied to that circuit: For that wave-length, does the combination hj′ act as a capacity?

A. Very nearly so.

348 X Q. What does "very nearly so" mean?

A. By "very nearly so" I mean that the frequency response, resonant frequency, is what one would obtain with a capacity, alone, to within approximately 12 parts in 1600.

349 X Q. Does that mean that it does or that it does not act as though it were a capacity?

A. If that whole primary hj′ combination were shut up in a box so that you could not see it, and if you applied external electromotive force and measured voltages and currents to the thing, and plotted a curve, voltage against [fol. 2079] current, you could not distinguish the result from that of a condenser alone to within the precision mentioned, 12 parts in 1600.

350 X Q. That is, if you applied to that box a wave-length of 1628 meters—and maintained it, constant?

A. Yes.

351 X Q. The indications would be that whatever was in that box had a capacity reactance, is that right?

A. Yes, that's it.

352 X Q. Now, the antenna circuit, column 5, as I understand it, consists of the antenna f', the coil g', at least in cases 2 and 3 of tune 3——

A. Yes.

353 X Q. —and whatever is in this box that we speak of, namely, h and j', and the ground connection, is that right?

A. Yes.

354 X Q. I understood you to say a few minutes ago that that was not a simple series circuit but a complex series circuit, is that right?

A. If both j' and h are in the box, parallel.

355 X Q. And if you cannot tell which is in the box, how can you tell whether it is a simple or a complex series circuit?

A. No way of telling.

356 X Q. The only way you can tell is by measuring what occurs when that wave-length is applied, isn't that right? [fol. 2080] A. It would behave like a simple series circuit there, and you could not tell whether it was or was not a complex series circuit.

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358 X Q. As far as external behavior was concerned?

A. Yes.

By Commissioner Gordon:

359 Q. I do not just understand that last answer, and particularly with the idea of this whole thing being in a box and applying tests to it. If, for instance, you applied a constant electromotive force, would that, a test of that kind, indicate it was a simple series circuit?

A. No, you would have to vary some element in order to determine and plot a characteristic curve, like whatever was included between terminals on the box. You would have to vary their frequency or the voltage that is applied.

360 Q. But now if you had a condenser there alone in the box, a simple series circuit and condenser, and applied a

direct electromotive force to that, no current would flow, would it?

A. Applied a DC, no, no current would flow except for leakage current.

361 Q. But if you had this particular combination in a box and applied a DC current to it, what would happen?

A. Current would flow. You would know in that case [fol. 2081] by applying DC. I was considering only the application—I thought that was limited by the question to a signal voltage applied.

362 Q. I do not know what it was limited to, but you said if it was in a box you could not tell whether it was a simple series circuit or not, as I understood.

A. All predicated upon the assumption of an applied AC electromotive force.

By Mr. Blackmar:

363 X Q. Of the wave-length contained in column 5 of exhibit BBB, is that right?

A. Yes, that is right. That is the way I understood it. You are perfectly correct, Your Honor; if you will allow me to apply DC I will tell you whether there is a coil in there or not.

364 X Q. Incidentally, I understand you to say that in column 5 the wave-length of the entire antenna circuit is less than the resonant wave-length of hj' in the three cases under tune 3, and is greater, in tune 4. Can you explain that?

A. All the differences between columns 5 and 6 are very small, a small fraction of one percent, and, to be frank, I do not know at the present moment what the cause of any difference of excess or defect over 1640 means. There may be some reason, but I do not see any at the present moment. [fol. 2082] 365 X Q. What bothers me, for example, in the case of Case 3 of Tune 3, is that you start with a resonant wave-length of 1640 meters for the parallel circuit hj', and then you add a coil g' and an antenna on the one end of it, and connect the other end to earth, and get a resultant wave-length which is shorter.

A. That is, now, the tune 3?

366 X Q. Yes.

A. Yes.

* * * * * * *

I am sorry, I cannot answer, right now, I would have to look at the calculations and run through them again to make sure if there were any physical reason for that discrepancy, or whether it was simply a matter of the numerical values being different in the different cases. I cannot answer it without going over the calculations.

368 X Q. I am not going to ask you to do that, but certainly if you add a coil g' with 21 turns in it, that alone will increase the wave-length, would it not, rather than decrease it?

A. That would increase the wave-length if it were not for the h. By itself, it would increase the wave-length, yes.

369 X Q. And added to a circuit hj', it would increase the wave-length, would it not?

A. Well,——

[fol. 2083] 370 X Q. I won't ask you to speculate on it, Doctor Wheeler.

A. I cannot give you the answer, right off. I am sorry. I wish I could. If I were quick enough, maybe I could, but I cannot, right now.

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(Tr. 2206)

378 X Q. Just one more subject, I think. Suppose that with the Marconi patent before you in 1904 you set up a transmitter and a receiver in accordance with tune 3 of the tables on page 4; and I will ask you to assume that as a matter of fact the wave-length transmitted by the transmitter was 135 meters; maybe something went wrong, or whatever the reason may have been. Now, you are located at the receiver. Can you tell me what you would do to try to receive that transmitted signal, with the patent in front of you and with all of its teachings before you?

A. I would first reduce the number of turns included in the coil g', if necessary, to zero. If that had not shortened the resonant wave-length of the antenna circuit sufficiently, I would then reduce the value of the capacity h.

379 X Q. And do you think from your calculations that by doing those two things you could receive a wave-length of 135 meters?

[fol. 2084] A. I think so. I could not tell, without a little computation, exactly, but I think so.

Mr. Blackman: That is all.

Redirect examination.

By Mr. Houghton:

380 R. D. Q. Doctor Wheeler, in answer to a question on cross-examination, you stated that the thickness of the silk insulation on the wire used in winding coil j' would affect the value of the inductance calculated for that coil. What can you say as to the extent of that effect?

A. I would say that that effect would be very small, probably less than one per cent.

381 R. D. Q. In answer to another question on cross-examination, you stated that the distributed capacity of coil j' had been neglected in determining the overall resonant wave-lengths for tunes 3 and 4. What can you say as to the extent of the effect of considering the distributed capacity on the overall wave-length?

A. Distributed capacity of the coil j' would be very small in comparison with the value 4600 micromicrofarads, for the capacity h, and as it would effectively be in parallel with h, it would increase that capacity by a small amount, which I should judge to be not as great as one per cent.

382 R. D. Q. Also, on cross-examination, you stated that increasing the closeness of coupling between the primary and secondary of the Fig. 2 of the Marconi patent, would [fol. 2085] affect the tuning of the primary circuit. What can you say as to the extent of that effect?

A. In my opinion that effect would also be very small. I cannot put any numerical estimate on it, however.

Mr. Houghton: That is all.

Recross-examination.

By Mr. Blackmar:

383 R. X Q. Besides the distributed capacity of j', am I correct in understanding that you also neglected the distributed capacity of the coil g'?

A. I did.

384 R. X Q. And the distributed inductance of the antenna?

A. No.

385 R. X Q. That was taken into consideration?

A. That was taken into account.

386 R. X Q. In the case of tunes 1 and 2, where there is no condenser h, is the distributed capacity of j' still negligible?

A. That depends upon your definition of "negligible". The effect will be greater. The distributed capacity of that—now, I am not saying that this is my guess as to the distributed capacity, but suppose it were 10 micromicrofarads, the capacity with which it is in series is 240, I have assumed, micromicrofarads, and the capacity of those in series would be less than 10. It would make considerable difference in that case, if we were to take it into account.

[fol. 2086] (Tr. 2263)

Louis Alan Hazeltine, a witness produced on behalf of the defendant, having been first duly sworn by said Commissioner, was examined, and in answer to interrogatories testified as follows:

Direct examination.

By Mr. Edwards:

Q. 1. Dr. Hazeltine, where do you reside?

A. I reside at Hoboken, New Jersey.

Q. 2. What is your occupation?

A. I am professor of physical mathematics at Stevens Institute of Technology.

Q. 3. Will you state what training and experience you have had in the development of the radio art, particularly with respect to radio transmitters and receivers, and also what experience you have had in connection with the licensing under patents in that art?

A. I graduated from Stevens Institute of Technology in 1906 with the degree of Mechanical Engineer. The following year I spent with the General Electric Company in Schenectady, gaining practical experience in electrical engineering lines. I then joined the electrical engineering department of Stevens and remained with that department until 1925, becoming head of the department, with the title "Professor of Electrical Engineering," in 1918.

I started the special study of radio in the winter of 1914-1915, following the work of E. H. Armstrong with [fol. 2087] the regenerative vacuum tube. My study at

that time culminated in a paper on the Oscillating Audion, as it was then called, read before the Institute of Radio Engineers, which contained the first general treatment of that subject of a mathematical sort.

During 1918 and 1919 I was connected with the Washington Navy Yard, having to do principally with the development and design of radio receiving apparatus. During that time I designed the receiver known at the SE 1420, which superseded prior navy receivers and went into wide use. Subsequently, I continued in consulting radio work and also in my own experiments in radio engineering, and I developed the neutrodyne radio receiver, containing features on which patents were issued to me, and that receiver went also into very wide use, this time use by the general public in broadcast reception.

I was a member of the three of the four National Radio Conferences called by the then Secretary of Commerce, Herbert Hoover, to advise the Department of Commerce in the regulation of radio broadcasting, which was then in its infancy.

I have served the Institute of Radio Engineers in various capacities, having been president and having been in several periods a member of the board of directors. I am a Fellow of the Institute of Radio Engineers, of the American [fol. 2088] Institute of Electrical Engineers, of the American Physical Society and of the American Association for the Advancement of Science.

I have received the honorary degree of Doctor of Science from Stevens and the degree of Master of Arts from Columbia.

In connection with the development of the neutrodyne receiver I had the experience of negotiating with manufacturers looking toward licensing them to manufacture these receivers under my patents, and I entered into an agreement with a group of manufacturers to license them for a royalty that was based on 5 per cent. and which included whatever patents I had or might secure in the radio receiver field and also the services that I might give them in the development of that field and in any defensive litigation.

[fol. 2089] (Tr. 2316)

X Q. 138. Then is it not true that in considering the action of a particular circuit you must consider not only the con-

stants of that circuit but the constants of any circuit which may be coupled to it?

A. Yes, in general.

X Q. 139. And if, for example, you have an arrangement such as the antenna circuit of the SE 950 with the condenser in parallel to the primary coils, the frequency or wave-length to which the antenna circuit will respond depends not only upon the inductance and capacity of that parallel circuit but also upon the antenna capacity and inductance and other leads that may be connected to it and the associated secondary circuit; is that correct?

A. Generally, but not always with equal weight in the receiver in which the primary and secondary are inductively tuned. It was on this type of receiver customary to work with a loose coupling, and under those conditions the effect of one circuit on the other is relatively slight as compared with a neutrodyne, which you were asking about previously, where the coupling is relatively close. The antenna capacity is important in determining the natural wavelength or frequency of the antenna circuit, but in such a receiver as the 950, in the ordinary use, the antenna inductance is generally not of much importance because it is quite low.

[fol. 2090] X Q. 140. But the antenna capacity does have a substantial effect on the natural frequency of the closed circuit?

A. Oh, yes.

X Q. 141. The parallel circuit?

A. Yes.

X Q. 142. And in Figure 2 of the Marconi patent is it not also true that the frequency, to which the parallel circuit hj', will thus respond, is materially affected by the presence of the coil g' and the antenna?

A. I should suppose so; yes.

[fol. 2091] (Tr. 2426)

X Q. 229. It was pointed out that your report, Exhibit JJJ, as supplemented by Exhibit KKK, contained no reference to a comparative test of the series and parallel connections. In the first place, when you were on the Salem, on the trip that is covered by the report, do you remember whether or not you made such a comparative test?

A. I do not recall at the present time whether I did or not.

X Q. 230. Do you recall whether or not you utilized the parallel connection of the antenna condenser?

A. A recent reading of my report makes me state that I did this, yes.

X Q. 231. And is that referred to in either Exhibit JJJ or the supplemental portion of Exhibit KKK?

A. I will have to look and see. The use of a condenser in parallel with the primary coupling coil in the case of the Telefunken receiver used in this test is shown in both Exhibit JJJ and Exhibit KKK in paragraph 17. In addition, the same is shown for the Federal Receiver used in that test in Exhibit JJJ.

X Q. 232. Was either of those receivers so arranged that the antenna condenser could have been connected in series, as well as in parallel?

A. Yes.

[fol. 2092] X Q. 233. Why did you use the parallel connection, rather than the series connection?

A. Because of the length of wave, I obtained better results. That was known before I went on board, and was continued as the optimum condition to use.

X Q. 234. And in making these tests, which are referred to, in which you used that connection, were you endeavoring to secure the strongest signal that you could secure?

A. Yes, I was.

X Q. 235. And in those tests, then, you used the parallel connection, rather than the series connection?

A. Yes.

[fol. 2093] (Tr. 2460)

Mr. Edwards: I offer in evidence as one exhibit copies of patents to DeForest No. 1507016, granted September 2, 1924, and 1507017, granted September 2, 1924.

(Received and marked Defendant's Exhibit UUU.)

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(Tr. 2461)

Mr. Edwards: I also offer in evidence Armstrong patent No. 1113149 granted October 6, 1914.

(Received and marked Defendant's Exhibit VVV.)

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[fol. 2094] (Transcript, page 2530)

Mr. Edwards: I also offer in evidence a photostat of a certified copy of the specification, claims, oath, and draw-

ings in the matter of the application of Reginald A. Fessenden, Serial No. 740,429, for Patent No. 706,735, granted August 12, 1902, to Reginald A. Fessenden.

Mr. Blackmar: In view of the fact that the patent, itself, is before Your Honor, I have no objection to this exhibit. In fact, I think it is necessary, to explain the patent.

Mr. Edwards: I ask that this be marked "Defendant's Exhibit CCCC."

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(Transcript, page 2541.)

Mr. Edwards: In view of the discussion, it is stipulated, subject to correction should error appear, that the La-Fayette station located at Croix d'Hins, near Bordeaux, France, was constructed by the United States Navy and completed and first commenced transmission, on August 21, 1920.

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[fol. 2095] GEORGE H. CLARK (Tr. 2582)

Q. 80. I have here three books, the first two of which are entitled "Manual of Wireless Telegraphy (Radio) for the Use of Naval Electricians," one dated 1913 and the other 1915; and also one entitled "Robison's Manual of Radio Telegraphy and Telephony—1918." Will you state what you know of your own personal knowledge of the distribution of these books in the Navy Department or throughout the Navy Department?

A. I saw one in every shore and ship station that I ever visited in the Navy.

Mr. Blackmar: I offer in evidence as Plaintiff's Exhibit 470 the title page and pages 134 and 137 of the 1913 Manual.

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(Tr. 2587)

Mr. Blackmar: I would like to add, to the offer on that, page 187.

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Mr. Blackmar: I also offer in evidence the title page and pages 134, 137, and 189, from the 1915 Manual, as Plaintiff's Exhibit 471.

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[fol. 2096] (Tr. 2588)

Mr. Blackmar: I also offer as Plaintiff's Exhibit 472 the title page and pages 142, 145, and 215 of "Robison's Manual of Radio Telegraphy and Telephony—1918."

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Q. 81. Mr. Clark, I note in each of Plaintiff's Exhibits, 470, 471, and 472, the following statement:

"The aerial circuit should be tuned with a variable condenser in series for short waves and in parallel (around inductance) for long waves (Fig. 92)."

As one familiar with the art in the period 1913 to 1918, what is your understanding of what is meant in that statement by short waves and by long waves?

* * * * * * *

(Tr. 2589)

A. The terms "Short waves" and "long waves" refer respectively to the lower and upper ranges of the wave-length range of the receiver in each case. They do not refer to specific wave-length designations or values.

Q. 82. That is, it does not mean above and below a certain figure under all conditions?

A. No.

* * * * * * *

[fol. 2097] CLARENCE DENTON TUSKA (Tr. 2612)

CLARENCE DENTON TUSKA, a witness produced on behalf of the plaintiff, having been first duly sworn by said Commissioner, was examined, and in answer to interrogatories testified as follows:

Direct examination.

By Mr. Blackmar:

Q. 1. Mr. Tuska, will you give your name to the reporter?

A. Clarence Denton Tuska.

Q. 2. And your residence?

A. 717 West Mt. Airy Avenue, Philadelphia, Pennsylvania.

Q. 3. And what is your present occupation?

A. I am employed by the Radio Corporation of America at Camden, New Jersey, where I am a member of the Patent Department.

* * * * * * *

(Tr. 2613)

A. I became interested in radio about 1908 as an amateur. From about 1908 until about 1923 I had an amateur transmitting-receiving station, and in the latter part of that time owned and operated a broadcasting station. About 1915, with the late Hiram Percy Maxim, I founded the American Radio Relay League, which is as association of amateur radio operators. In connection with that League, I started a magazine, which is now known as QST. QST was the official organ of the American Radio Relay League, and in [fol. 2098] the early days it was necessary for me to act as editor and advertising solicitor and, in fact, all positions. In this capacity, I was placed in touch with many of the leading manufacturers of radio apparatus in the years 1915 and up to the beginning of the entry of the United States into the World War.

At the beginning of the war, I was first given a position as a civilian engineer in the Signal Corps of the U. S. Army. In the latter part of 1917 I was commissioned a second lieutenant in the army and was occupied with the establishment of a radio school at Ellington Field, Houston, Texas. I had complete charge of that radio school, and after it was operating and training radio operators and radio mechanics, I was sent to the University of Texas to revise the radio course of study which was being given there in training radio mechanics or radio operators for the Air Service.

I was assigned to Love Field, Dallas, Texas, where I had charge of the radio officers' course for a short time.

I was then sent to Camp McClellan at Anniston, Alabama, where I was detached under instructions to organize a school for the training of radio operators in the United States Field Artillery, so that those operators might cooperate with the Air Service observers in the direction of artillery gunfire.

[fol. 2099] I neglected to mention that prior to the entry of the United States into the World War I acted as a con-

sulting radio engineer for the A. C. Gilbert Company of New Haven, Connecticut, and I also——

Q. 7. What was the business of that company?

A. The A. C. Gilbert manufactured mostly toys; but at the time, Mr. Gilbert, who was president of the company, wanted to manufacture radio receivers of the amateur type. In connection with my first employment with Mr. Gilbert, I came in contact with patent matters and license matters as prevailed in the field to 1916.

* * * * * * *

[fol. 2100] (Tr. 2617)

A. During the time when I first acted as a consulting engineer for the A. C. Gilbert Company, I was attending Trinity College in Hartford, Connecticut, where I obtained the degree of Bachelor of Science. At the expiration of the World War I organized the C. D. Tuska Company, for the purpose of manufacturing radio devices, and, at the same time, I continued—or renewed, rather—my relations with Mr. Gilbert. The renewed relations extended only over a few months, when my duties in the Tuska Company required all of my time.

The radio business of the Tuska Company grew rapidly as broadcasting came into the field. Since my duties included not only the design of apparatus, but also the management of the company, I became very much interested in patent matters, and filed a number of applications for U. S. Letters Patent.

Q. 9. Were those on inventions that you yourself had made?

A. Most of them were on inventions that I had made, but some were made by other employees of the company. Of these applications, I do not know the exact number maturing into patents, but it is probably fifteen or eighteen. I also obtained and negotiated licenses for the company.

About 1925 or 1926 Mr. A. Atwater Kent, of the Atwater Kent Company, became interested in the Tuska Company, [fol. 2101] and acquired all of the capital stock. This purchase was made primarily to obtain the patent rights which I had acquired for the company. The activities of the Tuska Company were suspended, and I joined the Atwater Kent Company in 1926. Prior to my official employment, I worked for Mr. Kent on patent matters, particularly in

regard to litigation. I was with the Kent Company from 1926 to 1935, and during that time assisted in the preparation of the defense of suits filed against the Kent Company, and testified in several of the suits; for example, RCA vs. Edmonds.

Q. 10. Pardon me. Were you testifying as an expert, or a fact witness, or what?

A. I think in those suits it was a mixture. I also assisted in the preparation of Hazeltine versus Wildermuth. Edmonds was also involved in a suit with Latour. I did a great deal of work in the accounting which resulted from the suit entitled Hazeltine versus Wildermuth.

In 1935 I resigned from the Atwater Kent Company and joined the Patent Department of the Radio Corporation of America. Since I have been with the Radio Corporation I have testified as an expert in the suit in Boston, which, I believe, was Cabot versus Eastern Radio.

Q. 11. Was that a suit involving radio apparatus?

A. Yes.

* * * * * * *

[fol. 2102] Q. 63. Have you read and are you familiar with Marconi patent No. 763,772?

A. Yes, I have, and I am familiar with it.

Q. 64. In your opinion, is the disclosure of the patent summed up in the tables on page 4 of the patent?

A. No. The tables on page 4 are included in the patent as examples, and not a summation.

Q. 65. And, in your opinion, are there other combinations that are within the teaching and disclosure of the patent?

A. Yes; an infinite number of combinations.

Q. 66. Do you understand that the patent teaches that the condenser h in Figure 2 is or is not to be variable?

* * * * * * *

A. I understand that the condenser h of Figure 2 is variable. The specification points that out rather distinctly, first describing the condenser c of the transmitter, and then later saying that the condenser h is similar to the condenser c which is previosly described as variable.

Q. 67. Now, will you please describe the operation of Figure 2 of the Marconi patent, as you understand it, from the disclosure of the patent?

Q. 68. I will add to my question that, in answering, I would appreciate it if you would comment on the descrip-

[fol. 2103] tions of the operation of that figure by defendant's witnesses.

* * * * * * *

(Tr. 2640)

A. Figure 2 of the Marconi patent is a schematic diagram of a radio receiver. It includes an antenna circuit comprising a capacity area f', a lead A, a loading coil g', a coupling inductor j', which is shunted by a tuning condenser h, and a connection to Earth. The secondary circuit includes coupling inductors j_2 and a pair of variable loading inductors g_2, the shunt condenser h', coherer T, a by-pass condenser j_3, choke coils C_1, C_2, a battery B, and a receiver R. The patent teaches different modes of operation of this circuit. In the simplest mode of operation, the circuit h j' would be tuned to the transmitting wavelength and the secondary circuit, by adjusting the shunt condenser h' or the loading coils g_2, would be tuned to the same wavelength.

Q. 69. Let me interrupt you. You say that the circuit h j' would be tuned to the desired wavelength. Do you mean that circuit, regardless of its associated elements?

A. Oh, no. The circuit including all of the associated elements, and including all of the reactive effects of each on the other. That is generally recognized when we speak of tuning.

[fol. 2104] Q. 70. You mean the entire primary circuit?

A. Entire primary circuit. It includes the antenna capacity, antenna inductance, and any other capacities or inductances which are associated.

Q. 71. Including g', for example?

A. Including g', if g' is used.

Q. 72. All right.

A. While this is the simplest mode of operation, the patent teaches other modes by means of which octave tuning may be employed. In the case, for example, of tune No. 3, as noted in the tables on page 4 of the patent, the transmitting wavelength will be approximately 200 meters.

Q. 73. Was that figure given by any of defendant's witnesses?

A. That is the approximate figure given by Dr. Wheeler. I have independently checked that figure, and find that 200 is approximately the correct wavelength for the transmitter circuits of tune No. 3.

[fol. 2105] Q. 74. Let me interrupt on another thought there. You say you have calculated; is it possible to calculate that with a high degree of accuracy upon such data as there is in the patent?

A. I am not sure whether you mean that the calculations can be correct, or whether you mean that, having calculated it, the operating wavelength will correspond exactly to the calculations.

Q. 75. That is what I mean, the latter.

A. With the latter meaning, no. You can calculate it to a fair degree of approximation, but not exactly.

Q. 76. You have stated the transmitting wavelength as approximately 200 meters. Will you continue?

A. The receiving station for the 200-meter wave is also [fol. 2106] specified. It will be observed that the loading coil g' in the receiver is adjusted up to 21 turns, which permits the operator to resonate the antenna circuit as a whole to 200 meters. But there is also an element h j', which must receive consideration. Dr. Wheeler calculated that the frequency to which h j' would respond when connected in the antenna circuit would be about 1640 meters. Assuming that Dr. Wheeler's calculations are sufficiently accurate for our purpose, it follows that the antenna circuit as a whole will be responsive to wavelengths of 200 meters and approximately 1600 meters. It is apparent that 1600 meters is eight times the wavelength of 200 meters or corresponds to what Marconi calls octave tuning.

I am sure that Marconi had this type of tuning in mind in describing tune No. 3, because I have determined the essential information which Dr. Wheeler said he was unable to calculate. In so far as his calculations are concerned, I agree with Dr. Wheeler that it would be very difficult to calculate the secondary of the receiving transformer No. 2. Unfortunately, Dr. Wheeler made a glaring error when he considered this portion of the circuit. Because he couldn't calculate the secondary of the receiving transformer No. 2, he elected to take an entirely different transformer, simply because he could calculate it.

Q. 77. In which figure of the patent is transformer No. 2 shown?

[fol. 2107] A. Transformer No. 2 corresponds to the schematic diagram Figure 6.

Q. 78. And in which figure of the drawing is the trans-

former shown as to which Dr. Wheeler made his calculations?

A. As I recall his testimony, he used the fourth form of induction coil, as shown in Figure 8.

Q. 79. And which form of transformer coil is required by Tune No. 3 that you are now considering?

A. Tune No. 3, as now considered, requires receiving transformer No. 2, which is schematically illustrated in Figure 6.

* * * * * * *

(Tr. 2644)

A. The receiving transformer No. 2, which I am now considering, has a secondary circuit which has two serially connected windings——

* * * * * * *

A. Transformer No. 2 is described in Figure 6 and in the specification, page 3, lines 85 to 108, inclusive. As I pointed out, the receiving transformer No. 2 has two windings, j_2, which are serially connected. Each of these windings includes 500 turns, making 1,000 turns in all.

Furthermore, they are wound in layers, so that the first layer includes 77 turns and the subsequent layers each include a lesser number of turns. If Dr. Wheeler had consid- [fol. 2108] ered this transformer secondary and had attempted to estimate carefully the probable inductance, I think he would have reached the conclusion which I reached, namely: that the secondary would be tuned to 1600 meters.

Confronted with the difficulty of calculating, I had a duplicate made, so that I would be sure of my preliminary estimate, and I found that, as closely as can be determined, making due allowance for the difference in the British and American wire gauges, the transformer secondary of Figure 6 resonates at 1600 meters. It now becomes very clear that Marconi described, in tune 3, a transmitter operating with both circuits tuned to 200 meters radiating a wavelength of 200 meters, which is received by the circuit of Figure 2 at both the fundamental and an octave, and the octave is impressed on the secondary. This mode of operation is a feasible one, and clears up a great deal of the misunderstanding which I mentioned when I began the original answer.

I would like to go on. It should be understood that since the antenna circuit as a whole responds to 1600 meters, it is not essential that it also respond to 200 meters. Furthermore, I should like to emphasize that the octave mode of tuning is not the only method of tuning the circuit of Figure 2 to a transmitter radiating waves on 200 meters. The patent teaches that the antenna and secondary circuits of the antenna should be tuned either to the fundamental fre- [fol. 2109] quency of the transmitter or to multiple of that frequency; and in discussing the second case we should not lose sight of the normal mode of operation in which the antenna circuit as a whole would be tuned to the fundamental and the secondary as a whole would be tuned to the same wavelength. It should also be understood that the transformer No. 2 given in the receiving table would not be used, as this transformer is designed to operate at the long wavelength.

By the Commissioner:

Q. 83. I wonder if you can point out to me where the specification ties in the transformer, receiving transformer, illustrated in Figure 6 of the drawings, and described on page 3, beginning with line 85, with a specification number for the transformer.

A. May I answer that at length, your Honor?

Q. 84. Surely.

A. The first receiving transformer is described on page 3, in the first full paragraph.

By Mr. Blackmar:

Q. 85. Of the second column?

A. Of the second column. The second receiving transformer is described in the second full paragraph of the second column of page 3. The third form of receiving transformer is described in the third full paragraph of the second column of page 3, while the fourth form of receiving [fol. 2110] transformer is described in the fourth full paragraph of page 3. Since the two last paragraphs very definitely state the third form and the fourth form, I am sure that the first paragraph describes the first form, the second paragraph the second form, while the third and fourth definitely state that they are the third and fourth, respectively. Does that answer your Honor's question?

The Commissioner: Yes.

Q. 86. I think you might also explain the reference in the tables on page 4 to the transformers; tie that in together.

A. The explanation which I have just given about the first four paragraphs of the second column on page 3 is further borne out by the tables of the receiving station on page 4 of the patent. It will be noted that the receiving station employs for tunes Nos. 1 and 2, No. 1 induction coil; for tunes 3 and 4, No. 2 induction coil; for tune No. 5, No. 3 induction coil; and tune No. 6 calls for the fourth induction coil. Therefore, these four induction coils which are the receiving transformers, the receiving transformers we are discussing, must be found within the specification of the patent; and I have already pointed out that 3 and 4 are identified definitely, and, since they follow the other two paragraphs, it seems only reasonable to conclude that the first paragraph fully describes the receiving the trans- [fol. 2111] former No. 1 and the second paragraph in question the receiving transformer No. 2.

Q. 87. Are those transformers in the text referred to as induction coils?

A. Yes; in the text they are referred to as induction coils.

Q. 88. What, if any, consideration did Professor Hazeltine give, when he was considering the operation of this Figure 2, to the secondary circuit?

A. Professor Hazeltine's testimony, as I heard it, definitely stated that the coupling between the primary and secondary was loose, and therefore he would entirely neglect the effect of the secondary, so I do not believe that he gave them careful consideration.

Q. 89. And, utilizing transformer No. 2 for tune 3, could the secondary circuit, in your opinion, be tuned to in the neighborhood of 200 meters?

A. No, it could not be tuned to 200 meters.

Q. 90. You spoke of the primary circuit, the antenna circuit, responding both to 200 meters and 1600 meters, approximately. Will you briefly explain how that can be?

A. A complex circuit in which inductance and capacity are connected in separate branches, such as shown in Figure 2, will have a resonant characteristic in which the antenna circuit as a whole, or the circuit including these inductances [fol. 2112] and capacities as a whole, responds to two different wavelengths. These two wavelengths correspond generally to the wavelengths of the circuits taken separ-

ately, but when they are coupled together the effect of the coupling is to move the wavelength which is lower to a still lower value, and the wavelength which is higher to a still higher value.

However, the network as a whole will respond to applied currents of the two frequencies, so that two distinct resonant points are present in the network considered as coupled together or as a whole.

Q. 91. Is either of those wavelengths the same as any separate portion of the circuit considered by itself?

A. Oh, no. They are always changed by the association with the associated circuit.

Q. 92. Now, you stated, I think, that, when two circuits, each having its own natural wavelength, are brought together and associated, the two wavelengths of the system—if there are two—would go in opposite directions, so to speak; that is, the modification of the wavelengths would go in opposite directions. In that correct?

A. That is correct.

Q. 93. Will you refer, please, to Defendant's Exhibit BBB, which is entitled "Marconi Antenna Circuit Tunes," which was put in through Dr. Wheeler, and state whether there is anything in there that appears to you to be incon- [fol. 2113] sistent with that operation of two associated circuits.

A. Yes. First of all, the figures in the right-hand column of Exhibit BBB, 1640 which refers to the wavelength of the circuit h j' alone indicate a longer wavelength than is obtained when the so-called wheel circuit h j' is associated with the antenna circuit, including the loading coil. The figures given for the associated circuit from 1628 to 1641 are not the figures which would be obtained if 1640 is correct. However, I have checked Dr. Wheeler's calculations and think that the error is not necessarily in the second column from the right, but, rather, is in the column to the extreme right. I feel that he made a pardonable error, so far as slide rule calculations are concerned, but an unpardonable error so far as knowledge of the operation of tuned circuits is concerned. He could have seen on mere inspection that there was something wrong and looked for the error. The actual wavelength constants which Dr. Wheeler calculated will be approximately 1590 meters. When using this resonant wavelength for the so-called wheel circuit

h j' alone, the figures in the second column from the right on Exhibit BBB are substantially correct.

There is another method which should, perhaps, have occurred to Dr. Wheeler. In circuits of the type illustrated at Figure 2 of the Marconi patent, not only are the resulting [fol. 2114] wavelengths spread further apart, but there is a fundamental relationship, namely, the product of the two circuit wavelengths taken alone should equal the product of the wavelengths of the resulting combination. It would, therefore, only have been necessary to multiply two sets of two figures to determine the accuracy of the original figures.

Q. 94. Is this principle of the spreading of the wavelength when the circuits are brought together and this rule as to products set forth in the literature of the art?

A. The manner of the spreading of the wavelengths, due to the mutual coupling of two circuits, is set forth in the art in considerable detail. However, I do not know offhand of any textbook which shows this relationship. As a matter of fact, the relationship which I have given for the type of circuits illustrated at Figure 2 of the Marconi patent, probably does not apply when the two circuits are coupled solely by mutual inductance. In such case,—for example, I am thinking of the work of Dr. Pierce, set forth in his textbook, which was first published in 1910—he gives the relationship between the original wavelengths and the resulting wavelengths, but he does not give the fundamental relationship which from his formulas may be derived; and I think, upon derivation, we find that the multiplied wavelengths which result from the coupling must in turn be [fol. 2115] modified by a constant. This is because he was discussing only the case of mutual inductive coupling.

Q. 95. You have used and defendant's witnesses have used the term "wheel circuit." Will you explain what you mean by that?

A. By the term "wheel circuit" I mean, and I believe the defendant's witnesses also mean, a circuit including lumped inductance and capacity, and resonating at one specific frequency, such as h j' of Figure 2 in the Marconi patent when taken alone.

Q. 96. Now, Commander Dow said that the condenser h in Figure 2 of the Marconi patent acts as a series condenser. Dr. Wheeler also said that the antenna circuit was

essentially a series circuit. Do you agree with those statements?

A. No, I do not agree. In so far as the antenna circuit is concerned, it is a complex circuit, but viewed from the resulting wavelengths in the secondary circuit, the antenna circuit is a shunt tuned circuit; that is, the condenser h shunting the coil j' tunes to the wavelength of 1600 meters.

Q. 97. And in that respect is the operation of Figure 2 of the Marconi patent the same as that of the antenna circuits in defendant's receivers, where the parallel con- [fol. 2116] denser is connected across both the primary of the coupling coil and across the loading coil?

A. In so far as the defendant's receivers are concerned, the connections are the same—although I don't know if defendant's receivers were tuned to octaves.

Q. 98. In those defendant's receivers are the antenna circuits shunt-tuned, as you described Figure 2 of the Marconi patent?

A. Well, the defendant's receivers, in the case of Group No. I in the longer wavelength ranges, are shunt-tuned.

Q. 99. I am referring to where the parallel connection to the condenser is used.

A. Wherever the parallel connection is used in defendant's receivers, they are shunt-tuned.

Q. 100. Commander Dow, at page 1375 of the record, testified as follows:

"As explained, the condenser h of Figure 2 is used as a part of the resonant system, consisting of the antenna f', the coil g', the condenser h, and the earth. When this circuit is resonant to the incoming frequency, the maximum voltage exists across the condenser h.

"The Commissioner: You are now talking about the disclosure of the patent?

[fol. 2117] "The Witness: Oh, yes.

"A. (Continuing:) The maximum voltage exists across the condenser h, and a maximum of current flows through the coil j'. However, the current which flows through the coil j' under these conditions is not nearly as great as would be the case where the condenser h and the coil j' were adjusted so as to provide a circuit which was resonant to the received frequency or wavelength."

Do you agree with that statements?

A. No, I do not agree; and I disagree for at least two reasons. First, with a complex circuit such as Figure 2, I do not believe that we are justified in neglecting any element of the circuit, which is apparently what is done in the first part of the testimony you have quoted at page 1375. Further, considering that the coil j' is connected as apparently he assumes in the second part of the quoted testimony, then the maximum current will flow when the circuit as a whole is tuned, rather than the wheel circuit taken alone. When the wheel circuit alone is tuned to the transmitter wavelength and the wheel circuit is then connected in the antenna circuit of Figure 2, the resultant frequency will be different and will not necessarily be the best tuning, and, in fact, we know that the best tuning will be when the circuit as a whole is tuned to the wave-length to be received or an octave thereof.

(Tr. 2656.)

[fol. 2118] Q. 105. Are you generally familiar with the circuits of the defendant's receivers that are involved in this accounting?

A. Yes.

Q. 106. I call your attention to Plaintiff's Exhibit 96, a copy of which is found in Volume I of the record on the main case opposite page 183. Referring particularly to the receivers made in 1917 and later, with type numbers, will you please compare the antenna circuits of those receivers with the antenna circuit of the receiver shown in Plaintiff's Exhibit 95. If you wish to refer to any particular receiver——

A. I would like to. Referring to defendant's receiver SE 143, SE 143, when operated with the shunt tuning condenser corresponds to Plaintiff's Exhibit 95, as follows: The antenna f corresponds to the antenna which would be connected to the receiver SE 143. The load coil g' corresponds to one of the inductance sections in the primary circuit of the receiver SE 143. The coupling inductance j of Exhibit 95 corresponds to the coupling inductance of the primary of the receiver SE 143, while the shunt-tuning condenser h of Exhibit 95 corresponds to the shunt-tuning condenser of the primary circuit of the receiver SE 143.

This similarity which I have described with respect to SE 143 would correspond to a similar connection of all

of the receivers in Group III, and would correspond to the longer wavelength operation of the receivers in Groups I and II.

(Tr. 2657.)

[fol. 2119] Q. 107. And in defendant's receivers, when utilized with the parallel connection, is the antenna condenser connected across the same elements as in Plaintiff's Exhibit 95?

A. Yes. The connection in Plaintiff's Exhibit 95 shows the condenser h shunted across both the coupling coil j and the loading coil g'. This corresponds to the connection of the shunt condenser in the primary circuit of defendant's receivers.

Q. 108. If there are any differences between the antenna circuit of defendant's receivers utilizing the parallel connection and the circuit of Figure 2 of the Marconi patent, are those differences also present between Exhibit 95 and Figure 2 of the Marconi patent?

A. Yes; there is a difference in Figure 2 of the Marconi patent. The condenser h is shunted across the coupling coil j', but not across the loading coil g'.

Q. 109. And in that respect Figure 2 is different, not only from defendant's receivers with the parallel connection, but also from Plaintiff's Exhibit 95. Is that correct?

A. Yes; the same difference exists between Figure 2 and Exhibit 95 as exists between Figure 2 and the defendant's receivers.

Q. 110. What do you find in the Marconi patent as to whether or not Marconi contemplated omitting or reducing [fol. 2120] to zero coil g' in Figure 2?

A. In the table on page 4 which describes the specific arrangements of some of the receiving stations, the coil g' is omitted in tune No. 1, 45 turns of the coil g' are included in tune No. 2, while a variable number of turns is specified in tune No. 3. In tune No. 4, 100 turns of the coil g' are specified; whereas in tunes Nos. 5 and 6, no turns of the loading coil g' are specified.

Q. 111. What do you find in the patent as to whether or not the coil g' is to be located between the antenna f' and the coil j'?

A. Page 2, column 2, beginning line 86, specifies that the variable inductance g' is interposed in the primary cir-

cuit of the transformer and preferably located between the cylinder f′ and the coil j′.

Q. 112. If the coil g′ were omitted, or reduced to zero, then would the difference which you spoke of between the Figure 2 of the Marconi patent, and Plaintiff's Exhibit 95 or defendant's receivers with the parallel connection still exist?

A. No; there would be no practical distinction between Plaintiff's Exhibit 95 and Figure 2 of the Marconi patent or the defendant's receivers when used with the parallel shunt connection, because the coil g′ of Exhibit 95 may also be reduced to zero. I think perhaps that last state-
[fol. 2121] ment isn't clear. The coil g′ of Exhibit 95 may also be reduced to zero.

* * * * * * *

(Tr. 2666.)

Q. 127. Referring to extending the wavelength range of the primary circuit of a given receiver utilizing a series tuning condenser, it has been testified, as I understand it—I think by Commander Dow—that you could obtain as long a wave range as you desired for that circuit by increasing either the inductance or the capacity, or both. Do you agree with that?

A. That statement has to be broken down. There are three statements, and I don't agree with all of it.

Q. 128. Will you state the situation?

A. The statement is that the operating range may be increased by increasing the series tuning capacity or the inductance, or both. First, let us consider increasing the tuning range by increasing the series capacity. I don't agree with that statement. There is a practical limit, which is a very definite limit, to the amount the range may be increased by increasing the series capacity. The limit of series capacity is infinity, or a short-circuit.

[fol. 2122] Q. 129. You mean infinity and short-circuit are the same thing, electrically?

A. They correspond, electrically. So that, if the capacity is made very large, we merely approach the capacity of the antenna, and it becomes a limit. After that, you can increase the series capacity 1,000 times or a million times, and it will have practically no effect.

Q. 130. You said that is a practical matter. Is it also true theoretically?

A. It is true theoretically. You can show by checking up these values that an increase of 1,000 times only means a very few meters theoretically; and after that it doesn't increase at all.

Q. 131. Before you take up the others, and, preliminarily, what is a reasonable value for the natural wavelength of an antenna as of the period we are considering?

A. During the period we are considering, the natural wavelength of antennas on battleships was approximately 365 meters.

Q. 132. I will ask you to assume that there is inserted in that antenna sufficient inductance, which, without any capacity, will bring the wavelength up to 1,000 meters. How much, if at all, above 1,000 meters could you tune that antenna to by utilizing a series condenser?

[fol. 2123] A. You never can tune the antenna to wavelengths longer than 1,000 meters by inserting series capacity. The series capacity reduces the natural wavelength of the antenna and does not increase it. Probably, one of the main reasons why series capacity is used, is to enable the antenna to respond to wavelengths less than, for example, 365 meters.

Q. 133. I think you wanted to complete your answer to the original question.

A. The second part of this apparently simple statement is that the antenna's natural period can be increased by increasing the inductance—it is possible to increase the natural period by increasing the inductance. However, one should not forget that the resistance of a loading inductor increases more rapidly than the reactance, which would lead to an intolerable situation, because the resistance of the antenna circuit would increase rapidly and the resultant selectivity and sensitivity would be less than would be obtained if we didn't put in so much inductance that the resistance became very much greater than it should be. So that I can only agree in part with this portion of Commander Dow's statement.

With respect to the third possibility, that we increase both series capacity and series inductance, we run into the difficulty that the minimum of the variable capacitor or variable condenser increases as we attempt to make the [fol. 2124] maximum larger. He pointed out that, by very, very careful design, it is possible to keep the minimum

fairly low. I don't think that would be a practical matter. I think this is more of a theory. If we retain the series condenser, no matter how large its maximum may be, then we must add still more loading inductance than if we did away with the series condenser. So this makes the situation even worse, because you are adding one thing to make the wavelength greater, and another thing that takes it away. So this is one of those "lift yourself up by your own bootstraps" propositions.

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(Tr. 2671.)

Q. 134. Mr. Tuska, will you explain what is meant by the terms "series circuit" and "parallel circuit"?

A. As the terms are used in the radio art, and are applied to circuits, including capacity and inductance, the meanings are as follows: first, a "series circuit" means a circuit in which the generator, the capacity and the inductance, are serially connected. Second, the "parallel circuit" means a circuit in which the generator, the inductance and the capacity, are all connected in shunt. Any circuit, including only capacity and inductance, may be viewed as a series circuit or a parallel circuit provided we specify where the generator shall be located.

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(Tr. 2672.)

[fol. 2125] Q. 137. Commander Dow, in his testimony, arrived at the conclusion that, to increase the wavelength o' an antenna circuit in a receiver, it was better to add a loading inductance than to use a parallel condenser. Do you agree with that?

A. No, I do not agree; because a loading inductance increases the cost, size, and weight of the receiver, and it is not—it does not possess the electrical advantages of the parallel condenser when used for tuning to the long wavelengths.

Q. 138. You heard Commander Dow testify, I think?

A. No, I did not hear him.

Q. 139. Have you studied his testimony?

A. I have read his testimony and studied it.

Q. 140. Will you state, as you recollect them, the reasons advanced by Commander Dow for the conclusion that I stated in the preceding question, and state whether you

consider those reasons to be correct; and, if not, why not?

A. I think that Commander Dow had two principal reasons. The first reason, he said, was the matching of the antenna impedance to the impedance of the tuned circuit, such as h j' in Figure 2 of the Marconi patent. The second reason which he gave was that the loss of resistance [fol. 2126] in a condenser used in series was less important to the operation of the receiver then than in the case of the condenser not being there.

As to the first reason, the matching of impedances, the Commander was evidently confused by modern art, in which a transmission line is connected between an antenna and a tuned circuit. In such installations, it is desirable to match the impedance of the line to the terminating networks, so that the line acts as a transmission line and not as a tuned or tunable circuit. If the transmission line is not properly terminated, standing waves appear, and the purpose of the line, or the utility, is defeated. This action of the transmission line is entirely different—an entirely different affair from the connection of an antenna to a circuit which includes the antenna and resonates as a whole. If the antenna is viewed in the normal and proper manner, it becomes a part of the tuned circuit, and the impedance of the tuned circuit as a whole is just the same, whether the antenna is connected in series or in parallel. The resulting impedance is the same in both cases. I think the difficulty that Commander Dow may have had, was his failure to view the equivalent circuit to the antenna which is the capacity of the antenna with the generator in series.

[fol. 2127] Under these circumstances, the generator itself never shunts the tuned circuit, but is always in series with one of the elements.

As to the second ground, as I understood his reason, the resistive losses in the series condenser are present, whether you use loading coils or not, so we can dismiss this matter. However, we should not dismiss the resistance of the loading coil, which increases more rapidly as the loading coil is increased than the reactance of the coil.

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(Tr. 2676.)

Q. 147. To summarize: does the problem of impedance matching arise in the antenna circuit of the radio receiver

such as is shown in Figure 2 of the Marconi patent, or such as is utilized in the defendant's receivers, either with a series condenser or with a parallel condenser?

A. No. It is not a problem to be considered. It does not arise.

Q. 148. And is there ever any effort made to match impedances?

A. Under these circumstances?

Q. 149. Under those circumstances, yes.

A. No.

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[fol. 2128] (Tr. 2681.)

Q. 157. Mr. Tuska, speaking comparatively briefly, what does this Pupin patent teach as of its date, to one skilled in the art?

A. Pupin Patent No. 640516 teaches how two or more audi-frequency line telegraph transmitters may be connected to two or more selective line telegraph receivers. The patent clearly relates to a low frequency telegraph system, which is connected to a transmission line.

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(Tr. 2683.)

Q. 159. Mr. Tuska, do you find anything which is utilized in any of the defendant's receivers which are asserted to infringe claim 16 of the Marconi patent, and which is disclosed in the Pupin patent and not disclosed in the Marconi patent? I might add to that——

A. The answer to your question is No.

Q. 160. I might add to that—confine your answer to the radio frequency portion of the defendant's receivers.

A. The answer is No.

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(Tr. 2683.)

[fol. 2129] Q. 162. Have you read and are you familiar with the Fessenden patent 706735, which is Defendant's Exhibit LL in this case?

A. Yes; I have read the patent in question and I am familiar with it.

Q. 163. Have you also read Defendant's Exhibit CCCC, a copy of the application, as filed, for this Fessenden patent?

A. Yes, I have read Defendant's Exhibit CCCC, which is a certified copy of the Fessenden application, as filed.

Q. 164. Will you briefly explain the disclosure of the Fessenden application, as filed, Defendant's Exhibit CCCC?

A. The Fessenden application, as filed, Defendant's Exhibit CCCC, discloses a transmitter which includes an antenna conductor 5, a capacity element 5-a, a serially connected spark gap 4, 4, which is shunted by a capacitor 18, and an induction coil, which is connected through the key to a power source and through its secondary to a spark gap which I have designated. This transmitter is an open antenna transmitter, and it radiates waves which are received by a receiving station. The receiving station includes an antenna conductor 6, which is serially connected through field coils 7 to the earth. Within field coils 7 is included a coil 8 which acts as a galvanometer to indicate visually the reception of signals. Condenser 19, which [fol. 2130] shunts the field coils, may be used. In some of the other figures of the patent, variations of this arrangement are shown. In one such variation, Figure 2, the antenna circuit is connected through an induction coil to the field coils of the galvanometer. The induction coil consists of an antenna winding, 12, and secondary winding, 11.

A further modification is shown in Figures 3 and 4, in which the coil 8 is arranged to contact variably a resistor, 14, which is included in a local telephone circuit 15-16. A still further modification is shown in Figure 5. In this arrangement, the field coils are indicated as 16 and 16-a, and these coils are differentially connected.

Q. 165. With respect to Figure 1, you used the phrase "open antenna transmitter." What do you mean by that?

A. I meant a transmitter in which the spark gap was serially connected in the antenna circuit, and in which no tuning was used.

Q. 166. According to the application, as filed, what purported to be the new disclosure therein as to subject matter?

A. The disclosure was that of a receiving device in which the operation depended upon the reaction of coils in one element upon a second element. This meant the reaction of the coils in the field coils 7 upon the galvanometer 8.

[fol. 2131] Q. 167. Commander Dow referred specifically to the condensers 18 and 19 in Figure 1. What do you find

in the application, as filed, describing those condensers or their function?

A. In the last paragraph of the specification, page 5, lines 23 to 26, it is stated that "a condenser 18 may be connected in series or in shunt with the sending or generating wire or wires 5 and a condenser as 19 may be connected in series but preferably in shunt with the field coil or coils 7."

Q. 168. Is there anything else in the application as filed with respect to those two condensers?

A. Yes; claim 4 on page 6.

Q. 169. Disregarding the claims; in the specification, is there anything additional?

A. That is all I find.

Q. 170. What is the reference in claim 4?

A. The latter part of claim 4 specifies, "A condenser connected in series or shunt with said field."

Q. 171. What field is referred to there?

A. The antecedent is a little ambiguous, but he means the field coil or coils.

Q. 172. Commander Dow, at pages 1640 to 1642, and again at page 1647 of the record, pointed out where he found in the Fessenden patent, Defendant's Exhibit LL, a teaching [fol. 2132] that Fessenden's antenna circuits were tuned. Do you find the same or any similar or equivalent statements in the Fessenden application, as filed, Defendant's Exhibit CCCC?

A. The first reference to Commander Dow's testimony, on page 1640, refers to the Fessenden patent, and quotes line 101 on page 2. I do not find the same statement in the Fessenden application, as filed.

Q. 173. Or any similar or equivalent statement?

A. The first part of the statement which says "A condenser 19 may be connected in shunt with the field coil or coils" is included; but the entire meaning of the sentence is changed when he adds that "For the purpose of obtaining as large a current as possible in the neld coil 7, as this increase in current will give a greater torque to the ring h." There is no such thought in the original filed application.

On page 1641, Commander Dow states that the Fessenden specification, beginning line 106 of the patent, includes a rather long explanation showing the results which he (Fessenden) got. The statement of Commander Dow goes on

to refer to the antenna current in the Fessenden device, being larger than the current in the receiving conductor. There is no corresponding statement in the Fessenden application, as filed.

[fol. 2133] Q. 174. You refer to line 106. On what page in the specification is that?

A. Commander Dow did not give the number, but I will. He apparently had in mind page 2, second column, lines 106 and so forth. (Witness examines paper.) Mr. Blackmar, will you please point to the reference you had in mind on page 1647?

Q. 175. I was referring to XQ. 771 and the answer.

A. This question XQ. 771 says, in effect, that the condenser 19 and the inductance 7 are stated by Fessenden to be made resonant to the incoming frequency, and it refers to the same place in the specifications to which the witness, Commander Dow, has previously referred. I do not find any statement in the Fessenden application, as filed, about tuning the "circuit, consisting of the condenser 19 and the inductance 7, so as to make them resonant to the incoming frequency."

Q. 176. What, if anything, is there in the radio frequency circuits of the defendant's receivers that are asserted to infringe claim 16 of the Marconi patent which is present in the disclosure of the Fessenden patent that is not present in the disclosure of the Marconi patent?

A. Nothing.

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(R. 2718.)

[fol. 2134] The Commissioner: Mr. Tuska, during the mid-morning recess, I will ask you to prepare as an exhibit a sketch illustration of the testimony which you have given, relative to what you have termed the parallel connection and what you have termed the series connection of the tuning condenser. These sketches can be merely diagrammatic in character, and for comparative purposes; and I am not interested in having the details, we will say, of the secondary circuit, such as the detector or receiver. In other words, I think the sketches should be limited to the radio circuits.

The Witness: Yes, sir.

Mr. Blackmar: Would it be helpful to add a third sketch, showing a loading coil in a series circuit?

The Commissioner: Yes. I think that might additionally [fol. 2135] illustrate the testimony of the witness.

Mr. Blackmar: As I understand it, these are antenna circuits?

The Commissioner: Antenna circuits.

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(Tr. 2720)

By Mr. Blackmar:

Q. 249. Mr. Tuska, have you prepared the sketch that the Commissioner requested?

A. Yes.

Q. 250. I notice that in the left-hand or series connection and the loading coil sketch the primary tuning condenser is below the inductances, whereas in the right-hand the series connection sketch, it is above. Is there any particular reason for that?

A. No. It could be in either place.

Mr. Blackmar: I ask that the sketch be marked Plaintiff's Exhibit 477 in evidence.

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(Tr. 2721)

By the Commissioner:

Q. 253. Let me ask this: in conventional sets at this time where was the condenser actually connected?

A. In general, it was between the coupling coil and the ground.

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[fol. 2136] Cross-examination. (Tr. 2722)

By Mr. Houghton:

X Q. 255. Mr. Tuska, referring to Plaintiff's Exhibit 477, the sketches just prepared by you, the middle figure, as I understand it, is drawn to show the shunt primary tuning condenser?

A. Yes.

X Q. 256. Then, is not the word "or" in your legend there surplusage?

A. The reason I put "or" there is because I have used both terms in my testimony, and I understand this was an illustration of my testimony. Sometimes, I have called it the primary condenser of the antenna circuit; sometimes I have just called it the primary tuning condenser, and sometimes just the shunt condenser.

X Q. 257. And the same reason accounts for the "or" in the right-hand sketch on the exhibit?

A. Yes.

X Q. 258. When you were testifying regarding Figure 2 of the Marconi patent and tune No. 3 thereof, it was not clear to me just which circuits or which component subcircuits you identified as responding to the several wavelengths that you mentioned. If I understood correctly, you testified that the transmitter of tune 3, transmitted on approximately 200 meters.

A. That is correct.

[fol. 2137] X Q. 259. What parts of the primary circuit of Figure 2 resonated to 1600 meters approximately and to 200 meters approximately?

A. Referring to Figure 2 of the Marconi patent, it will be seen that the antenna circuit is a complex circuit Because it is a complex circuit, it responds to two wavelengths. One is 200 meters, and the other is 1600 meters. I cannot pick out any elements and say this element is responsible. I have to take all of the elements into consideration. If you wish to know what branch of the complex circuit is responsive to a wave slightly above 200 meters, and which branch is responsive to a wave slightly below 1600 meters when the two circuits are disconnected, the two branches are disconnected, I can answer that.

X Q. 260. Please do.

A. The element which, if disconnected, responds to a wavelength slightly greater than 200 meters in Figure 2 of Marconi patent are the antenna f', connecting wire A, loading coil g' and the earth connection E. The elements which are responsive, when they are disconnected, to a wavelength slightly less than 1600 meters are the condenser n and the coil j' connected to the earth E.

X Q. 261. With respect to the circuit you have just identified as responding to 200 or slightly above 200 meters, you identified only an incomplete course from the antenna [fol. 2138] to the ground. Did you omit an element in that circuit that responds to slightly over 200 meters?

A. I thought I said that g′ was connected to the ground. If I didn't, I should have.

X Q. 262. And in that circuit resonating to slightly above 200 meters, approximately what number of turns of the load coil g′ are considered as in the circuit?

A. Approximately 21 turns.

X Q. 263. Suppose you consider the series circuit comprising antenna f′, 21 turns of the load coil g′, the condenser h, with the value given for tune three, connected to earth. In connection with that circuit, did you check the wavelength given in the third column of defendant's Exhibit BBB?

A. Do you mean whether I checked the mathematics to see whether any error had been made in the calculation?

X Q. 264. That is correct.

A. So far as I know, Dr. Wheeler's calculation was correct.

X Q. 265. And he shows there, in the third column, in the line identifying coil g′ as having 21 turns, that the wavelength of that series circuit f′, g′, h and E is approximately 200 meters, is it not?

A. That is correct.

[fol. 2139] X Q. 266. Do you mean to indicate that it would make virtually no difference in the wavelength whether the antenna and 21 coils of g′ were connected directly to the earth or connected to earth through the value of the condenser identified for tune 3?

A. Yes; I assume when you say it is essentially the same, it isn't a big change. It would be practically the same. The reason for it is that the condenser is so large that it can be neglected. When one has a very large condenser connected in series with a very small condenser, you can neglect the larger one.

X Q. 267. Did you further testify that the over-all frequency or one of the over-all frequencies to which the primary circuit of figure 2, tune 3, responds, is also nearly 200 meters?

A. I do not think I used the term "over-all"; but I did testify that one of the resulting frequencies upon coupling the two branches was a response of about 200 meters.

X Q. 268. Then it is your testimony that it makes practically no difference in the tune of the primary circuit to include the large condenser h in series or to omit it; and

also that it makes practically no difference in the tune when the condenser h is present to include the coil j'?

A. That is correct. The effect of the circuit which we have called the wheel circuit, h j' on the 200-meter response, is very slight. There is an effect, but it isn't great.

[fol. 2140] X Q. 269. Then the principal element in establishing the 200-meter tune of the entire primary circuit of Figure 2, tune 3, is what element?

A. I think I have already testified that you can't pick one element out of this complex circuit, and say that that element is responsible for any particular tune. You must view the thing as a whole, as it is, and I don't know any way that I could put the blame on any one element for what happens.

X Q. 270. It is your testimony, is it not, that the antenna and the coil g' connected directly to earth will resonate at substantially the same frequency as the entire primary circuit shown in Figure 2. Is that correct?

A. No, that is not correct. I testified—and I tried to be very clear about it—that the antenna circuit as a whole in tune 3 responds to two frequencies, or two wavelengths, one of which is about 200 meters, and the other is 1600; and you cannot separate them. They are there together.

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(Tr. 2727)

[fol. 2141] X Q. 273. Assume that the antenna f' is connected through 21 turns of the load coil g' and the other end of the load coil g' is connected directly to earth—that is, assume that the circuit h j' is entirely omitted. Is it your testimony that the antenna load coil to earth circuit would resonate to substantially 200 meters?

A. I have not testified to that. Accepting the assumption, it does respond to approximately 200 meters.

X Q. 274. Referring further to your testimony regarding the Marconi patent, Figure 2, tune No. 3, did I understand correctly that the secondary j_2, the secondary circuit including j_1, according to your calculations and observation, resonates to 1600 meters, approximately?

A. You haven't quite phrased what you thought my testimony was. I think you will find I said that the coils j_2—there are two of them—and the coils g_2—there are two of them, plus the distributive capacities of the circuit, bracket the wavelength of about 1600; and by that I meant that by

varying the coils g_2, you could tune the secondary circuit to 1600 meters.

X Q. 275. Did you further testify that 1600 meters is an octave of the 200 meter fundamental; that is, it is eight times 200?

A. Yes.

[fol. 2142] X Q. 276. By "octave" do you mean an harmonic?

A. No. The terms, even today, are confused in the art; but I did not mean an harmonic.

By the Commissioner:

X Q. 277. An octave would be double, would it not?

A. As I understand it, the "octave" comes from the word "eight,"—numbers bearing a relation to eight.

X Q. 278. Then you use the term "octave" in a different sense from the musical scale?

A. Yes. We didn't include the term "eight." It just happens that eight comes in twice; that is just a mere incident. By "octave" I meant a certain integral number of times the wavelength.

By Mr. Houghton:

X Q. 279. An integral number of times the wavelengths?

A. An integral number of times the wavelength.

X Q. 280. Was it your testimony that in tune 3, the circuit of Figure 2, receiving a signal at the transmitting frequency of 200 meters would excite the secondary tune to resonate to this octave or 1600 meters?

A. Yes.

By the Commissioner:

X Q. 281. As we use these terms today, is not the term "harmonic" appropriate?

[fol. 2143] A. Yes, we use it today; but I do not think "harmonic" is the term to use, although there is some confusion on that because we get into the problem of whether you mean multiples of or fractions of—and then we have to begin to talk about sub-harmonics; and there is another trouble, what you are going to call the fundamental. Some people call it one thing, some another.

X Q. 282. In this case, 200 meters was the fundamental?

A. And 1600 meters is eight times 200, which is an integral number——

X Q. 283. Would it be appropriate to term that the "harmonic"?

A. There is a lot of question whether you would call it the eighth or third or some other number. It is eight. If we say eight times, we avoid confusion.

By Mr. Houghton:

X Q. 284. You also testified that the secondary in Figure 2, tune 3, could not be tuned to 200 meters with the constants given in the table for the values of j_2 and g_2, I believe?

A. The fundamental response of the secondary circuit with the constants give will be 1600 meters. I don't think I testified that it couldn't be tuned to 200, or it might not respond to 200, but that, with the constants given, it will be 1600 meters.

[fol. 2144] X Q. 285. You have just referred to "harmonics". What is your definition of an harmonic with reference to a fundamental?

A. I should say that an harmonic is an integral number of times the frequency of the fundamental.

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(Tr. 2731)

X Q. 287. What is the frequency corresponding to 200 meters?

A. 200 meters is 1500 kilocycles.

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X Q. 289. What is the frequency corresponding to a wave length of 1600 meters?

A. That is approximately 188 kilocycles. There is a fraction. I don't recall what it would be.

X Q. 290. Regarding the 1500 kilocycles corresponding to the 200-meter wavelength as the fundamental, could that give an harmonic of 188 kilocycles corresponding to 1600 meters?

A. Not as I have defined "harmonic." As I have defined "harmonic."—I only went to higher frequency, and, as I said to the Commissioner, with that definition you also have to bring in sub-harmonics, so that we would have in this case

a sub-harmonic; or, if you prefer to start with 1600 meters, you can go the other way and call it the harmonic.

X Q. 291. I believe the Commissioner's question established that you were regarding 200 meters as the fundamen- [fol. 2145] tal. If you had a receiver receiving this fundamental and receiving the quantity of current which a normal receiver would obtain on a received signal strength could that primary circuit of the receiver excite a secondary tuned to 1600 meters?

A. In the time of Marconi and the circuits we are discussing, yes, it would. The reason is that the waves are complex. They are not pure waves. They are highly damped, and they include not only the fundamental frequency but many other frequencies—so that you get into a situation which cannot be compared to the conditions of today, where we have pure waves or continuous waves.

X Q. 292. Then it is your testimony that, with a transmitted wave of 200 meters received by the circuit of Marconi Figure 2, tune 3, the secondary circuit of that figure tuned to 1600 meters would respond to the received signal; is that correct?

A. I have not testified quite that way. I have said that the antenna circuit as a whole is responsive to two frequencies; and one of these frequencies is 200 meters and the other is 1600 meters; that the coupling between the antenna circuit and the secondary is the coupling between two circuits which are responsive to 1600 meters; and that combination, the thing we are dealing with here, will respond to 1600. It will also have some response, due to the impure waves, to 200 meters, other than this direct [fol. 2146] 1600-meter response; but the antenna responds equally well to the wavelengths, and the secondary circuit responds to the 1600.

X Q. 293. But the transmitted wavelength on tune 3 is 200 meters?

A. That is correct.

By the Commissioner:

X Q. 294. Would it be proper to say that the 1600 meters is an even harmonic of the fundamental 200 meters?

A. Not as I have defined "harmonic." I started with the fundamental frequency, and I defined "harmonic" as the integral number of higher frequencies, which I think is the

way we use the word today; so that, under these circumstances, it would not be correct.

X Q. 295. As I understand your testimony, you have your fundamental wavelength of 200 meters coming in on your primary circuit, and your secondary circuit is tuned to 1600 meters. Now, what is the particular relationship between the two? I know that one is numerically eight times the value of the other. Does that combination operate better than if the secondary circuit was tuned with, say, 1400 meters or 1300 meters? Is there some particular relationship caused——

A. Yes; it must be multiplied by a whole number, such as [fol. 2147] 2, 3, 4, 5, 6, 7, 8, 9, and so on; and that is what we mean.

By Mr. Houghton:

X Q. 296. When you say "it must be multiplied," what do you mean—the frequency?

A. The fundamental wavelength, if we start with the fundamental wavelength of 200 meters in this particular arrangement.

By the Commissioner:

X Q. 297. Then would this be true: that the 200-meter wavelength—with the 200-meter wavelength coming in on the primary, suppose we could adjust the secondary through a range of frequencies, would we get a response if the secondary were adjusted at 200 and then, as we increased the wavelength of the secondary down to, say, 300, we would get a decrease of response, and if we came up to 400 we would get an increase?

A. That is correct.

X Q. 298. And that would be true when we went to 500? What would we get—a decrease?

A. 500 would be a decrease.

X Q. 299. How about 600?

A. 600 would be an increase.

X Q. 300. So, then, as we take each multiple, even an even multiple of the fundamental, we get an increase?

A. That is correct.

* * * * * * *

[fol. 2148] (Tr. 2745)

Redirect examination.

By Mr. Blackmar:

R. D. Q. 326. Referring to the sketch that you made at the Commissioner's request, just to be sure what it means, is it intended to be representative in detail either of the circuits of the Marconi patent or of the circuits of the defendant's receivers?

A. No, it is not intended to represent details of these circuits.

* * * * * * *

(Tr. 2746)

R. D. Q. 327. Is it merely illustrative of more or less conventional circuits?

A. It is a schematic illustration of conventional circuits to show the difference between the parallel connected condenser and a series connected condenser and a series connected condenser with a loading coil in the antenna circuit.

* * * * * * *

(Tr. 2747)

[fol. 2149] R. D. Q. 333. Using the analogy of music, or, more particularly, of the piano, if 200 meters is analogous to two octaves above the middle C, using octaves in the ordinary sense of the piano, is it correct to say that 1600 meters is equivalent to two octaves below middle C?

A. Yes.

R. D. Q. 334. That is, in the piano scale, as you go upward or downward an octave, you double or halve the frequency?

A. Yes, that is my understanding.

R. D. Q. 335. Or halve or double the wavelength?

A. Yes.

* * * * * * *

(Tr. 2748)

R. D. Q. 338. Considering the Marconi patent as a whole, does it, in your opinion, as one skilled in the art, teach that the only ways in which the condenser h of Figure 2 would be utilized, are those set forth in tunes 3 and 4 of page 4 of the patent?

A. No, it certainly is not my understanding that the condenser h is limited to the uses corresponding to tunes 3 and 4 of the tables on page 4 of the Marconi patent. Might I specifically refer to the paragraph which I recently read on the second column on page 2, at the bottom of the column, [fol. 2150] which specifically describes the tuning of the four circuits, all to the same wavelength or natural period? It is quite clear, from the teaching of the patent, that the receiver for tune 3 of the transmitter could be tuned to the same wavelength, rather than an octave. I think that the octave tuning is more unusual than the tuning to the fundamental. I might add that it has some utility to tune to octaves, and that use can be made of this feature. But the principal teaching of the patent is certainly that all four circuits are tuned to the same wavelength.

R. D. Q. 339. You mean primary teaching of the patent; is that what you mean?

A. Yes.

R. D. Q. 340. Because it also discloses the octave tuning?

A. Yes.

R. D. Q. 341. If the arrangement of the receiver of tune 3 was to be tuned both in primary and secondary to the transmitter, would the inductance coil or transformer, No. 2, be used?

A. No. You would select another of the transformers; or, in accordance with the specific instructions of the patent—I will read from the last paragraph, second column, of page 3: "Other forms of transformers which may be employed by me are described and claimed in my British Patent No. 7777 of 1900."

. . . . . .

[fol. 2151] (Tr. 2783)

Mr. Blackmar: If your Honor please, Mr. Tuska has supplied a formal drawing of Plaintiff's Exhibit 477, and I have his drawing and request that it be marked Plaintiff's Exhibit 477-A in accordance with the understanding on the record.

. . . . . .

[fol. 2152] GEORGE H. CLARK

(Tr. 2811)

A. Within the years mentioned in the records, namely, 1918 and 1919, I have only two records. I have previous

records to a great extent when such work was being done in greater quantity. These two records are, first, a log of station IDO, Rome, and in my log book 3/29/18 I placed the notation that the wavelength of this station was 11,000 meters. The second entry is station LCM, Stavanger, under date 2/18/18. I have in my log book a record that it was received at 10,300 meters on the secondary dial of the receiver.

Q. 275. Now, you have, I believe, also, records—possibly in other years—for the German stations at Nauen and Eilvese. Is that right?

A. I have a record for Nauen only. I never measured Eilvese, though I copied it often.

Q. 276. What was the date of the German record?

A. 11/8/17.

Q. 277. November 8, 1917?

A. Yes, sir.

Q. 278. What were the call letters and what was the wavelength of that station?

A. The call letters were POZ, and my record gives a value of 12,500 meters for the station.

Q. 279. What other stations have you there for the year 1917——

[fol. 2153] Mr. Edwards: Are those in his records, you mean? Do you mean that is in his record?

Q. (279, continued). Yes, I mean those in your records, and of which you have a memorandum before you.

A. I have a record of Station MUU, Carnavon; and as of date 11/5/17 I recorded the wavelength as 14,000 meters.

Q. 280. Do you know where Carnavon is located?

A. Carnavon is in Wales. I also have a record ——

Q. 281. That, I assume, is by hearsay, is that right?

A. I never was at the station. It is from reading and hearsay and official lists of the Navy.

Q. 282. Will you continue, please?

A. I have also copied station YN, Lyons, France. That was recorded by me under date of 12/5/17 as sending on a wavelength of 15,000 meters. Those are all that I have for that year.

* * * * * * *

[fol. 2154] CLARENCE D. TUSKA

(Tr. 2908)

Q. 2. Have you recently at my request considered the various receivers purchased by the defendant herein and asserted by the plaintiff to utilize the subject matter of Claim 16 of Marconi Patent No. 763,772 for the purpose of estimating the monetary saving that resulted in connection with these receivers from the use of the subject matter of that claim?

A. I have.

Q. 3. Generally speaking, was there any direct monetary saving resulting to the defendant from the use of the subject matter of that claim?

A. There was.

Q. 4. What was the cause of that monetary saving?

A. If the defendant had not used the parallel connection of the antenna tuning condenser in the primary circuit it would have been necessary to use additional inductance in the antenna circuit.

Q. 5. In order to do what?

A. In order to cover the wavelength range of the secondary circuit as given in the instruction books or testimony here.

* * * * * * *

(Tr. 2952)

[fol. 2155] Q. 109. In arriving at that opinion, Mr. Tuska, what advantages did you consider as resulting from the use of the parallel connection?

A. I considered a number of advantages:

(1) At the longer wavelengths within the operating range the sensitivity is greater with the parallel connection;

(2) At the longer operating wavelengths the selectivity is greater;

(3) If no additional inductance coils are required the receiver may be made more compact with the parallel connection;

(4) If no additional loading coils are required the receiver with the parallel connection will weigh less than a receiver using the series connection with additional loading coils;

(5) The original design of a receiver with parallel tuning in the antenna circuit is less complex and less expensive than a receiver employing the series connection;

By the Commissioner:

Q. 110. That is the monetary advantage that you have already covered, is it not?

A. I think it is the design, not the cost of the receiver after it is built; but the initial receiver has to be designed.

[fol. 2156] By Mr. Blackmar:

Q. 111. Referring to development cost?

A. The development cost of the first model of the receiver. Then there are a number of operating advantages. For example, the range is greater with the parallel connection at the longer wavelengths. The interference problem is diminished at the longer wavelengths with the parallel connection.

Q. 112. There are others?

A. The question of material certainly is a factor which I had to consider, since these receivers involved war operations. With the parallel connection no loading coils would be supplied and this would mean a diminished problem of service. There would be less parts to keep in stock, less bases to be equipped with additional devices. There would also be less possibility of the receiver being damaged if it had less parts. There would be less possibility of the receiver requiring repairs with a smaller number of parts.

* * * * * * *

[fol. 2157] ROBERT A. LAVENDER

(Tr. 1699)

ROBERT A. LAVENDER, a witness produced on behalf of the defendant, having been first duly sworn by said Commissioner, was examined, and, in answer to interrogatories, testified as follows:

Q. 1. Will you state your occupation?

A. I am an officer of the United States Navy in retired status.

Q. 2. Will you state your education, training, and the various positions you have occupied, having in mind par-

tiendarly knowledge of radio transmission and reception and also in particular the use or operation of such instruments in the navy and, further, the value of licenses under patents for the use of such apparatus?

A. I graduated from the United States Naval Academy in 1912, in which or in the course of which instruction was a fundamental course in electricity and radio engineering.

. . . . . .

(Tr. 3010)

Examining the wavelength formula, it is seen that the wavelength is equal to a constant (used by me as 1884) multiplied by the square root of the product of the inductance and the capacity.

In other words, for a definite wavelength you may select a certain value of inductance; that will determine the capacity that is necessary for the L× value combined, and by [fol. 2158] multiplication will give you the value determining the other side of the equation, namely, the wavelength; so that if you double the capacity of an antenna, you immediately halve the value of the inductance that is necessary to have that particular wavelength.

. . . . . .

[fol. 2159] CLARENCE DENTON TUSKA

(R. 3272)

Before referring to Plaintiff's Exhibit 480-A for Identification, I should like to refer briefly to the Bureau of Standards book, circular C 74, beginning on page 66, and extending through page 68. This section describes "Effects of Dead Ends."

All inductance coils used in radio frequency circuits have not only the property of inductance but also have capacity as well. Whenever the amount of capacity of a coil is material, it cannot be neglected in determining the characteristics of the coil and the circuit in which the coil is used.

In this section the Bureau of Standards book points out that the turns which are substantially "dead," are, in effect, far from "dead," but are an important element of the circuit. By way of example, the book describes a wave-meter circuit in which the inductance coil is tapped. Fig. 51 illustrates such a circuit with four taps. The coil La which is

represented as a turn or two, corresponds to the coupling coil in the SE 950. The condenser C_1 corresponds to the algebraic sum of the antenna capacity and the tuning capacity. The coil marked large L, corresponds to the new coil on Exhibit MMMM. The turns in use are represented as small l, while the overhanging or unused turns are [fol. 2160] represented as l'. The distributed capacity of the unused turns is represented as C_0. Every element of Figure 51 will be found in the modification of the SE 950 proposed by Commander Lavender.

On the next page, the tuning characteristic of this wave-meter is shown in Figure 53. Actually, the characteristic should be a single line extending from a point near the zero of the wave-meter condenser upwardly to the maximum of 180. Instead of finding a single line, the measured characteristic of this wave-meter showed that the wavelength increased gradually from 100 meters to approximately 220 meters, at which point the curve breaks abruptly, and begins again at about 260 meters at 10 on the condenser scale; thereafter rising until the maximum range of 500 meters is reached at 180 on the scale. One who wished to use this wave-meter would not be able to receive any wavelengths between approximately 220 and 260 meters. In my previous testimony I referred to this condition as a hiatus in the tuning characteristic.

By the Commissioner:

Q. 240. Was that the same thing that Mr. Clark testified to this morning as a "trap circuit"?

A. I think it is, due to a different reason. I think the trap circuit has a slightly different characteristic, but it still has the property of two circuits which are coupled, and which have different wavelength characteristics. They may have the same wavelength characteristics.

[fols. 2161-2162] Q. 241. And they both involve distributed capacity?

A. And they both involve distributed capacity, but not quite in the same manner. It may be the same.

Mr. Blacknar: I notice that this happens to be a comparatively recent edition of the Bureau of Standards circular. May I borrow the circular which is the earlier edition, for a minute? While I do not think it makes any difference when it was published, because the only thing we are inter-

ested in is how the receiver would have worked with such a coil, yet Commander Lavender has been kind enough to lend me the 1918 edition of such a circular, and I should like Mr. Tuska to state whether similar subject matter appears therein.

A. (Continuing:) Yes, the same subject matter appears on both pages; on pages 66, 67, and 68.

Mr. Blackmar: I will offer in evidence as Plaintiff's Exhibit 481 and 1918 Edition of the Bureau of Standards Circular, so that it may appear what the witness was talking about, pages 66, 67, and 68 of the 1918 Edition of the Bureau of Standards Circular, and I request permission to put in photostatic copies of those pages.

* * * * * * *

[fol. 2163] IN SUPREME COURT OF THE UNITED STATES

STIPULATION DISPENSING WITH THE PRINTING OF EXHIBITS ON APPLICATION FOR WRIT OF CERTIORARI

It Is Hereby Stipulated and Agreed by and between counsel for petitioner and respondent herein, subject to the approval of the Court, that, on the application for writ of certiorari herein, only those portions of the record herein comprising the pleadings, the testimony, and the findings of fact, conclusions of law, orders, judgment, and opinions of the Court of Claims of the United States herein as set forth at pages 1 to 169, inclusive, of the Transcript of the pleadings, etc., herein, and at pages 1 to 1599, inclusive, [fol. 2164] and pages 2833 to 3196, inclusive, of the "Parts of the Evidence Agreed to by Parties as Material to Errors Assigned", need be printed, said pages 1 to 1599, inclusive, comprising Volumes I and II thereof, and said pages 2833 to 3196, inclusive, comprising Volume VI thereof; and that the Exhibits of the parties comprising those referred to in the Findings of Fact of the Court of Claims and made a part thereof by reference, now enclosed in a sealed package endorsed by the Assistant Clerk of the Court of Claims, and also those embodied in Volumes III, IV, V, and VII of the "Parts of the Evidence Agreed to by Parties as Material

to Errors Assigned", need not be printed but may be submitted to this Court on the application for writ of certiorari herein in the form in which they are filed in this Court.

Dated, August 28, 1942.

Abel E. Blackmar, Jr., Richard A. Ford, Counsel for Petitioner.

Aug. 31, 1942.

Charles Fahy, Solicitor General of the United States.

[fol. 2165] Supreme Court of the United States, October Term, 1942

No. 369

Order Extending Time Within Which to File Petition for Certiorari

Upon Consideration of the application of counsel for the Petitioner,

It Is Ordered that the time within which to file petition for certiorari in the above-entitled cause be, and the same is hereby, extended to, and including, Sept. 4th, 1942.

Harlan F. Stone, Chief Justice of the United States.

Dated this 21st day of May, 1942.

[fol. 2166] In the Supreme Court of the United States, October Term, 1942

No. 373

Order Extending Time Within Which to Apply for a Writ of Certiorari

On consideration of the motion of counsel for the petitioner in the above-entitled cause, and good cause therefor having been shown, it is now here ordered that the time within which a petition for writ of certiorari may be filed

herein is hereby extended for a period of sixty days from July 6, 1942, i.e. to September 4, 1942.

Harlan F. Stone, Chief Justice of the Supreme Court of the United States.

June 23rd, 1942.

Endorsed on Cover: File No. 46,870, 46,874, Court of Claims, Term No. 369. Marconi Wireless Telegraph Company of America, Petitioner, vs. The United States. Term No. 373. The United States, Petitioner vs. Marconi Wireless Telegraph Company of America. Petitions for writs of certiorari and exhibit thereto. Filed September 2, 1942. September 3, 1942. Term No. 369 O. T. 1942, 373 O. T. 1942.

SUPREME COURT OF THE UNITED STATES, OCTOBER TERM, 1942

No. 369

ORDER ALLOWING CERTIORARI.—Filed December 14, 1942

The petition herein for a writ of certiorari to the Court of Claims is granted. And it is further ordered that the duly certified copy of the transcript of the proceedings below which accompanied the petition shall be treated as though filed in response to such writ.

SUPREME COURT OF THE UNITED STATES, OCTOBER TERM, 1942

No. 373

ORDER ALLOWING CERTIORARI.—Filed December 14, 1942

The petition herein for a writ of certiorari to the Court of Claims is granted. And it is further ordered that the duly certified copy of the transcript of the proceedings below which accompanied the petition shall be treated as though filed in response to such writ.

CLERK'S COPY

Vol. IV

EXHIBITS

TRANSCRIPT OF RECORD

Supreme Court of the United States

OCTOBER TERM, 1942

No. 369

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA, PETITIONER,

vs.

THE UNITED STATES

No. 373

THE UNITED STATES, PETITIONER,

vs.

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA

ON WRITS OF CERTIORARI TO THE COURT OF CLAIMS

PETITIONS FOR CERTIORARI FILED (SEPTEMBER 2, 1942.
SEPTEMBER 3, 1942.

CERTIORARI GRANTED DECEMBER 14, 1942.

SUPREME COURT OF THE UNITED STATES

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ON WRITS OF CERTIORARI TO THE COURT OF CLAIMS

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327	DeForest U. S. patents Nos. 824,637, 836,070, 867,876, 867,877, 867,878, 841,386 and 979,275	2781	3199
335	Robison's Manual of Radio Telegraphy, etc., 1924, pages 239-241	2811	3229
343	Decree—Marconi Co. v. National Electric Signalling Co., November 18, 1914	2814	3233
344	Decree—Marconi Co. v. National Electric Signalling Co., November 18, 1914	2821	3239
347	Decree—Marconi Co. v. DeForest Radio Tel. & Tel. Co. et al., October 9, 1916	2823	3240
348	Decree—Marconi Co. v. DeForest Radio Tel. & Tel. Co., July 18, 1917	2831	3246

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349—Decree—Marconi Co. v. DeForest Radio Tel. & Tel. Co., July 9, 1919	2834	3247
363—Report on Congressional Bill for Settlement of damages for infringement of radio patents	2836	3249
364—Decree—Marconi Co. v. Kilbourne & Clark Mfg. Co., July 16, 1917	2840	3254
—Waterman Drawing No. 1	2845	3258
—Waterman drawing No. 2	2846	3258
—Waterman drawing No. 3	2847	3259
410—Sketch made by witness Clark (showing series and parallel connections)	2848	3260
413A—Instruction Book for Navy Type SE-143 receiver (pages 1, 2A, 4A, 13A)	2849	3261
419—Sketch made by witness Clark entitled "SE-950 Analysis of Switching for Series-Shunt Connections of Primary Condenser"	2853	3265
420—Sketch made by witness Clark entitled "SE-1012 Analysis of Switching for Series-Shunt Connection of Pri. Condenser"	2854	3266
440—Pickard chart entitled "SE-143. Maximum & minimum ranges, series & parallel"	2855	3267
441—Pickard chart entitled "Assumed calibration of SE-143 primary condenser"	2856	3268
453—Sketches shown to and drawn by defendant's witness Dow on cross-examination	2857	3269
454—Sketch shown to defendant's witness Dow on cross-examination	2858	3270
455—Sketch shown to defendant's witness Dow on cross-examination	2859	3271
462—Pages 12 and 17 of December 1912 Log Book of Clark	2860	3272
472—Title page and pages 142, 145 and 215 of "Robinson's Manual of Radio Telegraphy and Telephony for the use of Naval Electricians" by Commander S. S. Robison, U. S. Navy (1918)	2862	3274
477A—Formal drawing of Plaintiff's Exhibit 477 (Reproduced at p. 142, Vol. I)		
Defendant's exhibits:		
A—Sketch of bulb demonstrated before Judge Mayer	2867	3278
B—Exhibits 2 and 3 in DeForest case	2868	3279
C—Waterman Sketches A to F	2869	3280
D—Blue print of amplifier shown Waterman	2870	3281
I—Miller drawings A to M	2871	3282
J—U. S. patent to Edison No. 307,031, October 21, 1884	2884	3295
K—U. S. patent to DeForest No. 879,532, February 18, 1908	2888	3299
L—"The Thermionic Tube", by Van der Bijl, 1920, pp. XV, XVI, XVII and 42, 108, 112, 266, 271	2892	3303
M—"Proceedings of the London Physical Society", 1910, Vol. 22, pp. 360-363	2898	3311

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X—"Wireless Telegraphy", 1921, by Leggett, pp. 112-160, 161, 375	2901	3315
O—U. S. patent to Hewitt No. 781,001, January 31, 1905	2906	3320
P—U. S. patent to Hewitt No. 781,002, January 31, 1905	2910	3323
S—"The Principles Underlying Radio Communication", 1919, pp. 288, 304, 313	2914	3327
T—"The Principles Underlying Radio Communication", 1922, p. 402	2919	3332
U—"Electric Wave Telegraphy and Telephony", by Fleming, 1916, pp. 98, 109	2919	3332
V—"Wireless Telegraphy and Telephony", by Eccles, 1918, pp. 215, 216, 220	2921	3335
W—"The Radio Review", 1919, p. 26-29	2925	3339
X—"Journal of the Institution of Electrical Engineers", 1900, Vol. 30, p. 232	2925	3340
Z—Certified copy of Navy Department report by Clark on Bellini-Tosi Direction Finder Tests, 1915	2944	3362
A-1—Manual of Wireless Telegraphy for the Use of Naval Electricians", 1915, pp. 132, 133, 134, 139-141	2951	3371
B-1—"Robison's Manual of Radio Telegraphy and Telephony", 1918, p. 156	2959	3381
C-1—"Wireless Telegraphy and Telephony" by Turner, 1921, p. 88	2960	3382
D-1—"Guide to the Study of the Ionic Valve" 1919, p. 19	2961	3383
E-1—"Proceedings of Physical Society of London", February 1914, p. 102	2961	3383
F-1—Bulletin of the Bureau of Standards, 1911, Vol. 6, No. 4, pp. 527-542	2962	3384
G-1—"Practical Wireless Telegraphy" by Bucher, 1918, pp. 143, 144, 145, 148, 151, 154, 157, 172, 174	2973	3398
H-1—"Proceedings of the Institute of Radio Engineers", August 1916, pp. 322, 325	2984	3411
I-1—"Proceedings of the Royal Society", 1890, Vol. 47, pp. 118-126	2985	3413
J-1—"Proceedings of the Royal Institute", 1890-1892, pp. 34-49	2995	3425
K-1—"The Electrician", February 21, 1890, pp. 393-395	3009	3443
L-1—"The Electrician", February 28, 1890, pp. 417-420	3016	3449
M-1—"Proceedings of the American Institute of Electrical Engineers" 1897, Vol. 14, pp. 31-35 (pp. 42-43 included by stipulation)	3025	3459
N-1—"Proceedings of the Physical Society of London", March 27, 1896, pp. 187-242	3033	3466
P-1—Translation of Dett's Ex. O-1	3073	3515

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T-1—"Philosophical Magazine", 1899, Vol. 48, Thomson article beginning p. 547	3078	3519
A-2—French patent to Valbreuze No. 328, 687, May 7, 1903	3100	3540
B-2—Translation of Deft's. Ex. A-2	3106	3547
C-2—"The Thermionic Valve", by Fleming, 1919, pp. 102–116	3111	3551
E-2—Millikan Sketch	3122	3565
F-2—"London Electrician":		
Sept. 14, 1888, pp. 584–589		
Sept. 21, 1888, pp. 625–627		
Sept. 28, 1888, pp. 663–665		
Oct. 5, 1888, pp. 697–698		
Oct. 12, 1888, pp. 725–726		
Oct. 19, 1888, pp. 757–758		
Oct. 26, 1888, pp. 788–789		
Nov. 9, 1888, pp. 16–18		
Nov. 16, 1888, pp. 41–44	3123	3566
M-2—Loftin Sketch F (coupling effect)	3148	3590
O-2—Loftin Sketch G (Coupling effect)	3149	3591
P-2—Loftin Sketch H (comparison loose coupling, plain gap)	3150	3592
Q-2—Loftin Sketch J	3151	3593
R-2—Loftin Sketch K (comparison Waterman Sketch 2 and Marconi effect)	3152	3594
U-2—U. S. patent to Pupin, No. 640,516, Jan. 2, 1900	3153	3595
V-2—Loftin Sketch L (Lodge patent No. 609,154)	3159	3600
W-2—Loftin Sketch M (Marconi receiver 1899)	3160	3601
X-2—U. S. patent to Tesla No. 645,576, Mar. 20, 1900	3161	3602
Y-2—British patent to Tesla No. 20981 of 1896	3169	3609
Z-2—British patent to Braun No. 1862 of 1899	3181	3620
A-3—British patent to Braun No. 12420 of 1899	3186	3623
B-3—Loftin Sketch N (Stone 4-tuned circuit system)	3191	3627
D-3—Loftin Sketch O (quenched gap effect)	3192	3628
E-3—Letter from Baker to Stone, July 22, 1899	3193	3629
F-3—Letter from Stone to Baker, June 30, 1899	3194	3630
G-3—Letter from Stone to Baker, July 18, 1899	3198	3634
H-3—Affidavit of Joseph B. Baker	3207	3644
I-3—Affidavit of Joseph B. Baker	3208	3645
K-3—Letter from Baker to Brown, June 3, 1902	3209	3646
N-3—Letter from Baker to Stone, July 22, 1899	3209	3646
P-3—U. S. patent to Stone No. 714,756, Dec. 2, 1902	3211	3648
Q-3—U. S. patent to Stone No. 714,831, Dec. 2, 1902	3231	3667
R-3—File wrapper and contents of U. S. patent to Stone No. 714,756, Dec. 2, 1902	3250	3685
B-4—"Tesla Hook", 1894 (portion)	3388	3723
E-4—"London Electrician", 1894:		
June 8, 1894, pp. 153–155		
June 15, 1894, pp. 186–190		
June 22, 1894, pp. 204–205		

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July 6, 1894, pp. 271–274 July 13, 1894, pp. 299 July 20, 1894, pp. 332–335	3438	3872
J-4—"Electric Waves", by Hertz, 1893, pp. 183, 184	3458	3890
R-4—Loftin Sketch A (Tesla transmitter)	3461	3892
S-4—Loftin Sketch B (Popoff receiver)	3462	3893
Z-4—Navy Manual of 1915, p. 58	3463	3894
A-5—Loftin Sketch P	3465	3895
B-5—"London Electrician", 1909, pp. 332, 333	3466	3897
C-5—"London Electrician", 1911, pp. 171–175	3468	3900
D-5—"Wireless Telegraphy", by Zenneck, 1915, pp. 87–97, 390–391	3478	3911
E-5—"Wireless Telegraphy and Telephony", by Eccles, 1918, pp. 199–200	3488	3924
F-5—"Principles Underlying Radio Communication", 1922, pp. 377–378	3490	3926
G-5—"Wireless Telegraphy", by Leggett, 1921, preface and pp. 9, 17, 55–59	3495	3933
N-5—Marbourgne Sketches, Figs. 1–8, inclusive	3506	3942
O-5—Pickard chart	3509	3945
Q-5—Marriott Sketch	3510	3946
S-5—Sammis Sketch	3511	3947
T-5—Sammis Sketch (plain aerial)	3512	3948
U-5—Sammis Sketch (coupled circuit)	3513	3949
V-5—Diagram No. 1 in DeForest case	3514	3950
W-5—Diagram No. 2 in DeForest case	3515	3951
X-5—File wrapper and contents of U. S. patent to Marconi No. 763,772, June 28, 1904	3516	3953
H-6—U. S. patent to Marconi No. 627,650, June 27, 1899	3691	4085
L-6—U. S. patent to Tesla No. 649,621, May 15, 1900	3695	4089
M-6—U. S. patent to Braun No. 797,169, Aug. 15, 1905	3700	4093
N-6—U. S. patent to Braun No. 797,544, Aug. 15, 1905	3702-A	4096
Q-6—Sketch of tube produced by Weagant demonstrating above tests	3704	4099
S-6—"Journal of the Society of Arts", Feb. 23, 1894, pp. 274–280, article by Preece entitled "Electric Signaling Without Wires"	3705	4100
V-6—Loftin diagram of apparatus of Claimant's Exhibit 224	3713	4107
W-6—Loftin Sketch R (effect of resistance on response of circuit)	3714	4108
Y-6—Plaintiff's Exhibit 22 in suit of Radio Corporation v. Splitdorf	3715	4109
Z-6—Defendant's Exhibit 11-A in suit of Radio Corporation v. Splitdorf	3716	4110
JJ—Dow sketch (two figures)	3717	4111
KK—U. S. patent to Pupin No. 640,516 (Same as Defendant's Exhibit U-2)		

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Defendant's exhibits—Continued		
LL—U. S. patent to Fessenden No. 706,735 (Reproduced as part of plaintiff's exhibit 171)		
MM—Dow sketch (re. Fig. 1 of Fessenden; Fig. 2 of Marconi)	3732	4112
PP—Dow sketch showing comparison between circuit in which all elements are in series, where a loading coil is used, and a circuit in which parallel condenser is used	3733	4113
BBB—Tabulation of Marconi antenna circuit tunes	3734	4114
UUU—U. S. patents to DeForest Nos. 1,507,016, 1,507,017	3735	4115
Stipulation as to printing of exhibits	3751	4131

[fol. 2167] PLAINTIFF'S EXHIBIT No. 7

[Printed From a Certified Copy]

Royal Courts of Justice,
Tuesday, 21st February, 1911.

IN THE HIGH COURT OF JUSTICE, CHANCERY DIVISION

Before Mr. Justice Parker

MARCONI and Others

v.

THE BRITISH RADIO TELEGRAPH AND TELEPHONE COMPANY, LIMITED

[From the Shorthand Notes of Cherer, Bennett & Davis, 8, New Court, Carey Street, W. C., and of Corfield & Hersee, 22, Chancery Lane, W. C.]

Counsel for the Plaintiffs: Mr. J. M. Astbury, K. C., Mr. A. J. Walter, K. C., and Mr. J. Hunter Gray (instructed by Messrs. Coward & Hawksley, Sons & Chance).

Counsel for the Defendants: Mr. T. Terrell, K. C., and Mr. Colefax (instructed by Messrs. G. F. Hudson, Matthews & Company).

JUDGMENT

Mr. Justice PARKER:

This is an action for the infringement of *inter alia* the Letters Patent No. 7777 of 1900 for an invention of improvements in apparatus for wireless telegraphy. The infringement is denied, and it is contended that the Letters Patent [fol. 2168] are invalid, on various grounds to which I shall presently refer. First, however, it will be convenient to say a few words on the subject of wireless telegraphy generally, and the problems which its practical application has involved; for only in this way can a proper conclusion be reached either as to the nature of the invention or as to the soundness of the objections raised to the validity of the patent in question. Wireless telegraphy in the sense in which I am using the expression, operates by means of disturbances in the ether produced by the sudden discharge

of a Leyden jar or other condenser, and in this respect must be distinguished from inductive telegraphy which, though it also operates without the aid of wire conductors, depends for its effect upon the current which is induced in a circuit generally called the secondary circuit, when it is cut by the lines of force in the magnetic field created round itself by an electric current in another circuit usually called the primary circuit. I understand it to be mathematically demonstrable that the sensitiveness of the secondary circuit to the influence of the lines of force in the magnetic field of the primary circuit diminishes in proportion to the cube of the distance, whereas the energy of the disturbances in the ether produced by the sudden discharge of a condenser falls off only as the square of the distance. From this it seems to follow that as a means of conveying signals or messages to a distance the utilisation of these disturbances must be far more efficient than the utilisation of the lines of force in a magnetic field. A condenser can be charged in any convenient manner, and either by a continuous or by an alternating current, though the latter is preferable. Its sudden discharge is usually secured by arranging a circuit commencing in one plate and ending in the other plate of the condenser, and containing a spark gap of such a length that when in process of charging the pressure in the condenser has reached a certain point, the air between the balls of the gap is broken down, and a spark passes across the gap. Until the spark passes the circuit is incomplete, and no discharge takes place, but the spark renders the air between the balls of the gap a conductor, and by suddenly completing the circuit, causes the condenser to discharge instantaneously through the gap. What exactly happens during the exceedingly short interval of time during which the spark exists was thoroughly investigated more than half a century ago. In or about the year 1839 Henry arrived at the conclusion that during this interval the electricity [fol. 2169] with which the condenser was charged surged or oscillated with incredible rapidity through the spark gap between the positive and negative plates of the condenser. He had been studying the inductance of electric circuits, that is the effect on an electric current of the magnetic field which it creates in its own neighbourhood, and having found that inductance in electrical phenomena was in many respects equivalent to inertia in physics, he conceived of the charge in the condenser as rushing from the positive

plate through the spark gap to the negative plate overcharging such plate and then rushing back again, the process being repeated until by loss of energy due to resistance or otherwise an equilibrium was finally established.

After Henry the matter was taken up by Kelvin and Helmholtz, who not only proved by experiment and calculation that Henry's theory was correct, but established beyond all doubt the necessary conditions as to resistance, capacity and inductance of the circuit in which it was proposed to create such an oscillatory discharge and the law of the frequency of such oscillations. For the present purpose it will be sufficient to remember (1) that the resistance of such a circuit must never exceed a certain maximum which appears to be the square root of four times the inductance divided by the capacity, otherwise there will be no sudden discharge at all, but a gradual and non-oscillatory one; (2) that resistance means loss of energy and the consequent damping of the oscillations and therefore should be kept as low as possible; and (3) that the frequency though affected by the resistance of the circuit when such resistance is high depends where the resistance is low almost entirely on the capacity and inductance varying inversely as the square root of their product, so that the frequency can be increased or diminished by diminishing or increasing either the capacity or the inductance.

In or about 1868 Clark-Maxwell again devoted considerable attention to the subject, but from a different point of view. He was engaged in investigating the phenomena of light, and incidentally the nature of the ether supposed to pervade space and to be the medium by which light travels. He examined the theoretic effect which the oscillatory discharge of electricity established by Kelvin and Helmholtz would have on the ether and came to the conclusion that each complete oscillation would create an etheric disturbance or wave which would travel in all directions through [fol. 2170] space with the velocity of 300,000,000 metres a second. The wave length or distance each wave had travelled before the next succeeding wave started on its course would depend on the frequency of the oscillations, being the velocity of 300,000,000 metres divided by such frequency. If the frequency were 1,000,000 the wave length would be 300 metres, and so on. It is unnecessary to attempt to explain even if I were able how or why such waves must theoretically be created by an oscillatory electric dis-

charge or their precise nature. It will be sufficient to say that their properties are such that if and whenever they strike across a circuit capable of carrying an oscillating current of electricity they will induce or tend to induce in such circuit electrical oscillations corresponding in frequency with their wave length.

What Clark-Maxwell proved theoretically, Hertz demonstrated as a fact. He arranged his discharge circuit in such a way that the oscillations would readily part with their energy to the surrounding ether, his idea being to increase the amplitude of the waves and make them easier to detect. For this purpose he opened his circuits by separating the two plates of his condenser. Further, by reducing the capacity and inductance of his circuit as much as possible, he increased the frequency of his oscillations, his object or one of his objects being to create short waves which would be more convenient for laboratory experiments. In this way he arrived at what is known as the Hertz radiator. In order to detect the ether waves created by his radiator, he bent a piece of wire in the form of a hoop, the two ends slightly overlapping each other, and one fitted with a sharp point, which though it nearly touched the other in fact left the tiniest of intervals by way of a spark gap. Lastly, he conceived the idea of rendering his detector more sensitive by utilising as far as possible the principle of sympathetic resonance. Inasmuch as this principle plays a considerable part in the invention covered by the patent in question, I shall have to deal with it somewhat fully. Just as it is possible to start a clock by a series of gentle taps administered to its pendulum, provided that the taps follow each other at intervals of time corresponding with the time period of the pendulum's swing, so that the series of taps has a cumulative effect on the pendulum and no one of them undoes the work another has done: just as in an analogous way it is possible to make a violin or piano string sound by singing in its neighbourhood its own appropriate note, the sound [fol. 2170] waves following each other at the appropriate intervals of time, so that each wave adds to the effect of the waves which have preceded it, and none of them undoes what another has done, so Hertz conceived that if his detector were tuned to the same time period as his radiator, the series of ether waves created by the latter would have an accumulative effect on the former, and this effect would be easier to detect. With this object, proceeding according

to the laws established by Kelvin, he adjusted the inductance and capacity of his detector, so that it had the same time period as his radiator. By means of his detector so tuned and placed in his laboratory at some little distance from his radiator he for the first time established experimentally the truth of Clark-Maxwell's theory showing how the ether waves due to the electric oscillations in the radiator striking across the detector induced in the latter an oscillating electric current which manifested itself by a minute spark in the tiny spark gap. This was in the year 1889, and in 1890 Branly, working on the same lines, first used for the detection of ether waves what is known as the coherer principle based on facts which I understand had been previously discovered at any rate as to metals by Lodge. A glass tube containing metal filings is a bad conductor by reason of the imperfect contact between the filings, but if it be subjected to the influence of an electric current, contact between the filings is established or improved, they cohere, and the tube becomes a good conductor. If such a tube, therefore, be placed in the circuit of a battery the circuit is incomplete because the tube is not a conductor and no current passes. Branly arranged such a tube so that while still in the battery circuit it could be subjected to the influence of the oscillating current induced in the detector by the ether waves. When so subjected he found that the filings cohered, the tube became a conductor completing the battery circuit so that the battery current passed and moved a galvanometer also contained in such circuit. It thus became possible to detect the existence of the ether waves by an ordinary galvanometer. Inasmuch however as the filings in the coherer when once they have been made to cohere under the influence of an electric current continue to cohere until their contact is mechanically destroyed, it is necessary in order to detect a succession of signals that some mechanical appliance should be provided whereby the contact should be destroyed and the tube rendered non-conductive as soon as the galvanometer had had [fol. 2171] time to move. In 1892 the result of Hertz's experiments was becoming generally known, and Crokes in an article in the "Fortnightly Review" first suggested that it might lead to a system of wireless telegraphy based on the creation and detection of ether waves. In 1893 Hertz died, and in the following year Lodge lectured before the Royal Institution on Hertz's work in connection with ether

waves. This lecture, which was repeated at Oxford shortly afterwards, was an event of great importance, not only because it brought the subject upon which Hertz had been experimenting prominently before the scientific world, but because in it Lodge explained with great exactness the various difficulties attending the full utilisation of the principle of sympathetic resonance for the purpose of the detection of ether waves. It is these difficulties which Marconi claims to have overcome by the invention the subject of the patent in question in this action, and I propose, therefore, to state them as clearly and shortly as I am able. To start a clock by gently tapping its pendulum not only must the taps be rightly timed with reference to the period of the pendulum, but there must be a long series of taps of approximate equal strength. Again, to set a violin or piano string sounding by singing to it its own appropriate note the note must be sustained so as to give a long series of sound waves of approximately equal amplitude. In like manner, if the principle of sympathetic resonance is to be utilized to its full extent in the detection of ether waves there must be a long series of waves of equal, or approximately equal, amplitude. Such a series of waves can only result where the oscillations from which they proceed occur in a circuit which loses its energy very slowly, for, as the energy in the circuit decreases, so does the amplitude of the ether waves which it creates. It must not, therefore, waste its energy either by internal resistance, or by giving it out too lavishly to the surrounding ether. On the other hand, if ether waves are to be detected at any great distance, they must be waves of substantial amplitude, for their effect diminishes as the square of the distance, and to create waves of any substantial amplitude, the oscillating circuit must give up its energy readily to the surrounding ether. It follows that a circuit which is a good conserver of energy, and therefore one capable of creating a series of waves of approximately equal amplitude is a bad radiator; and, on the other hand, a good radiator, which will perhaps surrender 70 to 80 per cent of its energy to the ether during each [fol. 2172] oscillation is necessarily a bad conserver of energy, and will not create a long series of waves of approximately equal amplitude, but one big wave followed by a short train of waves of rapidly diminishing amplitude. On the other hand, if the problem be looked at from the point of view of the detector there is a similar difficulty. A

good radiating circuit will be a good absorbing circuit, but it will not be a good conserving circuit. In other words, the more susceptible it is to the ether waves the less it is fitted to accumulate and store up the effect of a train of waves, because its tendency is to part forthwith with any energy it receives. This being so, it follows that the arrangements Hertz himself made were in the nature of a compromise; his radiator was a good radiator but a bad oscillator; it readily gave out its energy to the ether, but the waves it created were not a train of waves of approximately equal amplitude. Its oscillations were rapidly damped, not by internal waste due to resistance, but by external loss, and the resulting ether waves consisted of one wave of great amplitude followed by a few others of rapidly diminished amplitude. On the other hand, Hertz's detector, being an approximately closed circuit, was not a good absorber capable of use at great distances, but, on the other hand, it was a good conserver of energy, and therefore well calculated to accumulate the effect of a series of waves. In one of the experiments which Lodge showed at his lecture before the Royal Institution he used an approximately closed circuit both for his radiator and for his detector, getting his effect by great precision of tuning, but he was careful to point out that a closed circuit is both a feeble radiator and a feeble absorber, and not therefore, adapted for action at a distance. Lodge summed up the difficulty in these words: "The two conditions of conspicuous energy of radiation and persistent vibration electrically produced are at present incompatible." This is as true as when Lodge said it, if we remember that he was referring to a single circuit. On the 2nd June, 1896, Marconi applied for his patent in connection with wireless telegraphy No. 12039 of 1896. This was the first patent ever granted for a system of wireless telegraphy based on the creation and detection of ether waves. It embodied a great number of details which need not be considered. It will be enough to remember the following points: In the first place, Marconi made use of an open circuit both to create and detect his waves: in other words, to use the terms now in vogue, his transmitter [fol. 2173] was a good radiator and his receiver a good absorber, though by virtue of these very qualities the former could not create nor the latter accumulate the effect of such a series of waves of equal amplitude as would be necessary for utilising to the full the principle of sympathetic reso-

nance. Nevertheless, for what it was worth he tuned the two circuits together as Hertz had done. In the next place, Marconi replaced the horizontal Hertz radiator by a vertical wire of considerable height connected through a spark-gap to the earth. These improvements were admittedly a great advance, though the precise reason why a vertical aerial with a connection to earth is so much more effective than a horizontal or unearthed aerial appears to be a matter of considerable doubt. Lastly, he made use in his receiver of an improved Branly coherer connected with a mechanical arrangement for decohering the metal filings by a continuous and rapid series of taps. I gather that with the apparatus described in his first patent, without the aid of any subsequent improvement, Marconi, or the Plaintiff Company, which in 1897 was formed to work the patent, succeeded in sending messages over a distance of many miles, and thus fully demonstrated the possibility and utility of a system of wireless telegraphy based on the creation and detection of other waves.

Marconi's system, as shown in his 1896 patent, had, however, several drawbacks: not only was there the drawback explained by Lodge that his transmitter being a good radiator could not create, and his receiver being a good absorber could not store up the effect of such a long train of waves as was required for utilizing the principle of resonance, but there was also the further drawback that the electric energy he could get into his transmitter was somewhat limited. In the first place, the charge which his transmitting circuit would hold was limited by its capacity, and the capacity of a vertical wire such as he proposed to use is not great, nor is it practical to increase it very greatly by increasing the length of the wire or by the addition of capacity areas. In the next place, the voltage which could be obtained in such a circuit was limited by the tendency of an open circuit, consisting of a vertical wire, to a brush discharge. His store of energy was thus limited, and, such as it was, he could not employ it economically, because he could not get such a series of waves as was necessary for fully utilising the principle of resonance. It is necessary to [fol. 2174] bear these drawbacks in mind in considering the next patent to which I shall refer.

On the 10th of May, 1897, before the acceptance of Marconi's complete specification, Lodge applied for his patent No. 11575 of 1897 for improvements in syntonised teleg-

raphy without line wires. In this patent he returns to the problem of using the principle of sympathetic resonance in a system of wireless telegraphy, laying stress not only on its effectiveness at great distances but on the fact that it enables one or more receiving stations with properly tuned receivers to receive messages without other stations with receivers tuned to different frequency or wave length being in any way disturbed; in other words, in order to secure a selectivity which for practical purposes is of the greatest moment. He was, of course, confronted with the difficulty he himself had explained in his lecture, namely, the impossibility of a good radiator being a persistent vibrator or of a good absorber being a good accumulator, but he recognized that if he could get a long series of waves he could afford to diminish the amplitude of the first few of them. He therefore compromised matters by increasing the persistence of vibration of his radiating circuit at the expense of its radiating qualities and increasing the accumulative power of his receiving circuit at the expense of its absorbing qualities. Both circuits as in Marconi's 1896 patent were open circuits, but Lodge effected his compromise by the introduction of an inductance thus for the purpose of syntony obtaining a somewhat longer series of waves of approximately the same amplitude, while at the same time he increased his available energy by the introduction of two capacity areas, of such a shape as to minimise the tendency of his circuit to a brush discharge, thereby increasing the amperage of his oscillations and their possible potential. It will thus be seen that he appreciated the drawbacks I have mentioned as incident to Marconi's 1896 system and to some extent met them. In other respects his system resembled Marconi's. His aerial was vertical and not horizontal, and he says it may be earthed if desired, and he too uses a coherer of metal filings with a mechanical de-cohering arrangement.

Later the same year Lodge applied for another patent, No. 29505, of 1897. This relates to inductive telegraphy and its only importance for the purposes of this case, if indeed it has for such purposes any importance at all, is that the [fol. 2175] primary and secondary circuits used by him have adjustable arrangements for precise tuning and are tuned to the same frequency, so that the secondary, which, like the primary, is a closed circuit, may operate by accumula-

tion on the principle of resonance and that selectivity may be secured.

This was followed in 1898 by Silvanus Thompson's patent, No. 525, of 1898, which also relates to inductive telegraphy and follows the same lines. I do not think that either of these patents throws any light on the difficulties incident to utilising the principle of resonance in a system of telegraphy based on the creation and detection of ether waves.

The next patent to which I must refer is Marconi's patent No. 12326 of 1898. The invention disclosed includes an improved receiver in which the aerial is connected to earth through the primary of a transformer, the secondary circuit of which contains the coherer, his object being to step up the voltage so as to ensure that the coherer will more readily be affected. He goes with great detail into the construction of the transformers appropriate for his purpose. They are all of them air core transformers such as had been used by Tesla for the purpose of stepping-up the voltage of alternating currents of exceedingly high frequency. Marconi subsequently obtained two further patents, No. 6982 of 1899, and No. 25186 of 1899, relating to this form of receiver. I have now mentioned all that I consider necessary to the interpretation of Marconi's patent of 1900, which is the patent in question in this action. It is true that this patent was preceded by Braun's patent No. 1862 of 1899, which is relied on as an anticipation, and with which I shall have to deal presently. But there is no evidence that Braun's patent was put into practice or became generally known before the date of Marconi's patent of 1900, and I cannot, therefore, treat the former as relevant to the true interpretation of the latter.

I will proceed, therefore, to consider Marconi's patent of 1900. Marconi commences his specification with the statement that the object of his invention is not only to increase the efficiency of the apparatus theretofore employed, but to secure selectivity. To any electrical engineer conversant with the problems of wireless telegraphy this statement would, I think, at once suggest Lodge's patent of 1897, and the difficulties it was intended to meet, namely, the difficulty of obtaining such a train of waves as was necessary for selec- [fol. 2176] tivity, and the difficulty of increasing the available store of energy in the transmitter. The specification then refers to the transmitter described in Marconi's 1896 patent,

with its vertical wire connected to earth through the spark gap, and proceeds as follows: "According to the present invention, the vertical wire is connected to earth through the secondary winding of a transformer of a kind suitable for the transformation of very rapidly alternating electric currents, and the primary of this transformer is connected to the spheres or terminals of the sparking appliance. A condenser of suitable capacity is introduced in series with the primary." The effect of this arrangement is reasonably clear. He gets two circuits, the circuit of the primary containing a condenser, which could be of any desired capacity, with the usual provision for its discharge through the spark gap, and the circuit of the secondary, containing the vertical wire. This device, he says, enables much more energy to be imparted to the radiator than heretofore, the approximately closed circuit of the primary being a good conserver, and the open circuit of the secondary being a good radiator of wave energy. Here, at any rate, he obviously refers to the difficulty explained by Lodge, and proposes to meet it without any sacrifice such as Lodge's patent involved. Lodge has said with truth: You cannot have your circuit doing two incompatible things, however desirable, at the same time. Marconi says, in effect: Take two circuits and let one do one of the things and the other do the other. The electrical engineer reading the specification would thus be led not only to expect a long train of ether waves created through the medium of an open radiating circuit by persistent oscillations occurring in a closed conserving circuit, but an actual increase in the total available energy of the radiating circuit, this increase depending on the conserving qualities of the closed circuit. In other words, the latter would be a reservoir of energy for the former. The inventor then proceeds to describe how this result is brought about. The arrangement, he says, works as follows: On pressing the key and actuating the induction coil in order to produce a signal, the condenser in circuit with the transformer (he means, of course, the primary of the transformer) is charged and subsequently discharges through the spark gap. If the capacity, the inductance, and the resistance of the circuit are of suitable values, that is, if the conditions worked out by Kelvin are fulfilled, the discharge [fol. 2177] is oscillatory, with the result that alternating currents of high frequency pass through the primary of the transformer and induce similar oscillations in the sec-

ondary, these oscillations being communicated to the elevated conductor (that is, to the radiating aerial), the circuit of which should be suitably attuned for the purpose. There is no doubt that this means tuned to the primary circuit. The object of this tuning is nowhere expressly stated, but I think the only reasonable inference is that the object was to get the full effect of the principle of sympathetic resonance as between the primary and the secondary circuits; in other words, that the long train of oscillations of equal amplitude which would take place in the primary because it was a good conserver of energy might, on the principle of resonance, gradually build up, and thereafter maintain, a like train of oscillations in the secondary.

In maintaining this train of oscillations in the secondary the primary would thus be playing much the same part as the mechanism which in a clock supplies at the appropriate time the energy lost by the pendulum in its swing. In this way more energy would be imparted to the radiator first because the energy of the primary circuit could be increased by choosing a condenser of suitable capacity, and secondly, because the primary circuit, being a good conserver of energy, could act as a reservoir, on which the radiating circuit could draw as required. The inventor next states that the effect of the oscillations in the elevated conductor or aerial is to inductively affect similar distant conductors or aerials i. the self-induction and capacity of the latter are of suitable value or values. This appears to me to point to the cumulative effect of a train of ether waves created by the transmitting aerial upon the receiving aerial if the latter be tuned to the former. Then, after stating at the receiving end a receiver is employed such as is described in the Marconi patents of 1898 and 1899, to which I have already referred, that is a receiver in which the vertical wire is connected to earth through the primary of a transformer, the secondary of which contains the coherer, the inventor proceeds as follows: "The four circuits, namely, those including the primary and secondary of the transformer in the transmitter and the primary and secondary of the transformer in the receiver, should be so adjusted as to make the electric time period the same in each, that is the product of the self-induction multiplied by the capacity, the [fol. 2178] same in each. But in lieu of the time periods being the same in each they may be harmonics of each other." In other words, all four circuits are to be tuned together.

He does not expressly state the object of tuning between the circuits in the transmitter and the circuits in the receiver, but this would be sufficiently clear to anyone acquainted with the progress of wireless telegraphy, more especially as he does state how selectivity is thereby secured. Nor again does he expressly state why the two circuits of the receiver are to be tuned together, but this again is I think sufficiently indicated by what he has said of the circuits in the transmitter. The primary circuit of the receiver is a good absorber but a bad conserver of energy, and, therefore, not adapted to store up the cumulative effect of a long train of waves. He means this accumulation to take place in the secondary circuit of the receiver to make sure that the coherer shall be broken down and the signal get through. He is not now proposing to use a transformer for the purpose of raising the voltage of a current to act on the coherer, but for the purpose of getting a circuit which will accumulate the effect of a train of waves without the absorbing qualities of his aerial being affected. The rest of the specification is taken up with a detailed description with reference to drawings of the apparatus he proposes to use and minute directions as to how such apparatus is to be varied so as to be attuned to nine distinct time periods, or, as he calls them, tunes. The claims are reasonably clear. The first is for a transmitter for electric wave telegraphy, consisting of a spark producer having its terminals connected through a condenser with one circuit of a transformer, the other circuit being connected to a conductor and to earth or a capacity, the time period of electrical oscillations in the two circuits being the same or harmonics of each other. I think the words "or a capacity" are only introduced lest someone using the invention should say there was no infringement because there was no earth connection. The second claim is for a system of electric wave telegraphy in which both the transmitter and the receiver contain a transformer the time period of electrical oscillations in the four circuits of the two transformers being the same or harmonics of each other. The third claim is for a system of electrical wave telegraphy in which both the transmitter and the receiver contain a transformer one circuit of which is a persistent oscillator and the other a good radiator or absorber of electrical oscil- [fol. 2179] lations, all four circuits having the same time period or being harmonics of each other, substantially as described. This claim corroborates what I have said as to

the use of the two circuits in the receiver being tuned together. The fourth claim is for apparatus for wireless telegraphy substantially as described and illustrated in the drawings.

The interpretation I have put on the patent in question appears to me after careful consideration the true and indeed the only possible interpretation, but before leaving the subject I ought to deal with a matter on which considerable stress was laid at the trial. All the scientific witnesses agreed that the cumulative effect of the oscillations in one circuit upon another circuit tuned to it depends upon how the two circuits are coupled together. To get the full cumulative effect the circuits must be what is called loosely coupled, for the cumulative effect of the primary on the tuned secondary diminishes as the coupling is tightened. The specification contains no express direction as to whether the circuits are to be loosely or tightly coupled, but once more all the scientific witnesses were at one in thinking that in 1900 to an electrical engineer a direction to get a cumulative effect in one circuit by means of the oscillations in another tuned to it would be in effect a direction to couple the circuits loosely, though the defendants' witnesses doubted whether they would have read the specification as giving this direction to get a cumulative effect.

In my opinion this direction is impliedly if not expressly given in the specification. The inventor wants selectivity which it was known required a train of waves of approximately equal amplitude. No tight coupling would secure this train of waves. The inventor wants his primary to act as a reservoir of energy for his tuned secondary and loose coupling would be necessary if the energy in the reservoir were to be used economically and to the best advantage. Further, an examination of the detailed apparatus described in the specification as appropriate for each of the nine specified tunes shows that in every case, except one, the coupling between the circuits is very loose, while in the excepted case it is sufficiently loose to allow of some considerable cumulative effect, and the plaintiffs' witnesses proved that this effect was sufficient for practical purposes. The question of coupling was further proved to be important in the following respect. By reason of some reaction of the secondary on the primary circuit, there must always be a tendency to the production of oscillations of two distinct time periods, [fol. 2180] and consequently of ether waves of two distinct

lengths. This tendency diminishes as the looseness of the coupling between the circuits increases. If the coupling is very loose, it may be ignored for practical purposes, and the ether waves may be treated as a single series of waves of equal length, but if the tightness of the coupling be increased, we have two series of ether waves of two distinct wave lengths. In one of the tunes dealt with in the specification, the tightness of the coupling is 30 per cent. (absolute tightness being represented by 100) and with this degree of tightness there are admittedly two series of ether waves of two distinct wave lengths. It appears, however, that this so far from being a disadvantage, may at times be convenient, for a distant receiver will respond if tuned to either wave length. It must be remembered that there is no plea of insufficiency, and all this matter of tight or loose coupling is relevant only on the question of interpretation. The suggestion is that I ought not to interpret the patent in a manner which would give rise to doubts as to its insufficiency, and that, if I interpret it as including tight as well as loose coupling, such an interpretation would assist the defendants in establishing their pleas of invalidity based on want of utility, anticipation by Braun's 1899 patent, and want of subject matter. Having come to the conclusion that the specification in effect contains a direction to couple the circuits loosely, so that the effect of the primary on the secondary may be cumulative, I need not further pursue the matter.

As I interpret the patent, the essential features of the invention thereby disclosed are as follows: In order to get over a well-known difficulty in applying the principle of resonance as between transmitter and receiver in a system of wireless telegraphy, a difficulty involved in the impossibility of a single circuit being at once a good radiator, or absorber and a persistent oscillator, the inventor proposes to substitute for a single circuit in both transmitter and receiver a pair of circuits, one of which is so constructed as to radiate or absorb readily and the other of which is so constructed as to oscillate persistently and be a good conserver of energy. The two circuits of the transmitter are tuned together, and linked by means of a transformer in such a way that electrical oscillations in the closed and persistently oscillating circuit build up, and, inasmuch as the primary can act as a reservoir of energy for the secondary, maintain similar oscillations in the

[fol. 2181] open and readily vibrating secondary. Similarly, the two circuits of the receiver, tuned to the same time period as the circuits of the transmitter, are linked through a transformer in such a way that electrical oscillations in the readily absorbing primary build up similar oscillations in a closed and conserving secondary until such oscillations have strength to break down the coherer.

It is not disputed that if this be the invention it does get over to a very great extent if not entirely, the difficulty it was designed to meet. The open and readily radiating circuit of the transmitter produces a long train of ether waves of approximately equal amplitude without any sacrifice of its radiating qualities, and with an increased available energy, the energy given off by each oscillation being replaced by energy drawn from the closed and persistently oscillating primary circuit. The open and readily absorbing circuit of the receiver itself, unable to accumulate the effect of a long train of waves without a sacrifice of its absorbing qualities, hands over the task to a closed and conserving secondary circuit, which accumulates such effect until the coherer breaks down and the message gets through. Further, if this be the invention its utility is undoubted, for it at once doubled the distance to which effective messages could be sent by means of ether waves and effectively secured selectivity in all cases in which the receiving stations were not so near as to be disturbed by single waves or the first three or four waves of a series. Having ascertained the essential features of Marconi's invention, I propose next to consider whether it was anticipated by Braun's patent No. 1862 of 1899. Braun's patent involves many difficulties. The inventor commences his complete specification by classifying electrical vibrations into three groups: 1, those with the low frequency of ordinary alternating currents mechanically produced; 2, those with the much higher frequency of oscillations produced by the discharge of Leyden jars with or without induction coils in circuit, which I take to mean with or without the introduction into the circuit of inductances for the purpose of lowering the frequency and increasing the resulting wave length; 3, those of the enormous frequency produced by Hertz, not by means of Leyden jars and special induction coils, but by ordinary conductors, the capacity and induction of which is relatively small. He proceeds to state that for wireless telegraphy inventors have hitherto confined their attention

[fol. 2182] to the third group which he calls Hertzian waves, their one object being to increase the frequency. He then mentions a certain practical inconvenience involved in using waves of very high frequency, and says that his invention is intended to obviate this inconvenience and that he does this by making use of electrical oscillations belonging to the second group and having only a small frequency compared with the frequencies hitherto adopted. It is reasonably clear on the evidence that Braun was imperfectly acquainted with what was being done by Marconi. The latter was already using and Lodge had proposed to use electrical oscillations which would belong to the second of Braun's groups. Braun proceeds as follows: "Another, and perhaps even more important advantage in using slower vibrations is that their potential and amplitude, and thereby the energy transmitted is more easily increased. When the Hertzian waves are used there is a certain length of spark which must not be exceeded if the circuit is required to excite vibrations, otherwise the vibrations would be damped too much, the constraint of the system giving way gradually instead of suddenly, but this means that the effective potential is limited, which if slower oscillations are used either does not occur or can be very easily avoided." There was a great deal of controversy at the trial as to what this passage means, and whether it is sense or nonsense, and I do not think that any complete agreement was arrived at. It is fairly clear that Braun is proposing to increase the energy transmitted to the ether by his radiating circuit and considers that this result may be attained by increasing the potential and amplitude of the electrical oscillations in such circuits, and he further considers he can more easily increase such potential and amplitude if he uses slower oscillations. He points out what I conceive to be the fact that if Hertz waves be used the potential or voltage cannot exceed the voltage which is sufficient to break down the spark gap. He further points out that if in order to get a higher voltage you begin to increase the length of the spark gap, you are soon pulled up by Kelvin's law as to the maximum resistance allowable if there are to be electrical oscillations at all, for to increase the length of the spark gap is to increase the resistance in the circuit. This also, I conceive to be true. Unfortunately, what he says of Hertz waves is equally true whatever the

wave frequency. In no case can you increase the length of the spark gap indefinitely without being pulled up by [fol. 2183] Kelvin's law. He may mean that you can get a greater allowable resistance if you use longer waves, that is, if you increase the product of the capacity multiplied by the inductance, but if the maximum allowable resistance is the square root if four times the inductance divided by the capacity, this must depend upon whether you increase such product by increasing the inductance or increasing the capacity, that is not on increasing the wave length, but on the means adopted for securing such increase. Further, it is not clear on the evidence whether you could by increasing the wave length in any way obtain a higher potential in the oscillations resulting from the discharge of the condenser, the maximum potential is limited not only by the length of the spark gap but also by the tendency of the circuit to a brush discharge, and in other ways, and this renders the problem one of considerable complexity. Braun next proceeds to say that he has found that the oscillations produced by the discharge of Leyden jars of usual size in a circuit having moderate self-induction are very convenient for the purpose of transmitting signals and that the experiments also show that with an equal expenditure of energy in the transmitting circuit it is preferable to use the slower vibrations. Here again it is by no means clear to what he is referring, unless it be to the practical inconvenience already mentioned as incident to the use of Hertzian waves. Braun then says that the Leyden jar or whatever other apparatus is used for the production of the electric impulses is connected with the spark gap of a Ruhmkorff apparatus or a Wimshurst influence machine and provided with the well-known vertical sending wire preferably of considerable length and that in the receiving station the ordinary arrangement may also be used for the vertical receiving wire, the coherer, local battery and signalling device, such as Morse or the like. Obviously, in this passage he is referring to things which he conceives to be in common use and to form no part of his own invention. To what he is referring is, however, again a difficult question. An electrical engineer might, no doubt, at first sight consider the reference to be to Marconi's vertical aerial, which, at the date of the patent, was, in fact, of considerable length, but then an electrical engineer conversant with the art would or might on second thoughts be

led to doubt this, for he would be well aware that Marconi was already using frequencies of the class which Braun claimed to be using for the first time, and would, [fol. 2184] therefore, conclude that Braun was unacquainted with Marconi's aerial, and meant merely a vertical wire of very small inductance and very small capacity, such as, if used by itself, would involve great frequency of vibration. Further, if, notwithstanding this, he took the reference to be to Marconi's usual apparatus both in the transmitting and receiving stations he might not improbably conclude that Braun did not intend to tune, for he is apparently decreasing the frequency of the transmitting circuit without providing for any corresponding decrease in the frequency of the receiving circuit. Braun proceeds to say that in order that his invention may be clearly understood he has shown in the accompanying drawings, by way of example, some arrangements of circuits for transmitting signals by means of the electric oscillations above described, that is by means of oscillations of his second group, but he adds that his invention is not limited to the precise arrangements shown, for these can be varied very considerably and electrical oscillations of a low frequency suitable for transmitting signals according to his invention can be produced in various other ways. This obviously means that the essential feature of his invention is the use of frequencies of his second group however produced and not in any particular means of producing them. Accordingly his first claim is for the improvement in the transmission of electrical signals without connecting wires which consists in using electrical vibrations of comparatively low frequency such as are produced by the discharge of Leyden jars with or without induction coils in circuit substantially as described. He has a second claim to a combination of apparatus substantially as described.

I have now examined the letterpress of Braun's specification without any particular reference to his drawings and I think it clear that such letterpress does not contain even the remotest suggestion of the problem which Marconi's patent of 1900 was intended to solve much less any suggestion bearing on its solution. If, therefore, the latter patent has been anticipated by anything in Braun's specification it must be by something disclosed in Braun's drawings. All these drawings are diagrammatic, no working details whatever being given, and if anything approaching Marconi's

1900 invention is to be got out of them it can only be by supplying the working details in such a way as will secure the object Marconi had in view. The Drawing No. 1 shows [fol. 2185] the vertical wire or aerial connected with the inner coating of a Leyden jar, the inner and outer coatings of which are connected to the two small balls of a spark gap, the circuit also containing a small induction coil. Drawing No. 3 shows the same arrangement, a pair of Leyden jars in series being substituted for a single Leyden jar. The Drawings No. 2 and No. 4 correspond to the Drawings No. 1 and No. 3 respectively, with this exception that in them the induction coil is shown as the primary coil of a transformer, one of the terminals of the secondary being connected to the vertical wire or aerial and the other in Drawing No. 2 to the outer coating of the jar, and in Drawing No. 4 to some capacity, possibly the earth. It appears from the letterpress that the object of this transformer is to step up the voltage. This cannot, I think, be taken as showing the manner in which the inventor conceived that the potential of his circuit might be more easily increased by using oscillations of less frequency, for it is a method equally applicable to oscillations of any frequency. Its effect, however, in achieving the object in view would depend largely on the conditions of the two circuits as to tight or loose coupling as also on their relative capacities, the maximum possible voltage in the secondary increasing as its capacity decreases. As appears from the body of the specification Braun evidently conceived the well-known vertical wire to which he referred to be of very small capacity compared with the Leyden jar he proposed to introduce into his transmitter, and also that the circuit of this Leyden jar would be the circuit which determined both the energy transmitted to the ether and the length of the ether waves. He says nothing as to the time period of the secondary circuit though possibly he thinks he can increase the potential of the oscillations in it by means of a transformer, probably just because it had relatively small capacity. He must, therefore, I think, have contemplated that the time period of the primary would be forced on the secondary, whatever its natural time period, which could only be effectively done by the tightest possible coupling. This conclusion is corroborated by the Drawings No. 1 and No. 3 in which, strictly speaking, there is one circuit only. Even if, as is possible from one

point of view, these drawings be looked upon as containing two circuits, those circuits are as tightly coupled as may be, though here again the degree of tight or loose coupling would depend on working details which, as well as any suggestion of tuning the two circuits, are altogether absent. [fol. 2186] My conclusion is that though any one with a knowledge of Marconi's 1900 invention could easily adapt Drawings No. 2 and No. 4 to obtain his result by supplying appropriate working details, including tuning appliances, and otherwise, the drawings themselves do not, any more than the letterpress, contain any suggestion either of the problem — of the working details appropriate to its solution. It follows that Braun's specification does not in any way anticipate Marconi's 1900 patent unless indeed it can be shown that an electrical engineer, acting in the light of what was generally known at the date of Braun's patent, must have necessarily arrived at Marconi's result. I cannot think this to have been the case. In my opinion any competent engineer would most probably have put Braun's specification altogether aside as being founded on a mistake as to the frequencies then in use and otherwise containing so many points of difficulty. He would have said Marconi is already doing what this man claims and it is useless pursuing the matter further. Even if he had been struck with and desired to test the apparatus diagrammatically shown in the drawings, there would be no reason why he should work on Drawings No. 2 and No. 4 rather than on those numbered 1 and 3, unless his object was to get high voltage in the vertical wire. If he desired higher voltage he would I think have coupled his circuits as tightly as possible and rushed his current through. Even if he had thought of tuning he would have thought of it only in connection with securing a high voltage and not in connection with securing a cumulative action by the primary on the secondary so as to get a long train of waves. That I am right in this conclusion will be further evident when I consider, as I must now proceed to do, the objection to Marconi's patent founded on want of subject matter. In considering the plea of want of subject matter it is important to notice that in the receiver the mere introduction of two circuits instead of one was no novelty. In Fig. 14 of Lodge's 1897 Patent he shows the open circuit of his receiving aerial linked through a transformer with a closed

circuit containing the coherer, his idea being as he states to leave his receiving aerial freer to vibrate electrically without disturbance from attached wires. The secondary circuit as shown is not tuned to, nor can it be tuned to, the circuit of the aerial. This, in my opinion, is exceedingly strong evidence that Marconi's 1900 invention was not so obvious as to deprive it of subject matter. Here [fol. 2187] was Lodge, an electrical engineer of first-rate ability, actually devising means to get over the difficulty he had himself explained in his lecture, the difficulty that a good radiating or absorbing circuit is a bad oscillating circuit and a bad conserver of energy. To get over this difficulty, he is making a compromise at both ends by partially sacrificing the radiating or absorbing qualities of his aerial. He introduces two circuits at the receiving end, and yet he does not see that if only he utilised the principle of resonance, as between those two circuits the problem would be solved, at any rate at the receiving end, and really the problem at the transmitting end is the same problem from the reverse point of view. The common knowledge of the art was so far as material for the present purpose, the same when Lodge prepared his 1897 specification as when Marconi prepared his 1900 specification. How then can I treat as obvious at the latter date what so able a man as Lodge entirely failed to see at the former date, how far Lodge was from grasping the advantage of having two circuits is also apparent from his Fig. 4. In this he has, in a way, two circuits in his transmitter, but his object is not to use one as a reservoir for the other, but, on the contrary, when once he has charged his radiating circuit to separate it entirely from its source of supply. Again, in his 1898 patent Marconi introduces in his receiver a pair of circuits linked through a transformer, his object being to raise the voltage in the secondary and thus give the coherer in circuit with the secondary a better chance of breaking down. He does not, any more than Lodge, tune the two circuits together as he might have been expected to do if tuning them were really so obvious a matter. In the two patents of Lodge and Silvanus Thompson relating to induction telegraphy the transmitter and receiver are tuned and it is of course true that transmitter and receiver in such a system may be looked on as the primary and secondary of an exceedingly loosely coupled transformer, but induction telegraphy in-

volves no such difficulty in the application of the principle of resonance as is involved in telegraphy by ether waves, and the tuning in these cases bears really no analogy to the tuning of a pair of circuits in Marconi's system. Then again the defendants referred to Tesla's Patents of 1891 and 1896 as containing information from which anyone in 1900 would have known that two transformer circuits ought to be tuned together. In his first patent, Fig. 1, Tesla shows a transformer by which he proposed to raise the [fol. 2188] voltage of the oscillations produced by the sudden discharge of a condenser for the purpose of lighting lamps. His circuits, therefore, are coupled as tightly as may be, no tuning being suggested, if indeed tuning be possible at all. In Tesla's second patent he make a great point of tuning his circuits, but while on the one hand he directs the tuning of some circuits which cannot possibly be tuned together he fails on the other hand to give any direction at all for the tuning together of his discharge and working circuits, the only pair of circuits a direction to tune which might have been relevant. This is rather curious, because in a lecture delivered by him in 1893 he showed a transformer the secondary of which contained an adjustable condenser for the purpose of tuning it to the primary. In this lecture he had discussed the theory of resonance generally, but expressed doubts as to its utility if applied to any system of telegraphy without the aid of wires, and I should infer that in 1896 he doubted its utility as applied to any of the purposes within the scope of that patent.

There was some evidence that the manufacturers of Tesla transformers before they sell them adjust the primary to the secondary in such a way that if the terminals of the secondary are connected by short wires with the balls of an adjustable spark gap they get the longest possible spark. This is said to be tuning but if it is the tuning is destroyed by the terminals being connected to any other circuit when the apparatus is in use. There was some evidence too that when Tesla transformers are used in the laboratory the operator adjusts the secondary to the primary by varying the number of turns in one or both till he gets the best result. This also is said to be tuning, but Mr. Swinburne, who has great experience in such matters, says that until he came into court he never heard of any such practice.

I can hardly hold, therefore, that it was common knowledge that where a transformer was used the circuit of the primary and secondary should be tuned together. Finally it is said and truly said that Oudin used high frequency transformers in which the primary and secondary circuits were tuned. I think the whole of the evidence in this respect may be summed up as follows. High frequency transformers had been used for the purpose of stepping up voltage and for this purpose only. For stepping up voltage the transformer coils should be coupled as tightly as possible, that is so arranged that all or as many as possible of the lines of force in the magnetic field of the primary [fol. 2189] should cut the secondary coil. But however tightly the transformer coil may be coupled, the tightness of the coupling of the circuits of which they form part will depend on the relative values of the mutual and self-induction existing in the system, and the conditions may therefore be such that a really tight coupling becomes impossible. It was found that in such a case the effect of the transformer in stepping up the voltage was diminished unless the two circuits were adjusted, and this adjustment was in reality a rough tuning of one circuit to the other. The object was in every case to overcome the disadvantage of the coupling being loosened by the prevailing conditions of the circuits, and to get the maximum effect in raising the voltage in the secondary. This is the most that can be said, and I am not clear that even this was a matter of general knowledge. The application of tuning to cure the necessary evils of loose coupling is very different from deliberately coupling two circuits loosely and tuning them together in order that one may be a reservoir for and have an accumulative effect on the other and thus create such a long train of waves as was necessary for securing the full benefit of resonance between the receiver and transmitter in a system of wireless telegraphy. Marconi does not use his transformer to secure higher voltage or for any purpose for which a transformer so far as the evidence goes had ever been used before. In the literature quoted there is no trace of the idea underlying his invention nor, so far as I can see, a single suggestion from which a competent engineer could arrive at this idea. I hold, therefore, that the plea of want of subject matter entirely fails.

The only other plea of invalidity is based on a suggested prior grant contained in Braun's second patent of 1899, the

complete specification of which was not accepted or published till after the date of Marconi's 1900 patent, and which, therefore, could not be relied upon as an anticipation. This plea of prior grant was not, I think, really pressed. Braun's second patent in effect claims the arrangement shown in Figs. 2 and 4 of his earlier specification, except that the aerial is earthed in each case. He may have applied for this subsequent patent because the provisional of his earlier patent did not in any way foreshadow Figs. 2 and 4, or because he had found Figs. 2 and 4 more satisfactory with an earthed aerial. He says nothing of tuning, and his specification contains a passage which in my opinion is inconsistent with the two circuits being intended to be tuned together. I cannot see how it can be said that [fol. 2190] this patent contains a grant of the invention described in Marconi's 1900 patent.

Having come to the conclusion that Marconi's 1900 patent is a good and valid patent, I must now proceed to consider the question of infringement. The defendants propose to make use of a system of wireless telegraphy called the Balsillie system and fully described in a pamphlet entitled the Balsillie System of Radio Telegraphy which was put in at the trial. It is admitted that they have offered for sale apparatus made in substantial accordance with this pamphlet and have actually sold and installed such apparatus on board a ship called the "Nonsuch." Further, it is reasonably clear on the evidence that the apparatus described in the pamphlet and actually installed on the "Nonsuch" has the following characteristics. The transmitter contains two circuits one a closed circuit which is a good conserver of energy and a persistent oscillator, and the other an open circuit which is a good radiator. These circuits are intended to be tuned together and contain adjustable devices by which the capacity or inductance, or both, may be varied for that purpose. They are also linked together in such a way that the oscillations in the closed circuit will gradually build up and maintain like oscillations in the open circuit, so that the latter produces a long train of ether waves of approximately equal amplitude and not one big wave followed by three or four of rapidly diminished amplitude. Similarly the receiver has two circuits, one an open circuit which is a good absorber and the other a closed circuit which is a good conserver of energy. These circuits also are intended to be

tuned together and also to the time period of the circuits in the transmitter and have tuning devices for that purpose. They are also so linked that the oscillations induced in the open circuit by a train of waves may have a cumulative effect on the closed circuit gradually building up oscillations of sufficient amplitude to be readily detected. It appears, therefore, that the defendants' apparatus contains all the essential features of the invention protected by Marconi's 1900 patent. How then can it be said that there is no infringement?

The defendants' contention that there is no infringement is based on the following considerations: In the apparatus described by Marconi, the two circuits of both the transmitter and the receiver are linked through what he calls a transformer, and it is clear at any rate in the body of the specification that he is contemplating an instrument with two [fol. 2191] separate coils. The defendants say that the word "transformer" is in ordinary parlance confined to a two coil instrument, and that Marconi's claims (at any rate, when read with the body of the specification) are limited to a transformer in its ordinary sense with two separate coils. They say that they have not themselves used any such instrument and do not intend to use any such instrument in their transmitter. If they intend to use any such instrument in their receiver, which they have not yet done, Marconi, they say, cannot complain, for he has not claimed his receiver separately, but only in conjunction with his transmitter. The instrument they have used and so far at any rate as their transmitter is concerned intend to use is not a two coil instrument but a single coil instrument. It is not in ordinary parlance a transformer at all, but what is known as an auto-transformer; it does not, they say, act as the transformer acts entirely by mutual induction, but partly by mutual induction and partly by what is called inductive shunt, and they can, they say, perfectly easily eliminate the mutual induction altogether and make their instrument act entirely by inductive shunt. Further they say that their auto-transformer is a new discovery so that the doctrine of equivalents has no application.

On these grounds they contend that they have not infringed and will not infringe Marconi's patent by any use of the Balsillie system described in the pamphlet. There was at the trial a considerable amount of evidence directed to this question of infringement, and on such evidence I

have come to the following conclusions. The name transformer was originally given to instruments used for stepping up or stepping down the voltage of an electric current and had direct reference to the effect produced. Thus, the instrument by which a current of 30 amperes and 100 volts was transformed or converted into a current of 10 amperes and 300 volts, or *vice versa* was appropriately called a transformer. The instrument originally and most generally used to step up or step down voltage had two distinct and separate coils. The amount by which the voltage was stepped up or stepped down depended on the number of turns in the secondary compared with the number of turns in the primary coil. If the number of turns in each was precisely the same, and the coils were tightly coupled in the sense that all the lines of force in the magnetic field of the primary cut the secondary, then theoretically the voltage in [fol. 2192] the secondary would be the same as in the primary and there would be no transforming effect in its original sense at all. An instrument so arranged might, however, serve other useful purposes as for example where it was desired to avoid in a working circuit any metallic connection with the source of supply though it was not desired to step up or step down the voltage and an instrument so arranged became known as a "1 to 1" transformer, that is, a transformer which strictly speaking had no transforming effect but had other uses. As soon as the word "transformer" came to be used as including an instrument which had no transforming effect on the current, the word not unnaturally began to connote not any change in the voltage but a transformation of electrical energy in one circuit into magnetic energy in the field and back again into electrical energy in another circuit, in other words, that the current in the secondary was an induced current. Meanwhile, it had been discovered that for the purpose of stepping up or stepping down voltage an instrument need not have two separate coils. The same effect could be obtained if the instrument had a single coil, part of which was common to both circuits and the whole or part of which was in one circuit only; the extent to which the current was stepped up or down still depending on the number of turns in the secondary as compared with the number of turns in the primary. This instrument was originally sold simply as a transformer, but it became generally known as an auto-transformer to distinguish it from a transformer which still generally de-

noted an instrument with two separate coils. It should be noticed that in an auto-transformer if the whole coil is common to both circuits there is no step up or step down in voltage and, therefore, no transforming effect in the proper sense of the word. It is a 1 to 1 auto-transformer. Further, if the whole coil is common to both circuits the element of mutual induction is eliminated and the instrument operates entirely by inductive shunt. It was suggested during the trial that inductive shunt does not involve the conversion of electrical into magnetic energy and its re-conversion into electrical energy in the secondary circuit, so that on the footing that the word "transformer" connotes such conversion and reconversion a 1 to 1 auto-transformer is not a transformer in any sense of the word. This suggestion could not however be sustained. In considering the action of the inductive shunt in an auto-transformer, at any rate when employed in such a system as the defendants', it is [fol. 2193] necessary to concentrate one's attention successively on the conditions prevailing at different moments during the time period (itself exceedingly minute) during which an oscillation takes place. These conditions are continually varying for the oscillations in the secondary are necessarily out of step with the oscillations in the primary. I think that all the expert witnesses finally agreed that though at some moments electrical energy might be passing from the primary to the secondary circuit without any conversion into or re-conversion from magnetic energy yet at other times the electrical energy in the secondary consists to a great extent if not entirely of energy, derived originally it is true from the primary but which has undergone such conversion and re-conversion; in other words, there are times in which the electrical energy in the secondary is the result of induction pure and simple. There would appear, however, to be this difference, between a 1 to 1 transformer with two coils and a 1 to 1 auto-transformer, namely, that the whole coil being in both circuits the element of mutual inductive effect between the parts of the coil in one circuit and the parts of the coil in the other circuit may be said to be eliminated, but this is a question of words rather than of substance if as seems to be the case the 1 to 1 auto-transformer operates mainly by induction. Long before 1900 the theory of auto-transformers had been worked out and it had been proved and was known that whatever the mode in which they acted they could be arranged to produce

the same effect in the secondary as an ordinary transformer with two coils and they were extensively used for transforming purposes instead of ordinary transformers whenever there was no particular reason to avoid metallic connection between the secondary circuit and the source of supply. A 1 to 1 auto-transformer was not however used, there being no obvious purposes for which it might be useful. Its properties, however, were I think equally well known. Before Tesla's experiments with currents of high frequency and great potential the transformers and auto-transformers in general use were provided with iron cores, such cores affording an easy path for the lines of force in the magnetic field. Tesla found that for stepping up high frequency currents the iron core was a disadvantage and his transformers were air core transformers. Marconi made use of air core transformers in his patents of 1898 and 1899 and no doubt refers to them in his 1900 patent when he speaks of 'transformers suitable for the transformation of very rapid al- [fol. 2194] ternating electric currents. It does not appear that air core auto-transformers had ever been used prior to this patent except by Oudin whose papers will be found in the green book containing the papers relied on by the defendants in their objections. I cannot conceive, however, that an electrical engineer in, say, 1899 would have any doubt that what could be done by an air core two coil transformer could also be done by an air core auto-transformer. Of course in applying any electrical instrument for the first time to produce a desired effect an engineer may possibly meet with some unforeseen difficulty, but I am satisfied that if at the date of Marconi's 1900 patent a competent electrical engineer conversant with wireless telegraphy had had Marconi's invention explained to him and had been asked whether you could substitute for Marconi's two coil transformers auto-transformers whether arranged one to one or otherwise, he would unhesitatingly have answered in the affirmative, and if this be so the use of the air core auto transformer even if arranged one to one in Marconi's system could never have afforded subject matter for a new patent or be called a new discovery.

Under the circumstances to which I have referred it is not unnatural that the plaintiff should be able to quote numerous cases in which the word "transformer" has been used to include auto-transformer or in which an auto-transformer has been called a transformer, and that on the other

hand the defendants should be able to quote numerous instances in which an instrument is called an auto-transformer to distinguish it from an ordinary transformer with two coils. When the word "transformer" is used, its meaning must depend largely on the context. My general impression is that anyone who ordered a transformer from a manufacturer of electrical instruments would expect to get and would be supplied with a two coil instrument. On the other hand, a contract for electrical works in which transformers *simpliciter* are specified for purposes not requiring the absence of metallic connection between the secondary and the source of the supply would, I think, be complied with by providing auto-transformers. There can, I think, be no doubt that anyone reading first the body of Marconi's Specification and then his claims, would conclude that the instrument he refers to in the claims as a transformer was an instrument with two coils, though the words of the claims taken alone might include auto-transformers. If therefore the use of an instrument with two coils were [fol. 2195] an essential feature of the invention the action would fail. In my opinion, however, the use of a two coil instrument is not an essential feature of Marconi's invention at all. The essential features of his invention I have already stated and will not repeat. The merit of the invention lies in the idea rather than in the particular means by which he carries it out. Given the problem consisting in the difficulty of a single circuit doing two inconsistent things at the same time, given the idea of solving this problem by a division of labour between two circuits tuned together and linked so that the cumulative effect of resonance might come into play between them, it would not I think have been very difficult for any competent engineer to work out the details. Clearly some form of inductive linkage (to use Mr. Dugald Clerk's expression) would be necessary and Marconi took, and I think most engineers would have taken, the most obvious means of securing this linkage, namely, a two coil transformer. It is, however, a matter of indifference so far as the essence of this invention is concerned whether a transformer or an auto-transformer be used. Looking at the first claim of the specification it is a claim for a transmitter involving a combination of parts, and among others two tuned circuits and a transformer, the latter supplying the necessary linkage. In the second and third claim the transformer has the same function. The

fourth claim is for apparatus substantially as described in the specification and illustrated in the drawings. Turning to the defendants' apparatus it seems to me that it contains everything of real value in every single claiming clause, the only difference being that the necessary inductive linkage is supplied through an auto-transformer and not through a two coil transformer, and this in no way affects the result. It is a well-known rule of patent law that no one who borrows the substance of a patented invention can escape the consequences of infringement by making immaterial variations. From this point of view the question is whether the infringing apparatus is substantially the same as the apparatus said to have been infringed. In the present case I cannot doubt that a jury would say that the defendants' apparatus was substantially the same as that shown in Marconi's 1900 patent. Again, where the patent is for a combination of parts or a process, and the combination or process, besides being itself new, produces new and useful results; everyone who produces the same results [fol. 2196] by using the essential parts of the combination or process is an infringer even though he has in fact altered the combination or process by omitting some unessential part or step and substituting another part or step which is in fact equivalent to the part or step he has omitted. The question here again is one of the essential features of the invention said to have been infringed. If that part of the combination or that step in the process for which an equivalent has been substituted be the essential feature or one of the essential features, there is no room for this doctrine of equivalents, and to ascertain the essential features of an invention, the specification must be read and interpreted by the light of what was generally known at the date of the patent. A good instance of the application of the doctrine will be found in the case of *Benno Jaffe and Darmstaedter Lanolin Fabrik* v. *John Richardson & Co.* in the 11th Patent Office Reports, pages 93 and 261, where the use of a centrifugal machine in the process was both specified and claimed but the process was a new process and led to a new and useful result, and a defendant who had used the whole process, omitting the centrifugal machine and substituting a settling tank to do what the centrifugal machine had been intended to do, was held to be an infringer, for the use of a centrifugal machine was not an essential feature, but the means used to secure one particular result in a

process which was itself new and produced a new result. It was argued that the doctrine of equivalents has no application where the equivalent used was unknown at the date of the patent. I do not think this can be accepted as a correct proposition of law. It would for example be absurd to hold that a person who had invented a new mechanical device which would have the same effect as, say, a cam, could lawfully make use of all patents in which a cam formed part of or was a step in the combination or process specified or claimed. The argument was based entirely on *Heath* v. *Unwin*, in 5 House of Lords Cases, page 505. That case however does not appear to me really to support the argument. The patent there was for a process of manufacturing cast steel by the use in the melting pot of a specified quantity of carburet of manganese, an expensive metallic substance. The use of this particular substance was of the essence of the invention and no one who did not use it could possibly infringe. The defendant had not used it, at any rate directly; he had put into the melting pot a paste made [fol. 2197] of oxide of manganese and coal tar. There was evidence however that in the melting pot this paste produced carburet of manganese and that the carburet of manganese so produced was the operative agent in securing the beneficial result. Did the defendant then infringed the patent by this indirect use of carburet of manganese? It was held not. The fact that the paste produced the carburet in the melting pot was a new and valuable discovery. Had it been known at the date of the patent that a paste of coal tar and oxide of manganese when put in the melting pot produced carburet of manganese and had it been also known at the date of the patent in what proportions you ought to use the two former substances to produce in the melting pot the required proportion of the latter substances there would have been an infringement not by virtue of the rule of equivalents to which I have been referring in connection with a non-essential feature of the invention, but because there would have been an actual use of an essential feature. No use of any substance other than carburet of manganese, however well known it was at the date of the patent that such substance would have the same chemical effect as carburet of manganese could have infringed a patent in which the use of carbaret of manganese was an essential feature. When the use of a particular chemical substance is of the essence of the invention, the inventor must of course be

taken to have claimed the use of that substance to the exclusion of all other chemical substances (see *Nobel Explosive Company* v. *Henderson*, 12 R. P. C., 164), and there is no room at all in such a case for the doctrine of equivalents in the ordinary sense of the expression. But a claim to the use of a particular substance may well cover the use of two other substances known when combined to produce the particular substance in question. The two substances may then be said to be an equivalent for the substance claimed but this is a use of the word which differs from its ordinary use where the doctrine of equivalents is concerned.

Being of opinion that every claiming clause of Marconi's patent of 1900 is a claim for an entirely novel combination producing an entirely new and useful result and that the use of a two coil transformer is no essential part of his invention, I hold that the defendants, who in my opinion have taken all the essential parts of the invention, are infringers notwithstanding they have substituted an auto-transformer for a transformer in the combination claimed and notwithstanding that the use of an auto-transformer [fol. 2198] with an air core for any such purpose as that for which Marconi has used the transformer may have been new.

The action, therefore, in my opinion succeeds.

Mr. Gray: There are several matters I have to ask your Lordship about, first of all there are two other patents; of course, they are minor matters.

Mr. Colfax: I do not know about that.

Mr. Gray: I mean as compared with this one. Both sides agree that at present we are not prepared to try them, if your Lordship will give us leave to apply later. Will your Lordship give me a certificate that the validity of the patent has come in question and a certificate that the breaches are reasonable and proper. As regards the costs I am going to ask your Lordship to say that the costs should be on the higher scale and that your Lordship should allow three counsel. I think if ever there was a case for it this is the one. It has been done in previous cases.

Mr. Justice Parker: I generally do not give costs on the higher scale unless it is a case in which a lot of experiments were necessary.

Mr. Gray: There were a good many experiments in the first instance by the defendants, it saved the plaintiffs from

putting forward experiments afterwards, no doubt. I submit this is eminently one of the cases where the higher scale costs should be allowed. It has been done in many cases before.

Mr. Justice Parker: Has it been done in any but chemical cases?

Mr. Gray: Yes, in the *Dunlop Pneumatic Tire Company, Limited*, v. *Wapshare Tube Company, Limited*. That was with respect to tires, a very much simpler matter than this, before Mr. Justice Buckley, as he then was, and he allowed three counsel. It has been done in other cases besides.

Mr. Colfax: There is one fact which will not have escaped your Lordship with reference to the application for three counsel, namely, that the defendants fought the action by two counsel only.

Mr. Gray: Perhaps that is one of the reasons why they have failed.

[fol. 2199] Mr. Colefax: That may be, but I suggest there is no necessity why your Lordship should certify for three counsel if one party has conducted the case by two. That is surely sufficient reason why three counsel should not be allowed on the other side. That is one question. With regard to higher scale costs there are certain cases. My learned friend has alluded to one which is generally cited, but I do think this, that in every case what your Lordship is suggesting has been the real ground, namely, that there has been considerable experimental work. I do not think there has been experimental work here at all.

Mr. Gray: Yes.

Mr. Colefax: We had certain experiments conducted here, but that is not experimental investigation.

Mr. Justice Parker: It may be to your advantage to get costs on the higher scale.

Mr. Colefax: It may be ultimately, and that is our hope, if I may say so. However, that is a matter for your Lordship entirely. My learned friend, I think, is not quite entitled to a certificate——

Mr. Gray: I have not quite finished—the breaches so far as they relate to this patent.

Mr. Justice Parker: So far as this patent is concerned I think you are entitled to a certificate as far as the breaches are concerned, and a certificate that the validity of the patent came in issue if you ask for one.

Mr. Gray: Yes.

Mr. Colefax: Subject to one point—I do not know what turns on it—I do not think my friend proved (b) of his particulars.

Mr. Gray: I understand they were all admitted. Is not that so?

Mr. Colefax: It is only a small point, if it has been admitted let the certificate extend to it, I am not certain of it for the moment. That is as to the exhibition at the Physical Society. If it has been admitted, by all means let it extend to it: if not, it ought to come out: it is a very small matter.

Mr. Gray: Will your Lordship give me costs on the higher scale and certify for three counsel?

Mr. Justice Parker: I think myself that it is a case reasonably fit for three counsel; it was a very long and laborious case but I doubt about the costs on the higher scale. [fol. 2200] Mr. Gray: May I read the judgment of Mr. Justice Buckley in the case of *The Dunlop Tire Company v. The Wapshare Tube Company?* It is reported in R.P.C. Volume 17. The judgment is on page 459. Mr. Justice Buckley says: "I have to deal with two matters here, first the question of whether the costs of three counsel should be allowed, and secondly whether the costs should be allowed upon the higher scale. As to the employment of three counsel, I will read what Mr. Justice Fry said in *Kirkwood v. Webster* (Law Reports, 9 Chancery Division, page 239). We all know that Mr. Justice Fry was a Judge who was strict in these matters, and he was not likely to give costs incautiously. *Kirkwood v. Webster* was a case of fraud. The principle is stated in these words. He says: 'Though I feel, as other Judges have done, that in cases of this kind I ought not, without very strong reasons, to differ from the conclusion of the Taxing Master, I must in the present case dissent from his conclusion and hold that the defendant was entitled to employ three counsel. I think that the case falls within the rule laid down by Lord Justice Turner in *Pearce v. Lindsay*, and that it was essentially necessary for the purpose of doing justice that three counsel should be employed. I do not speak of a physical or a mathematical necessity, but I think that the case was one in which a reasonable and prudent man, acting with ordinary prudence, would not have ventured to come into court without three counsel.' It appears to me that what I have to consider is whether this case is one in which a reasonable

and prudent man, acting with ordinary prudence, would not have ventured to come into court without three counsel. In that I disregard altogether the probability that one counsel would be absent at some time during the trial. It is the duty of counsel to attend to their cases throughout, if circumstances will allow. I do not think that three counsel ought ever to be allowed on the ground that somebody may be away. The only test I have to apply is whether, assuming all three counsel will be here all the time, a reasonable and prudent person would have employed three counsel. I think he would."

Mr. Colefax: Your Lordship sees upon that case your Lordship has to find that the defendants were imprudent in coming into court with only two counsel if that test be applied.

Mr. Gray: That is only dealing with the question of three counsel. May I go on with the part as to costs? "The [fol. 2201] other question is whether the costs ought to be taxed on the higher scale. There the rule is this: 'The higher scale may be allowed if, on special grounds arising out of the nature and importance or the difficulty or urgency of the case, the Court or the Judge, shall at the trial or hearing or further consideration,' and so on, 'think that such allowance ought to be so made upon such special grounds as aforesaid.' What I have to say is whether in my judgment, exercised to the best of my discretion, there were here special grounds arising out of the nature and importance of the case. Now, Lord Justice Cotton in the case of *Ellington v. Clark* seems to have laid this down. I do not say that this is a general or inflexible rule, but as regards that case he said: 'When the plaintiffs brought scientific witnesses, it was necessary for the defendants to bring scientific witnesses, and in such a case we think costs ought to be allowed on the higher scale.' I do not in the least understand the learned Lord Justice to say that if the plaintiff chooses to call scientific witnesses the costs ought to be always allowed on the higher scale. The question must be whether the scientific witnesses are really wanted. I then ask myself this question: Was scientific evidence in this case wanted? I cannot doubt it for a moment. The questions I have had to consider have been very complicated questions of mechanics, on which very skilled persons have had very great difficulty in arriving at a conclusion. I think

that the case is one in which, upon special grounds, the costs ought to be allowed upon the higher scale."

Mr. Justice Parker: I have considered it once or twice before, and the conclusion I came to myself in these chemical cases where I will say a great amount of out of court work is required in experiments and otherwise in order to enable the scientific witnesses to give their evidence, that is a case for costs on the higher scale, but I have never done it myself in a purely mechanical case or in an electrical case.

Mr. Gray: This was done in the Dunlop case. It was purely a question of tires and complicated questions of mechanics arose there: and here there are electricity and mechanics as well.

Mr. Justice Parker: I think I will certify that it was a proper case for three counsel, but give costs on the ordinary scale. Nowadays you get your scientific witnesses always allowed.

[fol. 2202] Mr. Gray: Of course, as there are two other patents, there would usually be only one order. I do not know whether your Lordship will allow a separate order to be drawn up on this?

Mr. Justice Parker: The order can be drawn up on this, and I will direct the rest of the trial to stand over.

Mr. Colefax: That is one of the matters I want to address your Lordship upon.

Mr. Gray: I ask your Lordship to say that the plaintiffs shall have the costs of this action except so far as increased by the two other patents which are much less important matters. This was the main patent; the other part of the action is merely as to part of the apparatus, one the spark gap and the other the detector, a very small part of the whole system.

Mr. Justice Parker: I think before this came into court, it was arranged that one patent should be tried.

Mr. Gray: The other two patents were to be considered later or at all events to stand over for further consideration.

Mr. Justice Parker: You are entitled to your full costs except any additional costs there may be in having put the other patents in, and I will direct the rest of the case to stand over, with liberty to apply.

Mr. Gray: If your Lordship pleases.

Mr. Justice Parker: That would be the right form, I think, Mr. Colefax, would not it?

Mr. Colefax: I do not quite follow what that means. Is my friend going to abandon the other two patents or not?

Mr. Gray: No.

Mr. Colefax: Either he abandons the other two patents, in which case we get judgment, or he does not.

Mr. Justice Parker: No. I think the arrangement was, after I had given my judgment in this case, the matter was to stand over that the parties might consider.

Mr. Colefax: If your Lordship pleases. I am quite content with that.

Mr. Justice Parker: If I let the matter go over with liberty to apply, that will be sufficient.

Mr. Colefax: If your Lordship pleases, I am quite content with that. There must be no execution in respect of the [fol. 2263] costs upon this patent until it is determined whether or not my learned friends' clients are going on on the other two patents, because of course it is perfectly obvious we have a set-off for costs if they abandon the other two.

Mr. Gray: We never suggested that we were going to abandon the other two.

Mr. Colefax: Then it is quite clear it cannot be suggested you can draw up an order on which you are to proceed to execution in respect of the costs of this patent.

Mr. Gray: I submit so.

Mr. Colefax: No, that is the point I desire to submit to your Lordship, that that would not be right at all. If my friends are going on on the other two patents and they fail, the costs in the other two may in fact amount even to more than the costs on this. I do not say whether they will or will not; they are quite serious questions raised. It is all very well for my friend to say they are trivial patents, they have not assumed that aspect in the few words that have been said about them by Mr. Astbury. It would not be right that we should be forced to pay costs on this patent until they determine what they are going to do on the other two. If they are not going on, we get certain costs which will be set off. If they are going to fight them, we may get costs enough to wipe out anything on this patent. In any case it would not be right, I submit, that there should be execution in respect of the judgment on this patent until the other two patents are dealt with. Either they abandon them, or your Lordship hears the case on them.

Mr. Justice Parker: I do not see why not. The idea was this patent should be disposed of and the parties should have an opportunity of appealing and carrying it if they liked to the highest tribunal of the land separately.

Mr. Gray: That is so.

Mr. Colefax: I have not appreciated that in any case.

Mr. Justice Parker: It was really to be treated as a separate action on this patent.

Mr. Colefax: What I did understand was there was to be an opportunity for the plaintiffs to consider whether they would go on with the other two or not, but I never understood that the suggestion was that this action should remain [fol. 2204] in abeyance with respect to the other two patents pending an appeal which might go to the House of Lords on this patent, I never understood that. I do not think that is the arrangement between the parties.

Mr. Justice Parker: I think you will find there is a reference to it in the shorthand notes.

Mr. Colefax: I am quite aware it was suggested that they should have time to consider whether they would go on with the other two, but I think that is the whole length that it went—it was not intended to go straight on.

Mr. Justice Parker: It was intended that the order should be drawn up and appealed, before, necessarily, the other cases came on; they were to be so far treated as separate actions if you could do that.

Mr. Colefax: I am not aware of the passage on the shorthand notes, I may be wrong about that.

Mr. Gray: I really understood that if the plaintiffs succeeded on this patent it would not matter in the least about the other two patents to the defendants, because they cannot use their system. I understand it was on that principle that the matter was left.

Mr. Colefax: I can certainly say we never have taken that line at all, because that is not in accordance with the facts. Would your Lordship allow this matter to stand over to be looked into? I will look into the shorthand notes. My learned friend Mr. Terrell is not here; he may have made some arrangement which I am not aware of; what your Lordship suggests is not my understanding of the arrangement.

Mr. Justice Parker: No, I think the proper course is to give judgment on this patent, and let the rest stand over.

Mr. Colefax: Then there is one other matter.

Mr. Justice Parker: It certainly was not within my view that the order should not be drawn up until the other patents were disposed of; if I had thought that I should probably have insisted on hearing all the patents together. I was told that if this patent was proceeded with only, and an order drawn up so that the parties could appeal it, very likely the others would never be heard of at all.

Mr. Colefax: I am not questioning your Lordship's recollection, but I have not that in mind myself.

There is one other matter; would your Lordship stay the injunction if we give notice of appeal, say, within 14 or 10 [fol. 2205] days? That, I submit, would be right. Why I mention it is this. I understand that there is apparatus on ships for which conceivably we may still be responsible; there is some difficulty in getting that apparatus off those ships. I should suggest no harm could be done if the injunction was stayed.

Mr. Justice Parker: So far as the injunction is concerned, what do you say, Mr. Gray, to staying it?

Mr. Gray: I am afraid the plaintiffs will not agree to that. If there are particular circumstances as to one or two boats that the defendants are in a difficulty about, I do not think the plaintiffs will be harsh; but subject to that, I submit that the injunction should go.

Mr. Colefax: It is obvious that, supposing that we should succeed ultimately, we have in the meantime, if the injunction is to go, to pull off certain apparatus from certain ships.

Mr. Gray: That is the common practice in all cases where the defendant gets judgment against him.

Mr. Justice Parker: I do not see why you should have a stay of execution with regard to fresh sales; but, if it is a question of getting apparatus off ships, perhaps it would be convenient to leave the things on board the ships where there has been an installation.

Mr. Gray: I ask your Lordship to let the injunction go at once; the plaintiffs will consider any special case in which the defendants find a difficulty. I ask your Lordship not to stay the injunction.

Mr. Colefax: I ask your Lordship to stay the injunction except insofar as future sales are concerned. I ask your Lordship not to allow the injunction in respect of user of apparatus already installed, pending the Appeal.

Mr. Gray: Difficulties always do occur when a defendant infringes on account of some contract he is carrying out, but I have never heard that put forward as a ground for a stay.

Mr. Justice Parker: It is put forward. I think the proper thing to do would be, if notice of appeal is served within ten days, did you say——

Mr. Colefax: I said 14.

Mr. Justice Parker: If notice of appeal is served within 14 days, I think the operation of the injunction ought to be suspended during the appeal, so far as it affects the user of any instrument already installed by them on board ship. [fol. 2206] Mr. Colfax: If your Lordship pleases; that is all I am asking.

Mr. Gray: The injunction against the use is a different thing; this injunction only operates as regards the defendants supplying apparatus to any other boat.

Mr. Justice Parker: It will not be suspended as regards that.

Mr. Gray: The users are not the defendants.

Mr. Colefax: You are forgetting; that may or may not be so.

Mr. Justice Parker: There are two ends.

Mr. Colefax: The apparatus may still be ours. If your Lordship says that, that will satisfy me.

Mr. Justice Parker: I think that will be reasonable. That will not justify you in installing a lot more.

Mr. Colefax: No, my Lord, I entirely appreciate that. I was not asking in respect to future installations.

Mr. Justice Parker: Then it will be an ordinary judgment in the action on this particular patent, and the costs will be costs of the whole action except so far as increased by the joining in the action of the other patents.

Mr. Gray: If your Lordship pleases.

Mr. Justice Parker: The rest of the action as to the other patents is to stand over generally, with liberty to either party to apply.

Mr. Gray: If your Lordship pleases.

Mr. Justice Parker: What do you want in the shape of relief besides an injunction—anything?

Mr. Gray: Two certificates, and delivery up. Of course, the delivery up will equally stand so far as anything that

Marconi Ex. 819

PLAINTIFF'S EXHIBIT #19

Marconi Re-issue patent (11,913)

UNITED STATES

DEPARTMENT OF

UNITED STATES PATENT OFFICE.

To all to whom these presents shall come, Greeting.

THIS IS TO CERTIFY that the annexed is a true copy from the Records of this Office of the

Reissue Letters Patent of

Guglielmo Marconi, Assignor, by mesne assignments, to

Marconi's Wireless Telegraph Company, Limited,

FILED JAN 11 1928 CLERK OF COURT

Number 11,913, Granted June 4, 1901,

for

Improvement in Transmitting Electrical Impulses and Signals and Apparatus Therefor.

IN TESTIMONY WHEREOF I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington, this 23rd day of September, in the year of our Lord one thousand nine hundred and sixteen and of the Independence of the United States of America the one hundred and forty-first.

T. W. H. Clay

Acting Commissioner of Patents.

No. 11,913.

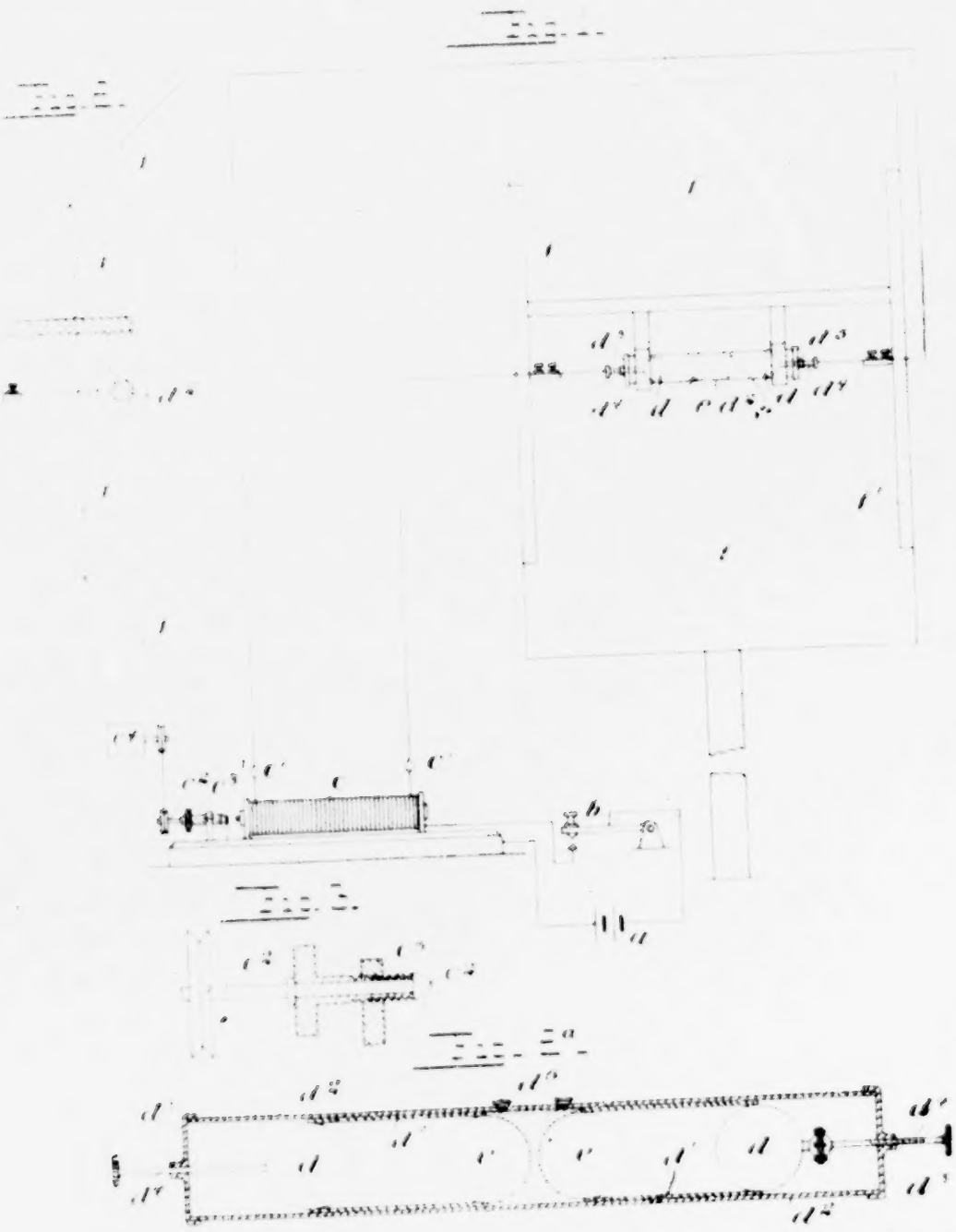
Reissued June 4, 1901.

G. MARCONI.

TRANSMITTING ELECTRICAL IMPULSES AND SIGNALS AND APPARATUS THEREFOR.

Original No. 586,193, dated July 13, 1897. Application filed April 2, 1900.

3 Sheets—Sheet 1.



WITNESSES:

INVENTOR,

BY

ATTORNEYS.

No. 11,913. Reissued June 4, 1901.

G. MARCONI.

TRANSMITTING ELECTRICAL IMPULSES AND SIGNALS AND APPARATUS THEREFOR

Application filed Apr. 2, 1901.

3 Sheets—Sheet 2.

Fig. 4.

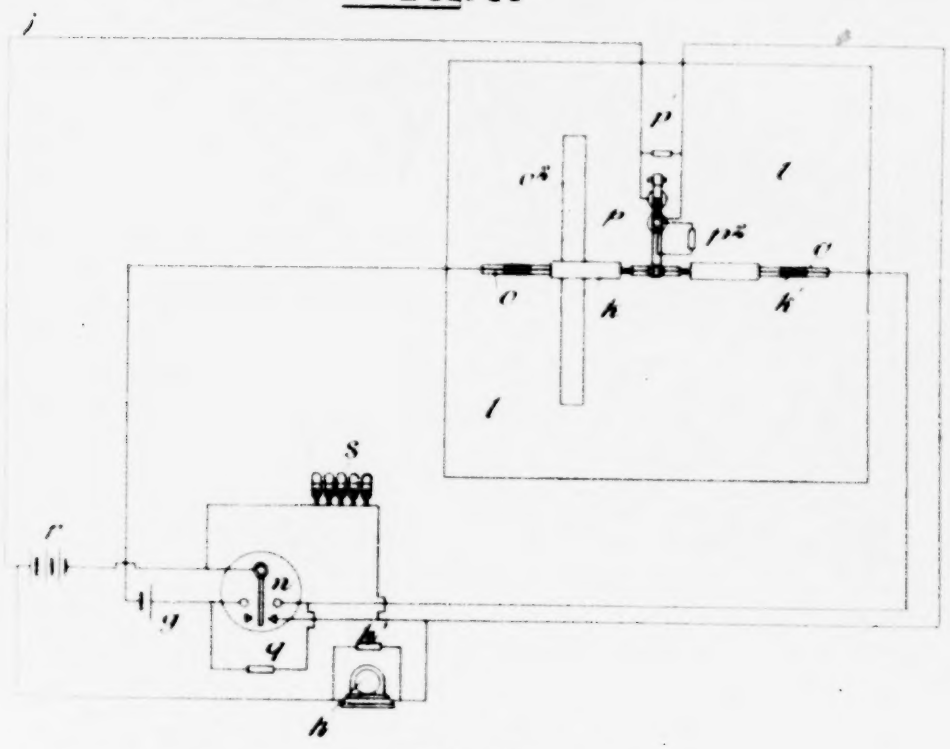


Fig. 5.

Fig. 8.

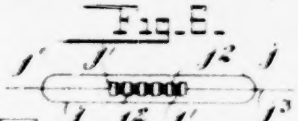


Fig. 7.

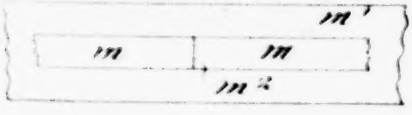


Fig. 6.

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No. 11,913. Reissued June 4, 1901.

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TRANSMITTING ELECTRICAL IMPULSES AND SIGNALS AND APPARATUS THEREFOR

Application filed Apr. 1, 1901.

3 Sheets—Sheet 3.

Fig. 9.

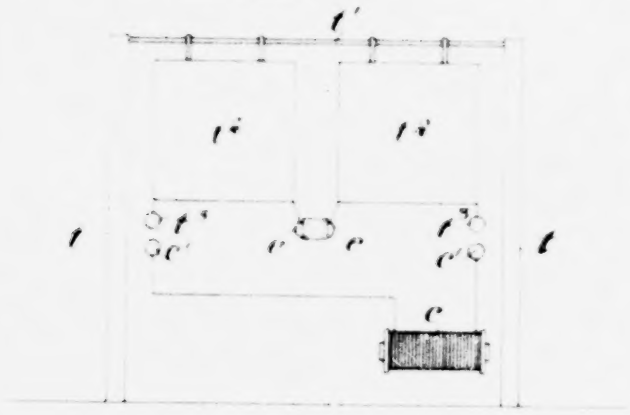



Fig. 10.

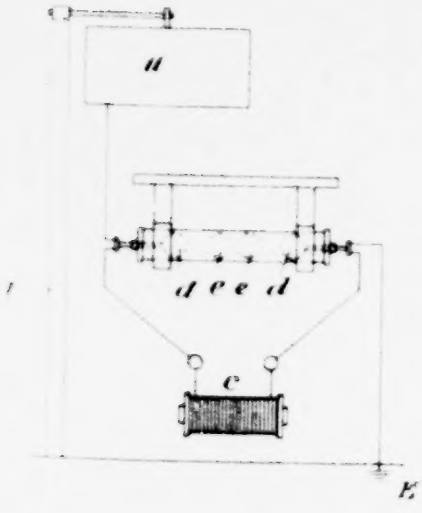
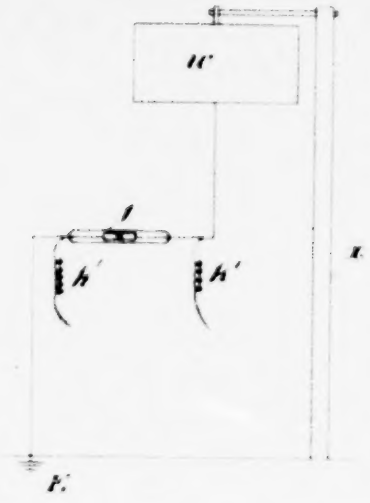


Fig. 11.



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UNITED STATES PATENT OFFICE.

GUGLIELMO MARCONI, OF LONDON, ENGLAND, ASSIGNOR, BY MESNE ASSIGNMENTS, TO MARCONI'S WIRELESS TELEGRAPH COMPANY, LIMITED, OF ENGLAND.

TRANSMITTING ELECTRICAL IMPULSES AND SIGNALS AND APPARATUS THEREFOR.

SPECIFICATION forming part of Reissued Letters Patent No. 11,913, dated June 4, 1901.

Original No. 586,193, dated July 13, 1897. Application for reissue filed April 1, 1901. Serial No. 53,898.

To all whom it may concern:

Be it known that I, GUGLIELMO MARCONI, a subject of the King of Italy, residing and having a post-office address at 18 Finch Lane, Threadneedle street, London, England, have invented certain new and useful Improvements in Transmitting Electrical Impulses and Signals and in Apparatus Therefor, of which the following is a specification.

According to this invention electrical signals, actions, or manifestations are transmitted (through the air, earth, or water) by means of oscillations of high frequency, such as have been called "Hertz rays" or "Hertz oscillations." All line-wires may be dispensed with. At the transmitting-station I preferably employ a Ruhmkorff coil having in its primary circuit a Morse key or other signaling instrument and at its poles appliances for producing the desired oscillations. The Ruhmkorff coil may, however, be replaced by any other source of high-tension electricity. When working with large amounts of energy, it is, however, better to keep the coil or transformer constantly working for the time during which one is transmitting, and instead of interrupting the current of the primary interrupting the discharge of the secondary. In this case the contacts of the key should be immersed in oil, as otherwise, owing to the length of the spark, the current will continue to pass after the contacts have been separated. At the receiving-station there is a local-battery circuit containing any ordinary receiving instrument and an appliance for closing the circuit, the latter being actuated by the oscillations from the transmitting-station. When transmitting through the air, and it is desired that the signal should only be sent in one direction, I place the oscillation-producer at the transmitting-station in the focus or focal line of a reflector directed to a receiving-station, and I place the circuit-closer at the receiving-station in a similar reflector directed toward the transmitting-station. When transmitting signals by the aid of earth connections, I connect one end of the oscillation-producer and one end of the circuit-closer to earth and the other ends to plates preferably electrically tuned with each other in the air and insulated from earth.

Figure 1 is a diagrammatic front elevation of the instruments at the transmitting-station when signaling through the air, and Fig. 2 is a vertical section of the transmitter. Fig. 2^a is a longitudinal section of the oscillator to a larger scale. Fig. 3 shows a detail of the trembler-break on a larger scale. Fig. 4 is a diagrammatic front elevation of the instruments at the receiving-station. Fig. 5 is an enlarged view of the receiver. Fig. 6 shows a modification of the tube *j*. Fig. 7 shows the detector. Fig. 8 is a full-sized view of the liquid resistance. Figs. 9 and 10 show modifications of the arrangements at the transmitting-station. Fig. 11 shows a modification of the arrangements at the receiving-station.

Referring now to Fig. 1, *a* is a battery, and *b* an ordinary Morse key closing the circuit through the primary of a Ruhmkorff coil *c*. The terminals *c'* of the secondary circuit of the coil are connected to two metallic balls *d d*, fixed by heat or otherwise at the ends of tubes *d' d'*, Fig. 2^a, of insulating material, such as ebonite or vulcanite. *e e* are similar balls fixed in the other ends of the tubes *d'*. The tubes *d'* fit tightly in a similar tube d^2, having covers d^3, through which pass rods d^4, connecting the balls *d* to the conductors. One (or both) of the rods d^4 is connected to the ball *d* by a ball-and-socket joint and has a screw-head upon it working in a nut in the cover d^3. By turning the rod, therefore, the distance of the balls *e* apart can be adjusted. d^5 represents holes in the tube d^2, through which vaseline, oil, or like material is introduced into the space between the balls *e*.

The balls *d* and *e* are preferably of solid brass or copper, and the distance they should be apart depends on the quantity and electromotive force of the electricity employed, the effect increasing with the distance so long as the discharge passes freely. With a coil giving an ordinary eight-inch spark, the distance between *e* and *e* should, to assure good results, be from one twenty-fifth to one-thirtieth of an inch and the distance between *d* and

about one and one-half inches. Other conditions being equal, the larger the balls the greater is the distance at which it is possible to communicate. I have generally used balls of solid brass of four inches diameter, giving oscillations of ten inches length of wave.

If a very powerful source of electricity giving a very long spark be employed, it is preferable to divide the spark-gap between the central balls of the oscillator into several smaller gaps in series. This may be done by introducing between the big balls smaller ones of about half an inch diameter, held in position by ebonite frames.

I find that the regularity and power of the discharge of an ordinary Ruhmkorff coil with a trembler-break on its primary is greatly improved by causing one of the contacts of the vibrating break to revolve rapidly. I do this preferably by having a revoluble central core c^2, Fig. 3, in an ordinary screw c^3, which is in communication with platinum contacts. I cause the said central core, with one of the platinum contacts attached to it, to revolve, preferably, by connecting it to a small electric motor c^4. This motor can be worked by the same circuit that works the coil or, if necessary, by a separate circuit. The connections are not shown in the drawings. By this means the platinums are kept smooth and any tendency to stick is removed. They last, also, much longer. At the receiving station is a battery whose circuit includes an ordinary telegraphic instrument (or it may be a relay or other apparatus which it is desired to work from a distance) and a circuit-closer.

In Fig. 4, g is the battery, and h a telegraphic instrument on the derived circuit of a relay n.

The appliance I employ as a circuit-closer is shown at Fig. 5, and consists of a glass tube j, containing metallic powder or grains of metal j', each end of the column of powder being connected to a metallic plate k of suitable length to cause the system to resonate electrically in unison with the electrical oscillations transmitted. The glass tube may be replaced in some places by one of gutta-percha or like material. Two short pieces j^2, preferably of thick silver wire of the same diameter as the internal diameter of the tube j, so as to fit tightly in it, are joined to two pieces of platinum wire j^3. The tube is closed and sealed onto the platinum wires j^3 at both ends.

Many metals can be employed for producing the powder or filings j', but I prefer to use a mixture of two or more different metals. I find hard nickel to be the best metal, and I prefer to add to the nickel filings about ten per cent. of hard-silver filings, which increase greatly the sensitiveness of the tube to electric oscillations. By increasing the proportion of silver powder or grains the sensitiveness of the tube also increases; but it is better for ordinary work not to have a tube of too great sensitiveness, as it might be influenced by atmospheric or other electricity. The sensitiveness can also be increased by adding a very small amount of mercury to the filings and mixing up until the mercury is absorbed.

The mercury must not be in such a quantity as to clot or cake the filings. An almost imperceptible globule is sufficient for a tube. Instead of mixing the mercury with the powder one can obtain the same effects by slightly amalgamating the inner surfaces of the plugs which are to be in contact with the filings. Very little mercury must be used, just sufficient to brighten the surface of the metallic plugs without showing any free globules. The size of the tube and the distance between the two metallic stops may vary under certain limits. The greater the space allowed for the powder the larger and coarser ought to be the filings or grains.

I prefer to make my sensitive tubes of the following size: The tube j is one and one-half inches long and one-tenth or one-twelfth of an inch in internal diameter. The length of the stops j^2 is about one-fifth of an inch, and the distance between the stops is about one-thirtieth of an inch. I find that the smaller the space between the stops in the tube the more sensitive it proves; but the space cannot under ordinary circumstances be excessively shortened without injuring the fidelity of the transmission.

The metallic powders ought not to be fine, but, rather, as coarse as can be produced by a large and rough file.

All the very fine powder ought to be removed by blowing or sifting.

The powder ought not to be compressed between the stops, but, rather, loose and in such a condition that when the tube is tapped the powder may be seen to move.

The tube must be sealed; but a vacuum inside it is not essential. A slight vacuum, however, results from having heated it while sealing it. Care must also be taken not to heat the tube too much in the center when sealing it, as it would oxidize the surfaces of the silver stops and also the powder, which would diminish its sensitiveness. I use in sealing the tubes a hydrogen and air flame. A vacuum is, however, desirable, and I have used one of about one one-thousandth of an atmosphere, obtained by a mercury-pump. It is also necessary for the powder or grains to be dry and free from grease or dirt, and the files used in producing the same ought to be frequently washed and dried and used when warm.

If the tube has been well made, it should be sensitive to the induction of an ordinary electric bell when the same is working at one to two yards or more from the tube.

In order to keep the sensitive tube j in good working order, it is desirable, but not absolutely necessary, not to allow more than one milliampere to flow through it when active. If a stronger current is necessary, several

tubes may be put in derivation between the tuned plates; but this arrangement is not quite as satisfactory as the single tube. It is necessary when using tubes of the type I have described not to insert in the circuit more than one coil of the Leclanche type, as a higher electromotive force than 1.5 volts is apt to pass a current through the tube even when no oscillations are transmitted. I can, however, construct tubes capable of working with a much higher electromotive force. Fig. 6 shows one of these tubes. In this tube instead of one space or gap filled with filings there are several spaces separated by sections of tight-fitting silver wire. A tube thus constructed, observing also the rules of construction of my tubes in general, will work satisfactorily if the electromotive force of the battery in circuit with the tube is equal to 1.2 volts multiplied by the number of gaps. With this tube, also, it is well not to allow a current of more than one milliampere to pass.

The tube *j* may be replaced by other forms of imperfect electrical contacts.

The plates *k* are of copper or aluminium or other metal, about half an inch or more broad, about one-fiftieth of an inch thick, and preferably of such a length as to be electrically tuned with the electric oscillations transmitted. The means I adopt for fixing the length of the plates is as follows: I stick a rectangular strip of tin-foil *m* (see Fig. 7) about twenty inches long, (the length depends on the supposed length of wave that one is measuring,) by means of a weak solution of gum, onto a glass plate *m'*. Then by means of a very sharp penknife or point I cut across the middle of the tin-foil, leaving a mark of division m^2. If this detector is held in the proximity (four or five yards) and parallel with the axis of the oscillator in action it will show little sparks at m^2. If the length of the pieces of tin-foil approximates to the length of wave emitted from the oscillator, the spark will take place between them at a certain distance from the transmitter, which is a maximum when they are of suitable length. By shortening or lengthening the strips, therefore, it is easy to find the length most appropriate to the length of wave emitted by the oscillator. It is desirable to try this detector in the focus or focal line of the reflector. The length so found is the proper length for the plates *k*, or rather these should be about half an inch shorter on account of the length of the sensitive tube *j*, connected between them.

Instead of the tuned plates *k* tubes or even wires may be employed.

f is a cylindrical parabolic reflector made by bending a metallic sheet, preferably of brass or copper, to form and fixing it to metallic or wooden ribs *f'*

l is a cylindrical parabolic reflector similar to that used at the transmitting-station.

The reflectors applied to the receiver and transmitter ought to be, preferably, in length and opening the double at least of the length of wave emitted from the oscillator.

It is slightly advantageous for the focal distance of the reflector at the receiving-station to be equal to one-fourth or three-fourths of the wave length of the oscillation transmitted.

I have hitherto only mentioned the use of cylindrical reflectors; but it is also possible to use ordinary concave reflectors, preferably parabolic, such as are used for projectors.

It is not essential to have a reflector at the transmitters and receivers; but in their absence the distance at which one can communicate is much smaller.

When no oscillations are sent from the transmitting-station, the tube *j* does not conduct the current and the local-battery circuit is broken; but when the powder or tube is influenced by the electrical oscillations from the transmitter it conducts and closes the circuit. I find, however, that when once started the powder in the tube continues to conduct even when the oscillations from the transmitter have ceased; but if it be shaken or tapped the circuit is broken. A tube well prepared will instantly interrupt the current passing through it at the slightest tap, provided it is inserted in a circuit in which there is little self-induction and small electromotive force, such as a single cell, and where the effects of self-induction have been removed by one of the methods which I will presently describe.

The two plates *k* communicate with the local circuit through two very small coils *k'*, which I will call "choking-coils," formed by winding a few inches of very thin and insulated copper wire around a bit of iron wire about an inch and a half long. The object of these choking-coils is to prevent the high-frequency oscillation induced across these plates by the transmitter from dissipating itself by running along the local-battery wires, which might weaken its effect on the sensitive tube *j*. These choking-coils may, however, be sometimes replaced by simple thin wires. They may also be connected directly to the tube *j*. The local circuit in which the sensitive tube *j* is inserted contains a sensitive relay *n*, preferably wound to a resistance of about twelve hundred ohms. This resistance need not be necessarily that of the relay, but may be the sum of the resistance of the relay and another additional resistance. The relay ought to be one possessing small self-induction.

The plates *k*, tube *j*, and coils *k'* are fastened by means of wire stitches *o'* to a thin glass tube *o*, preferably not longer than twelve inches, firmly fixed at one end to a strong piece of timber o^1. This may be done by means of wood or ebonite grasping-screws.

I do the tapping automatically by the current started by the tube, employing a trembler *p* on the circuit of the relay *n* similar in construction to that of an electric bell, but having a shorter arm. This vibrator must

be carefully adjusted. Preferably the blows should be directed slightly upward to prevent the filings from getting caked. In place of tapping the tube, the powder can be disturbed by slightly moving outward and inward one or both of the stops j^2, the trembler p being replaced by a small electromagnet (or magnets) whose armature is connected to the stop.

I ordinarily work the telegraphic receiver h (or other instruments) by a derivation, as shown, from the circuit which works the trembler p. They can also, however, be worked in series with the trembler. When working ordinary sounders or Morse apparatus, a special adjustment of the same is sometimes needed to enable one to obtain dots and dashes. Sometimes it is necessary to work the telegraphic instruments or relays from the back stops of the first relay, as is done in some systems of multiple telegraphy. Such adjustments are known to telegraphic experts.

By means of a tube with multiple gaps it is possible to work the trembler and also the signaling or other apparatus direct on the circuit which contains the tube; but I prefer, when possible, to work with the single-gap tube and the relay, as shown. With a sensitive and well-constructed trembler it is also possible to work the trembler with the single-gap tube in series with it without the relay.

In derivation on the terminals of the relay n is placed an ordinary platinoid resistance double-wound (or wound on the "bight," as it is sometimes termed) coil q of about four times the resistance of the relay, which prevents the self-induction of the winding of the relay from affecting the sensitive tube.

The circuit actuated by the relay contains an ordinary battery r of about twelve cells and the trembler p, the resistance of the winding of which should be about one thousand ohms, and the core ought preferably to be of soft iron, hollow and split lengthwise, like most electromagnets used in telegraph instruments. In series or derivation from this circuit is inserted the telegraphic or other apparatus h which one may desire to work. It is desirable that this instrument or apparatus if on a derivation should have a resistance equal to the resistance of the trembler p. A platinoid resistance h' of about five times the resistance of the instrument is inserted in derivation across the terminals of the instrument and connected as close to the same as possible. In derivation across the terminals of the trembler p is placed another platinoid resistance p', also of about five times the resistance of the trembler. A similar resistance p^2 is inserted in a circuit connecting the vibrating contacts of the trembler. In derivation across the terminals of the relay-circuit it is well to have a liquid resistance s, which is constituted of a series of tubes, one of which is shown full size in Fig. 8 filled with water acidulated with sulfuric acid. The number of these tubes in series across the said terminals ought to be about ten for a circuit of fifteen volts, so as to prevent, in consequence of their counter electromotive force, the current of the local battery from passing through them, but allowing the high-tension jerk of current generated at the opening of the circuit in the relay to pass smoothly across them without producing perturbing sparks at the movable contact of the relay. It is also necessary to insert a platinoid resistance in derivation on any apparatus one may be working on the local circuits. These resistances ought also to be inserted in derivation on the terminals of any resistance which may be apt to give self-induction.

I find it convenient when transmitting across long distances to make use of the transmitter shown in Fig. 9.

f f are two poles connected by a rope f', to which are suspended, by means of insulating-suspenders, two metallic plates f^2 f^2, preferably in the form of cylinders closed at the top, connected to the spheres e (in oil or other dielectric, as before) and to the other balls f^3 in proximity to the spheres c', in communication with the coil or transformer c. The balls f^3 are not absolutely necessary, as the plates f^2 may be made to communicate with the coil or transformer by means of thin insulated wires. The receiver I adopt with this transmitter is similar to it, except that the spheres e are replaced by the sensitive tube j and plates k, while the spheres f^3 are replaced by the choking-coils k', in communication with the local circuit. It may be observed that, other conditions being equal, the larger the plates at the transmitter and receiver and the higher they are from the earth and to a certain extent the farther apart they are the greater is the distance at which correspondence is possible.

When transmitting with connections to the earth or water, I use a transmitter as shown in Fig. 10. I connect one of the spheres d to earth E, preferably by thick wire, and the other to a plate or elevated conductor u, carried by a pole v and insulated from earth, or the spheres d may be omitted and one of the spheres e be connected to earth and the other to the plate or conductor u. At the receiving-station, Fig. 11, I connect one terminal of the sensitive tube j to earth E, also by a thick wire, and the other to a plate or elevated conductor w, preferably similar to u. The plate w may be suspended on a pole x and must be insulated from earth. The larger the plates of the receiver and transmitter and the higher from the earth the plates are carried the greater is the distance at which it is possible to communicate. When using the last-described apparatus, it is not necessary to have the two instruments in view of each other, as it is of no consequence if they are separated by mountains or other obstacles. At the receiver it is possi-

ble to pick up the oscillations from the earth or water without having the plate *w*. This may be done by connecting the terminals of the sensitive tube *t* to two earths preferably at a certain distance from each other and in a line with the direction from which the oscillations are coming. These connections must not be entirely conductive, but must contain a condenser of suitable capacity—say one square yard of surface. Balloons can also be used instead of plates on poles provided they carry up a plate or are themselves made conductive by being covered with tin-foil. As the height to which they may be sent is great, the distance at which communication is possible becomes greatly multiplied. Kites may also be successfully employed, if made conductive by means of tin-foil.

The apparatus above described is so sensitive that it is essential either that the transmitters and receivers at each station should be at a considerable distance from each other or that they should be screened from each other by stout metal plates. It is sufficient to have all the telegraphic apparatus in a metal box and any exposed part of the circuit of the receiver inclosed in metallic tubes which are in electrical communication with the box. Of course the part of the apparatus which has to receive the radiation from the distant station must not be inclosed, but possibly screened from the local transmitter by means of metallic sheets. When working through the earth or water, the local receiver must be switched out of circuit when the transmitter is at work, and this may also be done when working through air.

The operation of my apparatus and system of communication or signals is as follows: The Ruhmkorff coil or other source of high tension electrically capable of producing Hertz oscillations being in circuit with a signaling instrument—such as a Morse key, for instance—the operator by closing the circuit in the way commonly employed for producing dots and dashes in ordinary telegraphy will cause the oscillator to produce either a short or a more prolonged electric discharge or spark or succession of sparks, and this will cause a corresponding short or more prolonged oscillation in the surrounding medium corresponding in duration to the short or longer electrical impulse which in ordinary telegraphy produces a dot or dash. Such oscillations of defined character will thereupon be propagated as such throughout the medium and will affect a properly-constructed instrument at a distant receiving-station. At such station the imperfect-contact instrument is in circuit with a relay, and when oscillations from the transmitting-station reach and act upon such imperfect contact its resistance is reduced, and the circuit is thereby closed during the continuance of the oscillation and for a length of time corresponding thereto. The closing of the relay-circuit causes the sounder or other signal apparatus to act in accordance with the particular oscillation received, and the oscillation also immediately starts the action of the shaking or tapping device, which so shakes the powder in the imperfect-contact instrument as to cause it to break circuit as soon as the oscillation ceases which has closed the circuit and produced a movement of the signaling instrument corresponding thereto. I am therefore enabled to communicate signals telegraphically without wires by thus artificially forming oscillations at the transmitting-station into definite signals by means of a signaling instrument and receiving and reading the same at a receiving-station by an imperfect-contact instrument, which when acted upon by such defined oscillations operates, first, to close the circuit in accordance with the received oscillation and produce a corresponding movement of the receiving instrument, relay, or sounder, and also to operate a shaking device to automatically reopen the circuit immediately after the reception of each oscillation, thereby preserving the results of its defined character in the action of the receiver.

All the details specified herein of construction of the sensitive tube and its connections are desirable for great efficiency; but the fundamental features of my system of transmission are not restricted to such details.

I am aware that the sensitiveness of various apparatus, including tubes containing filings, to more or less distant electrical disturbances has been observed in a general way and that it has also been proposed to disturb the conductivity of such filings by various instrumentalities for shaking the tubes containing the same. I am also aware that the use of tubes containing metallic powders of several separate kinds has been described or suggested in connection with certain experiments relating to so-called "coherers," but I am not aware that the utility of a mixture of metallic powders has ever previous to my invention been ascertained and utilized for the purpose of obtaining the required degree of sensitiveness in such an instrument.

I am aware of the publication of Professor Lodge of 1894, at London, England, entitled "*The Work of Hertz*" and the description therein of various instruments in connection with manifestations of Hertz oscillations. I am also aware of the papers by Professor Popof in the *Proceedings of the Physical and Chemical Society of Russia* in 1895 or 1896; but in neither of these is there described a complete system or mechanism capable of artificially producing Hertz oscillations and forming the same into and propagating them as definite signals and capable of receving and reproducing, telegraphically, such definite signals; nor has any system been described, to my knowledge, in which a Hertz oscillator at a transmitting-station and an imperfect-contact instrument at a receiving-station are both arranged with one terminal

to earth and the other elevated or insulated; nor am I aware that prior to my invention any practical form of self-recovering imperfect-contact instrument has been described.

I believe that I am the first to discover and use any practical means for effective telegraphic transmission and intelligible reception of signals produced by artificially-formed Hertz oscillations.

What I claim is—

1. In an apparatus for communicating electrical signals by means of a producer of Hertz oscillations, and a signaling instrument, the combination, in the receiver, of an imperfect electrical contact, a circuit through the contact, and a receiving instrument operated by the influence of such oscillations on said contact, substantially as and for the purpose described.

2. In an apparatus for communicating electrical signals by means of a producer of Hertz oscillations and a signaling instrument, the combination, in the receiver, of an imperfect electrical contact, a circuit through the contact, and means, controlled by said circuit, operating to shake the contact, substantially as and for the purpose described.

3. The combination, in an apparatus for communicating electrical signals, of a spark-producer at the transmitting-station, an earth connection to one end of the spark producer, an insulated conductor connected to the other end, an imperfect electrical contact at the receiving-station, an earth connection to one end of the contact, an insulated conductor connected to the other end, and a circuit through the contact, substantially as and for the purpose described.

4. The combination, in an apparatus for communicating electrical signals, of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, an imperfect electrical contact at the receiving-station, an earth connection to one end of the contact, an insulated conductor connected to the other end, a circuit through the contact, and means, controlled by the circuit, for shaking the contact, substantially as and for the purpose described.

5. The combination, in an apparatus for communicating electrical signals, of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, an imperfect electrical contact at the receiving-station, choking-coils connected to each end of the contact, an earth connection to one end of the imperfect contact, an insulated conductor connected to the other end, and a circuit through the coils and contact, substantially as and for the purpose described.

6. The combination, in an apparatus for communicating electrical signals by means of a producer of Hertz oscillations, and a signaling instrument, an imperfect electrical contact at the receiving-station, choking-coils connected to the contact, a circuit through the coils and contact, and means, controlled by the circuit and operating to shake the contact, substantially as and for the purpose described.

7. The combination, in an apparatus for communicating electrical signals by means of a producer of Hertz oscillations and a signaling instrument, an imperfect electrical contact at the receiving-station, means, connected to each end of the contact, to prevent the oscillation from dissipating itself, a circuit through said means and contact, and means controlled by the circuit and operating to shake the contact, substantially as and for the purpose described.

8. The combination, in an apparatus for communicating electrical signals, of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, a tube containing metallic powder at the receiving-station, an earth connection to the powder and an insulated conductor also connected therewith, and a circuit through the powder, substantially as and for the purpose described.

9. The combination, in an apparatus for communicating electrical signals, of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, a tube containing metallic powder, and an insulated conductor also connected therewith, a circuit through the powder and means, controlled by the circuit, for shaking the powder, substantially as and for the purpose described.

10. The combination, in an apparatus for communicating electrical signals, of a spark-producer at the transmitting-station, an earth connection to one end of the spark-producer, an insulated conductor connected to the other end, a tube containing metallic powder at the receiving-station, choking-coils connected to the powder, an earth connection to the powder and an insulated conductor also connected therewith, and a circuit through the coils and powder, substantially as and for the purpose described.

11. The combination, in an apparatus for communicating electrical signals, of a producer of Hertz oscillations, electrically connected with a signaling instrument at the transmitting-station, a tube containing metallic powder at the receiving-station, choking-coils connected to the powder, a circuit through the powder, and means, controlled by said circuit, for shaking the powder, substantially as and for the purpose described.

12. The combination, in an apparatus for communicating electrical signals, of a producer of Hertz oscillations, electrically connected with a signaling instrument at the transmitting-station, a tube containing metallic powder at the receiving-station, chok-

ing-coils and earth connection through condensers connected to the powder, a circuit through the coils and powder, and means, controlled by the circuit, for shaking the powder, substantially as and for the purpose described.

13. The combination, in an apparatus for communicating electrical signals, of a producer of Hertz oscillations, electrically connected with a signaling instrument at the transmitting-station, a tube containing metallic powder at the receiving-station, electrically-tuned devices connected to the powder, a circuit through the powder, and means, controlled by said circuit, for shaking the powder, substantially as and for the purpose described.

14. In a receiver for electrical oscillations, the combination of an imperfect electrical contact, tuned metallic plates connected to it, a circuit through the contact, and means, controlled by the circuit, for shaking the contact.

15. In a receiver for electrical oscillations, the combination of an imperfect electrical contact, choking-coils connected to the contact, a circuit through the coils and contact, and means, controlled by the circuit, for shaking the contact.

16. In a receiver for electrical oscillations, the combination of an imperfect electrical contact, tuned metallic plates and choking-coils connected to the contact, a circuit through the same, and means, controlled by the circuit, for shaking the contact.

17. In a receiver for electrical oscillations, the combination of a tube containing a mixture of metallic powders, a circuit through the same, and means, controlled by the circuit, for shaking the powder.

18. In a receiver for electrical oscillations, the combination of a tube containing a metallic powder or powders and mercury, a circuit through the same, and means, controlled by the circuit, for shaking the powder.

19. In a receiver for electrical oscillations, the combination of a tube, metallic plugs in the tube, metallic powder between the plugs, metallic plates connected to the plugs, choking-coils connected to the plugs, and a circuit through the coils, plugs and powder.

20. In a receiver for electrical oscillations, the combination of a tube, metallic plugs in the tube, metallic powder between the plugs, metallic plates connected to the plugs, choking-coils connected to the plugs, a circuit through the coils, plugs and powder, and means, controlled by the circuit, for shaking the powder.

21. In a receiver for electrical oscillations, the combination of a tube, metallic plugs in the tube, a mixture of metallic powder and mercury between the plugs, choking-coils connected to the plugs, a circuit through the coils, plugs and powder, and means, controlled by the circuit, for shaking the powder.

22. In a receiver for electrical oscillations, the combination of an imperfect electrical contact, choking-coils connected to the contact, a circuit through the coils and contact, a relay controlled by the circuit, and means, controlled by the relay, for shaking the contact.

23. In a receiver for electrical oscillations, the combination of an imperfect electrical contact, a circuit through the contact, an electric trembler shaking the contact, and means for preventing the self-induction of the trembler from affecting the contact.

24. The combination of a transmitter capable of producing electrical oscillations or rays of definite character at the will of the operator, and a receiver located at a distance and having a conductor tuned to respond to such oscillations, a variable-resistance medium in circuit with the conductor, whose resistance is altered by the received oscillations, means, controlled by the received oscillations, for restoring the resistance medium to its normal condition after the reception of such oscillations, and means for rendering the received oscillations manifest.

In witness whereof I have hereunto signed my name, at 18 Finch Lane, in the city of London, the 29th day of January, in the year 1901.

GUGLIELMO MARCONI.

In presence of—
SAMUEL FLOOD PAGE,
HUBERT WILLOUGHBY CORBY.

Disclaimer in Letters Patent Reissue No. 11,913.

DISCLAIMER.

11,913. Reissue. *Guglielmo Marconi*, London, England. TRANSMITTING ELECTRICAL IMPULSES AND SIGNALS AND APPARATUS THEREFOR. Patent dated June 4, 1901.

Disclaimer filed March 10, 1906, by the assignee, Marconi Wireless Telegraph Co.

Enters its disclaimer—

"To said first claim."

"The first claim is as follows:

"1. In an apparatus for communicating electrical signals by means of a producer of Hertz oscillations, and a signaling instrument, the combination, in the receiver, of an imperfect electrical contact, a circuit through the contact, and a receiving instrument operated by the influence of such oscillations on said contact, substantially as and for the purpose described."—[*Official Gazette, March 20, 1906.*]

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2-3

PLAINTIFF'S EXHIBIT #20

Lodge Patent in Suit (609154)

UNITED STATES

DEPARTMENT OF

UNITED STATES PATENT OFFICE.

To all to whom these presents shall come Greeting:

THIS IS TO CERTIFY that the annexed is a true copy from the Records of this Office of the

Letters Patent of

Oliver Joseph Lodge,

Number 609,154, Granted August 16, 1898,

for

Improvement in Electrical Telegraphy.

FILED JAN 11 1923 CLERK DC

IN TESTIMONY WHEREOF I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington, this 23rd day of September, in the year of our Lord one thousand nine hundred and sixteen and of the Independence of the United States of America the one hundred and forty-first.

Acting Commissioner of Patents.

2-370

No. 609,154

THE UNITED STATES OF AMERICA,

TO ALL TO WHOM THESE PRESENTS SHALL COME:

Whereas Oliver Joseph Lodge,

of

Liverpool, England,

has presented to the Commissioner of Patents a petition praying for the grant of Letters Patent for an alleged new and useful improvement in Electric Telegraphy,

a description of which invention is contained in the specification of which a copy is hereunto annexed and made a part hereof, and has complied with the various requirements of law in such case made and provided; and

Whereas upon due examination made the said claimant is adjudged to be justly entitled to a patent under the law;

Now therefore these Letters Patent are to grant unto the said

Oliver Joseph Lodge, his heirs or assigns for the term of seventeen years from the sixteenth day of August, one thousand eight hundred and ninety-eight, the exclusive right to make, use, and vend the said invention throughout the United States and the Territories thereof.

In testimony whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed, at the City of Washington, this sixteenth day of August, in the year of our Lord one thousand eight hundred and ninety-eight, and of the Independence of the United States of America the one hundred and twenty-third.

[Seal]

Webster Davis

Assistant Secretary of the Interior.

COUNTERSIGNED:

A. P. Greeley

Acting Commissioner of Patents.

2220

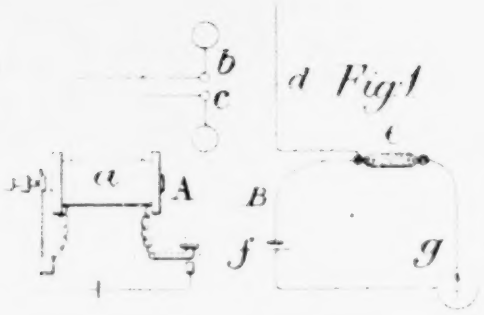
No. 609,154. Patented Aug. 16, 1898.

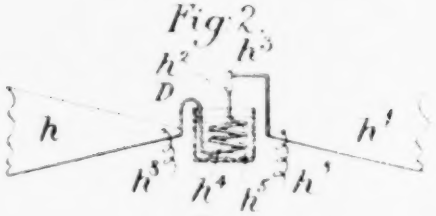
O. J. LODGE.

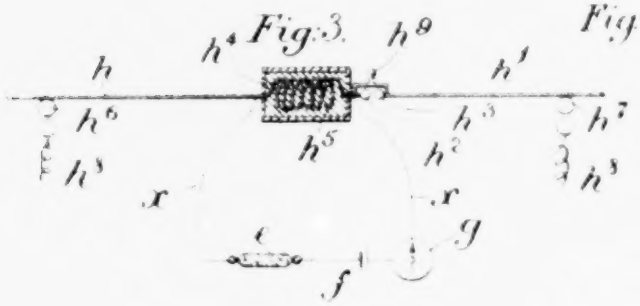
ELECTRIC TELEGRAPHY.

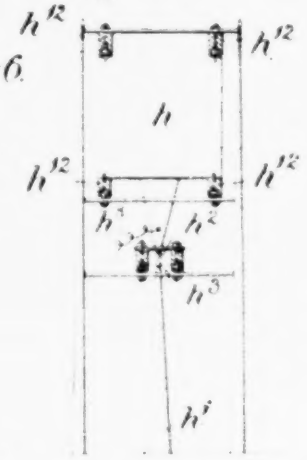
Application filed Feb. 1, 1898.

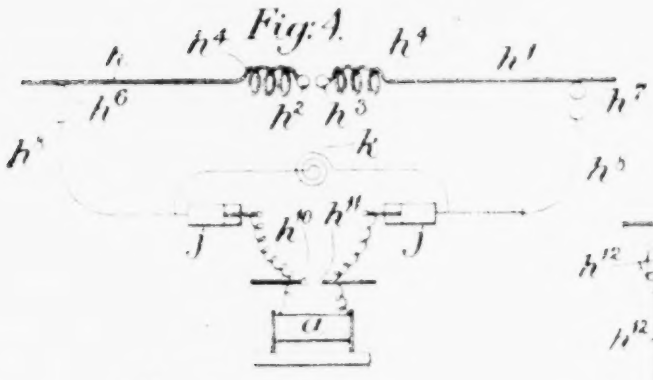
No Model. 2 Sheets—Sheet 1

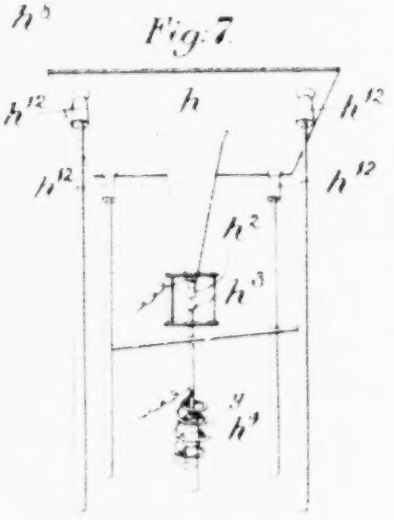


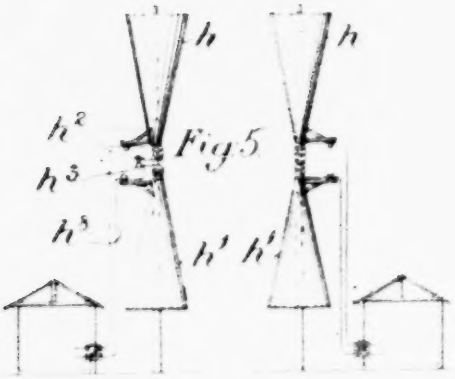












Witnesses:
E. A. Bullock
Maurice Thomas

Inventor
Oliver Joseph Lodge
by his Attorney
Alfred Langton Bigg

2542

No. 609,154. Patented Aug. 16, 1898.

O. J. LODGE.

ELECTRIC TELEGRAPHY.

Application filed Feb. 1, 1898.

(No Model.) 2 Sheets—Sheet 2.

Fig. 8.

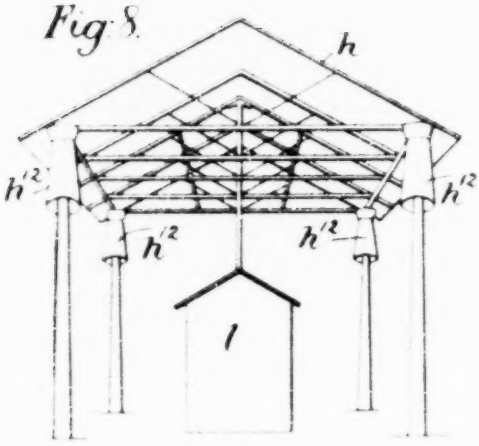


Fig. 9.

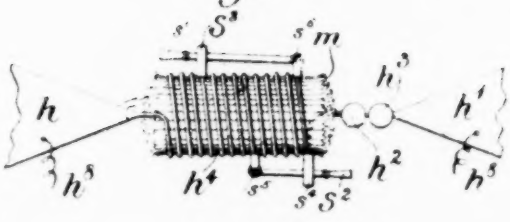


Fig. 12.

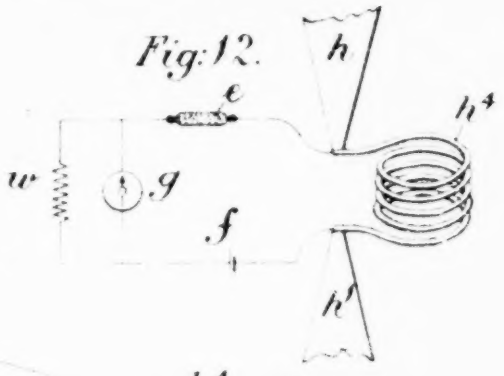


Fig. 10.

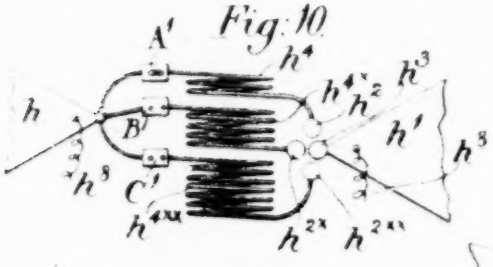


Fig. 11.

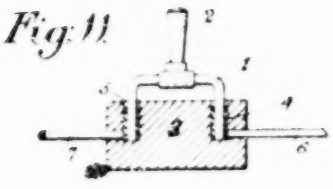
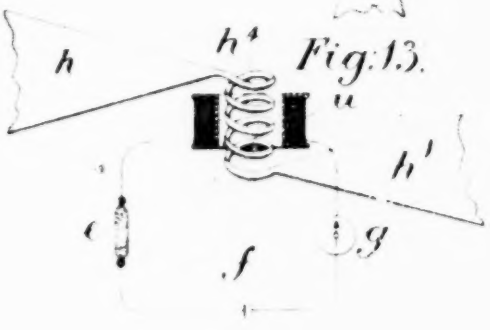


Fig. 13.



Witnesses:
E. A. Bullock
Manner Howard

Inventor:
Oliver Joseph Lodge
By his Attorneys
Baldwin Sundeon & Wright

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UNITED STATES PATENT OFFICE.

OLIVER JOSEPH LODGE, OF LIVERPOOL, ENGLAND.

ELECTRIC TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 609,154, dated August 16, 1898.

Application filed February 1, 1898. Serial No. 668,752. (No model.)

To all whom it may concern:

Be it known that I, OLIVER JOSEPH LODGE, a subject of the Queen of Great Britain, residing at Liverpool, in the county of Lancaster, England, have invented certain new and useful Improvements in Electric Telegraphy, of which the following is a specification.

The object of my invention is to enable an operator, by means of what is now known as "Hertzian wave telegraphy," to transmit messages across space to any one or more of a number of different individuals in various localities, each of whom is provided with a suitably-arranged receiver, and to effect the ancillary improvements the nature of which are hereinafter more particularly described and claimed.

The method of intercommunication consists, according to my invention, in utilizing certain processes and apparatus for the purpose of producing and detecting a sufficiently-prolonged series of rapid electric oscillations and in so arranging them that the excitation of a particular frequency of oscillation at the sending station may cause a telegraphic instrument to respond at a distant station by reason of being associated, through a relay or otherwise, with a subsidiary circuit capable of electric oscillations of that same particular frequency or of some multiple or submultiple of that frequency. Another distant station will similarly be made to receive messages by exciting at the sending-stations alternations of a different frequency, and so on, and thus individual messages can be transmitted to individual stations without disturbing the receiving appliances at other stations which are tuned or timed or syntonized to a different frequency. Each station will usually be provided with both sending and receiving apparatus.

In the accompanying drawings, which are diagrammatic representations, Figure 1 shows the simplest arrangement of emitter and receiver heretofore in use. Figs. 2, 4, 6, 7, 8, 9, and 10 show alternative arrangements to be adopted at signaling-stations or appendages thereto in accordance with my invention. Fig. 3, in addition to showing an emitter, serves to show a receiving-circuit and means whereby parts of the emitting arrangement is utilized for receiving purposes. Fig. 5 depicts the more prominent features of a long-distance arrangement, both sending and receiving. Figs. 12 and 13 illustrate alternative forms of connection of apparatus in a syntonic receiving-circuit with appendages, and Fig. 11 is a detail view hereinafter more particularly referred to.

Like letters and figures of reference indicate similar parts throughout the drawings.

A complete installation of Hertzian-wave telegraphy consists, in its simplest form, of the arrangement depicted in Fig. 1, wherein A represents the emitting apparatus, and B the receiving apparatus.

In the emitter illustrated in Fig. 1 electricity from a suitable source, such as a Ruhmkorff coil *a*, is supplied to a pair of conductors which discharge into each other from knobs *b* and *c* and thus excite oscillations, which emit one or two waves before they are damped out.

The receiving-circuit consists, essentially, of a collector *d*, a coherer *e*, a battery *f* or other suitable source of electrical energy, and a telegraphic receiving instrument *g*, all in electrical connection, as shown.

In carrying out my invention, and referring now to the subsequent figures of the drawings, I use a definite radiator consisting of a conductor or pair of conductors *k k'* of large capacity, arranged either as a Leyden jar or preferably spread out separately in space, one of them being the earth when desired. I join to *k* and *k'*, respectively, which I denominate "capacity areas," a pair of polished knobs *k² k²*, protected by glass from ultra violet light, which form the adjustable spark-gap. Between either capacity area and its knob I place a syntonizing self-inductance coil—that is, a coil of wire or metallic ribbon *k⁴*, preferably insulated with any solid or fluid insulator, as in Fig. 2, or in air, of shape suitable to attain greatest inductance with a given amount of resistance—the object of this coil being to prolong the electric oscillations occurring in the radiator, so as to constitute it a radiator of definite frequency or pitch and obtain a succession of tone-waves emitted, and thereby to render syntony in a receiver possible, because exactitude of re-

sponse depends on the fact that the total number of oscillations in a suitably-arranged circuit is very great, so that a very feeble impulse is gradually strengthened by cumulative action until it causes a perceptible effect on the well-known principle of sympathetic resonance.

I supply the electricity to the radiator from a Ruhmkorff or from a Tesla coil or from a Wimshurst or other known or suitable high-tension machine a in one of three ways, according to circumstances.

The first way is by leading wires from the machine a to the two knobs h^2 h^3, which is the customary plan and gives a discharge which follows upon fairly steady electric strain.

The second way consists, as shown in Fig. 3, in having a supplementary pair of spark-gaps h^6 h^7, (which I call the "supply-gaps,") one knob of each (called the "receiving-knob") being attached to the middle or other convenient point of each capacity area h h', and the other knob of each pair (called the "supply-knobs") being connected by wires h^8 to the Ruhmkorff coil and brought moderately near the first, so that when the coil is in action the capacity areas shall receive their positive and negative charge by aerial disruption—that is, in a sudden manner—rather than by the slower process of metallic conduction, and shall then be left to discharge into each other through the connecting-coil h^4 and across the short spark-gap between the knobs h^2 h^3. The best width of this gap depends upon circumstances, and it may be closed altogether without stopping the action. The gap between the knobs h^2 h^3 may be optionally closed by a shunt h^9.

In the third plan, as indicated in Fig. 4, I interpose in each of the wires h^8 leading from the Ruhmkorff coil a to the supply-knobs a Leyden jar or other suitable condenser j able to stand a high potential, so that the knobs are supplied from the outer—that is, the uninsulated—coat of each jar, while between the inner coats or coil-terminals I arrange a third spark-gap, (called the "starting-gap,") also consisting of suitable knobs h^{10} h^{11}. The outer coats of the jars must not be insulated from each other, and I usually join them by an induction-coil of fairly thin wire k, so as to permit thorough charging. When the discharge occurs, this wire acts as an alternative path or by-pass, but does not prevent the sparks at the supply-gap.

By both of the means described with reference to Figs. 3 and 4 I charge the two capacity areas h h', which together with the uninsulated conductors connected thereto constitute the radiator by a sudden discharge or impulsive rush. The advantage of this is that charges accumulated over a long period of time from a source of small electromotive force can be discharged in a very short time, and therefore with great electromotive force and violence, when supplied by wires in the usual way. Moreover, the capacity areas of a radiator are more conveniently employed as the capacity areas of a receiver without need of disconnection.

The arrangement described with reference to Fig. 4 illustrates most completely the method of charging the capacity areas h h' with an impulsive rush. The action is as follows: The Ruhmkorff machine a charges the jars j, whose outer coats are connected, and discharges them at the starting-gap h^{10}. This spark precipitates a discharge at the supply-gaps h^6 h^7 and suddenly supplies the capacity areas h h' with electric charges, which then surge through the connecting-coil h^4 (divided into two parts in this figure) and spark into each other at the discharge-gap between the knobs h^2 h^3. This last discharge is the chief agent in starting the oscillations which are the cause of the emitted waves; but it is permissible in the arrangements of Figs. 3 and 4 to close this last gap when desired and so leave the oscillations to be started by the sparks at the supply-gaps only, whose knobs must in that case be polished and protected from ultra-violet light, so as to supply the electric charge in as sudden a manner as possible.

As charged surfaces or capacity areas spheres or square plates or any other metal surfaces may be employed; but I prefer, for the purpose of combining low resistance with great electrostatic capacity, cones or triangles or other such diverging surfaces with the vertices adjoining and their larger areas spreading out into space; or a single insulated surface may be used in conjunction with the earth, the earth or conductors embedded in the earth constituting the other oppositely-charged surface.

Radiation from an oscillator consisting of a pair of capacity areas is greater in the equatorial than in the axial direction, and accordingly when sending in all directions is desired it is well to arrange the axis of the emitter vertical. Moreover, radiation polarized in a horizontal plane—that is, with its electric oscillations vertical—is less likely to be absorbed during its passage over partially-conducting earth or water. A pair of insulated capacity areas arranged for long-distance signaling is shown on the left-hand side of Fig. 5. Fig. 6 shows a single insulated capacity area h with the earth acting as the other surface and leading up to the spark-knobs h^2 h^3 by a triangular sheet or cone h, so as to afford good conductance even to rapidly-alternating currents. The wire h^8 in this case leads to one terminal of the Ruhmkorff coil, the other terminal of which is taken to earth. The capacity area h is insulated, as indicated at h^{12}.

in Fig. 7, where instead of being vertical, as shown in Fig. 6, the capacity area h is slanting or horizontal.

In Fig. 7 the syntonizing-coil h^4 is shown as surrounding a large telegraph-insulator g, which insulator divides the upper from the lower part of the rod carrying the discharge-knob h^3. The spiral h^4 bridges over the gap thus caused, uniting the rod above and below the insulator and so affording an earth connection.

Fig. 8 shows an insulated metal surface in the form of a roof of a shed or building which may be used as a capacity area, with suitable connection and apparatus (not shown) inside the little house l.

The self-inductance coil represented at h^4 in all applicable figures is a coil of highly-conducting wire or ribbon, well insulated by air or by some other medium, as already described, or else covered to a sufficient thickness with insulating material of such shape as to have maximum self-inductance for a given resistance, and it may be either a flat coil inclosing a considerable plane area or it may be a cylindrical coil wound upon a finely-subdivided iron core, as shown at m in Fig. 9, the core being either ring-shaped or U-shaped or straight.

The discharge-knobs h^2 h^3 may be arranged at one end of such coil, as shown in Figs. 2, 3, 7, and 9, or the coil may be in two halves with the knobs inserted in the middle, at pleasure. (See Figs. 4 and 5). Several such coils h^4 h^{4x} h^{4xx}, with their knobs h^2, h^{2x}, and h^{2xx}, may, as shown in Fig. 10, be arranged for use with a single pair of capacity areas, and any one of them may be brought into action by a suitable switch, so that the desired frequency of vibration or syntony for a particular distant station is attained by replacing one coil by another, for the frequency can be adjusted either by varying the capacity of the condenser or jar or other conductor employed or the charged body on the one hand or by varying the number and position of coils or other portion of the discharge-circuit on the other. That discharger is in action whose spark-gap is allowed to operate, and a switch A B C can determine which of a set of different coils shall be utilized for a given distant station. Fig. 11 illustrates the form of switch indicated in Fig. 10.

In Fig. 11 the numeral 1 designates a metallic union piece, 2 is its handle, of insulating material, and 3 is a suitable insulating base. The union-piece 1 dips into mercury-cups 4 and 5, with which the leads 6 and 7 are connected.

A plan alternative to that described with reference to Fig. 10 is to connect the capacity areas through one pair of knobs and a single large coil of a considerable number of turns, as shown in Fig. 9, and to have keys or plugs or switches s^3 and s^4, whereby some of the spires or turns of the coil can be shunted out of action, so that the whole or any smaller portion of the inductance available may be used in accordance with the correspondingly-attuned receiver at the particular station to which it is desired to signal.

Fig. 9 shows two hand-levers s^3 s^4 hinged, respectively, to the coil at s^5 s^6. The bar of each lever is made of metal, while the handle is of insulating material. s^3 s^4 are movable metallic spring-clips connected to the said coil and adapted to grip the levers when they are depressed, so as to make good contact. Thus each lever when pressed down shuts out all the spires of the coil between the two ends of such lever. This arrangement may be used either in lieu of or in combination with interchangeable inductance-coils, such as shown in Fig. 10, and in the latter case they are useful for correcting slight errors in tuning for any one station. The one I call an "adjustable" coil and the other I call "replaceable" or "interchangeable" coils, and both, since they tend to a like end and behave similarly, may be included by the term "variably-acting" coil.

A receiver or resonator consists of a similar pair of capacity areas connected by a similarly-shaped conductor or self-inductance coil, the whole constituting an absorber arranged so as to have precisely the same natural frequency of electrical vibration as the radiator in use at the corresponding emitting-station, so that it can accumulate the received impulses—that is to say, can act cumulatively; but it must not have a spark-gap, such as h^2 h^3, or if it have a spark-gap the same must be carefully closed or shunted or bridged across by a good short conductor—for example, like Fig. 11—before the arrangement can be properly used as a cumulative receiver. Identically the same capacity areas and self-inductance coil can be used at will either as emitter or as receiver—that is, either as radiator or as resonator (see Fig. 5)—if it be convenient to do so, on condition that the "discharge" spark-gap h^2 h^3 of the radiator is perfectly closed whenever acting as receiver.

Thus referring to Fig. 3 it will be seen that that diagram illustrates a combined emitting and receiving apparatus. When in use as a radiator, the gap between the discharge-knobs h^2 h^3 is left open. When utilized as a resonator, the said gap is closed by the shunt h^5, (there supposed to be like Fig. 11,) and the coherer c, battery f, and telegraphic receiving instrument g are connected through a thin wire x from each end of the coil h^4—that is, from each of the capacity areas.

If the Ruhmkorff machine a has been actually connected to the capacity areas h h, as in Fig. 2, then it must be detached and substituted by the coherer-circuit when a receiver is wanted, but if the charge was supplied through supply gaps h^5 h^5, as in Figs. 3 and 4, (and this is the best plan,) then the Ruhm-

korff connections can be left unaltered, as the action of the resonator is then in no way affected, provided always that the coil is not put into activity while the receiving-circuit is connected up.

A coherer consists of any arrangement which drops in resistance on receipt of an electric impulse and rises to its old resistance on being subjected to a mechanical impulse, such as a tremor or a tap.

A coherer-circuit is any known arrangement for observing or recording effects due to fluctuations in the electrical resistance of a coherer.

As coherer I use either a light single-point contact or Branly's arrangement of a pair of conductors embedded in metallic grains or powder or filings; but I prefer selected iron-filings of uniform size sealed up in a good vacuum and with the communicating surfaces or electrodes reduced to points or thin platinum wires fused into the glass and with their ends close together; or I may use any other suitable apparatus with an appropriate device for tapping back. In some cases I find that a coherer restores itself sufficiently without specially-arranged tremor and that in these cases a telephone is the quickest responder that can be used.

As coherer-circuit I usually arrange the coherer in simple series with a battery (voltaic or thermal) and a galvanometer, telephone, or other indicator, or a recorder of fluctuations of current, and I then connect the terminals of this series of instruments to the capacity areas of the receiver close to its self-inductance coil, so that this same coil of wire completes and forms an essential part of the coherer-circuit. The coherer is thus affected by every electrical disturbance occurring in the connecting-coil or in its capacity areas and by aid of the battery at once enables the telegraphic or telephonic instrument to appreciate and indicate the signals. This plan is shown in Figs. 3 and 12. It is an improvement on any mode of connection that has previously been possible without the connecting-coil.

In some cases I may, as shown in Fig. 13, surround the syntonizing-coil of the resonator with another or secondary coil *u* (constituting a species of transformer) and make this latter coil part of the coherer-circuit, so that it shall be secondarily affected by the alternating currents excited in the conductor of the resonator, and thus the coherer be stimulated by the current in this secondary coil rather than primarily by the currents in the syntonizing-coil itself, the idea being thus to leave the resonator freer to vibrate electrically without disturbance from attached wires.

In all cases it is permissible and sometimes desirable to shunt the coils of the telegraphic instrument by means of a resistance or a capacity, as shown at *w* in Fig. 12, in order to connect the coherer more effectively and closely to the capacity areas or receiving arrangement whereby it is to be stimulated.

What I claim, and desire to secure by Letters Patent of the United States, is—

1. In a system of Hertzian-wave telegraphy, the combination, with a pair of capacity areas, of a self-inductance coil inserted between them electrically for the purpose of prolonging any electrical oscillations excited in the system and constituting such a system a radiator of definite frequency or pitch.

2. In a system of Hertzian-wave telegraphy, the combination, with a pair of capacity areas, of a self-inductance coil inserted between them electrically for the purpose of prolonging any electrical oscillations excited in the system, thus constituting the system a resonator or absorber of definite frequency or pitch, and a distant radiator of corresponding period capable of acting cumulatively.

3. In a system of Hertzian-wave telegraphy, the combination, with a pair of capacity areas, of electrical means having a spark-gap inserted between them and serving to syntonize them and means for bridging or shunting the spark-gap, whereby the apparatus is adaptable for use at will either as a radiator or resonator.

4. In a system of Hertzian-wave telegraphy, the combination, with a pair of capacity areas, of a number of self-inductance coils having different amounts of self-induction each of which is capable of being switched in or out of circuit, serving to syntonize any such radiator to a corresponding resonator or vice versa, whereby signaling may be effected between any two or more correspondingly-attuned stations without disturbing other differently-attuned stations.

5. In a system of Hertzian-wave telegraphy, the combination, with a pair of capacity areas, of a variably-acting self-inductance coil, serving to syntonize such a radiator or resonator to any other such resonator or radiator, whereby signaling may be effected between any two or more correspondingly-attuned stations without disturbing other differently-attuned stations.

6. In combination, a pair of capacity areas connected by a coil of wire serving as the radiator in a system of Hertzian-wave telegraphy, means for syntonizing such radiator, and means for charging it by aerial disruption or impulsive rush.

7. In a system of Hertzian-wave telegraphy, the combination of a pair of capacity areas such as *h*, *h*, means for syntonizing such capacity areas, a receiving-circuit completed through one or both of such capacity areas, and means for bridging over the discharge-gap between such capacity areas when they are to be used as a receiver, whereby such capacity areas are rendered adaptable for use at will either as a radiator or resonator.

8. In combination, in a system of syntonic Hertzian-wave telegraphy, a pair of capacity areas, a self-inductance coil and a secondary

coil surrounding said self-inductance coil, which secondary coil forms part of the coherer-circuit substantially as and for the purpose set forth.

9. The combination, in the receiving-circuit of a system of Hertzian-wave telegraphy, of a variably-acting self-inductance coil, connecting the capacity areas, a coherer, a battery, a receiving instrument, and a shunt across the coils thereof substantially as and for the purpose set forth.

In testimony whereof I have hereunto subscribed my name.

OLIVER JOSEPH LODGE.

Witnesses:
A. F. SPOONER,
J. SUTTON.

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PLAINTIFF'S EXHIBIT # 21
Marconi patent in suit (763,772)

UNITED STATES

DEPARTMENT OF

UNITED STATES PATENT OFFICE.

To all to whom these presents shall come, Greeting:

THIS IS TO CERTIFY that the annexed is a true copy from the Records of this Office of the

Letters Patent of

Guglielo Marconi, Assignor to

Marconi's Wireless Telegraph Company, Limited,

FILED
JAN 11 1923
COURT OF CLAIMS

Number 763,772, Granted June 28, 1904,

for

Improvement in Apparatus for Wireless Telegraphy.

IN TESTIMONY WHEREOF I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington, this 23rd day of September, in the year of our Lord one thousand nine hundred and sixteen and of the Independence of the United States of America the one hundred and forty-first.

Acting Commissioner of Patents.

6—1628

2—370.

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No. 763,772,

THE UNITED STATES OF AMERICA,

TO ALL TO WHOM THESE PRESENTS SHALL COME:

Whereas Guglielmo Marconi,

of

London, England,

has presented to the Commissioner of Patents a petition praying for the grant of Letters Patent for an alleged new and useful improvement in Apparatus for Wireless Telegraphy,

He having assigned his right, title, and interest in said improvement to Marconi's Wireless Telegraph Company, Limited, of London, England,

a description of which invention is contained in the specification of which a copy is hereto annexed and made a part hereof, and has complied with the various requirements of law in such case made and provided; and

Whereas upon due examination made the said claimant is adjudged to be justly entitled to a patent under the law;

Now therefore these Letters Patent are to grant unto the said

Marconi's Wireless Telegraph Company, Limited, their heirs or assigns for the term of seventeen years from the twenty-eighth day of June, one thousand nine hundred and four, the exclusive right to make, use, and vend the said invention throughout the United States and the Territories thereof.

In testimony whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed, at the City of Washington, this twenty-eighth day of June, in the year of our Lord one thousand nine hundred and four and of the Independence of the United States of America the one hundred and twenty-eighth.

[Seal]

E. B. Moore

Acting Commissioner of Patents.

No. 763,772. PATENTED JUNE 28, 1904. 2590

G. MARCONI.

APPARATUS FOR WIRELESS TELEGRAPHY.

APPLICATION FILED NOV 10, 1900

NO MODEL.

Fig. 1.

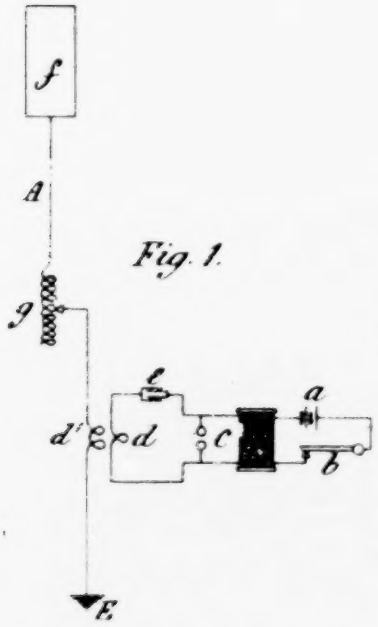


Fig. 2.

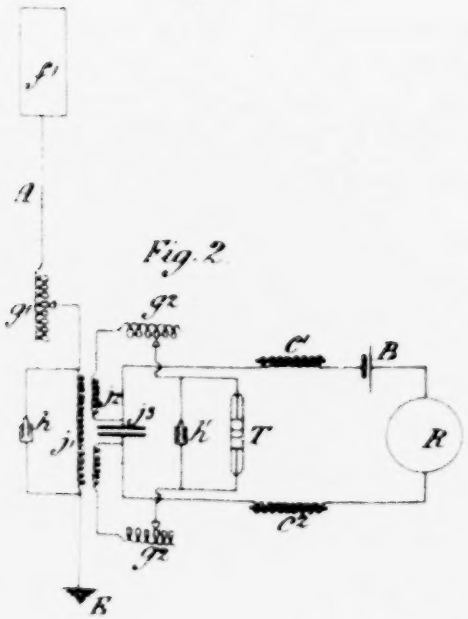


Fig 3

Fig 4

Fig 5

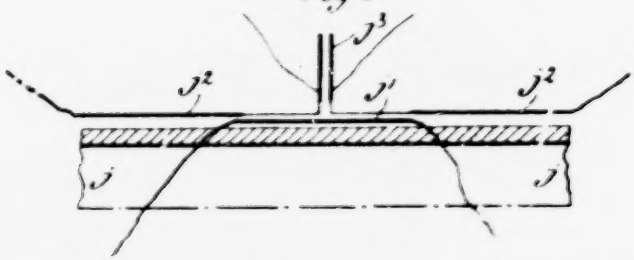


Fig 6.

Fig 7.

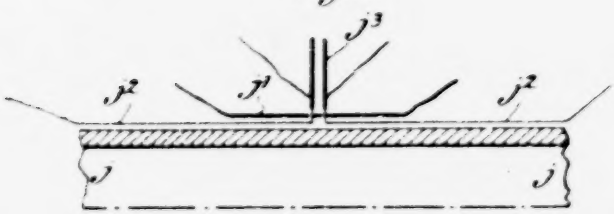
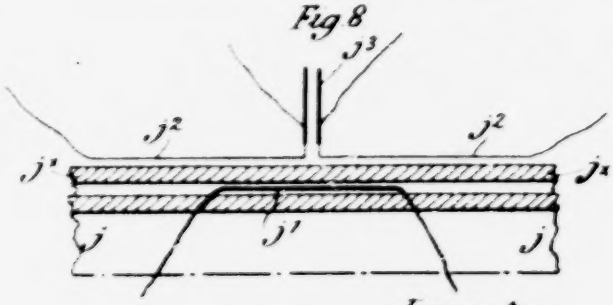


Fig 8.



Witnesses

Inventor

GUGLIELMO MARCONI,

Bakewell Bakewell & Hayford & Dyer

UNITED STATES PATENT OFFICE.

GUGLIELMO MARCONI, OF LONDON, ENGLAND, ASSIGNOR TO MARCONI'S WIRELESS TELEGRAPH COMPANY, LIMITED, OF LONDON, ENGLAND.

APPARATUS FOR WIRELESS TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 763,772, dated June 28, 1904.

Application filed November 10, 1900. Serial No. 36,010. No model.

To all whom it may concern:

Be it known that I, GUGLIELMO MARCONI, electrician, a subject of the King of Italy, residing and having a post-office address at 18 Finch Lane, Threadneedle street, in the city of London, England, have invented certain new and useful Improvements in Apparatus for Wireless Telegraphy, of which the following is a specification.

My invention relates to apparatus for communicating electrical signals without wires and by means of Hertz oscillations or electric waves; and the object of the invention is to increase the efficiency of the system and to provide new and simple means whereby oscillations or electric waves from a transmitting-station may be localized when desired at any one selected receiving station or stations out of a group of several receiving-stations.

In my prior United States patent No. 586,193 (Reissue No. 11,913, dated June 4, 1901) I have shown and described the combination at a transmitting-station of an oscillation-producer, such as an induction-coil, having one end of its secondary coil connected to one contact of a spark-producer and to the earth and having the other end of the said secondary connected to the opposite contact of the spark-producer and to a vertical wire or elevated plate, and I have further shown at a receiving-station an imperfect contact connected in circuit with a vertical receiving-wire and with the earth. According to the present invention the system includes at the transmitting-station the combination, with an oscillation-transformer of a kind suitable for the transformation of very rapidly alternating currents, of a persistent oscillator, and a good radiator, one coil of said transformer being connected between the aerial wire or plate and the connection thereof to earth, while the other coil of the transformer is connected in circuit with a condenser, a [illegible] of Hertzian oscillations or electric waves shown in the form of a spark-producer, and an induction-coil (constituting the persistent oscillator) controlled by a signaling instrument. The complete system also includes at a receiving-station an oscillation-transformer one coil whereof is included between the aerial receiving-wire and earth, constituting a good absorber of electrical oscillations, while a device responsive to electric waves, such as an imperfect contact or a device for operating the same, is included in a circuit with the other coil of said transformer. The system also requires as essential elements thereof the inclusion in the lines (at both stations) from the aerial conductor to the earth of variable inductances and the use at both stations of means for varying or adjusting the inductance of the two circuits at each station to accord with each other. By this arrangement of apparatus I am able to secure a perfect "tuning" of the apparatus at a transmitting-station and at one or more of a number of receiving-stations.

Referring to the accompanying drawings, Figure 1 indicates diagrammatically the arrangement of apparatus at a transmitting-station. Fig. 2 indicates diagrammatically the arrangement of apparatus at a receiving-station. Figs. 3 and 4 are views, plan and side, of the preferred form of transformer at the transmitting-station. Figs. 5, 6, 7, and 8 are diagrammatic views of forms of transformers at the receiving-station.

The transmitting-station is provided under my present invention with a source *a* of current electrically connected in circuit with the primary of an induction-coil *c* and with a circuit-closing key *b* or otherwise controlled by a signaling instrument. In the secondary circuit of said induction-coil the spherical terminals or other contacts of a spark-producer or other electric-wave or oscillation producer are included with a shunt therefrom, in which shunt is included the primary coil *d* of an oscillation-transformer, such as *C*. A condenser *e*, preferably one provided with two telescoping metallic tubes separated by a dielectric and arranged to readily vary the capacity by being slid upon each other, is included in one connection from the induction-coil to the transformer winding *d*. The secondary coil *f* of the transformer is connected at one end to the earth E and at its other end to a vertical wire V or an elevated plate *g*.

It is also [illegible] of the induction-

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coil and associated parts for producing the electric waves or oscillations I may use any other proper means for producing such waves or oscillations—such, for instance, as a generator of alternating electric currents.

The illustrated arrangement of parts at a transmitting-station enables much more energy to be imparted to the radiator *f*, the approximately closed circuit of the primary being a good conserver and the open circuit of the secondary being a good radiator of wave energy. My experiments have demonstrated that the best results are obtained at the transmitting-station when I use a persistent oscillator—an electrical circuit of such a character that if electromotive force is suddenly applied to it and the current then cut off electrical oscillations are set up in the circuit which persist or are maintained for a long time—in the primary circuit and use a good radiator—*i. e.*, an electrical circuit which very quickly imparts the energy of electrical oscillations to the surrounding ether in the form of waves—in the secondary circuit.

In operation the signaling-key *b* is pressed, and this closes the primary of the induction-coil. Current then rushes through the transformer-circuit and the condenser *e* is charged and subsequently discharges through the spark-gap. If the capacity, the inductance, and the resistance of the circuit are of suitable values, the discharge is oscillatory, with the result that alternating currents of high frequency pass through the primary of the transformer and induce similar oscillations in the secondary, these oscillations being rapidly radiated in the form of electric waves by the elevated conductor.

For the best results and in order to effect the selection of the station or stations whereat the transmitted oscillations are to be localized I include in the open secondary circuit of the transformer, and preferably between the radiator *f* and the secondary coil *d*, an inductance-coil *a*, Fig. 1, having numerous coils, and the connection is such that a greater or less number of turns of the coil can be put in use, the proper number being ascertained by experiment.

At the receiving-stations employing my present invention I prefer to use a receiver such as those described in my several United States Patents, Nos. 586,193, 627,650, 647,007, 647,676, 647,699, and 668,315, capable of being affected by electrical waves or oscillations of high frequency.

As a responder to electric waves I may use at the receiving-station any of the now well-known forms of such devices, such as those which depend for their action on the reduction of the resistance of a metallic microphone by the action of electric waves or "coherers," for a form of which is disclosed in my Patent No. 645,576. I may employ one which depends for its action on the increase of the resistance of the device under the influence of the electric waves or "anticoherers," such as described by Branly in *La Lumière Electrique* of June 13, 1891, or I may use those which depend upon the action of an electric wave as a magnetizing or demagnetizing agency, such as I have disclosed in my application Serial No. 132,974, filed November 28, 1902, or I may use various other well-known devices, such as the electrolytic, electrothermal, electromagnetic, or electrodynamic responders.

Referring to Fig. 2, *f'* indicates a plate or cylinder (not essential at either transmitter or receiver) at the upper end of an elevated conductor A, which is connected to the primary coil *j'* of a transformer or induction-coil and thence to earth E. In a shunt around said primary *j'* I usually place a condenser *h*, preferably similar in construction and operation to the condenser *e*. An inductance-coil *g'* of variable inductance is interposed in the primary circuit of the transformer, being preferably located between the cylinder *f'* and the coil *j'*, and the inductance of said coil may be adjusted in accordance with the method described by me in my Letters Patent of the United States No. 676,332 to harmonize with the inductance of coil *g* at the transmitting-station, Fig. 1 of the accompanying drawings, or with that of the coil or coils at one or more of the transmitting-stations included in the communicating system.

The secondary coil *j*² of the transformer is wound in two parts, preferably as described in my United States Letters Patent No. 668,315, dated February 19, 1901, and the outer ends of said coil are connected in certain cases through one or more interposed inductance-coils *g*², preferably of variable inductance, with the terminals of a coherer T or other detector of electrical oscillations. The inner ends of the split secondary coil are connected to the plates of a condenser *j*³. A condenser *h'* is sometimes included in a shunt around the detector T. B is a battery, and R a relay connected to the condenser *j*³ and controlling a telegraphing instrument or a printing device. *c'* and *c*² are choking-coils preventing oscillations from the secondary *j'* running into the battery-circuit, and thereby confining them to the wave-responsive device.

The capacity and self-induction of the four circuits—*i. e.*, the primary and secondary circuits at the transmitting-station and the primary and secondary circuits at any one of the receiving-stations in a communicating system—are each and all to be so independently adjusted as to make the product of the self-induction multiplied by the capacity the same in each case or multiples of each other—that is to say, the electrical time-periods of the four circuits are to be the same or octaves of each other.

In employing this invention to localize the

transmission of intelligence at one of several receiving-stations the time period of the circuits at each of the receiving-stations is so arranged as to be different from those of the other stations. If the time periods of the circuits of the transmitting-station are varied until they are in resonance with those of one of the receiving-stations, that one alone of all of the receiving-stations will respond, provided that the distance between the transmitting and receiving stations is not too small.

The adjustment of the self-induction and capacity of any or all of the four circuits can be made in any convenient manner and employing various arrangements of apparatus, those shown and described herein being preferred. In practice I have found the following preferred details of arrangements of apparatus to work well: The aerial conductors A at all stations and the conductor for the transformer-windings at the receiving-stations are composed of seven strands of copper wire .889 millimeters in diameter. The transformer at the transmitting-station may be of any of the following forms:

1. Around a block or core d^3, preferably a square block say .17 meters wide of insulating material is wound a primary coil d in length .946 meters, while the secondary d' consists of two turns or squares, one lying on each side of the primary. (See Figs. 3 and 4.) The insulation of both primary and secondary consists of 1.25 millimeters of rubber and one millimeter of jute, making a total thickness of 2.25 millimeters.

2. A transformer in all essential respects similar to 1, but with a primary of 1.93 meters and the core or block on which both primary and secondary are wound, is .3048 meters wide.

3. A transformer having a cylindrical core 10.16 centimeters in diameter and with a primary having ten turns wound thereon; over this, but separated by two millimeters of paper or other insulant, the secondary, also of ten turns.

Various forms of transformers, &c., which may be employed by me are described in my British Patent No. 7,777 of 1890.

The inductance-coils g and g' are preferably of copper wire 6.25 millimeters in diameter, wound on a cylinder 10.64 centimeters in diameter, with an interval of 2.28 millimeters between adjacent turns. The inductance-coils g^2 at the receiving-station are preferably of silk-covered copper wire .19 millimeter diameter wound upon cylinders 3.7 centimeters in diameter.

Various forms of induction-coils f f' may be used. Figs. 5, 6, 7, and 8 show details of different forms. The figures show diagrammatically greatly-enlarged longitudinal sections not strictly to scale. Instead of showing the section of each coil or layer of wire as a longitudinal row of dots or small circles, as it would actually appear, it is for simplicity shown as a continuous longitudinal straight line.

Referring to Fig. 5, the primary f' preferably consists of 3.046 meters of silk-covered copper wire, say, and seventy-one millimeters in diameter wound in one layer on a core of ebonite or other insulating material 2.9 centimeters in diameter. Insulating material is wound over and on each side of this, so as to make a cylindrical core, say, 3.13 centimeters in diameter, on which is wound the secondary, each half of which consists of 6.4 meters of silk-covered copper wire .19 millimeter in diameter joined to 13.41 meters of silk-covered copper wire .37 millimeter in diameters wound in the same sense as the primary, the thinner wire being over the primary and the thicker being beyond the ends thereof.

The form of induction-coil shown in Fig. 6 has a primary of one hundred turns of copper wire .027 centimeters in diameter wound on a core f (2.9 centimeters in diameter) with a single silk covering and coated with paraffin-wax. The secondary f' is of copper wire .013 in diameter, insulated with a single silk covering, and is wound over the primary, commencing in the middle and in the same way as the primary. Each half of the secondary is in layers of the following number of turns: first layer, seventy-seven turns; second layer, forty-nine turns; third layer, forty-six turns; fourth layer, forty-three turns; fifth layer, forty turns; sixth layer, thirty-seven turns; seventh layer, thirty-four turns; eighth layer, thirty-one turns; ninth layer, twenty-eight turns; tenth layer, twenty-five turns; eleventh layer, twenty-two turns; twelfth layer, nineteen turns; thirteenth layer, sixteen turns; fourteenth layer, thirteen turns; fifteenth layer, ten turns; sixteenth layer, seven turns; and seventeenth layer, three turns, making five-hundred turns in all.

A third form of induction-coil (shown in Fig. 7) has a primary of 3.048 meters of silk-covered copper wire .19 millimeter in diameter and a secondary of 30.48 meters of silk-covered copper wire .1 millimeter in diameter wound in one layer on a core four centimeters in diameter, the primary being in one layer outside of the secondary.

The fourth form of induction-coil is shown in Fig. 8. Its primary consists of 3.048 meters of silk-covered copper wire .27 millimeter in diameter wound on a core 2.9 centimeters in diameter and inserted in a tube f^3 of four centimeters external diameter, on which is wound the secondary of 27.432 meters of silk-covered copper wire .12 millimeter in diameter, the break at the middle of the secondary being over the middle of the primary.

Other forms of transformers which may be employed by me are described and claimed in my British Patent No. 7,777 of 1890.

The following tables give preferred adjustments, those details opposite any tune in the transmitting-station table being of course used in connection with those opposite the same tune in the receiving-station table:

Transmitting-Station.

Tune	Aerial conductor	Transformer d d'	Inductance number of turns d g inclusive	Capacity microfarads c	Length of spark in millimeters
No. 1	30.578 meters of cable	No. 1	None.	.007934	3
No. 2	do	No. 1	45	.016896	4
No. 3	do	No. 2	None	.004112	3
No. 4	do	No. 2	100	.016949	4
No. 5	Zinc cylinder 9.144 meters long, 1.524 meters in diameter and hoisted 3.048 meters above ground.	No. 3	None	.001630	12.5
No. 6	30.48 meters of cable	No. 3	None.	.000678	4

Receiving-Station.

Tune	Induction coil	Capacity in microfarads of—		Inductance introduced in—	
		A.	A	g' Number of turns.	g^2.
No. 1	No. 1	Omitted.	Omitted.	None	None
No. 2	No. 1	Omitted.	.0004	45	None
No. 3	No. 2	.006	Omitted.	Up to 21 may be inserted.	None.
No. 4	No. 2	.006	Omitted.	100	2 coils of 15.24 meters at each end of secondary
No. 5	No. 3	Omitted.	Omitted.	None	None
No. 6	No. 4	Omitted.	Omitted.	None	None

It will be observed that both the transmitter and the receiver are the same for tunes 1 and 2 and that when the capacity of the condenser c is varied the two stations can be brought into tune by including forty-five turns of each of the coils g g' and by introducing a condenser h of small capacity in parallel with the coherer T. Similarly the transmitter and receiver are the same for tunes 3 and 4, and when the capacity of c is varied the stations are tuned by including one hundred turns of each of the coils g and g' and by also including the coils g^2.

While I have herein shown and described details of construction and of arrangement found by me to be useful, yet I do not wish to be understood as confining my claims thereto. Obviously modifications which are within my invention will readily suggest themselves to skilled persons.

What I claim is

1. At a station employed in a wireless-telegraph system, a signaling instrument comprising an induction-coil, the secondary circuit of which includes a condenser discharging through a means which automatically causes oscillations of the desired frequency; an open circuit electrically connected with the oscillation-producer aforesaid and a variable inductance included in the open circuit, substantially as and for the purpose described.

2. At a station employed in a wireless-telegraph system, an oscillation-receiving conductor, a variable inductance connected with said conductor; a wave-responsive device electrically connected with said conductor and in circuit with a condenser, substantially as and for the purpose described.

3. At a station employed in a wireless-telegraph system, a signaling instrument comprising an induction-coil, the secondary circuit of which includes a condenser discharging through a means which automatically causes oscillations of the desired frequency, and the

primary circuit of which includes a generator; means for varying the primary circuit; an open circuit electrically connected with the oscillation-producer aforesaid, and a variable inductance included in the open circuit, substantially as and for the purpose described.

4. In a system of syntonic wireless telegraphy, a circuit so arranged as to form a persistent oscillator, a circuit so formed as to constitute a good radiator in inductive relation thereto, means for inducing in the oscillator-circuit electric undulations of a predetermined period, and means for attuning the natural period of vibration of each of said circuits to the period of the undulations so induced.

5. An element of an apparatus employed in a system of telegraphy by electric waves or oscillations of high frequency, comprising a conductor elevated at one end and connected to capacity at the other end, said conductor including a variable inductance and an element having appreciable capacity.

6. At a transmitting-station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating-conductor at one end and capacity at the other end, and whose primary is connected to a condenser-circuit discharging through a means which automatically causes oscillations of the desired frequency, and means for adjusting the oscillation period of each of the two circuits connected with the transformer to bring them into accord with each other, substantially as described.

7. An element of an apparatus employed in a system of telegraphy by electric waves or oscillations of high frequency, comprising an open circuit so arranged as to constitute a radiator of such waves or oscillations, and means for varying at will the natural period of vibration of the said circuit.

8. At a transmitting-station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating-conductor at one end and capacity at the other end, a variable inductance being included in said circuit, and whose primary is connected to a condenser-circuit discharging through a means which automatically causes oscillations of the desired frequency, substantially as described.

9. At a transmitting-station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating-conductor at one end and capacity at the other end, a variable inductance being included in said circuit, and whose primary is connected in series with an adjustable condenser and with a means which automatically causes oscillations of the desired frequency, substantially as described.

10. A system of wireless telegraphy, in which the transmitting-station and the receiving-station each contains an oscillation-transformer, one circuit of which is an open circuit and the other a closed circuit, the two circuits at each station being in electrical resonance with each other and in electrical resonance with the circuits at the other station, substantially as described.

11. In apparatus for communicating electrical signals, the combination, with an oscillation-transformer, at a transmitting-station, of an induction-coil; an electric circuit containing the secondary of said coil, a condenser and the primary coil of the oscillation-transformer; a producer of electric waves of high frequency electrically connected with the secondary of the induction-coil; a signaling instrument in circuit with the primary of the induction-coil; the secondary coil of the oscillation-transformer electrically connected, at one end to capacity and, at the other end, to an inductance, and an aerial conductor connected to the inductance, substantially as and for the purpose described.

12. In apparatus for communicating electrical signals, the combination, with an oscillation-transformer, at a transmitting-station of an induction-coil; an electric circuit containing the secondary of the said coil a condenser and the primary coil of the oscillation transformer; a producer of electric waves of high frequency connected with the secondary of the induction-coil; a signaling instrument in circuit with the primary of the induction-coil; the secondary coil of the oscillation-transformer electrically connected, at one end, to capacity and, at the other end, to a variable inductance, and an aerial conductor connected to the variable inductance, substantially as and for the purpose described.

13. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit, connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a variable inductance being included in said circuit, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and a condenser in circuit with the wave-responsive device, substantially as described.

14. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and means for adjusting the two transformer-circuits in electrical resonance with each other, substantially as described.

15. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a condenser located in said circuit between the coil and the capacity, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and means for adjusting the two transformer-circuits in electrical resonance with each other, substantially as described.

16. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, an adjustable condenser in a shunt connected with the open circuit and around said transformer-coil, a wave-responsive device electrically connected with the other coil of the oscillation-transformer, and means for adjusting the two transformer-circuits in electrical resonance with each other, substantially as described.

17. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and means included in each of said transformer-circuits, for adjusting said circuits in electrical resonance with each other, substantially as described.

18. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end, and capacity at the other end, a variable inductance being included in said open circuit, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and a variable inductance included in circuit with the wave-responsive device, substantially as described.

19. In a system of wireless telegraphy, the combination at a receiving-station, of an oscillation-transformer; an open circuit comprising, in part, an aerial conductor connected with one end of the primary coil of the oscillation-transformer; a connection from the other end of said coil to capacity; a variable inductance in said open circuit; and electrical connections from the secondary coil of the oscillation-transformer to a receiving instrument, battery, condenser, wave-responsive device and a variable inductance, substantially as and for the purpose described.

20. In a system of wireless telegraphy, a transmitting-station containing an oscillation-transformer, the primary of which is connected to a condenser-circuit discharging through a spark-gap which automatically causes electric waves of the desired frequency, the secondary of said transformer connected to an open circuit including a radiating-conductor, and with a capacity and a coil for charging the condenser aforesaid; a receiving-station containing an oscillation-transformer, the primary of which is connected with an oscillation-receiving conductor and with a capacity, a wave-responsive device connected with the secondary of said transformer, and a receiving instrument connected with the wave-responsive device, all in combination with means for bringing the four transformer-circuits, two at each station, into electrical resonance with each other, substantially as described.

GUGLIELMO MARCONI.

Witnesses:
R. B. RANSFORD,
C. E. WARREN.

PLAINTIFF'S EXHIBIT #22.
Fleming patent in suit (803,684)

2--3

UNITED STATES

DEPARTMENT OF

UNITED STATES PATENT OFFICE.

To all to whom these presents shall come, Greeting:

THIS IS TO CERTIFY that the annexed is a true copy from the Records of this Office of the

Letters Patent of

John Ambrose Fleming, Assignor to

Marconi Wireless Telegraph Company of America,

FILED
JAN 11 1923
COURT OF CLAIMS

Number 803,684, Granted November 7, 1905,

for

Improvement in Instruments for Converting Alternating Electric Currents into Continuous Currents.

IN TESTIMONY WHEREOF I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington, this 27th day of September, in the year of our Lord one thousand nine hundred and sixteen and of the Independence of the United States of America the one hundred and forty-first.

Commissioner of Patents.

6—1923

No. 803,684.

THE UNITED STATES OF AMERICA,

TO ALL TO WHOM THESE PRESENTS SHALL COME:

Whereas John Ambrose Fleming,

of

London, England,

has presented to the Commissioner of Patents a petition praying for the grant of Letters Patent for an alleged new and useful improvement in Instruments for Converting Alternating Electric Currents into Continuous Currents,

He having assigned his right, title, and interest, in said improvement, to Marconi Wireless Telegraph Company of America, a corporation of New Jersey,

a description of which invention is contained in the specification of which a copy is hereto annexed and made a part hereof, and has complied with the various requirements of law in such case made and provided; and

Whereas upon due examination made the said claimant is adjudged to be justly entitled to a patent under the law;

Now therefore these Letters Patent are to grant unto the said Marconi Wireless Telegraph Company of America, its successors ~~heirs~~ or assigns for the term of seventeen years from the seventh day of November, one thousand nine hundred and five, the exclusive right to make, use, and vend the said invention throughout the United States and the Territories thereof.

In testimony whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed, at the City of Washington, this seventh day of November, in the year of our Lord one thousand nine hundred and five, and of the Independence of the United States of America the one hundred and thirtieth.

[Seal]

F. I. Allen

Commissioner of Patents.

25339

No. 803,684. PATENTED NOV. 7, 1905.

J. A. FLEMING.

INSTRUMENT FOR CONVERTING ALTERNATING ELECTRIC CURRENTS INTO CONTINUOUS CURRENTS.

APPLICATION FILED APR. 19, 1905.

Fig 1

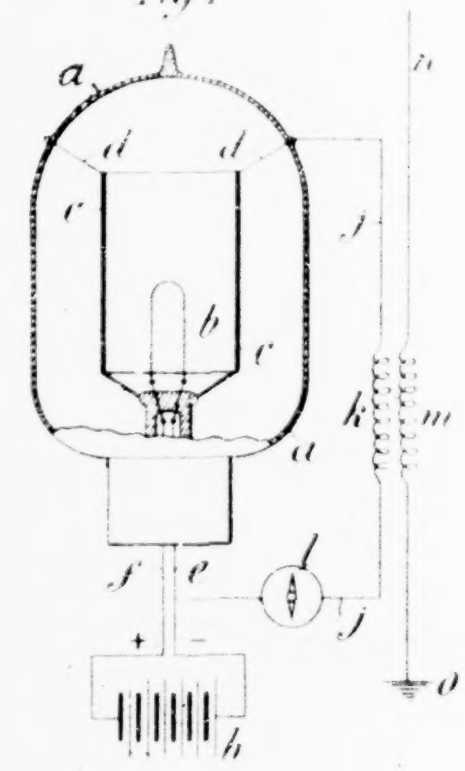


Fig 2

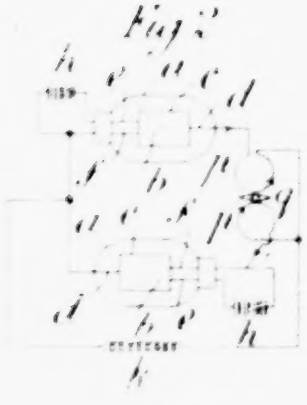
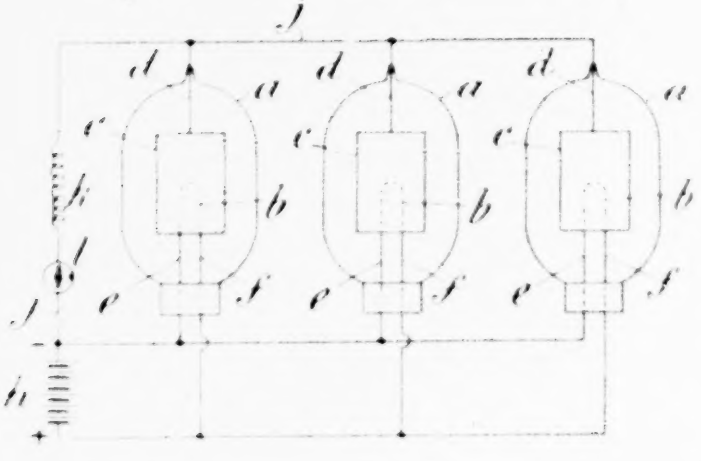



Fig 3



Witnesses

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UNITED STATES PATENT OFFICE. 2600

JOHN AMBROSE FLEMING, OF LONDON, ENGLAND, ASSIGNOR TO MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA, A CORPORATION OF NEW JERSEY.

INSTRUMENT FOR CONVERTING ALTERNATING ELECTRIC CURRENTS INTO CONTINUOUS CURRENTS.

No. 803,684. Specification of Letters Patent. Patented Nov. 7, 1905.

Application filed April 19, 1905. Serial No. 256,483.

To all whom it may concern:

Be it known that I, JOHN AMBROSE FLEMING, professor of electrical engineering, a subject of the King of Great Britain, residing at University College, Gower street, London, in the county of Middlesex, England, have invented certain new and useful Improvements in Instruments for Converting Alternating Electric Currents into Continuous Currents, of which the following is a specification.

This invention relates to certain new and useful devices for converting alternating electric currents, and especially high-frequency alternating electric currents or electric oscillations, into continuous electric currents for the purpose of making them detectable by and measurable with ordinary direct-current instruments, such as a "mirror-galvanometer" of the usual type or any ordinary direct-current ammeter. Such instruments as the latter are not affected by alternating electric currents either of high or low frequency, which can only be measured and detected by instruments called "alternating-current" instruments of special design. It is, however, of great practical importance to be able to detect feeble electric oscillations, such as are employed in Hertzian-wave telegraphy by an ordinary movable coil or movable needle mirror-galvanometer. This can be done if the alternating current can be "rectified"—that is, either suppressing all the constituent electric currents in one direction and preserving the others or else by changing the direction of one of the sets of currents which compose the alternating current so that the whole movement of electricity is in one direction. Many means have been devised and are in use for rectifying low-frequency alternating currents, such as are used in electric lighting. There are well-known forms of mechanical rectifier, also, there is a well-known form of electrochemical rectifier, depending on the fact that when a plate of carbon and aluminium is placed in any electrolyte which yields oxygen on electrolysis an electric current can only pass through this cell in one direction if below a certain voltage. Both these forms of rectifier are, however, inapplicable for high-frequency currents. I have found that the aluminium-carbon cell will not act with high-frequency currents.

I have discovered that if two conductors are inclosed in a vessel in which a good vacuum is made, one being heated to a high temperature, the space between the hot and cold conductors possesses a unilateral electric conductivity, and negative electricity can pass from the hot conductor to the cold conductor, but not in the reverse direction. As the hot conductor should be heated to a very high temperature—say near to the melting-point of platinum, (1,700 centigrade)—it should be of carbon, preferably in the form of a filament such as is used in any ordinary incandescent electric lamp. The cold conductor may be of many materials; but I prefer a bright metal, such as platinum or aluminium or else carbon. The two conductors are inclosed in a glass bulb similar to that of an incandescent lamp, and I generally heat the carbon filament to a high state of incandescence by a continuous electric current, the electrical connection to the filament and the cold conductor being made by platinum wires, sealed air-tight through the glass.

Figure 1 is a full-size sectional elevation of an instrument constructed according to this invention, the electrical connections being shown diagrammatically. This figure illustrates the application of the invention to wireless telegraphy. Figs. 2 and 3 show modifications to smaller scales.

In Fig. 1, *a* is a glass bulb, and *b* is a carbon filament like the carbon filament of an incandescent lamp, suitable, say, for taking a current of six to eight volts and two to four amperes. *c* is a cylinder of aluminium, open at the top and bottom, which surrounds but does not touch the filament. The cylinder *c* is suspended and steadied by platinum wires *d*, and the ends of the filament *b* are connected to platinum wires connected to the leads *e* and *f*. The platinum wires are sealed through the glass in the ordinary manner.

As a very high vacuum should be obtained in the bulb *a* and as a considerable quantity of air is occluded in the conductors, these should be heated when the bulb is being exhausted. The filament *b* can be conveniently heated by passing a current through it, while the cylinder *c* can be heated by surrounding the bulb *a* with a resistance-coil through which a current is passed, the whole being inclosed in a box lined with asbestos or the like. When, as hereinafter described, the cylinder *c* is re-

conductors adjacent to but not touching each other in the vessel, means for passing an electric current through one of the conductors, and a circuit outside the vessel connecting the two conductors.

3. The combination of a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for heating one of the conductors, a circuit outside the vessel connecting the two conductors, means tending to produce an alternating current in the circuit, and means for detecting a continuous current in it.

4. The combination of a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for passing an electric current through one of the conductors, a circuit outside the vessel connecting the two conductors, means tending to produce an alternating current in the circuit, and means for detecting a continuous current in it.

5. The combination of a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for passing a continuous electric current through one of the conductors, and a circuit outside the vessel connecting the two conductors.

6. The combination of a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for passing a continuous electric current through one of the conductors, a circuit outside the vessel connecting the two conductors, means tending to produce an alternating current in the circuit, and means for detecting a continuous current in it.

7. The combination of a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for heating one of the conductors, a circuit outside the vessel connecting the two conductors, an induction-coil having its secondary winding in the circuit and its primary winding connected to an aerial wire and earth, and means for detecting a continuous current in the circuit.

8. The combination of a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for passing an electric current through one of the conductors, a circuit outside the vessel connecting the two conductors, an induction-coil having its secondary winding in the circuit and its primary winding connected to an aerial wire and earth, and means for detecting a continuous current in the circuit.

9. The combination of a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for passing a continuous electric current through one of the conductors, a circuit outside the vessel connecting the two conductors, an induction-coil having its secondary winding in the circuit and its primary winding connected to an aerial wire and earth, and means for detecting a continuous current in the circuit.

10. The combination of a vacuous vessel, a carbon filament in the vessel, a metallic cylinder surrounding but not touching the filament, means for heating the filament, and a circuit outside the vessel connecting the filament to the cylinder.

11. The combination of a vacuous vessel, a carbon filament in the vessel, a metallic cylinder surrounding but not touching the filament, means for passing an electric current through the filament, and a circuit outside the vessel connecting the filament to the cylinder.

12. The combination of a vacuous vessel, a carbon filament in the vessel, a metallic cylinder surrounding but not touching the filament, means for heating the filament, a circuit outside the vessel connecting the filament to the cylinder, means tending to produce an alternating current in the circuit, and means for detecting a continuous current in it.

13. The combination of a vacuous vessel, a carbon filament in the vessel, a metallic cylinder surrounding but not touching the filament, means for passing an electric current through the filament, a circuit outside the vessel connecting the filament to the cylinder, means tending to produce an alternating current in the circuit, and means for detecting a continuous current in it.

14. The combination of a vacuous vessel, a carbon filament in the vessel, a metallic cylinder surrounding but not touching the filament, means for passing a continuous electric current through the filament, and a circuit outside the vessel connecting the filament to the cylinder.

15. The combination of a vacuous vessel, a carbon filament in the vessel, a metallic cylinder surrounding but not touching the filament, means for passing a continuous electric current through the filament, a circuit outside the vessel connecting the filament to the cylinder, means tending to produce an alternating current in the circuit, and means for detecting a continuous current in it.

16. The combination of a vacuous vessel, a carbon filament in the vessel, a metallic cylinder surrounding but not touching the filament, means for heating the filament, a circuit outside the vessel connecting the filament to the cylinder, an induction-coil having its secondary winding in the circuit and its primary winding connected to an aerial wire and earth, and means for detecting a continuous current in the circuit.

17. The combination of a vacuous vessel, a carbon filament in the vessel, a metallic cylinder surrounding but not touching the filament, means for passing an electric current through the filament, a circuit outside the vessel connecting the filament to the cylinder, an induction-coil having its secondary winding in the circuit and its primary winding connected to an aerial wire and earth, and means for detecting a continuous current in the circuit.

18. The combination of a vacuous vessel, a carbon filament in the vessel, a metallic cylinder surrounding but not touching the filament, means for passing a continuous electric current through the filament, a circuit outside the vessel connecting the filament to the cylinder, an induction-coil having its secondary winding in the circuit and its primary winding connected to an aerial wire and earth, and means for detecting a continuous current in the circuit.

19. The combination of two vacuous vessels, two conductors adjacent to but not touching each other in each vessel, means for heating one of the conductors in each vessel, two coils of a differential galvanometer, one coil being connected to the heated conductor in one vessel and the other coil being connected to the unheated conductor in the other vessel, a connection between the other pair of conductors, a connection between the coils, and a circuit connecting the two latter connections.

20. The combination of two vacuous vessels, two conductors adjacent to but not touching each other in each vessel, means for passing an electric current through and so heating one of the conductors in each vessel, two coils of a differential galvanometer, one coil being connected to the heated conductor in one vessel and the other coil being connected to the unheated conductor in the other vessel, a connection between the other pair of conductors, a connection between the coils, and a circuit connecting the two latter connections.

21. The combination of two vacuous vessels, two conductors adjacent to but not touching each other in each vessel, means for passing a continuous electric current through and so heating one of the conductors in each vessel, two coils of a differential galvanometer, one coil being connected to the heated conductor in one vessel and the other coil being connected to the unheated conductor in the other vessel, a connection between the other pair of conductors, a connection between the coils, and a circuit connecting the two latter connections.

22. The combination of two vacuous vessels, two conductors adjacent to but not touching each other in each vessel, means for heating one of the conductors in each vessel, two coils of a differential galvanometer, one coil being connected to the heated conductor in one vessel and the other coil being connected to the unheated conductor in the other vessel, a connection between the other pair of conductors, a connection between the coils, a circuit connecting the two latter connections, and means tending to produce an alternating current in the circuit.

23. The combination of two vacuous vessels, two conductors adjacent to but not touching each other in each vessel, means for passing an electric current through and so heating one of the conductors in each vessel, two coils of a differential galvanometer, one coil being connected to the heated conductor in one vessel and the other coil being connected to the unheated conductor in the other vessel, a connection between the other pair of conductors, a connection between the coils, a circuit connecting the two latter connections, and means tending to produce an alternating current in the circuit.

24. The combination of two vacuous vessels, two conductors adjacent to but not touching each other in each vessel, means for passing a continuous electric current through and so heating one of the conductors in each vessel, two coils of a differential galvanometer, one coil being connected to the heated conductor in one vessel and the other coil being connected to the unheated conductor in the other vessel, a connection between the other pair of conductors, a connection between the coils, a circuit connecting the two latter connections, and means tending to produce an alternating current in the circuit.

25. The combination of two vacuous vessels, a carbon filament in each vessel, a metallic cylinder in each vessel, surrounding but not touching the filament, means for heating the filaments, two coils of a differential galvanometer one coil being connected to the filament in one vessel and the other coil being connected to the cylinder in the other vessel, a connection between the other cylinder and filament, a connection between the coils, and a circuit connecting the two latter connections.

26. The combination of two vacuous vessels, a carbon filament in each vessel, a metallic cylinder in each vessel, surrounding but not touching the filament, means for passing an electric current through the filaments, two coils of a differential galvanometer one coil being connected to the filament in one vessel and the other coil being connected to the cylinder in the other vessel, a connection between the other cylinder and filament, a connection between the coils, and a circuit connecting the two latter connections.

27. The combination of two vacuous vessels, a carbon filament in each vessel, a metallic cylinder in each vessel, surrounding but not touching the filament, means for passing a continuous electric current through the filaments, two coils of a differential galvanometer one coil being connected to the filament in one vessel and the other coil being connected to the cylinder in the other vessel, a connection between the other cylinder and filament, a connection between the coils, and a circuit connecting the two latter connections.

28. The combination of two vacuous vessels, a carbon filament in each vessel, a metallic cylinder in each vessel, surrounding but not touching the filament, means for heating the filaments, two coils of a differential galva-

nometer one coil being connected to the filament in one vessel and the other coil being connected to the cylinder in the other vessel, a connection between the other cylinder and filament, a connection between the coils, a circuit connecting the two latter connections, and means tending to produce an alternating current in the circuit.

29. The combination of two vacuous vessels, a carbon filament in each vessel, a metallic cylinder in each vessel, surrounding but not touching the filament, means for passing an electric current through the filaments, two coils of a differential galvanometer one coil being connected to the filament in one vessel and the other coil being connected to the cylinder in the other vessel, a connection between the other cylinder and filament, a connection between the coils, a circuit connecting the two latter connections, and means tending to produce an alternating current in the circuit.

30. The combination of two vacuous vessels, a carbon filament in each vessel, a metallic cylinder in each vessel, surrounding but not touching the filament, means for passing a continuous electric current through the filaments, two coils of a differential galvanometer one coil being connected to the filament in one vessel and the other coil being connected to the cylinder in the other vessel, a connection between the other cylinder and filament, a connection between the coils, a circuit connecting the two latter connections, and means tending to produce an alternating current in the circuit.

31. The combination of two vacuous vessels, two conductors adjacent to but not touching each other in each vessel, means for heating one of the conductors in each vessel, two coils of a differential galvanometer, one coil being connected to the heated conductor in one vessel and the other coil being connected to the unheated conductor in the other vessel, a connection between the other pair of conductors, a connection between the coils, a circuit connecting the two latter connections, and an induction-coil having its secondary winding in the circuit and its primary winding connected to an aerial wire and earth.

32. The combination of two vacuous vessels, two conductors adjacent to but not touching each other in each vessel, means for passing an electric current through and so heating one of the conductors in each vessel, two coils of a differential galvanometer, one coil being connected to the heated conductor in one vessel and the other coil being connected to the unheated conductor in the other vessel, a connection between the other pair of conductors, a connection between the coils, a circuit connecting the two latter connections, and an induction-coil having its secondary winding in the circuit and its primary winding connected to an aerial wire and earth.

33. The combination of two vacuous vessels, two conductors adjacent to but not touching each other in each vessel, means for passing a continuous electric current through and so heating one of the conductors in each vessel, two coils of a differential galvanometer, one coil being connected to the heated conductor in one vessel and the other coil being connected to the unheated conductor in the other vessel, a connection between the other pair of conductors, a connection between the coils, a circuit connecting the two latter connections, and an induction-coil having its secondary winding in the circuit and its primary winding connected to an aerial wire and earth.

34. The combination of two vacuous vessels, a carbon filament in each vessel, a metallic cylinder in each vessel, surrounding but not touching the filament, means for heating the filaments, two coils of a differential galvanometer one coil being connected to the filament in one vessel and the other coil being connected to the cylinder in the other vessel, a connection between the other cylinder and filament, a connection between the coils, a circuit connecting the two latter connections, and an induction-coil having its secondary winding in the circuit and its primary winding connected to an aerial wire and earth.

35. The combination of two vacuous vessels, a carbon filament in each vessel, a metallic cylinder in each vessel, surrounding but not touching the filament, means for passing an electric current through the filaments, two coils of a differential galvanometer one coil being connected to the filament in one vessel and the other coil being connected to the cylinder in the other vessel, a connection between the other cylinder and filament, a connection between the coils, a circuit connecting the two latter connections, and an induction-coil having its secondary winding in the circuit and its primary winding connected to an aerial wire and earth.

36. The combination of two vacuous vessels, a carbon filament in each vessel, a metallic cylinder in each vessel, surrounding but not touching the filament, means for passing a continuous electric current through the filaments, two coils of a differential galvanometer one coil being connected to the filament in one vessel and the other coil being connected to the cylinder in the other vessel, a connection between the other cylinder and filament, a connection between the coils, a circuit connecting the two latter connections, and an induction-coil having its secondary winding in the circuit and its primary winding connected to an aerial wire and earth.

37. At a receiving-station in a system of wireless telegraphy employing electrical os-

cillations of high frequency a detector comprising a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for heating one of the conductors, a circuit outside of the vessel connecting the two conductors, means for detecting a continuous current in the circuit, and means for impressing upon the circuit the received oscillations.

JOHN AMBROSE FLEMING.

Witnesses:
H. D. JAMESON,
A. NUTTING.

Disclaimer in Letters Patent No. 803,684.

DISCLAIMER.

803,684. *John Ambrose Fleming*, London, England. INSTRUMENT FOR CONVERTING ALTERNATING ELECTRIC CURRENTS INTO CONTINUOUS CURRENTS. Patent dated November 7, 1905. Disclaimer filed November 17, 1915, by the assignee, *Marconi Wireless Telegraph Company of America*.

Enters this disclaimer—

"To the combinations of elements set forth in claims 1 to 6, inclusive, and 11 to 15, inclusive, respectively, of said Letters Patent, except as the same are used in connection with high frequency alternating electric currents or electric oscillations of the order employed in Hertzian wave transmission, and to the words in the specification: 'whether of low frequency or,' at page 2, lines 32 and 33; 'either,' at page 2, line 98; and 'or low-frequency alternating currents of,' at page 2, lines 98 and 99."

[*Official Gazette, November 23, 1915.*]

Form P. Cert. 1.

2606

Plaintiff's Exhibit #34, Printed copy of Marconi British patent #7777 of 1900.

PATENTS AND DESIGNS ACT, 1907.

IT IS HEREBY CERTIFIED by the Comptroller-General of Patents, Designs and Trade Marks that the annexed are true copies (as accepted) of the provisional specification lodged on the 26th April, 1900, in connection with the application of Marconi and another for Patent No. 7,777 of 1900, filed on the 26th April, 1900, and of the complete specification and drawings left in connection therewith on the 25th February, 1901.

It is also certified that the said complete specification was accepted on the 13th April, 1901; that the said provisional specification and complete specification and drawings were first printed and placed on sale in the Sale Branch of this Office on the 4th May, 1901; and that a Patent was granted in respect of the said application on the 25th June, 1901, and sealed as of the 26th April, 1900.

FILED JAN 31 1923 COURT OF CLAIMS

This certificate is issued for use in the United States of America.

WITNESS my hand this 8th day of April, 1917

Comptroller-General of Patents, Designs and Trade Marks.

BUILDINGS, LONDON, W.C.

(14611—14) Wt. 24902—4352 2000

2246

[Fourth Edition]

26607

N° 7777 A.D. 1900

Date of Application, 26th Apr., 1900
Complete Specification Left, 25th Feb., 1901—Accepted, 13th Apr., 1901

PROVISIONAL SPECIFICATION.

"Improvements in Apparatus for Wireless Telegraphy."

We, GUGLIELMO MARCONI, Electrician, and MARCONI'S WIRELESS TELEGRAPH COMPANY, LIMITED, both of 28, Mark Lane, in the City of London, do hereby declare the nature of this invention to be as follows:

The object of this invention is not only to increase the efficiency of the apparatus hitherto employed, but also to so control the action as to cause intelligible communications to be established with one or more stations only out of a group of several receiving stations.

In the Specification of a former Patent No. 12,039 of 1896, a transmitter is described which consists of an induction coil, one terminal of the secondary circuit being connected to a metal sphere connected to earth and the other to a similar sphere connected to an insulated conductor which generally takes the form of a more or less vertical wire which may or may not terminate or have attached to it a metal body of extended surface, giving it increased electrical capacity.

According to the present invention the vertical wire is connected to earth through the secondary winding of a transformer of a kind suitable for the transformation of very rapidly alternating electric currents and the primary of this transformer is connected to the spheres or terminals of the sparking appliance.

A condenser of suitable capacity is introduced in series with the primary or each end of the primary may be connected to one of the plates of two condensers of suitable capacity, the other plates of which are connected to the sparking appliance.

This device enables much more energy to be imparted to the radiator than heretofore, the approximately closed circuit of the primary being a good conserver and the open circuit of the secondary a good radiator of wave energy.

The arrangement works as follows:

On pressing the key and actuating the induction coil (in order to produce a signal) the condenser in circuit with the transformer is charged and subsequently discharges through the spark gap. If the capacity, the inductance, and the resistance of the circuit are of suitable values, this discharge is oscillatory, with the result that alternating currents of high frequency pass through the primary of the transformer and induce similar oscillations in its secondary these oscillations being communicated to the elevated conductor.

The circuit of the elevated conductor should preferably be suitably attuned for this purpose.

The effect of these oscillations in the elevated conductor is to inductively affect similar distant conductors if the self-induction and capacity of the said conductors is of a suitable value or values.

At the receiving end a receiver is employed capable of being actuated by electrical oscillations of high frequency such as those described in the Specifications Nos. 12,326 of 1898, and 6982 of 1899.

The transformer which has been used at the transmitting station preferably consists of two windings of a few turns of insulated wire. The length of the wire and dimensions of the transformers may vary between wide limits, but satisfactory results have been obtained when working with vertical wires 100 feet long, with coils constituted of 10, 20, 30, and 40 turns of copper wire two millimetres in diameter, insulated with gutta-percha or other suitable insulating material, each turn being about 4 inches in diameter, the primary and secondary being of the same thickness of wire and approximately of same length.

[Price 6d.]

The condensers used in connection with these transformers were usually three or four pint Leyden jars. If the inductance of the induction coil used at the receiving station is varied, the inductance of the condenser circuit, or the capacity of the condenser, or both, should also be varied at the transmitting station.

In employing this invention to localise the transmission of intelligence to one out of several receiving stations one of the following methods is adopted.

The inductance coils at the receiving stations are wound with different lengths of wire and the self inductance and capacity of the transformer, condenser and elevated wire is accordingly varied over wide limits. It is found that if these factors are varied at the transmitting station until the electrical system composed of the elevated wire and its associated transformer circuit are in resonance with the receiving elevated wire and its induction coil and coherer connections of one of the receiving systems, that one alone, out of all the number of receiving stations responds, provided that the distance between the transmitter and receiver is not too small. In this manner each receiving instrument can be adjusted to respond only to the transmitter when the inductance of that transmitter has a certain value or values.

At the receiving station the period of oscillation of the system can be altered by altering the capacity and self-induction of the elevated conductor by varying its section or by connecting it to conducting bodies of large surface, or by introducing inductance coils in series with it, preferably at its highest extremity, or by varying the dimensions of the wire and the size of the induction coils used.

The period of the receiving system may also be altered by associating with the circuit of the induction coils condensers of suitable capacity, placed some in parallel and some in series with the primary and secondary.

At the transmitter the frequency may be varied in the same way as has been described for the receiver.

Dated this 26th day of April 1900.

G. MARCONI.
MARCONI'S WIRELESS TELEGRAPH CO. LTD.
By G. MARCONI,
Director.
S. FLOOD PAGE,
HENRY S. SAUNDERS,
HENRY W. ALLEN,
Secretary.

COMPLETE SPECIFICATION.

"Improvements in Apparatus for Wireless Telegraphy."

We, GUGLIELMO MARCONI, Electrician, and MARCONI'S WIRELESS TELEGRAPH COMPANY, LIMITED, late of 28, Mark Lane, and now both of 18, Finch Lane, in the City of London, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:

The object of this invention is not only to increase the efficiency of the apparatus hitherto employed, but also to so control the action as to cause intelligible communications to be established with one or more stations only out of a group of several receiving stations.

In the Specification of a former Patent No. 12,039 of 1896, a transmitter is described which consists of an induction coil one terminal of the secondary circuit being connected to a metal sphere supported on a rod, and the other to a similar sphere connected to an insulated conductor which generally takes the form of a more or less vertically wire which may be connected to or have

attached to it a metal body of extended surface, giving it increased electrical capacity.

According to the present invention the vertical wire is connected to earth through the secondary winding of a transformer of a kind suitable for the transformation of very rapidly alternating electric currents and the primary of this transformer is connected to the spheres or terminals of the sparking appliance.

A condenser of suitable capacity is introduced in series with the primary or each end of the primary may be connected to one of the plates of two condensers of suitable capacity, the other plates of which are connected to the sparking appliance.

This device enables much more energy to be imparted to the radiator than heretofore, the approximately closed circuit of the primary being a good conserver and the open circuit of the secondary a good radiator of wave energy.

The arrangement works as follows:

On pressing the key and actuating the induction coil (in order to produce a signal) the condenser in circuit with the transformer is charged and subsequently discharges through the spark gap. If the capacity, the inductance, and the resistance of the circuit are of suitable values, the discharge is oscillatory, with the result that alternating currents of high frequency pass through the primary of the transformer, and induce similar oscillations in its secondary these oscillations being communicated to the elevated conductor.

The circuit of the elevated conductor should be suitably attuned for this purpose.

The effect of these oscillations in the elevated conductor is to inductively affect similar distant conductors if the self induction and capacity of the said conductors is of a suitable value or values.

At the receiving end a receiver is employed capable of being actuated by electrical oscillations of high frequency such as are described in the Specifications Nos. 12,326 of 1898, 6982 of 1899, and 25,186 of 1899.

The four circuits namely those including the primary and the secondary of the transformer in the transmitter and the primary and secondary of the transformer in the receiver should be so adjusted as to make the electric time period the same in each *i.e.* the product of the self induction multiplied by the capacity is the same in each case. But in lieu of the time periods being the same in each they may be harmonics of each other.

In employing this invention to localise the transmission of intelligence from a station to one only out of several receiving stations the time period of the circuits at each of these stations is so arranged as to be the same but different from those of the other receiving stations. If the time period of the circuits of the transmitting station are varied until they are in resonance with those of one of the receiving stations that one alone out of all the number of receiving stations will respond, provided that the distance between the transmitter and receiver is not too small.

The adjustment of the self induction and capacity of the circuits can be made in any convenient manner. As a practical guide to putting the invention in practice we subjoin the arrangements which we find work best.

Figures 1 and 2 are diagrams of the transmitter and of the receiver respectively, whilst Figure 3 shows a side view and Figure 4 an edge view of a transformer used at the transmitting station, and Figures 5 to 11 show various induction coils used at the receiving station.

a is a battery, *b* a Morse key, *c* a Ruhmkorff coil the primary of which is in circuit with the battery whilst the terminals of the secondary are connected to the primary *d* of a transformer one of the connections being through a condenser *e* or there may be a condenser in both of the connections. The secondary *d*¹ of the transformer is connected to an aerial conductor A which may have at its top a metallic cylinder *f* and to earth or a capacity E. Between the secondary and the aerial conductor or it might be between the secondary and earth is sometimes inserted an inductance coil *g* having numerous coils and the connection is such

that a greater or less number of turns of the coil can be put in circuit, the proper number to use being ascertained by experiment.

The receiver (Figure 2) consists of an aerial conductor A which may have a cylinder f^1 at its top connected through an inductance coil g^1 similar to g and through the primary j^1 of an induction coil to earth or a capacity E; a small condenser h may be inserted in parallel with the primary j^1.

The secondary j^2 of the induction coil is divided in the middle and has its inner ends connected to the plates of a condenser j^3 while its outer ends are connected it may be through inductance coils g^2 similar to g to a detector or coherer T; a condenser h^1 may be inserted in parallel with the detector. The local circuit containing a battery cell B and relay or telegraph instrument R is connected through choking coils c^1 c^2 to the plates j^3 of the condenser.

The condensers h h^1 are preferably in the form of two metallic tubes separated by a dielectric and sliding telescopically on each other as in this way their capacity can readily be varied with accuracy to tune the circuits.

The following are details of arrangements which have been found to work best.

The cable used for the aerial conductor at either station and for the transformer d d^1 at the transmitting station is in all the examples given composed of seven strands of copper wire ·889 m.m. in diameter. The aerial conductor at the receiving station is in each instance exactly similar to that at the transmitting station for the corresponding tune.

The details of the transformers d d^1 are as follows:—

Transformer No. 1. The total length of the primary d including connections to spark gap and condenser is ·946 metres and it is bent round a square d^2 of insulating material of which the side is ·17 metres long while the secondary d^1 consists of two turns or squares one lying on each side of the primary (see Figures 3 and 4). The insulation of both primary and secondary consists of 1·25 m.m. of rubber and 1 m.m. of jute making a total thickness of 2·25 m.m.

Transformer No. 2 is exactly similar to No. 1 except that the total length of the primary d is 1·94 metres.

Transformer No. 3. The primary consists of ten turns of cable wound on a cylindrical core 10·16 c.m. in diameter; over this but separated from it by 2 m.m. of paper or other insulating material is wound the secondary also of ten turns.

Transformer No. 4. The total length of the primary d is 1·50 metres and it is bent round a square of insulating material d^2 of which the side is ·3048 metres long while the secondary d^1 consists of 6 turns or squares three lying on each side of the primary in one layer. The insulation of both primary and secondary is the same as in No. 1.

Transformer No. 5. The primary consists of ten insulated wires each 1·5 metres long wound side by side in one layer and connected in parallel each wire making one turn on a square frame similar to that described for transformer No. 4.

Over this primary layer is put a covering of paper 1 m.m. thick, upon this is wound 48·64 metres of wire. The winding is arranged in layers, the number of turns in each successive layer being in the first layer that is in that nearest the primary 9, in the second 8, in the third 7, in the fourth 6, in the fifth 5, in the sixth 2.

The insulation is the same as in No. 1.

Transformer No. 6. The primary consists of seven wires wound side by side each wire making one turn on a square frame as used for transformer No. 4. The seven wires are joined in parallel and the length of each is 1·50 metres. Over this primary layer is wound a secondary 30·4 metres long, the winding being arranged in layers the number of turns in the successive layers being in the first layer 7 turns, in the second 6, in the third 5, in the fourth 4.

The transformers should be placed in an oil bath, especially if the turns are at all numerous.

The inductance coils g g^1 are of copper wire 6·25 m.m. in diameter wound on a cylinder 10·64 c.m. in diameter an interval of 2·38 m.m. being left between

adjacent turns while the inductance coils g^2 inserted in series with the secondary f^1 of the induction coil at the receiving station are of copper wire, silk covered, of ·19 m.m. diameter wound on cylinders 3·7 c.m. in diameter.

Figures 5 to 11 show details of the induction coils f^1 f^2.

These diagrams are greatly enlarged half longitudinal sections, but are not strictly to scale. In place also of showing the section of each coil or layer of wire as a longitudinal row of dots or small circles as it would actually appear, it is for simplicity shown as a continuous longitudinal straight line.

Induction coil No. 1 see Figure 5. The primary consists of 3·048 metres of silk covered copper wire ·71 m.m. in diameter wound in one layer on a core 2·9 c.m. in diameter. Insulating material is wound over and on each side of this so as to make a cylindrical core 3·43 c.m. in diameter on which is wound the secondary each half consisting of 6·4 metres of silk covered copper wire ·19 m.m. in diameter joined to 13·41 metres of silk covered copper wire ·37 m.m. in diameter wound in the same sense as the primary, the thinner wire being over the primary and the thicker being beyond the ends of the primary.

Induction coil No. 2 see Figure 6. The primary f^1 wound on a core 7·6 c.m. in diameter consists of 100 turns of copper wire ·007 c.m. in diameter insulated with single silk and coated with paraffin wax, the secondary f^2 is of copper wire ·019 c.m. in diameter insulated with single silk covering and is wound over the primary commencing in the middle and in the same sense as the primary. Each half of the secondary is in layers of the following number of turns: first layer 77, second 49, third 46, fourth 43, fifth 40, sixth 37, seventh 34, eighth 31, ninth 28, tenth 25, eleventh 22, twelfth 19, thirteenth 16, fourteenth 13, fifteenth 10, sixteenth 7, seventeenth 4, making 500 in all.

Induction coil No. 3 see Figure 7. The primary consists of 3·048 metres silk covered copper wire ·19 m.m. in diameter and the secondary 30·48 metres long of silk covered copper wire ·1 m.m. in diameter wound in one layer on a core 4 c.m. in diameter the primary being in one layer outside the secondary.

Induction coil No. 4 see Figure 8. The primary consists of 3·048 metres silk covered copper wire ·37 m.m. in diameter wound on a core 2·9 c.m. in diameter and inserted in a tube f^3 of 4 c.m. external diameter on which is wound the secondary of 27·432 metres silk covered copper wire ·12 m.m. in diameter, the break at the middle of the secondary being over the middle of the primary.

Induction coil No. 5 see Figure 9. The secondary consists of 7·315 metres of wire wound in one layer on a tube 5 cms. in diameter and is divided at its middle point, the wire being ·12 m.m. in diameter single silk covered.

There are two primaries each consisting of 2·75 metres of wire ·7 m.m. in diameter wound on tubes 6·5 cms. external diameter. The two primaries are placed symmetrically side by side one over each half of secondary and are joined in parallel.

Induction coil No. 6 see Figure 10. The secondary consists of 48·76 metres of single silk covered copper wire ·37 m.m. in diameter wound on a tube of 9·6 cms. diameter in one layer and is cut at its middle point. Symmetrically over the middle portion of the secondary is wound the primary 1·66 metres long of wire ·7 m.m. diameter, single silk covered.

Induction coil No. 7 see Figure 11. The primary consists of four wires each 6·1 metres long wound in four layers and joined in parallel, the layers being one under the other, the wire is ·71 m.m. in diameter insulated with a single covering of silk.

The secondary which is wound on a tube of 3·3 cms. external diameter consists of 11·23 metres of wire ·12 m.m. diameter insulated with a single covering of silk. The secondary is divided at its middle point and the primary is placed symmetrically inside the secondary.

The following table give the adjustments, those details opposite any tune in the transmitting station table being of course used in connection with those opposite the same tune in the receiving station table.

TRANSMITTING STATION.

Tune	Aerial conductor	Transformer *d* *d*¹	Inductance Number of turns of *g* included	Capacity in microfarads *e*	Length of spark in millimetres
N 1	36·576 metres of cable	N 1	None	·006934	3
N 2	ditto	N 1	45	·016395	4
N 3	ditto	N 2	None	·004112	3
N 4	ditto	N 2	110	·016849	4
N 5	Zinc cylinder 9·144 metres long, 1·524 metres in diameter hoisted 3·048 metres above ground	N 2	None	·001600	12·5
N 6	3·048 metres of cable	N 3	None	·000573	4
N 7	Four vertical wires each 4·86 metres long connected together at top and bottom but kept apart throughout their length by being suspended from the arms of a wooden cross each arm of which is 4 metres long	N 4	None	·016	6
N 8	One vertical wire 48 metres long	N 5	None	·007	6
N 9	One vertical wire 30·4 metres long	N 6	None	·0026	5

RECEIVING STATION.

Tune	Induction coil	Capacity in microfarads of h	Capacity in microfarads of h_1	Inductance introduced in g Number of turns	Inductance introduced in g^1
N° 1	N° 1	Omitted	Omitted	None	None
N° 2	N° 1	Omitted	·00004	45	None
N° 3	N° 2	·0046	Omitted	Up to 21 may be inserted	None
N° 4	N° 2	·0046	Omitted	100	2 coils of 15·24 metres at each end of secondary.
N° 5	N° 3	Omitted	Omitted	None	None
N° 6	N° 4	Omitted	Omitted	None	None
N° 7	N° 5	Omitted	Omitted	None	None
N° 8	N° 6	Omitted	Omitted	None	None
N° 9	N° 7	Omitted	Omitted	None	None

NOTE. In tune No. 9 a small condenser having an approximate capacity of ·00008 microfarad is inserted between the lower end of the receiving aerial conductor and the induction coil.

It will be observed that both the transmitter and the receiver are the same for tunes 1 and 2 and that when the capacity of the condenser e is varied, the two stations can be brought into tune by including 45 turns of each of the coils g g^1 and by introducing a condenser h^1 of small capacity in parallel with the coherer T. Similarly the transformer and receiver are the same for tunes 3 and 4 and when the capacity of e is varied, the stations are tuned by including 100 turns of each of the coils g g^1 and also by including the two coils g^2.

Tunes Nos. 7 and 8 give very good signals over a distance of 190 miles.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1 A transmitter for electric wave telegraphy consisting of a spark producer

having its terminals connected through a condenser with one circuit of a transformer the other circuit being connected to a conductor and to earth or a capacity the time period of electrical oscillations in the two circuits being the same or harmonics of each other.

2. A system of electric wave telegraphy in which both the transmitter and the receiver contain a transformer the time period of electrical oscillations in the four circuits of the two transformers being the same or harmonics of each other.

3. A system of electrical wave telegraphy in which both the transmitter and the receiver contain a transformer one circuit of which is a persistent oscillator and the other a good radiator or absorber of electrical oscillations all four circuits having the same time period or being harmonics of each other substantially as described.

4. Apparatus for wireless telegraphy substantially as described and illustrated in the drawings.

Dated this 26th day of February 1901.

G. MARCONI.
MARCONI'S WIRELESS TELEGRAPH CO., LD.
By Carpmael & Co.,
Agents.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.
[Wt. 57—250 12/1900.]

Fig. 1.

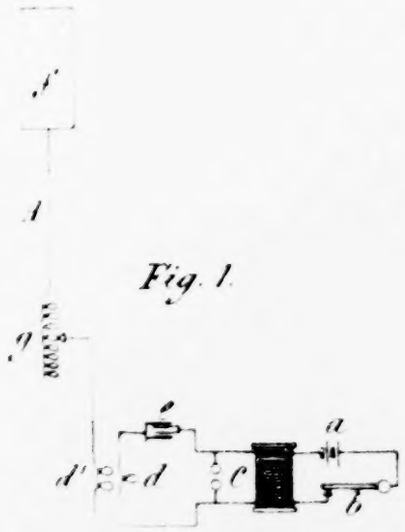


Fig 3

Fig 4

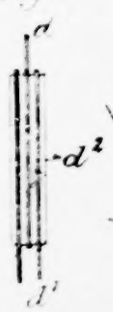


Fig 9

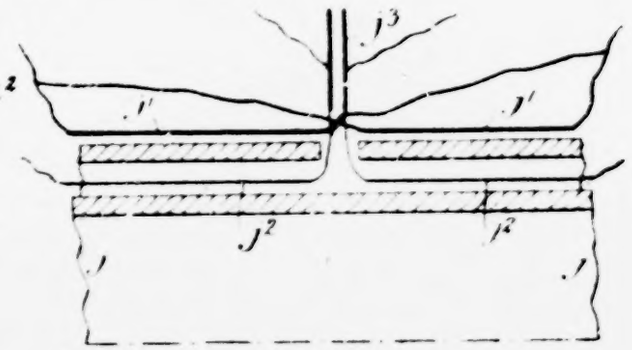


Fig 5

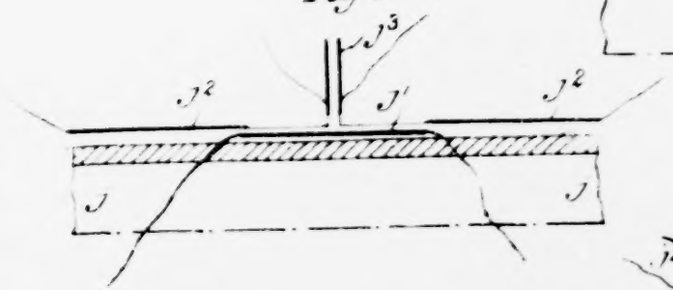


Fig 10

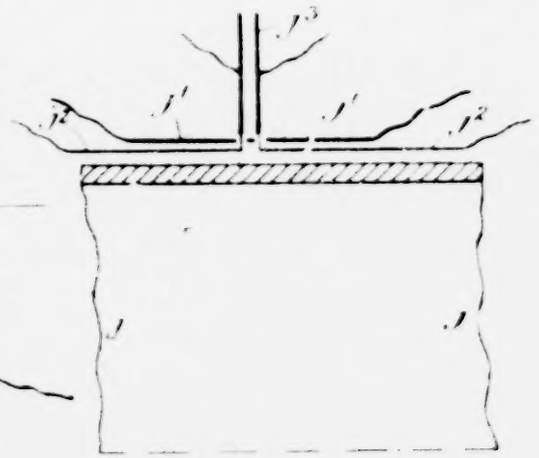


Fig 6

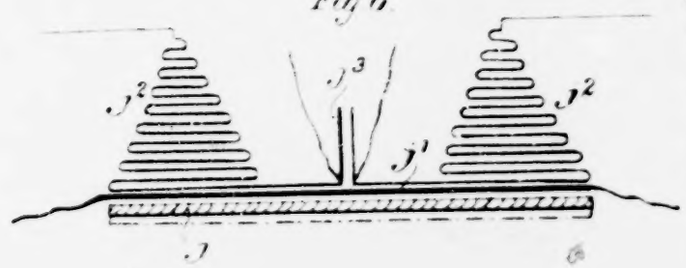


Fig 7

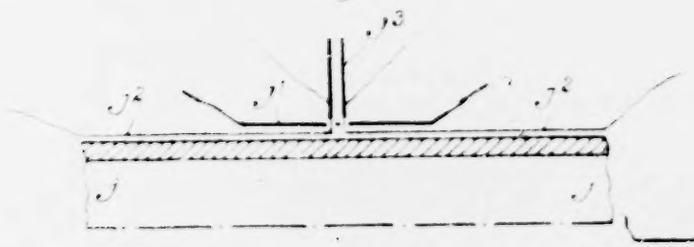


Fig 8

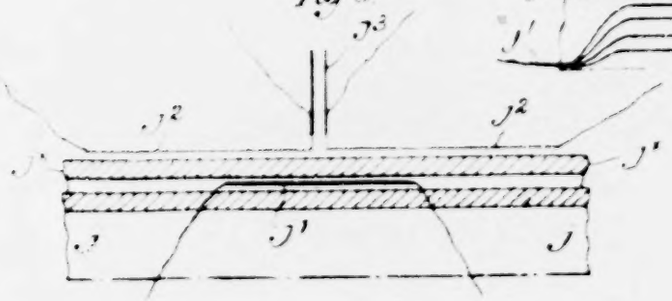


Fig 11

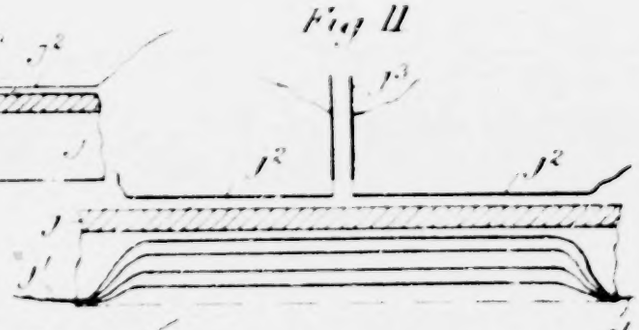
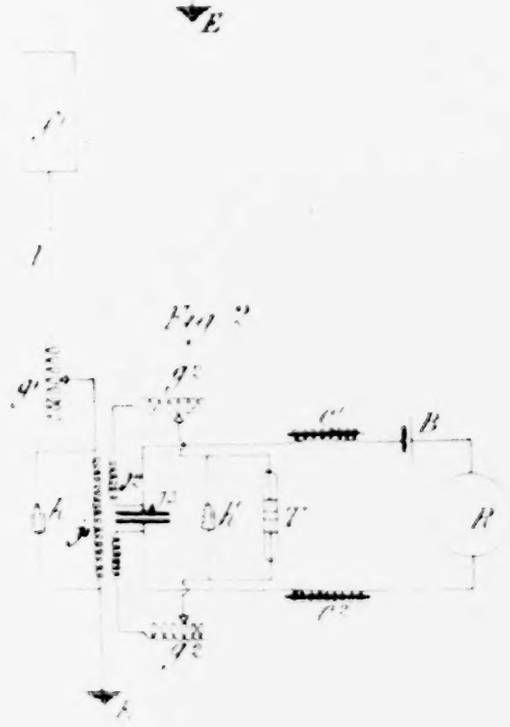


Fig 2.

[fol. 2256] PLAINTIFF'S EXHIBIT No. 35

ROYAL COURTS OF JUSTICE,
Friday, 24th July, 1914.

IN THE HIGH COURT OF JUSTICE. CHANCERY DIVISION

Before

Mr. JUSTICE EVE

and

Professor BERTRAM HOPKINSON (Assessor)

G. MARCONI AND MARCONI'S WIRELESS TELEGRAPH COMPANY, LIMITED,

v.

THE HELSBY WIRELESS TELEGRAPH COMPANY, LIMITED

[From the Shorthand Notes of Cherer & Co., 8, New Court, Carey Street, W. C.]

Mr. A. J. WALTER, K.C., and Mr. J. HUNTER GRAY (instructed by Messrs. Coward & Hawksley, Sons & Chance) appeared for the plaintiffs.

Mr. COURTNEY TERRELL and Mr. ARTHUR JAFFE (instructed by Messrs. Kenneth Brown, Baker, Baker & Co.,) appeared for the Defendants.

JUDGMENT

Mr. Justice EVE: This action was commenced on the 18th of October, 1912. At that date, and down to the expiry on the 25th day of April last, the plaintiffs were the owners of Letters Patent No. 7777 of 1900 for an invention of "improvements in apparatus for wireless telegraphy". They allege that the defendant infringed the said Letters Patent in 1911 by the construction and installation of an apparatus [fol. 2257] on board four steamships belonging to the London & North Western Railway Company. The defendants deny that they have infringed; and they allege that the Letters Patent are invalid by reason of certain prior publications; and on these two issues the case has been tried.

The area of conflict has been considerably curtailed, and the points in conflict greatly reduced by the fact that in 1911 the Letters Patent upon which the plaintiffs are suing were construed; and many of the objections raised by the Defendants in their Pleadings here were dealt with by Lord Parker (then Mr. Justice Parker) in an action brought by the Plaintiffs against other defendants. The apparatus used by the defendants in that action was held to be an infringement of the Plaintiff's patent, and it is admitted that the apparatus complained of in this action is for electrical purposes identical with the apparatus so held to be an infringement, except for the introduction into the primary circuit of two additional spark gaps and a through charging coil—but as the presence of the coil is consequent on the introduction of the two spark gaps, there is nothing substantial in that (See Questions and Answers Nos. 2457 and 2461).

The short point, therefore, on the issue of infringement which I have to decide is whether, by the introduction of the two spark gaps, the Defendants have produced an apparatus which does not come within the scope of the Plaintiff's patent. The object of the two additional spark gaps is the reduction of the length of the primary wave train; and that they do bring about some reduction is, in my opinion, established by the evidence. Indeed, that such is the case is not disputed by the plaintiffs; it is mainly a question of degree. The defendants put forward and rely on the Exhibit J. S. 9 as demonstrating diagrammatically the reduced length, of the primary wave train consequent on the introduction of the spark gaps; and they insist that optical experiments go to confirm the accuracy of the photographic material which forms the basis of that diagram. In estimating the credibility to be attached to J. S. 9—that is to say, in considering how nearly it approaches to an exact reproduction of facts—one has to give weight not only to the obvious physical difficulties of accurately reproducing by photography phenomena the duration of the existence of which is measured by millionths of a second; and the [fol. 2258] agencies employed in the reproduction; that is to say, such things as the sensitiveness of the photographic plate, and the actinic value of the metal constituting the spark gaps, but also the following facts admitted or proved in the course of the trial. (1) That the Defendants' installation works satisfactorily over the requisite distances; (2)

that it is not wasteful of energy; (3) that the coupling of the two circuits is a loose one in the neighborhood of 2 per cent, and certainly not exceeding 5 per cent; (4) that with loose coupling the transfer of energy must be in small doses, something like 3 per cent per oscillation; and (5) that substantially the whole of the energy in the primary has been in fact transferred to the secondary in the Defendants' apparatus when the primary has ceased to oscillate. The conclusion to which a consideration of these matters has led me, is that J. S. 9 cannot be accepted as quantitatively reliable. The alternative of accepting it as accurate leaves one face to face with more than one problem, to which I cannot find a satisfactory answer in the Defendants' evidence. For example (1) How can a large proportion of the energy be transferred from primary to secondary in 3½ oscillations with a coupling of less than 5 per cent; (2) If only that percentage of the energy which corresponds to this coupling is transferred, how can the Defendants' apparatus be either efficient or non-wasteful? and (3) If the whole of the energy is not transferred, what becomes of it? But as I have already stated, I am satisfied that the presence of the spark gap does substantially reduce the length of the primary wave train; and that after the primary has ceased oscillating the secondary continues to oscillate for a number of periods, and to radiate the pure wave of the aerial. The Defendants claim that the result of this is to improve the working of the installation, and that the cutting off or shutting down of the primary eliminates what has been called the double humped curve produced when surplus energy is returned from the secondary to the primary, as it can be when the primary is persistently oscillating while the secondary is radiating.

I think this may be the case; but I do not think it affects the real question which I have to answer. I think that question may be thus stated: Is it an essential feature of Marconi's invention that the primary should oscillate so that as energy is radiated by the aerial the primary will persistently replenish the secondary with at least an equiv- [fol. 2259] alent amount of energy, and thereby maintain the radiating secondary? I do not think it is. In both the Plaintiffs' and the Defendants' installations, the primary oscillations die down before the secondary oscillations are finished; and in this sense the question resolves itself into one of degree, dependent largely on the character of the

radiation employed. With a good radiator radiating in a single swing, a very large percentage of the energy transferred, the oscillations of the secondary must die down very quickly after those of the primary have died down: and in such an installation the primary may well be said not only to build up oscillations in the secondary, but thereafter to maintain them, and to be in the true sense the reservoir on which the secondary is persistently drawing for energy to replace that which is being contemporaneously radiated.

But with the radiators of, what I may perhaps call, more conservative capacities, the necessity for persistent maintenance is proportionately reduced: and although when such radiators are employed, the function of the primary is perhaps rather to build up than to maintain the secondary oscillations, it nevertheless does in fact both build them up and maintain them.

The Defendants rely greatly on these passages in Lord Parker's Judgment, wherein they claim that he expressly treats the maintenance of the secondary oscillations by the persistence primary oscillations as of the essence of the invention; but these passages must be read in relation to the particular infringement with which the court was then dealing; and in my opinion they are not equivalent to a construction of the patent which would have precluded the patentee from claiming protection for installations embodying radiators in which the oscillations could be built up and maintained without the necessity of keeping the primary persistently oscillating.

I think, notwithstanding the great ability which has been displayed in endeavoring to lead me to a different conclusion, that the Defendants have in substance appropriated the invention described in the Plaintiffs' Letters Patent, and that in the construction of their apparatus they have only introduced such modifications as are within Marconi's specification, and covered by his claim. I hold, therefore, that their apparatus was an infringement of the Plaintiff's patent.

[fol. 2260] This conclusion disposes of the Defendants' suggestion that their apparatus is Fig. 4 of Lodge's specification of 1897; but with regard to that figure, and the working of the apparatus there depicted, I am advised by the Assessor—whose valuable assistance throughout I take this opportunity of acknowledging—that Mr. Swinburne's evidence—illustrated in J. S. 16—is to be preferred to that of

Dr. Erskine Murray. It is possible that Lodge made an invention when he suggested, in connection with Fig. 4, that he would charge the aerial, and would then cut it off from the charging agent as rapidly as possible, leaving it free to swing independently and the Defendants may have taken this invention but even so, that does not mean that they have not also taken Marconi's invention, which relates to the nature of the charging agent; and can quite well be combined with Lodge's invention.

I do not think it is necessary to dwell at length on that part of the case which is concerned with the alleged prior publications. In my opinion, no evidence has been adduced in this case which qualifies in any way the conclusions at which Lord Parker arrived upon the question of Tesla's alleged anticipations, and which are to be found at lines 36 to 49 on page 213 of 28 Reports of Patent Cases. Nor, as a matter of construction, do I think that the passage on page 45 of the documents referred to in the Particulars of Objections, where the use by Ducretet of the Oudin resonator is dealt with, refers to anything else than a user for the purpose of tuning transmitter and receiver; and, as Dr. Erskine Murray admits, the passage of page 51 covers the same ground only. His evidence on this alleged anticipation is well summed up on page 243 of the Notes, where at Question 2947 he is asked: "Aye or no", do you suggest this taught the world the Marconi invention". And he replies: "I say it might teach the world—but there is always the teacher and the taught." That is not the sort of evidence on which I should be justified in holding that these passages relied on by the Defendants disclose an anticipation; and I decline so to do.

In my opinion, the Plaintiffs are right. They are entitled to a declaration that the Defendants' apparatus was, at the date of the Writ, and thereafter down to the 25th of April last continued, an infringement of the Letters Patent No. 7777 of the year 1900; to an inquiry as to the damages [fol. 2261] sustained by them in consequence of such infringement; and to the costs of the action down to and including this Judgment, to be taxed as between solicitor and client. The subsequent costs will be reserved; and there will be liberty to apply.

Mr. Hunter Gray: I ask your Lordship for a certificate that the Particulars of Breaches are reasonable and proper?

Mr. Justice Eve: Yes, with one exception.

Mr. Courtney Terrell: It is with one exception.
Mr. Hunter Gray: Yes.
Mr. Justice Eve: With that exception.

(Endorsed as follows):

In the High Court of Justice, Chancery Division, Royal Courts of Justice, 24th July, 1914. Before Mr. Justice Eve and Professor Bertram Hopkinson (Assessor). G. Marconi and Marconi's Wireless Telegraph Company, Limited, vs. The Helsby Wireless Telegraph Company, Limited, Judgment.

Coward & Hawksley, Sons & Chance, 30 Mincing Lane, E. C., Plaintiff's Solicitors.

[fol. 2262] PLAINTIFF'S EXHIBIT No. 36

Civil Tribunal of the Seine

(3RD CHAMBER)

24th December, 1912

Under the Presidency of M. BONJEAN

LETTERS PATENT.—WIRELESS TELEGRAPHY.—MARCONI'S SYSTEM.—PATENTABLE INVENTION.—FRESH COMBINATION OF MEANS ALREADY KNOWN.—SYNTONIZATION OF THE CIRCUITS.—SYNCHRONIZATION OF THE WAVES.—ANTICIPATION.—CLAIMED.—INCONTESTABILITY.—INFRINGEMENT.—ELEMENTS.—EMPLOYMENT OF THE CHARACTERISTIC PROCESS OF AN INVENTION.—SLIGHT MODIFICATION.—SUBSTITUTION OF EXCITATION BY DERIVATION FOR COUPLING BY INDUCTION.—INOPERATIVE CIRCUMSTANCE.—JUDGMENT.

1. *A patentable invention is constituted by the formation of a new device leading to a new industrial result, even though the same may be obtained by the combination of means that are already known and of elements that exist separately and are public property.*

From this point of view there are therefore grounds for acknowledging the appliance devised by Marconi for improving wireless telegraphy and which was the subject matter of his patent of 3rd November, 1900, No. 305,060, as

containing the characteristics of a patentable invention, which device contains the following characteristic features: (1) *The establishment of four circuits in tune with each other, that is, having all four the same period, the product of the self-induction by the capacity being the same in each of them, but with varying factors of multiplication, so that each of the four circuits is appropriated for its own particular function; and* (2) *as a consequence of the tuning of these four circuits in resonance with each other: synchronization between the transmitter and the receiver, synchronization between the primary circuit and the secondary circuit, on each side, such synchronization giving as a result a selectivity, in virtue of which the receiving station can only receive signals from the station or stations with which it is in tune.*

2. *There cannot be regarded as an anticipation opposable to this invention:*

Either the device of Lodge's patent No. 11,575 *of* 1897, *which contains at the receiving station only two circuits, which are not adjustable and consequently not tunable, i. e., which it is impossible to bring into resonance.*

Or that of Ducretet's patent containing one single circuit with transmitting antenna directly connected with the spark producer and foreign to the principle of syntonization;

Or the system of Braun's patents of 1899 *and* 1900, *which is based upon two untuned circuits and one transmission, and not upon four circuits syntonized two and two in two groups, which are in their turn syntonized with each other.* [fol. 2263] *Or the Tesla patents of* 1891, 1896 and 1897 *which have in view only the transmission of electric energy and not wireless telegraphy, and which in any case are foreign to the idea of syntonization, which is the basis of the Marconi system;*

Or finally the 1898 *patent of Marconi himself, that lapsed in* 1910 *owing to non-payment of the fee, which patent only contained two circuits for the receiver, and was likewise foreign to the idea of syntonization.*

3. *When, as in the case of Marconi's, a patent covers a combination of parts or a process producing new and useful results, anyone producing the same results by making use of the principal parts of the combination or of the process infringes the patent, even though he may have modified the combination or the process by the omission of an unimpor-*

tant part and by substituting therefore another equivalent part.

In particular, there should be considered as an infringement of the process and of the apparatus for wireless telegraphy devised and patented by Marconi, an arrangement for wireless telegraphy founded upon syntonization, which is the fundamental basis of the Marconi system for the reception of Hertzian waves, even though such syntonization should be obtained by means of indirect excitation by derivation instead of being by coupling through induction or in other words by the substitution of an auto-transformer (in particular a Oudin resonator) for the transformer made use of by Marconi.

Société Marconi *v.* Société Générale des Transports Maritimes, Compagnie Radiotélégraphique and Société Radioélectrique

The Tribunal

As regards the Form:

In view of the analogy between the actions, consolidates them in order to deal with the whole matter by one single decision.

Receives the Compagnie Radiotélégraphique as Plaintiffs in the cross-action.

Certifies to Legru that he leaves to the Court the question of infringement.

Certifies to the Société Générale des Transports Maritimes that that Company reserve their right to claim damages in the event of the substitution of the rented apparatus causing interference with its working.

As regards the Substance:

Whereas the Plaintiff Company is the holder of letters patent applied for on 3rd November, 1900, and granted on 31st February, 1901, under the number 305,960 for an improvement in wireless telegraphy;

Whereas the Plaintiffs allege that in violation of their rights the Société Générale des Transports Maritimes had [fol. 2264] provided some of their steamers with wireless telegraphy apparatus stated to be an infringement of the patent;

Whereas in consequence of an order made by the President of this Court dated the 12th October, 1911, upon a

summons dated 24th October, 1911, issued by Hardy, Bailiff, assisted from the technical point of view by M. Hubert, Engineer, a seizure for infringement was effected upon the steamer "Sidibrahim," of the Compagnie des Transports Maritimes, at anchor in the harbour of La Joliette at Marseilles, of apparatus belonging to wireless telegraphy plant alleged to be infringements, together with a sketch plan of the said installations, such seizure being effected in the absence of the operator of the wireless telegraphy cabin;

Whereas it was stated to the Bailiff by the Captain that other identical appliances were in existence, being installed upon three other steamers of the same company at anchor in the harbour of Marseilles—the "Italie," the "Parana" and the "Algérie";

Whereas it is not disputed that the apparatus the subject of the action had been installed with the concurrence of the Société Française Radiotélégraphique, which is, in fact, the owner of the same;

Whereas the Plaintiffs consequently claim jointly and severally against their opponents: In respect of the infringement applying for the confiscation of the apparatus seized, that the Société Française Radiotélégraphique be restrained from constructing, installing, exhibiting and offering for sale apparatus constituting an infringement of the patent; to an amount to be fixed by reference;

Whereas on their part the Société des Transports Maritimes à Vapeur, in the principal action, claim against the Société Radiotélégraphique on the ground that the latter is the owner of the articles seized, that the latter should be ordered to indemnify the former in respect of any judgments which might be granted against them in favour of the Marconi Company;

Whereas by their Statement of Claim of 14th October, 1912, the Compagnie Générale Radiotélégraphique claim that the Marconi patent shall be declared void on account of lack of novelty, alternatively, that same has lapsed owing to not having been worked in France during the three years following the application for the patent granted; and, finally, that the application should be rejected on account of the seized articles or apparatus not being an infringement of the Marconi patent.

Whereas the Plaintiffs, by virtue of the aforesaid order, which permitted the seizure at Marseilles for the same reasons and pursuant to the Summons of Guérard, Bailiff at Havre, under date of the 8th October, 1911, with the technical assistance of M. Noëll, Engineer in Arts and Manufacturers, had a seizure effected of various appliances for wireless telegraphy serving the steamer "Apache," belonging to Legru, such appliances at the time in question not being in the wireless cabin on board, but in a warehouse on shore;

[fol. 2265] Whereas the Bailiff found upon one of the appliances a plate bearing the inscription "Société Française Radioélectrique," and whereas in consequence the Marconi Company claim that the Société Radioélectrique should be subjected to the same penalties as those above mentioned against the Société Radiotélégraphique and the Société des Transports Maritimes à Vapeur;

Whereas Legru claims against the Marconi Company and the Société Radioélectrique that the latter, in the event of the former succeeding in the action, should reimburse to him the sum of 5,000 francs for the cost of the seized appliances and the expense of installing them on board the "Apache," and whereas the Société Radioélectrique in like manner with the Société Radiotélégraphique claims that the Marconi patent shall be declared void, and in any event to have lapsed on account of not having been worked in France within the prescribed period, and finally, that there is no infringement on account of differences existing between the patented device and the appliances seized;

Whereas henceforward the discussion is carried on, in like manner, with regard both to the arguments between the Marconi Company on the one hand and their two groups of opponents on the other, no useful purpose being served in following those discussions, which are necessarily somewhat abridged in comparison with the important arguments which have not been considered too lengthy in view of the task to be achieved, on the one hand to demonstrate the perfect validity of the patent and on the other to demonstrate its nullity on account of anticipations, and, alternatively, that it has lapsed on account of not having been worked, and finally, in the further alternative, the absence of infringement on account of sufficient differences between the patented device and the two sets of

apparatus not being identical, which were seized, the one at Marseilles against the Société des Transports Maritimes à Vapeur and their owner the Société Radiotélégraphique, and the other at Havre against Legru and the Société Radioélectrique, which supplied the same to him.

Whereas it is further necessary, prior to proceeding to the examination of the claims of the opposing parties, to reserve the double claims of the Marconi Company, with respect to each of the two groups of Defendants, to amend their original claims for damages by extending them to those acts of infringement which took place subsequent to the application; and of the Société Radioélectrique to the insertion of any decision to be given in their favour in fifteen newspapers by way of damages;

Whereas it is advisable to divide the study of the questions submitted to the Court into five parts: (1) History of wireless telegraphy, and the research which is indispensable before discussion of the terminology most commonly employed in this special branch of applied science; (2) Examination of the various Marconi patents and thereafter the [fol. 2266] evolution of his scientific effort; (3) An analysis of all the cases of anticipation claimed against the patent of 1900, which is the only one that is set up in the present action; (4) An examination of the complaint of non-working within the prescribed period; (5) A comparison of the devices alleged to be infringements of the Marconi apparatus and consequently an eventual justification of the charge brought against the Defendants.

Part First—History.

As regards the First Portion:

Whereas logically the name of wireless telegraphy should be applied to all processes employed by human ingenuity for the rapid transmission of thought from one place to another without any material link between the point of transmission and that of reception;

Whereas such was last century the "Chappe" telegraphy and at the present day optical telegraphy, which is at times the successful rival of wireless telegraphy properly called according to current terminology;

Whereas this admirable discovery was the result not of chance, like the electric battery, which was due to a current of wind that was vivified by the genius of Galvani, but was

a practical application of observations of purely speculative science:

Whereas, without recalling the researches of Henri about 1839 upon the inductance of electric circuits, it may suffice to say that wireless telegraphy is the industrial result of the theory of Hertzian waves, which is itself due to the development of Maxwell's discoveries:

Whereas, indeed, this scientist, while rejecting the idea of distant effects, necessarily arrived at the result of viewing electric and magnetic phenomena as being merely deformations of the interposed medium:

Whereas a fresh experimental fact brought about a confirmation of this hypothesis by leading to a theory which embraced together electricity, magnetism and light.

Whereas indeed, all electric or magnetic magnitudes can be connected with mechanical magnitudes, so that with the three fundamental mechanical units, length, mass and time, they can be measured, *i. e.*, the system designated C. G. S. or centimetre mass of a gram, and, second.

Whereas in seeking the value of the ratio existing between the electro-magnetic and electrostatic units, Maxwell obtained the figure of 300,000 kilometres per second, *i. e.* the speed of light, from which he reached the conclusion that there was not merely analogy but identity between the vibrations recognised by experience under their double electro-magnetic and luminous form, the former being the result of an alternating current and the latter of a source of light.

Whereas the scientist Hertz by his experiments confirmed the bold hypothesis of Maxwell, and whereas he brought out this scientist's truth, viz., that an electric source in dis- [fol. 2267] charging produces oscillations which are communicated, such as sound and light, to that mysterious ether in infinite space of which our atmosphere is not part, which is as imponderable as an absolute vacuum as it in no way disturbs the motions of heavenly bodies, and which nevertheless is so thoroughly existent as the necessary connecting link of matter that it scientifically permits the slightest noise, the smallest ray of light, the least movement imparting agitation to it, such as an electric impact, to proceed in every direction of a sphere, the point of departure of which is the centre, into the infinitude of time and space:

Whereas this motion is produced by means of waves analogous to those called forth by a body falling upon a

liquid surface which is immediately covered with circles, the centre of which is the point where the body disturbed the liquid, and which proceed ever widening, but diminishing in height towards the limits of the liquid sheet;

Whereas the special character of these waves in the ether as well as in the liquid, in spite of what in the latter case might be thought, is that the translateral progressive movement referred to above is only apparent; and whereas as a matter of fact in the trite example mentioned previously of a disturbed liquid sheet, a float upon the surface of the moving liquid does not alter its position in a horizontal or lateral direction, but merely rises on the apparent passage of the wave in order to descend again until it again rises under the action of the subsequent undulation; and that thus undulations can be compared to a palpitation without any lateral displacement of the fluid which is disturbed by any impact.

Whereas this special motion is called oscillation, whilst the motion of the waves from the centre to the periphery without displacement and without any transport of the fluid is called radiation; and whereas the length of time which a molecule raised by the undulation takes to re-descend to its point of departure, that is to say, the duration of the oscillation, is called the period of this oscillation; and whereas, finally, the wave length is the distance covered by the motion of radiation during the period of oscillation;

Whereas, in order more readily to study the waves bearing his name, Hertz wished to create short waves by increasing the frequency of the oscillations, which he achieved by the radiator that is also called after him and which is nothing but an emitter of waves in the ether;

Whereas, in order to reveal the waves that the eye could not perceive, Hertz constructed by means of a spiral of metal wire an open circle or detector to which he imparted peculiar sensitiveness by utilising, as far as possible, the very interesting principle of resonance, whence the name of resonator given to this apparatus; and whereas, as a matter of fact, just as a pendulum which is set in motion by a first impulse moves with increasing amplitude of oscillation if fresh impulses at each oscillation add their effect to [fol. 2268] the first one at intervals of time corresponding with the period of oscillation, *i. e.*, at the moment when the pendulum is moving in the direction in which the first impulse had driven it, whilst apart from this condition the

successive impulses, instead of exerting a cumulative effect, would destroy the effect already accomplished, just as in acoustics, by prolonging, for instance, the vibration of a note upon a string in the neighborhood of other strings of various tone values, the string having the same tone value as the one set in action or its octave, will in its turn vibrate in unison or in octane; whereupon Hertz concluded that if his receiver was regulated to the same period as the radiator, the series of waves created in the ether by the latter would have a cumulative effect upon the receiver and would make it more sensitive to its action;

Whereas Hertz was thus able in 1889 to demonstrate experimentally the correctness of Maxwell's theory and to show how the waves developed in the ether by an oscillating electric current manifested their presence by a spark, which was the first step towards wireless telegraphy;

Whereas Branly in his turn gave a fresh impulse to the discovery, that was as yet unsuspected, by utilising for the first time, in order to reveal the Hertzian waves, a coherer consisting of a glass tube filled with iron filings; whereas this tube is, as a matter of fact, a bad conductor, but becomes a good conductor when, under the action of an electric current, the particles cohere; and whereas Branly placed this tube in a special current, that was interrupted by this tube, which remained sensitive to the waves, so that when the waves met the coherence being produced, the current was re-established and operated the needle of a galvanometer which was also introduced into the circuit and which thus signalised the presence of the waves; whereas, of course, this effect being produced, care was taken to destroy the coherence by means of a suitable tap, thus interrupting the current and fitting the apparatus for again giving notice of the passage of fresh waves;

Whereas in 1892 Crooks was the first to suggest that the foregoing discovery might well lead to wireless telegraphy, and whereas Marconi, with the same idea in his mind, brought it to a sufficient degree of perfection to take out his first patent on 2nd June, 1896, thus inaugurating the marvellous invention which from this point of view makes him worthy of imperishable memory;

Whereas after these indispensable preliminaries defining the phenomena and the expressions, without a knowledge of which the discussion could not be followed, it is further

necessary to explain some new terms that will appear in the patents which remain to be examined;

Whereas in the first place in the matter in question one of the first functions is carried out by appliances usually called coils and sometimes designated transformers which are in principle composed of two concentric windings of metallic wires conducting electricity; whereas the first of [fol. 2269] these windings forming the primary circuit is therefore called the primary, whilst the second winding, called the secondary, constitutes the second or secondary circuit formed by induction or induced, when it is cut by lines of force of the magnetic field created by the passage of an electric current passing through the primary;

Whereas a distinction is made between a continuous current and an alternating or alternate current which resumes its intensity after having changed its direction and returning to zero; whereas the voltage of a current is the measure of the pressure of electricity in the current, whilst its intensity is the volume of current per unit of time; whereas the resistance is the difficulty experienced by the current in passing through a conductor under a definite electric pressure or voltage; whereas this resistance is usually produced by a coil surrounded by a wire and placed within the circuit where it produces a kind of throttling that permits of the volume of the current being varied;

Whereas the current which penetrates into a conductor does not at once acquire a stable condition on account of the expenditure of energy necessary for the creation of the magnetic field surrounding every electric conductor, which constitutes a real induction of the current upon itself; whereas this delay is called self-induction, which is very strong in coils with a core of soft iron; hence the term self-induction coils is applied to those with an electro-magnet or those without such a part, but any that are intended to retard the normal condition of the current;

Whereas induction is a phenomenon by means of which any electric circuit in the neighbourhood of a circuit, whether approaching or moving away from the same, gives rise to a current in the second circuit, and furthermore if these neighbouring currents are mobile, and if one of them is fed with alternating currents as already stated, a secondary current is produced by induction; whereas this phenomenon is the basis of transformers, the industrial

function of which has become so considerable, as they work of themselves, automatically; whereas they consist of more or less concentric coils; whereas the first winding, called primary, receives two alternating currents, which by induction give rise in the second winding, called the secondary, to another current bearing the same name, which is also alternating, varying in its voltage, its intensity, according to the characteristics of the windings of the coil, and is in any case induced, that is to say, formed by induction, when it is cut by lines of force of the magnetic field created by the passage of the primary current; whereas the classic type of this transformer is the Ruhmkorff coil, the primary of which is actuated by a continuous current, but which is rendered alternating, and the secondary of which gives sparks:

Whereas the condenser consists of two electric surfaces separated by an insulating coating, and is intended for the [fol. 2270] purpose of condensing and storing electric energy in order to supply it when required; whereas the faculty of storing electricity is called capacity:

Whereas if within an electric circuit comprising any source of electricity a conductor, a resistance, is connected to a condenser of a certain capacity and a self-induction coil; and if, on the other hand, the condenser is connected to a suitable source of electricity, and if in the condenser there is a gap, there will be a spark discharge, and according to the relations of resistances, of the capacities, and of the self-induction, there will be discharges of varying nature, continuous or oscillating, flowing alternately from one pole to the other:

Whereas, however, in this circuit the time of oscillation and consequently the period of the waves which will arise by the discharge of the spark are proportional to the product LC, that is of the capacity C multiplied by the self-induction L, according to Thomson's formula:

Whereas by the application of this principle, by varying the relations of the elements of the equation, it is possible to tune the periods of oscillation, so that interested circuits may be combined, which is precisely the condition of receptivity of wireless transmission:

Whereas, finally the name of antenna is applied to a device assuming various forms, but ordinarily composed of a long metallic wire erected in space, a condenser, a transmitter or receiver of waves, *i.e.*, a capacity.

Part Second—Examination of Various Marconi Patents

Whereas the Marconi device, patented in 1896, consists of a source of energy; one single electric circuit the spark producer, the self-induction and the antenna, which latter readily yields its energy to the ether in the form of oscillations and constitutes the capacity which with the self-induction provides the two factors, the product of which determines the periods of oscillation; whereas a second receiving circuit also contained the self-induction which, multiplied by the capacity of the condenser, with suitable adjustment gave the same product as that obtained by the same elements in the first circuit; and whereas this result precisely constituted the tuning of the two circuits in consequence of syntonization, ensuring the ready reception by the second circuit of the waves transmitted by the first; whereas, finally, the receiving circuit was provided with the improved Branly coherer in connection with a mechanical device which decohered the filings by a series of small and rapid taps;

Whereas this patent secured practical results and permitted of the establishment of wireless telegraphic stations, placing points several kilometres distant from each other in communication, but it was not able to escape from a law of which Lodge had spoken in his celebrated lecture in 1894, and which he expressed thus:

Whereas this double drawback existed in the Marconi ar- [fol. 2271] rangement; whereas as a matter of fact the transmitter through the very fact of being a good radiator was incapable of giving prolonged series of waves, and that the receiver by readily absorbing the waves was on that very account powerless to accumulate the effect of prolonged series, which condition, as we have seen, was indispensable for the proper utilisation of resonance;

Whereas under these circumstances Lodge applied for the patent 11575 of 10th May, 1897, taking up the general ground which Marconi had so well occupied, but remedying the drawbacks which have just been summarised by means of a compromise; whereas, indeed, not being able to abrogate the law he had promulgated he got over the difficulty by increasing the persistency of the oscillations in his radiator at the expense of its radiating qualities and increasing the possibility of his receiver accumulating the

effect of the waves striking the same at the expense of the absorption qualities; whereas the practical means was from the point of view of syntonization to introduce into the open circuit like that of Marconi an inductance producing a longer series of waves without greatly modifying their amplitude, and from the point of view of the increase of electric energy introducing two surfaces forming capacities, and having such a shape that the tendency of the circuit to lose its charge by brush discharge was reduced to a minimum whilst the amperage and the voltage of the oscillations was increased:

Whereas apart from this improvement upon the Marconi arrangement, that of Lodge was a reproduction of the same, whereas shortly after in the same year he took out a second patent number 29505, relating to inductive telegraphy, which is however interesting in view of the primary and the secondary of the system being provided with adjustable devices, permitting a precise syntonization and are tuned to the same frequency so that the secondary, which like the primary is a closed circuit, can act by the accumulation of the effects received by the application of the principle of resonance, which accomplishes selectivity:

Whereas there is no occasion to deal with Thomson's patent No. 525, taken out in 1898, relating to induction telegraphy, nor with Lodge's second patent, from which it does not very materially differ; these two patents, which are capable of furnishing interesting ideas, are without any direct bearing upon telegraphy by means of Hertzian waves, which was alone contemplated by the Marconi patents:

Whereas in the same year 1898 the latter took out a second patent under the number 12326:

Whereas the invention consists of an improved receiver in which the antenna is connected to earth through a primary, of which the secondary comprises the coherer, which raises the voltage so that the coherer may be more certainly affected by the signals received:

Whereas Marconi gives minute details as to the construction of these transformers which are without any iron core, [fol. 2272] according to the type adopted by Tesla, to raise the voltage of high frequency alternating currents.

Whereas he took out two further patents also relating to the form of the receiver just referred to under the numbers 6982 and 25186 of 1899:

Whereas without for the present dealing with the Braun patent taken out under number 1682 of the same year, we can at last approach the fundamental patent applied for by Marconi on 3rd November, 1900, and granted on 1st February, 1901, "for improvements in wireless telegraphy."

Whereas this patent is thus worded:

Letters Patent No. 305,960. Improvements in Wireless Telegraphy by the "Marconi Wireless Telegraph Company, Limited."

"The object of this invention is not only to increase the efficiency of the apparatus hitherto employed, but also to so control the action as to cause intelligible communications to be established with one or more stations out of a group of several receiving stations.

In the patent No. 261612, a transmitter is described which consists of an induction coil, one terminal of the secondary circuit being connected to a metal sphere connected to earth and the other to a similar sphere connected to an insulated conductor which generally takes the form of a more or less vertical wire which may or may not terminate in a metal body of extended surface, giving it increased electrical capacity.

According to the present invention the vertical wire is connected to earth through the secondary winding of a transformer suitable for the transformation of very rapidly alternating electric currents, and the primary of this transformer is connected to the spheres or terminals of the sparking appliance.

A condenser of suitable capacity is introduced in series with the primary or each end of the primary may be connected to one of the plates of two condensers of suitable capacity, the other plates of which are connected to the sparking appliance.

This device enables much more energy to be imparted to the radiator than heretofore, the approximately closed circuit of the primary being a good conserver and the open circuit of the secondary a good radiator of wave energy.

The arrangement works as follows:—

On pressing the key and actuating the induction coil (in order to produce a signal) the condenser in circuit with the transformer is charged and discharges through the spark gap. If the capacity, the inductance, and the resistance of

the circuit are of suitable values, the discharge is oscillatory, with the result that alternating currents of high frequency pass through the primary of the transformer, and induce [Vol. 2273] similar oscillations in its secondary, these oscillations being communicated to the vertical and elevated conductor.

The circuit of this conductor should be suitably attuned for this purpose.

The effect of these oscillations in the elevated conductor is to inductively affect similar distant conductors if the self-induction and capacity of the said conductors is of a suitable value or values.

At the receiving end a receiver is employed capable of being actuated by electrical oscillations of high frequency, such as those described in the Specification No. 28352l.

The four circuits, namely, those including the primary and the secondary of the transformer in the transmitter, should be so adjusted as to make the product of the self-induction multiplied by the capacity the same in each case, i. e., that their electric time period is the same, but they may also be harmonics of each other.

In employing this invention to localise the transmission of intelligence to one only out of several receiving stations the time period of the circuits at each of these stations is so arranged as to be different from those of the other receiving stations. If the time period of the circuits of the transmitting station are varied until they are in resonance with those of one of the receiving stations, that one alone out of all the number of receiving stations will respond, provided that the distance between the transmitter and receiver is not too small.

The adjustment of the self-induction and capacity of the circuits can be made in any convenient manner; those that are to be preferred are set forth in the following description:

Figures 1 and 2 are diagrams of the transmitter and of the receiver respectively, whilst Figure 3 shows a side view and Figure 4 an edge view of a transformer used at the transmitting station, and Figures 5 and 6 show various induction coils used at the receiving station.

A is a battery, B a Morse key, C a Ruhmkorff coil, the primary of which is in circuit with the battery, whilst the terminals of the secondary are connected to the primary D of a transformer, one of the connections being through a

condenser E or there may be a condenser in both of the connections.

The secondary D of the transformer is connected to an aerial conductor A which may have at its top a metallic cylinder F and to earth there is a capacity E. Between the secondary and the aerial conductor or it might be between the secondary and earth is sometimes inserted an inductance coil having numerous coils and the connection is such that a greater or less number of turns of the coil can be put in circuit, the proper number to use being ascertained by experiment.

The receiver (Figure 2) consists of an aerial conductor A which may have a cylinder F at its top connected through an inductance coil g^1 similar to G and through the primary [fol. 2274] j^1 of an induction coil to earth or a capacity E; a small condenser H may be inserted in parallel with the primary J^1.

The secondary J^2 of the induction coil is divided in the middle and has its inner ends connected to the plates of a condenser J^3, while its outer ends are connected it may be through inductance coil G^2 similar to G to a coherer T; a condenser H^1 may be inserted in parallel with the coherer.

The local circuit containing a battery cell B and relay or telegraph instrument R is connected through choking coils C^1 C^2 to the plates J^3 of the condenser.

The condensers H H^1 are preferably in the form of two metallic tubes separated by a dielectric and sliding telescopically on each other, as in this way their capacity can readily be varied to tune the circuits.

Whereas this abstract and highly scientific wording requires comment:

Whereas the invention, according to the happy wording of Mr. Seligmann, consists of the following: Since one single circuit in the initial arrangement of 1896 cannot be simultaneously a good radiator and a good oscillator, both for transmission and receiving, let us place two at each station combined, that is four; at the transmitting station a first highly closed circuit, which is very compact, containing an electric condenser, will be entrusted with the oscillation work, and then, through the medium of the transformer, will be placed in communication with a second circuit, that of the antenna, that of radiation, which is widely open and consequently excellent for its purpose. At the receiving station there are likewise two circuits: The

first, being a good absorber of electricity, will capture the waves by means of a transformer and will set in action another circuit suitable for properly preserving the electricity which will receive the Branly, the detector, the wave revealer;

Whereas this first result of the invention of the four currents is of supreme import, since it resolves in a very happy and simple manner the difficulty laid down by Lodge as insoluble, which, however, had already been partially overcome by him, as we have seen above;

Whereas the patent contains another equally important conquest from the point of view of the essential principle of resonance, the definition of which must again be borrowed from Mr. Seligmann, who expresses it as follows: The four circuits must be tuned together, that is to say, they will all four have the same period, and in each of the four circuits the product of the self-induction by the capacity will be the same, but with varying factors of multiplication, so that each of the four circuits may be suited to its own particular function. The four tuned circuits will therefore be all four in resonance with one another; there will be synchronization between the transmitter and the receiver, synchronization between the primary and the secondary circuit on each side, and from this synchroniza- [fol. 2275] tion between the four circuits there will result a selectivity, that is to say, the receiving station will only be able to receive signals from the station or stations with which it is in tune;

Whereas this result is considerable, for it permits of the principle of secrecy in communications by agreements between correspondents having adopted the special "frequency" for their communications;

Whereas it was this result that permitted certain important applications to be made, such as those of the Berlin Conference, which imposed upon commercial messages wave lengths of 600 to 300 metres, whilst it is evident that other wave lengths will be adopted for diplomatic or military communications, which will be equivalent to a cryptographic cypher;

Whereas such was evidently (as was also affirmed by Mr. Justice Parker in his elaborate enquiry before the High Court of Justice in London, which terminated by the judgment of 21st February, 1911, in favour of the Marconi patent) the thought of the inventor, in spite of certain defi-

ciencies in the wording of the patent specification, which does not in express terms set forth the object aimed at by this syntonization to be accomplished between the circuits of the transmitter and those of the receiver; but whereas this object is sufficiently evident to the specialists, more especially as the inventor really explains how the selectivity is obtained; whereas all the foregoing is impliedly comprised in the first paragraph of the patent specification; whereas such is likewise the case with respect to the necessity of syntonizing the two circuits of the receiver, which fact is necessarily deduced from the requirements and results of the device described;

Whereas to conclude as regards the synchronization of the patent, lines 23 to 28 on page 2 of the specification should be noted, which comment upon the adjusting processes, and lines 78 to 85 on the same page, which summarily describe the actual process of regulating, viz., of the condensers, preferably in the form of two metallic tubes separated by a dielectric, and fitting telescopically within each other, so as to permit of readily varying their capacity in order to tune it with the circuits;

Whereas that is synchronization by adjustment or practically by rule of thumb, whereas this synchronization might result (which would be more scientific but less adaptable) from the very construction of the appliances, their characteristics, the length of antenna, the number of turns of the induction coils, and the capacities of the condensers being calculated so that *a priori* the period of the transmitter and that of the receiver are the same at the various stations and consequently give the same result everywhere, which precisely constitutes syntonization and hence the working of the apparatus;

Whereas there is no occasion to follow the specification as regards the minute details given as to the transformers, nor as regards the study of the very interesting synoptic table at the end of page 3 and the beginning of page 4, and which constitutes the experimental table for six tunings [fol. 2276] of the adjustments of each group; whereas thus the table of the transmitting station places opposite the six tunings numbered from 1 to 6 the elements of the aerial conductor, the number of the transformer, the nature of the inductance, the capacity in microfarads, finally the length of the spark in millimetres; whereas on the other hand the table of the receiving station places opposite each of the

six tunings the number of the induction coil, the capacity in microfarads and the inductance;

Whereas the last point to be examined is what is called loose or close connection or coupling;

Whereas scientists, and particularly the specialists who gave evidence in fact at the hearing before Mr. Justice Parker, recognise that the cumulative effect to which oscillations produced in a circuit may give rise in another circuit syntonized with the first one depends upon the manner in which the two circuits are connected, and that in order to obtain the greatest possible cumulative effect the circuits must be what is termed loosely coupled, because the cumulative effect of the primary on the secondary, which is syntonized with it, decreases in proportion as the coupling is closer;

Whereas doubtless this principle is not expressly stated in the 1900 patent, which, however, does not in any way impair its value, the same resulting from a harmonious, logical and rational general theory, that is fruitful in results, precisely because it constitutes complete and new invention, and whereas indeed nothing compels the inventor to use a formal wording, but he is free as to the manner in which he sets out his description and is entitled to all the profits thereof, provided his ideas are really and sufficiently expressed; and that therefore, although no mention is made in the letters patent of the condition termed loose coupling, which is one of the important features of the invention, it is wholly included in the invention for the sufficient reason that no expert can read and consider the patent without finding in the same evidence in support of the claim to loose coupling, and this as far back as 1900; that indeed such an expert on reading a passage in which it is explained how it is possible to obtain in a circuit a cumulative effect by means of oscillations obtained in another in a second circuit syntonized with the first circuit, would have understood that it was a necessary condition to provide a loose coupling of these two circuits inasmuch as the inventor wishes to obtain selectivity which necessitates the employment of a series of waves of almost constant amplitude, which cannot be obtained by means of close coupling, that is to say, in which the proportion of penetration of the lines of force of the primary into the secondary is 30 per cent. and over;

Whereas under these conditions the Marconi patent, both from the practical point of view and that of applied theory, does seem to have been the first to accomplish a new and very important industrial result, borrowing from what he himself and others had already found during half a century [fol. 2277] of research, carried on at first in purely speculative science without the least thought of the future practical value, and then on industrial lines foreshadowed by the combined efforts of men of great intelligence, thus little by little lifting the veil from the, as yet, unknown, and arriving at the Marconi patent of 1900, and whereas this patent typifies a wonderful conquest to which the young man of science puts a finishing touch by his unrelenting perseverance, but which nevertheless will doubtless only be the landmark of a considerable advance in the development of that new science which puts at the service of man the mysterious Hertzian waves, but which will be followed by other advances, the final result of which will be the elucidation and putting into use of new mysteries. And whereas this law of continual advance has already produced the Fessenden System allowing communication at 300 kilometres (1907), that of Forest, in which the arc heated by means of alcohol reaches to 50 kilometres; that of Poulsen (1908), in which communication is carried over a distance of 270 kilometres; that of the Telefunken Company, covering 75 kilometres with twelve arcs in series in the arc (1906-1907); that of Rhumer, allowing telephonic communication to be carried on over a distance of 50 kilometers by means of a high tension arc and a thermo-electric detector; that of the naval officers Colin, Jeance and Mercier, allowing communication to be carried on over a distance of 200 kilometres (1908); that of Majorana, transmitting the human voice to a distance of 420 kilometers (November, 1908), better than with the ordinary telephone, with 60 metre antennae and with oscillations produced by means of a Poulsen arc and a receiver consisting of a detector with crystals;

But whereas, for the present, on this battle-field of our invasion of the unknown, the Marconi patent is based upon claims stated as follows: *(1) "a transmitter for electric wave telegraphy consisting of a spark producer, having its

* Extract from French patent No. 305,060, Page 4, Lines 18 to 76.

terminals connected through a condenser with one circuit of a transformer, the other circuit being connected to a conductor, and to a capacity (2) a transmitter for electric wave telegraphy, the combination of a transformer, one of the circuits of which is a persistent oscillator and the other a good radiator, and devices for creating oscillations in the oscillator (3) a transmitter for electric wave telegraphy, consisting of a spark producer, having its terminals connected through a condenser with one circuit of a transformer, the other circuit being connected to an earth conductor, the time period of the electric oscillations in the two circuits being the same or harmonies of each other (4) a transmitter for electric wave telegraphy, the combination of a transformer, one of the circuits of which is a persistent oscillator, and the other a good radiator, the time period of the electric oscillations in the two circuits being the same or harmonies of each other, and devices for creating oscillations in the oscillator (5) a system of electric wave teleg- [fol. 2278] raphy, in which both the transmitter and the receiver contain a transformer, the time period of the electric oscillations in the four circuits of the two transformers being the same or harmonies of each other (6) a system of electric wave telegraphy, in which both the transmitter and the receiver contain a transformer, one circuit of which is a persistent oscillator and the other a good radiator or absorber of electric oscillations, all four circuits having the same time period or being harmonies of each other (7) a transformer for electric wave telegraphy, the combination of a pair of terminals, or devices for producing sparks between the terminals; of a connection transformer between one of the turns of the transformer and the terminals, of a condenser in one of the connections, of a conductor, of a capacity and connections between the other turn of the transformer and the conductor and the capacity (8) apparatus for wireless telegraphy substantially as described and illustrated."

Part Third: Anticipations

Whereas the opponents of Marconi recognise that the latter had first the honour of obtaining practical results from the discovery of Branly in establishing telegraphic communication by means of Hertzian waves in the historical experiment between Dover and Calais, but whereas they

allege that Marconi only employed what had been discovered before him by Popoff, Tesla, Lodge, Braun and Ducretet;

Whereas all these independent endeavours tending however towards the same end are put forward as anticipations rendering the patent set up null and void by reason of want of novelty.

But whereas Marconi does not allege that he discovered at one stroke everything that constitutes his system; and that on the contrary he is modest enough to introduce his patent under the heading: "Improvements in wireless telegraphy," and whereas according to the French law a patent can be obtained for any combination bringing about by means of previously known processes a new industrial result, which is the only ambition of Marconi;

Whereas we are not concerned to discover whether the elements which constitute the patent of 1900 were or were not known, but whether the result obtained by Marconi was new, either in respect of a total or partial new arrangement or of an industrial result constituting an advance on the previous position;

Whereas, as has already been said, the four syntonised currents in particular constituted a new arrangement, Marconi being the first who succeeded in operating wireless telegraphy in a practical manner over long distances, thus securing his position of eminence in this branch of applied science.

Whereas, moreover, the anticipations which are alleged against the patent of 1900 would have been victorious only if they had established that this patent was an impudent [fol. 2279] plagiarism and not the synthetical result of interesting efforts but powerless to attain the same result;

Whereas these efforts deserve to be brought into prominence, since they were made by those scientists who following one another have the honour of having contributed to the success of a great discovery, some by purely speculative researches, as for instance, Henri in 1839, Maxwell, Hertz, Heaviside, Poyntwig and others, afterwards on the lines of practical applications, such as Branly, Sarrazin, Delarive, Poincaré, Bjerkness and Blondlot, modifying the formula of Hertz in order to amalgamate it with that of Thomson, Gutton and Turpin by means of his studies on interference fields and propagation in dielectrics; Righi

by means of his researches on reflection and refraction; Lebedeff from the point of view of optics with his electromagnetic waves; Blondel with his excellent calculations, and very many others;

Whereas Popoff, whose name has been mentioned as an anticipation, which fact has not been borne out either in the arguments or in the pleadings, had made considerable advance by his publications and his communications to Russian scientific societies, showing by his experiments that he could enable the Navy to transmit and receive signals over long distances; and whereas, starting on studies in atmospheric electricity, he had in theory reached wireless telegraphy and even the idea of tuning, but whereas he had not been able to set foot on the territory of actual practice, because he was unable to generate undulations powerful enough to produce the waves; just as in the case of Tesla he had not discovered the method of receiving them;

Whereas the foregoing is interesting because these details are supplied by Ducretet whose alleged anticipation, which will be discussed later, is swept away in advance by the fact that speaking with reference to Popoff on the matter of tuning (which forms the basis of the Marconi patent) as a preface to his own apparatus, he had no thought of using for himself this essential principle, from which it follows that he was, through his own fault, taking the opposite lines to the Marconi system;

Whereas, moreover, neither in the argument nor the submissions was any weight attached to the works of Popoff, which, while very interesting, have no influence on the Marconi patents in which other principles and entirely new mechanisms have been used;

Whereas under those circumstances it behooves us first to consider in their chronological order the anticipations referred to in the pleadings and in the submissions; that is to say, the Lodge patent of 1897, the Ducretet apparatus described in 1898, the second Marconi patent, which became public property on failure to pay the fees in 1910, the Braun patent number 1862 of 1899 and the Tesla patents, the first taken out in France in 1897; the other taken out in America in 1900; as to the Lodge patent (No. 11575 of 1897);

[fol 2280] Whereas due homage has been above paid to this learned Englishman who was the first to define exactly the real and apparently insurmountable difficulty, viz., that the strong radiation of the waves was incompatible with

the generation of persistent oscillations; and also to the ingenuity with which he partially overcame the before-mentioned obstacle by increasing the persistence of the oscillations in the radiator at the expense of its radiating qualities, and in the opposite direction by increasing the possibility of his receiver accumulating the effects of the waves that strike it at the expense of the absorbing qualities of that receiver;

But whereas the patent went further, inasmuch as it is taken out like that of Marconi under the modest heading of "Improvements in syntonised telegraphy without line wires," which is indeed, as in the case of Marconi, an evidence of considerable effect in the same direction pointed out by the 1896 patent;

Whereas Lodge in a description which Mr. Taillefer himself considers too long to be examined in all its details, demonstrated clearly that he came very near to the patent set up, but as a matter of fact fell just short of the last stage of the final invention capable of industrial application; and whereas, in fact, he faces the problem of the use of the resonance principle in a system of wireless telegraphy, insisting not only on the efficiency it should have over long distances, but also on the fact that in making use of this principle it ought to be possible at one or several receiving stations, provided with syntonised receivers, to receive messages, whilst other stations provided with receivers syntonized for a different frequency or wave length would be in no way affected, which, in practice, meant that it would be possible to secure selectivity under the conditions inseparable from this new mode of communication;

But whereas it is necessary to quote literally at least the characteristic parts of the patent, as follows:

The method of intercommunication consists, according to my invention, in utilising certain processes and apparatus for the purpose of producing and detecting a sufficiently prolonged series of rapid electric oscillations and in so arranging them that the excitation of a particular frequency of oscillation at the sending station may cause a telegraphic instrument to respond at a distant station, by reason of being associated, through a relay or otherwise, with a subsidiary circuit capable of electric oscillations of that same particular frequency, or of some multiple or sub-multiple of that frequency. Another distant station will similarly

be made to receive messages by exciting at the sending stations alternations of a different frequency, and so on; and thus individual messages can be transmitted to individual stations without disturbing the receiving appliances at other stations which are tuned or syntonised to a different [fol. 2281] frequency. Each station will usually be provided with both sending and receiving apparatus. * * *

As charged surfaces or capacity areas, spheres or square plates or any other metal surfaces may be employed, but I prefer, for the purpose of combining low resistance with great electrostatic capacity, cones or triangles, or other such diverging surfaces, with the vertices adjoining and their larger areas spreading out into space, or else a single insulated surface may be used in conjunction with the earth, or the conductors embedded in the earth constituting the other oppositely charged surface.

Radiation from an oscillator consisting of a pair of capacity areas is greater in the equatorial than in the axial direction, and accordingly, when sending in all directions is desired, it is well to arrange the axis of the emitter vertically. Moreover, radiation polarised in a horizontal plane, that is, with its electric oscillations vertical, is less likely to be absorbed during its passage over partially conducting earth or water. A pair of insulated capacity areas arranged for long distance signalling is shown on the left-hand side of Figure V.

Another plan, and one well adapted to secure accurate tuning, is to arrange some of the whole of a syntonizing coil so that its parts may be made to approach or recede from one another. This one I call an adjustable coil, the others I call replaceable or interchangeable coils.

A receiver or resonator consists of a similar pair of capacity areas connected by a similarly shaped conductor to a self-inductance coil, the whole constituting an absorber arranged so as to have precisely the same natural frequency of electrical vibration as the radiator in use at the corresponding emitting station.

Whereas Mr. Justice Parker, after having studied this patent, basing his argument on Figure XIV., justly calls attention to the fact that, according to Lodge, the open circuit of his receiving aerial is connected through a transformer with a closed circuit containing the coherer, in order to allow the electric oscillations to develop more freely in his receiving aerial without any disturbance from

attached wires; whereas the secondary circuit as it is represented is not syntonized and cannot be syntonised with the circuit of the antenna; hence it follows as the English Judge very well says in his own fashion that the 1900 invention of Marconi was not so obvious that the patent which protects it can be said to be deprived of its subject matter; and whereas he confirms this finding when he says:

In introducing two circuits at the receiving end, Lodge does not see that if only he had utilised the principle of [fol. 2282] resonance as between those two circuits the problem would have been solved, at any rate at the receiving end, and really the problem at the transmitting end is the same problem as the one requiring solution at the receiving end, but from the reverse point of view. The common knowledge of the art was, as far as material for the present purpose, the same when Lodge prepared his 1897 specification as when Marconi prepared his specification. How then can I treat as obvious at the latter date what so able a man as Lodge entirely failed to see in 1897.

Whereas Mr. Seligmann has clearly expressed this opinion, making it more striking when he says that Lodge has no idea whatever of the four circuits of Marconi; he uses a high capacity radiator, he endeavours to excite his radiator, and for this purpose he makes use of several devices for excitation, in one of which there is something vaguely resembling two circuits, but which is nothing of the sort: the purpose of the first circuit is to prevent communication between the source of energy and the excitation circuit; there is no common magnetic field between one circuit and the other, and both oscillation and radiation are entirely performed in the single circuit: "With the receiver we shall come nearer to, without however reaching the Marconi receiver, two circuits, with a common magnetic field, these circuits being capable of being put into communication by induction, which is a resemblance, but differing in that the purpose of this arrangement is to provide a screen, and not the cumulative effect of the Marconi device, to prevent the reaction of the coherer wires on the work of absorption on the two capacity surfaces, which constitute the antenna * * * the result sought after being that the resonator, the antenna, may vibrate without disturbing the attached wires, that is to say, those of the

coherer * * * far from endeavouring to unite them, it is sought to separate the functions of the antenna and that of the coherer; the two currents therefore have a common magnetic field * * * At this stage, Lodge is, so far as the receiver is concerned, very near to solving the difficulty but he did not understand that in using between the two circuits, the principle of resonance, the difficulty was solved, at least with regard to receiving. It has not been stated that in the two circuits the product of self-induction by capacity is the same in both, neither can they be adjusted; on these two circuits there likewise is no possibility of modifying them to enable them to be tuned one with the other; there are certainly two circuits, but not two circuits that can be tuned, and as it is not possible to regulate the two circuits, it is impossible to bring them into resonance."

Whereas it was justly held by the English Court on this point that the Marconi patent was valid:

Whereas it is true that the opposite side take consider-[fol. 2283] able pains to show that Mr. Justice Parker contradicted himself in afterwards granting an extension of time to the Lodge patent, but it is sufficient to read this latter judgment in order to be convinced that this apparent contradiction is explained by the modifications introduced into the original wording of the patent and as a kind of indirect remuneration for the efforts of Lodge although overridden by Marconi.

With regard to the researches of Ducretet:

Whereas the latter thus explains his apparatus in his communication on Hertzian wireless telegraphy in the issue of December, 1898, of the "Bulletin de la Société d'Encouragement pour l'Industrie Francaise" (p. 1632 and following):

As in the case of telegraphic apparatus the appliance consists of a transmitter and a receiver.

The principal part of the transmitter is a Ruhmkorf induction coil, which is very powerful if it is intended to operate a long distance. The model I have designed is quite portable and strong. The coil is entirely contained in a closed box filled with our insulating mixture. The condenser is fixed in the base. The sparks are hot and copious.

In the coarse wire inductor circuit there is either a Neef's magnetic hammer break with an immediate starter, or an interruptor with a continuous action motor, or an independent interruptor with cams and contacts immersed in an insulating liquid.

The independent interruptor with the continuous action motor is suitable for high power coils, and its working leaves nothing to be desired in regularity and speed.

A special key worked by hand produces long or short intermittent currents in the inductor circuit of the induction coil.

The current is generally supplied by a battery of accumulators or by a dynamo. It is this electrical energy of a certain intensity but of an electro-motive power of only a few volts which is transformed, in the neighbouring circuit of fine and long wire, well insulated from the inductor circuits, into a high electro-motive force exceeding 200,000 volts for a coil giving sparks 26 centimetres in length.

This very high tension allows of sparks being obtained which are discharged between the spark balls of the transmitting oscillator and thereby electric waves are projected into space.

It is unnecessary to point out that this transformation of electric energy of a high potential as set up by this induction coil is produced with a primary electric energy not exceeding 70 watts or about 1/10 h. p. In certain cases it is desirable to earth one of the terminals of the inductor wire at the same time as one of the terminals of the induced wire.

The oscillator can be constructed according to the data of Professor Rhigi; my design permits several combinations of sparks to be obtained and also allows of variations in [fol. 2284] their length. The trough R. receives the insulating liquid and the peep-hole allows the spark which is formed inside between the spheres to be observed.

The figure fully illustrates the transmitter which has just been described.

It comprises:

Induction coil,
Interruptor with independent motor,
Hand key,
Spark oscillator.

The system consists of two or three balls as used by Messrs. Lodge and Bose.

The outer insulating columns receive the discharging balls, the spark gap being adjustable.

The central column bears the intermediate ball which is fixed. The parts of these balls between which the sparks pass have been made rust-proof.

A special hardwood box with a lid encloses the whole; the sparks are hidden by means of plates. The complete apparatus being free from contact with the ball rods at any point cannot interfere with the discharge of the powerful Ruhmkorf coils.

This oscillator works without any insulating liquid. The wires of the induced circuit of the induction coil reach to the discharge balls of the oscillator. The connection to earth, the connection with the radiating wire of the mast.

The receiver illustrated in Figure III. is Ducretet's portable model, it is derived from that of Popoff.

Br is my adjustable model of Mc. Branly radio-conductor, with ivory tube. The filings are placed between the two variable pressure metallic conductors. The action of the outer air in the filings is avoided, as well as its renewal. Through the terminals T and L the electrodes of this tube of filings are connected, one to earth and the other to the collecting conductor wire which with the radiating wire forms the Hertzian line in space:

F.—Automatic tapper arranged after the manner of Popoff. It is provided with the adjustable parts R.

R.—Very sensitive polarized relay; it closes the circuit of the tube of filings Br and puts in action the local current, as has been said, for the purpose of operating the tapper and the registering apparatus.

In 1893, with the collaboration of Mr. Maréchal, we had pointed out the use of moving-coil galvanometers, in making use of the ballistic effect of the moving coil to form very sensitive telegraphic relays. They can be made of any dimensions.

Electric resistance without self-induction.

I am successfully using liquid resistance which my volt- [fol. 2285] ametric rheotome with aluminum rods allows me to obtain. These auxiliary resistances serve for the purpose of avoiding the effects of the induction current at breaking. The one on the left is not indispensable in every case.

The battery elements which are necessary for working this portable receiver are inside the box.

E and S are the interruptors of the current of those batteries.

In many cases this very portable apparatus is sufficient for reading the sounds of the Hertzian telegraphic signals. In order to register them it is sufficient to connect the two terminals R by a double conductor of any length to the terminals R of the portable automatic Morse, to which I shall refer again. An ordinary registering Morse apparatus arranged for that purpose can be employed; but we shall see later the acknowledged superiority of an automatic apparatus.

To register the electric waves produced by atmospherical disturbances it is sufficient to connect the terminals R (Figure 9) to those of a meteorological registering apparatus; this will be described in a special chapter.

Figure 10 shows all the parts of mechanism just described, combined at one station. The auxiliary resistances are not shown. This apparatus was the subject of a communication to the Académie des Sciences on the 2nd of May, 1898.

For military or exploration purposes the whole plant, viz., transmitters and receivers with masts and necessary equipment and posts to be sunk in the ground, can be placed inside telegraph or post office vans. High speed motor vans would be very convenient.

For flying Hertzian wave telegraphy the portable station shown on the figure will suffice for reading the sounds; it can always be connected to the portable registering apparatus.

Ducretet's automatic registering apparatus. As I have always stated, this registering apparatus works automatically; it does away with the telegraph operator for the immediate reception of the signals. In the case of Hertzian wireless telegraphy, this device is of great importance. On account of the extreme sensitiveness of the Branly radioconductor the receiver can register all electric waves capable of influencing the tube of filings, even if they are of atmospheric origin. It therefore would be necessary to keep a telegraph operator permanently at the apparatus in order to unwind the paper at each call and stop it when the electric waves ceased to act.

By making the receiver automatic I do away with the necessity for the actual presence of the operator for receiving the electric waves and signals.

Without any assistance, the receiver automatically unwinds the paper as soon as a wave acts upon it, and in the [fol. 2286] same manner stops as soon as the waves cease. A blank space separates each message or each record of atmospherical electric waves.

Whereas the quotation is not too long, inasmuch as this alone would induce any person who had but a superficial knowledge of the Marconi theory to ask himself how it could ever have been thought possible to discover in the Ducretet apparatus, consisting of a single circuit and in which the transmitting antenna is directly bound up with the spark producer, the same apparatus as that of Marconi with its two circuits syntonized one with the other, and influenced by a transformer and a condenser;

Whereas, moreover, as has been seen above, Ducretet began his description by a sketch of the system of Popoff in which he stated that this system was in part based upon tuning or, speaking precisely, on syntonization, and that he had not thought of making use of this essential element of the Marconi patent in his own apparatus, from which proceeds the most categorical denial of any possible anticipation;

Whereas, however, Ducretet was able to exchange messages between the Eiffel Tower and the Panthéon, just as Popoff had likewise sent signals to a distance, which Marconi does not think of contesting, for the very simple reason that he claims as his, not the principle of wireless telegraphy, but the improvements on the processes in use before he took out his patent.

With regard to the Marconi anticipation of 1898:

Whereas in this patent, which lapsed to the public in 1910 on failure to pay the fee and was then indeed without any interest, Marconi puts two circuits in his receiver, just as Lodge moreover did, not for the purpose of syntonising the director circuit and the receiving antenna circuit but simply to employ the transformer to increase the voltage at the terminals of the detector, and whereas it was for this reason that he gives 200 turns to the primary of the transformer, which he necessarily employs and 800 turns to his secondary, but whereas he does not point out any more than Lodge that the two circuits must be tuned, and does

not give any formula for this tuning by means of characteristic numbers or any process of regulation by tentative methods, as it seems natural he would have done if at that time the necessity for this syntonisation had been obvious.

With regard to the Braun Patent:

Whereas there exist three Braun patents: In France that of the 4th January, 1899; in England that of the 26th January of the same year, and finally that of the 7th July, 1900, granted in Germany after examination by the Patent Office;

Whereas this patent endeavers to solve numerous difficulties and commences the description by dividing the electric waves into three classes: (1) Those of *low* frequency obtained by ordinary alternating currents mechanically produced; (2) those of much higher frequency, pro- [fol. 2287] duced by a Leyden jar discharge with or without inductance coils in circuit, which no doubt means with or without the introduction into the circuit of inductance coils in order to reduce the frequency, and consequently to increase the wave length; (3) those of very high frequency produced by Hertz, not by means of Leyden jars and special inductance coils, but by means of ordinary conductors, the capacity and inductance of which are comparatively weak; and whereas Braun goes on to say that in wireless telegraphy the inventors up to that time had concentrated their attention upon the third group of oscillations which he calls Hertzian waves their only object being to increase their frequency; and whereas he afterwards mentions the practical difficulty resulting from the use of very high frequency waves, claiming that the object of his invention is to remove this difficulty by using electric oscillations belonging to the second group, *i.e.*, oscillations having a low frequency in comparison with the frequencies used up to that time, which suggests to Mr. Justice Parker the very judicious remark that the inventor was perfectly aware of what had been done by Marconi, as the latter was already using and Lodge had proposed to employ oscillations belonging to the second group of Braun;

Whereas Braun proceeds as follows: Another advantage, perhaps even of more importance in the use of slower oscillations, is that their potential and their amplitude and consequently the energy that is transmitted can more easily be increased. When Hertzian waves are employed there is a certain length of spark that cannot be exceeded when it

is desired to employ the circuit for the purpose of creating oscillations, otherwise the damping of the oscillations becomes too great, the tension of the system diminishing gradually, instead of doing so suddenly; the result is that the effective potential is limited, a disadvantage that does not occur, or that can easily be avoided, if slower oscillations are used;

Whereas it is rather difficult to discover the meaning of this sentence, which gave rise to important discussions in the English enquiry; and the most feasible meaning is that Braun has in view to increase the energy transmitted to the ether by means of the radiating circuit and that he considers that this result may be attained by increasing the potential and the amplitude of the electric oscillations in this circuit, and that he also considers that he can more easily increase this potential and this amplitude by making use of slower oscillations, pointing out, what is perfectly true, that if Hertzian waves are used the potential or voltage cannot exceed the voltage that can be borne by the spark producer without allowing the spark to pass;

Whereas he further points out that if in order to obtain a higher voltage one wishes to increase the length of the spark, it is soon found that the process cannot be continued inasmuch as according to Lord Kelvin's law there is a maximum resistance that cannot be exceeded if it is desired to [fol. 2288] produce oscillations; and that, in fact, an increase in the width of the spark gap results in an increase in the resistance of the circuit;

Whereas in this instance again the exact meaning of the description is not clear; and, indeed, what Braun says of the Hertzian waves is true whatever be the frequency of the oscillations;

Whereas Mr. Justice Parker in the following comments describes the position in a remarkable manner:—

> In no case can you increase the length of the spark gap indefinitely without being pulled up by Kelvin's law. Braun may mean that you can get a greater allowable resistance if you use longer waves, that is, the product of the capacity multiplied by the inductance, but if the maximum allowable resistance is equal to the square root of four times the inductance divided by the capacity, its increase is therefore produced when the wave length (or the product of the capacity by the inductance) is increased, or by in-

creasing the inductance, or by increasing the capacity, that is the increase of the maximum allowable resistance does not directly depend upon the increase of the wave length, but upon the means adopted for increasing such wave length. Further, it is not clear on the evidence whether you could by increasing the wave length in any way obtain a higher potential in the oscillations resulting from the discharge of the condenser: the maximum potential is limited not only by the length of the spark gap but also by the tendency of the circuit to a brush discharge, and in other ways, and this renders the problem one of considerable complexity.

Whereas Braun goes on to state that he has discovered that the oscillations produced by the discharge of Leyden jars of ordinary dimensions in a circuit having a moderate inductance are quite suitable for the transmission of signals and that the experiments show likewise that for the same expenditure of energy in the transmitting circuit it is preferable to have recourse to slower oscillations, this formula is insufficient, which caused Mr. Justice Parker to say: "Here again it cannot be said that Braun clearly expresses what he means to say, unless he means to refer to the practical difficulty which he has already mentioned as inherent to the use of the Hertzian waves."

Whereas Braun further states that the Leyden jar or any other apparatus used for producing electric oscillations is connected to the spark producer of a Ruhmkorff coil or a Wimshurst influence machine and is provided with the well-known vertical wire used for transmitting the waves, which wire must preferably have a considerable length; he also states that at the receiving station the ordinary device may likewise be utilised in so far as the vertical wire receiving coherer, the local battery and the registering [fol. 2289] device are concerned, as in a Morse or any similar apparatus;

Whereas it is evident that in this quotation he refers to things which he considers as being in current use and not forming part of his invention, strictly speaking; and whereas here again, however, it is difficult to ascertain what are the matters he refers to; and whereas an electrical engineer doubtless might at first sight think that Braun is referring to the vertical antenna of Marconi and which at the time of the Braun patent was in fact of considerable length.

but that on further reflection, as Mr. Justice Parker says, an electrical engineer well versed in the subject might think or might be led to think that the point is dubious, as he would remember that Marconi was already making use of frequencies of the kind which Braun claimed as having employed for the first time, and he would therefore arrive at the conclusion that Braun was not aware of the Marconi antenna and simply meant a vertical wire of such very low inductance and very low capacity, that, if it had been employed alone, it might have led to the creation of very high frequency oscillations; moreover, even if this electrical engineer were to suppose that Braun meant to describe the apparatus usually employed by Marconi in both the transmitting and the receiving stations, he would probably arrive at the conclusion that Braun had no intention to syntonise, inasmuch as in the process to which he called attention he apparently diminished the frequency of the transmitting circuit without indicating the method of effecting a corresponding decrease in the frequency of the receiving circuit;

Whereas Braun concludes his description by saying that in order that his invention should be clearly understood, he has shown in the drawings annexed to his patent, and as an illustration, some arrangements of circuits used for transmitting signals by means of electric oscillations of the kind just described; that is to say, by means of oscillations belonging to his second group, but whereas his invention is not limited to the precise arrangements which he described, because these latter may be very considerably modified and low frequency electric oscillations suitable for transmitting signals according to his system may be generated in several other ways.

Whereas this obviously means that the principal object of his invention consists in the use of frequencies belonging to the second group, whatever may be the mode of generating the same, and not in a particular process for obtaining the frequencies; and whereas it will be necessary to hold that his first claim refers to the improvement in the process of transmitting messages by means of electricity without a conducting wire, an improvement which consists in making use of electric oscillations of comparatively low frequency, such as those which are produced by the discharge of a Leyden jar with or without an inductance coil in the circuit, substantially in the manner described in the specifica-

[fol. 2290] tion; and that the second claim refers to a combination of apparatus substantially in accordance with the specification;

Whereas in view of all the foregoing it is clear that the wording does not contain the least hint with regard to the problem which the Marconi patent of 1900 proposed to solve, and still less, even any indication of efforts being made towards the solution of such a problem, from which it follows that if the Marconi patent was anticipated by anything similar to be found in the Braun specification, such should be seen in the drawings of Braun; and whereas all these drawings are diagrammatic, and no details whatever are given, and if it wished to derive from them anything approaching Marconi's invention of 1900, it is impossible to arrive at that result except by introducing certain details of construction, and so gaining the end Marconi had in view;

Whereas drawing No. 1 illustrates the vertical wire or antenna connected to the inner coating of a Leyden jar, the inner and outer coatings of which are connected to spark balls, and the circuit also contains a small inductance coil; whereas drawing No. 3 illustrates the same device with this difference, that the two Leyden jars connected in series take the place of the single Leyden jar of the drawing; whereas drawings Nos. 2 and 4 correspond to drawings Nos. 1 and 3 respectively, with this difference, that in these drawings the inductance coil is represented as constituting the primary of a transformer; one of the terminals of the secondary of that transformer connected to the vertical wire or antenna, and the other, according to drawing No. 2, to the outer coating of the Leyden jar, or, according to drawing No. 4, to a capacity of any kind, which may be the earth;

Whereas, according to the wording, the function of that transformer is to increase the voltage, although this cannot be considered as explaining the method in which the inventor thought that the potential of his circuit could easily be raised by utilising oscillations of comparatively low frequency, inasmuch as this method is equally applicable to oscillations of any frequency whatever;

Whereas, indeed, in order to arrive at the result which the inventor wished to attain, the effect of that transformer would in a large measure depend upon the condition in which the two circuits might be, with regard to their more or less close coupling and also to their relative capacities,

the maximum voltage possible to be reached in the second increasing in proportion as the capacity of the circuit decreases; and whereas it results from the wording of the specification that Braun obviously understood the well-known vertical wire of which he spoke as having a very low capacity in comparison with that of the Leyden jar which he proposed to introduce in his transmitter, and it likewise results from this wording that he considered that the circuit of that Leyden jar should be the circuit fixing the value of the energy transmitted to space and the length [fol. 2291] of the electric waves; Braun, however, says nothing of the time period of the secondary circuit, although it may be probable that he thinks he can increase the potential of the oscillations in this circuit by means of a transmitter, apparently simply on account of the low capacity of this circuit; he must therefore have fancied that the time period of the primary would necessarily apply to the secondary, whatever might have been its natural time period, a result which in reality could not be obtained otherwise than by resorting to the closest possible coupling;

Whereas this conclusion is corroborated by drawings Nos. 1 and 3, in which, strictly speaking, there is only one circuit; and, if, as from a certain point of view is possible, these drawings are considered as illustrating devices containing two circuits, it will be seen that these circuits are as closely coupled as possible, although, however, in this case also the degree of coupling would depend upon details of construction, which are not given; just as, moreover, no details with regard to the syntonization of the two circuits are given;

Whereas, however, if it is true that anybody well acquainted with the Marconi invention of 1900 could easily adapt the device illustrated by drawings Nos. 2 and 4 in such a manner as to obtain the results indicated by Marconi, by introducing into these devices proper details of construction as well as the arrangements referring to syntonization, &c., it is certainly no less true that neither the drawings nor the specification of the Braun patent contain any suggestion either of the problem to be solved, or of any detail of construction which would enable one to obtain a solution, from which it follows that the patent in question cannot be considered as an anticipation of Marconi's patent, seeing that there can be found in it nothing characteristic of the latter

patent, *i. e.*, four circuits syntonized in pairs, and in two groups in their turn syntonized with each other.

Whereas this finding is confirmed by Mr. Justice Parker in this ironical but eloquent manner: "In my opinion any competent engineer would most probably have put Braun's specification altogether aside as being founded on a mistake as to the frequencies then in use and otherwise containing so many points of difficulty. He would have said, 'Marconi is already doing what Braun claims and it is useless pursuing the matter further.' Even if he had been struck with, and desired to test, the apparatus diagrammatically shown in the drawings, there would be no reason why he should work on drawings Nos. 2 and 4 rather than on those Nos. 1 and 3, unless his object was to get high voltage in the vertical wire. If he desired higher voltage he would, I think, have coupled his circuits as tightly as possible and rushed his current through. Even if he had thought of tuning he would have thought of it only in connection with securing a high voltage and not in connection with securing a cumulative action by the primary on the secondary so as to get a long train of waves."

[fol. 2292] Whereas the Defendants in the inspired language of Me. Taillefer vainly endeavour to demonstrate the anticipation of Braun's patent with regard to resonance, which is understood to be the principal point of the argument, and whereas he expresses his view in saying that Marconi had combined Braun's transmitter with the Marconi-Lodge receiver, and whereas consequently the combination of the patent was not new in 1900 (Shorthand Notes, page 65).

But whereas Braun's patent did not mention tuning; and whereas if he employed two circuits and one transmitter he did not employ two syntonized circuits; and whereas consequently Marconi, founding his 1900 system on the four circuits theory, did not steal from Lodge and Braun but brought out an entirely new device containing elements which neither Lodge nor Braun had contemplated in combination; and if Marconi had limited his efforts to this, his patent would be above criticism, since a patent may be obtained for any new industrial result obtained by the combination of means already known; and there can be no question as to the reality of the industrial result of Marconi's combination as the world is now encircled with what did not exist before;

Whereas it is appropriate to quote in support of this finding the following passage from Pouillet, who is so deeply regretted, but who has found such worthy successors:

"To combine for the first time elements which had hitherto remained separated is, in fact, to apply them in a new manner. It is, therefore, of little importance whether all the elements of a machine were even for time immemorial public property, provided the combination be new. It is, indeed, one of the most usual forms of new discoveries."

With regard to the Tesla's Patents:

Whereas it is on this alleged anticipation that the last and greatest effort of the Plaintiffs was finally centred, treating as of secondary importance the anticipations which have just been ruled out, and this would seem impliedly to recognise as reasonable the sudden resumption of the attack on a new ground and with new weapons:

Whereas the Defendants review in succession the 1896 patent and that of October 25th, 1897, the first of which describes a transformer in which the secondary is connected to the antenna, the circuits tuned in such a manner that, as Mr. Taillefer says, there should be the closest possible resonance for the oscillations created in the primary, which would constitute an anticipation of Braun at *a fortiori* of Marconi; and whereas this would appear from a "Manual of Wireless Telegraphy", published in 1900, and in which Murray writes the following:

It is a transmitter in which there are two flat coils. It is an antenna circuit comprising two flat coils; the circuit is connected to a source of electricity. . . .

[fol. 2293] This source is generally a condenser laden to a high potential and discharged in rapid succession into the primary element. . . .

But when it will be desired to produce waves of very great length, an alternating dynamo of suitable construction may be used to supply the energy. . . .

The actual constant quantities of the coil constitute its time period. They are selected and adjusted in such a manner that the secondary system should be as far as possible in resonance with the oscillations created in this system by the primary. . . .

In collecting the energy of these disturbances in any terrestrial region at a distance from their source for any purpose. . . .

Whereas it is endeavoured to extract from this quotation a proof that the Tesla patent gave an exact description of Braun's transmitter, and pointed out that the actual constant quantities of the coils are adjusted and selected in such a manner that the secondary should be in the closest possible resonance with the oscillations communicated to this element by the primary;

Whereas the conclusion is drawn that there are in the transmitter two systems in resonance with each other; and whereas another quotation is given as follows:

In collecting the energy of these disturbances in any terrestrial region at a distance from their source for any purpose . . and, more especially, in appreciable amounts, the most economical results will be generally secured by the employment of my receiving transformer.

This invention, forming part of my system of transmission of energy through the natural media, has been fully explained in the patents first cited here, but for the better understanding of the present description it is diagrammatically illustrated in Fig. 174. Its most essential part is a circuit E^1 C^1 D^1, which is connected and arranged similarly to the transmitting circuit E C D, and which is inductively linked with a secondary circuit A^1. The latter, it scarcely need be stated, may be wound with any desired number of turns, such as will be best suited for the operation of the device designated by M. The receiving transformer is closely attuned to the oscillations of the transmitting circuit, so that, irrespective of the length of the conductor, the points of maximum potential coincide with the elevated terminal D^1, under which conditions the greatest amount of wave energy may be collected, &c.

[fol. 2294] Whereas it is submitted from the foregoing that there is a complete similarity between Tesla's invention and that of the four syntonized circuits of Marconi;

But whereas this becomes more and more doubtful on a perusal of Tesla's French patent of the 25th October, 1897, granted under number 271641;

But whereas it is necessary to preface this perusal by the two patents of Tesla taken out in 1891 and 1896;

Whereas in Figure 1 of his first patent Tesla illustrates a transformer by means of which he proposed to raise the voltage of the oscillations created by the sudden discharge of a condenser for the purposes of illumination. The coup-

ling of the circuits is in consequence as close as possible; and no mention is made of syntonization, even admitting that in this case it would have been possible to syntonize;

Whereas in his second patent Tesla insists on the fact that he syntonizes his circuits with each other, but whilst on the one hand he gives some explanations on the syntonization of some circuits which could not in fact be syntonized with one another, he gives none with regard to the syntonization of his discharge circuit with his working circuit, the two circuits with regard to which any reference to syntonization would have been of specific importance.

Whereas this is all the more strange as in a lecture which he gave in 1893, Tesla showed a transformer, the secondary of which comprised an adjustable condenser used for the purpose of syntonizing the secondary with the primary. In this lecture he had discussed the theory of resonance in general; he had expressed some doubts as to whether this could ever be of any use in a system of telegraphy without wires, which seems to prove that in 1896 Tesla doubted the utility of applying the principle of resonance to anything within the limits covered by his patent;

Whereas it is true, the makers of Tesla's transformers, before selling the same, adjusted the primary and secondary elements in such a manner that if the terminals of the secondary were connected to spark balls they obtained the longest possible spark, and it has been said that this was syntonization; but, the mere fact that when the apparatus is put into use, it may be connected to any circuit whatsoever;

Whereas it is also true that when Tesla transformers are employed in a laboratory, the secondary element must be adjusted with the first, by varying the number of turns in one of the two circuits or in both until the best result is obtained, and it has likewise been said this was syntonization; but Mr. Swinburn, who has a great experience in such questions, whose evidence was taken in the English enquiry, said that he had never heard of such adjusting;

Whereas Mr. Justice Parker concludes with these words: "I can hardly admit in consequence, that it was generally [fol. 2295] known that when a transformer was employed it was necessary to syntonize the primary element with the secondary";

Whereas it is impossible to form another impression on reading the French patent of the 25th October, 1897, which

has with so much energy been pleaded as an anticipation of Marconi's patent of 1900;

Whereas, to begin with, the head note alone would make it possible to think a mistake has been made, since it reads thus: "Improvements in systems for the Transmission of Electrical Energy and Apparatus for use therein."

Whereas it is sufficient to give the wording of this specification on which the adversaries of Marconi found all their hopes in order to understand clearly that it could not constitute an anticipation, but whereas in spite of the length of this document it is necessary to quote the same *in extenso* as extracts like translations often do not do justice to the exact meaning;

Whereas it may be that misplaced confidence in isolated quotations will not deprive the deductions of Maitre Taillefer of much of their value in spite of the very convincing precision of his argument;

Whereas in fact the patent is thus worded:—

The invention which forms the subject of the present application comprises a novel method or system for the transmission without the employment of metallic line conductors, and is primarily designed for use in cases where large amounts of electrical energy are to be transmitted to considerable distances, but the results arrived at are of such character and magnitude, as compared with any heretofore secured, as to render indispensable the employment of means and appliances and the utilization of effects essentially different in their characteristics and actions from those before used or investigated.

To be more explicit I may say that the transmission of electrical energy, which forms a part of my invention, demands for the attainment of practically useful results the production and conversion of excessively high electrical pressures. Heretofore, it has been possible, by means of the apparatus at command, to produce only moderate effective electrical pressures, and even these not without some risks and difficulties, but I have devised means whereby I am enabled to generate with entire safety and ease electrical pressures measured by hundreds of thousands, and even millions, of volts, and in pursuing investigations with such apparatus, I have discovered certain highly important and useful facts which render practicable the method of transmission of electrical energy hereinafter described.

Among these facts, and bearing directly upon the invention, are the following:—

[fol. 2296] 1. That with electrical pressures of the magnitude and character which I have made it possible to produce, the ordinary atmosphere becomes, in a measure, capable of serving as a true conductor for the transmission of the current.

2. That the conductivity of the air increases so materially with the increase of electrical pressure and degree of rarefaction, that it becomes possible to transmit through even moderately rarefied strata of the atmosphere electrical energy up to practically any amount and to any distance.

The system of transmission comprised in my invention, and which, as above stated, was rendered possible only by the production of apparatus of a character radically new and different from any before known, and which is based upon discoveries made in the investigation of the results thus produced, consists in producing at a given point a very high electrical pressure, conducting the current caused thereby to earth, and to a terminal at an elevation at which the atmosphere serves as a conductor therefor, and collecting the current by a second elevated terminal at a distance from the first.

In order to attain this result it is necessary to employ an apparatus capable of generating electrical pressures vastly in excess of any heretofore used, and to lead the current to earth, and to a terminal maintained at an elevation where the rarefied atmosphere is capable of conducting freely the particular current produced; then, at a distant point, where the energy is to be utilized, to maintain a terminal at or about the same elevation to receive the current and to convey it to earth through suitable means for transforming and utilizing it.

The apparatus which I have invented, and by means of which this method of transmission may be effected, is represented in the accompanying drawing, which is a diagrammatic illustration of the system.

A is a coil, generally of many turns or windings and of very large diameter, wound in spiral form either about a magnetic core or not, as may be desired. C is a second coil formed by a conductor of much larger size and smaller length, wound around and in proximity to the coil A.

In the transmitting apparatus the coil A constitutes the high tension secondary, and the coil C the primary of much

lower tension of a transformer. In the circuit of the primary C is included a suitable source of current.

One of the terminals of the secondary A is at the centre of the spiral coil, and from this terminal the current is led by a conductor B to a terminal D, preferably of large surface, formed of or maintained by such means as a balloon [fol. 2297] at an elevation, suitable for the purposes of transmission as before described. The other terminal, that of the secondary A, is connected to earth, and, preferably, to the primary also, in order that the latter may be approximately of the same potential as the adjacent portions of the secondary, thus insuring entire safety.

At the receiving station a transformer of similiar construction is employed, but in this case the long coil A^1 constitutes the primary and the short coil the secondary of the transformer. In the circuit of the latter are arranged lamps L, motors M, or other devices for utilizing the current. The elevated terminal D^1 connects with the centre of the coil A^1, and the other terminal of said coil is connected to earth, and preferably also to the coil C^1, for the reasons above stated.

The length of the high tension coil of each apparatus should be approximately one-quarter of the wave length of the electrical disturbance in the circuit. * * *

It will be observed that in coils of the character described, the potential gradually increases with the number of turns, and the difference of potential between adjacent turns is comparatively small, and a very high potential, impracticable with ordinary coils, may be successfully obtained.

As the main object of the invention is to produce a current of extremely high potential, this object will be facilitated by using a primary current of very considerable frequency, but the frequency of the current is, in large measure, arbitrary, for if the potential be sufficiently high and the terminals of the coils be maintained at a proper elevation where the atmosphere is comparatively rarefied, the intermediate stratum of air will serve as a conductor for the current produced, and the latter will be transmitted through the air with, it may be, even less resistance than through an ordinary copper wire.

The apparatus described, it may be observed, is useful as a means for producing currents of very high potential for other purposes than that of the present system, as, for

instance, the coils may be used singly for producing extremely high electrical potentials for any purpose, or used generally in the same manner as other electrical transformers for the conversion and transmission of electrical energy.

It will be understood that either of the coils or transformers and terminals may be movable, as, for instance, when carried by vessels floating in the air, or by ships at sea. In the former case the connection of one terminal with the ground might not be permanent, but might be intermittently or inductively established without departing from the spirit of the invention.

As to the elevation of the terminals D, D', it is obvious [fol. 2298] that this is a matter which will be determined not only by the condition of the atmosphere, but also by the character of the surrounding country.

Thus, for instance, if there be high mountains in the vicinity, the terminals should be at a greater height, and, generally, they should always be at an altitude much greater than that of the highest objects near them in order to reduce the loss by leakage. Since, by the means described, practically any potential that is desired may be produced, the currents through the air strata may be very small, thus reducing the loss in the air.

It will be observed that the phenomenon here involved in the transmission of electrical energy is one of true conduction, and is not to be confounded with the phenomena of induction, or of electrical radiation, which have heretofore been observed and experimented with, and which, from their very nature and mode of propagation, would render practically impossible the transmission of any considerable amount of energy to such distances as would be of practical importance.

To sum up, what I claim is:

1. The method of transmitting electrical energy herein described, which consists in producing at a given point a very high electrical pressure, conducting the current caused thereby to earth and to a terminal at an elevation at which the atmosphere serves as a conductor therefor, and collecting the current by a second elevated terminal at a distance from the first, as set forth.

2. A system for the transmission of electrical energy comprising in combination a source of current of very high pressure, connected respectively with earth and with a ter-

minal at an elevation where the atmosphere forms a conducting path for the current produced, a second elevated terminal at a distance from the first for receiving the current transmitted therefrom and means for utilizing the said current, as set forth.

3. The transformer herein described for developing or converting currents of high potential, comprising a low tension and a high tension coil, one terminal of the high tension coil being electrically connected with the low tension coil and with earth when the transformer is in use, as set forth.

4. The transformer herein described for developing or converting currents of high potential, comprising a low tension coil and a high tension coil wound in the form of a flat spiral, the end of the high tension coil adjacent to the low tension coil being electrically connected therewith and with earth when the transformer is in use.

[fol. 2299] 5. The transformer herein described for developing or converting currents of high potential in which the low tension coil and the high tension coil are wound in the form of a spiral, the coil of high tension being inside of, and surrounded by, the convolutions of the other and having its adjacent terminal electrically connected therewith and with earth when the transformer is in use, as set forth.

Whereas not a word in this lengthy document suggests the idea that the inventor had wireless telegraphy, Marconi's invention and the theory of four syntonized circuits in his mind; whereas it is needful to seek, and indeed quite unsuccessfully, for the desired evidence that this patent left Marconi nothing to discover in this phrase which is interpreted as the organisation of adjustment, viz.: "The length of the high tension coil of each apparatus should be approximately one-quarter of the wave length of the electrical disturbance in the circuit, this estimate being based on the velocity of propagation of the electrical disturbance through the coil itself and the circuit with which it is designed to be used."

Whereas in this somewhat obscure wording it is not really possible to find proof of the plagiarism charged against the very complete and clear definition of Marconi's claim respecting the four circuits; but whereas this alleged anticipation becomes still more unlikely on continuing the

perusal of a lengthy passage, which the Court has not thought necessary to reproduce, for the single phrase which follows demonstrates the really too technical character of the same: "To maintain a frequency of 925 metres per second, maintaining 925 stationary waves in a circuit of a length of 185 miles and each wave would be 200 miles in length, I should use in each high tension coil a conductor or 50 miles in length;"

Whereas the Defendants are, as a matter of fact, quite cognizant of the inability of this patent of 25th October, 1897, to constitute anticipation and they invoke the Tesla American patent, taken out in 1897 in America and published in March and May, 1900;

Whereas the question of adjustment according to Me. Taillefer is clearer in Tesla's American patent than in 1897, but the first part of which was published, strange to say, in March, 1900 (No. 645576), before the taking out of Marconi's English patent (April), and the second part subsequently, *i. e.*, the 4th March (? May) (No. 649621), so that the patent set up is found to be precisely hemmed in one month behind and one month in front by Tesla's patent; whereas the former, by its date, might constitute an anticipation in respect of the British Marconi patent; whereas the two would constitute anticipations of the French Marconi patent applied for on 3rd November, 1900, and granted on 1st February, 1901;

[fol. 2300] But whereas both the patents bear as the title of the invention, "System of transmission of electrical energy," which already appears to overthrow this alleged anticipation, since it is a question, as in Tesla's first patent, not of wireless telegraphy, but of the transmission of electric energy; whereas this is confirmed by the concise extracts, read by Me. Taillefer, and which exclusively refer to primary and secondary, to tuning as between them, and then to syntonization and sychronism.

But whereas it cannot for one moment be admitted that in this patent Tesla had wireless telegraphy in mind; whereas he would have mentioned it together with the lamps and the motor if he had desired to consider it as one of the powerful industrial operations which currents were destined to perform; whereas it is really taking too much for granted to allege that the current designed principally to serve for electric lighting or motive power undertakings could in the

inventor's contemplation likewise be applied to the subtle and delicate action required by wireless telegraphy.

Whereas, however, the statement of the specification with regard to syntonization must be considered as the main element of the alleged anticipation of the Marconi patent, while the opponents of Marconi are seen to be maintaining that this element of his patent possesses no scientific value, and in fact does not exist; and that by a fresh change of front they will combat the charge of infringement by maintaining that the Marconi apparatus has indeed four tuned circuits, whereas the appliances seized have not, and are in fact apparatus guiltless of any infringement;

Whereas this oscillation of truth, wavering according to the exigencies of the various arguments, is a matter that should be chronicled in so subtle an enquiry as that submitted to the Court;

Whereas the second patent of 15th May, in the first place, raises a very interesting question which has never yet been decided, viz., that of priority;

Whereas indeed this patent was published, as has just been observed, within the interval separating the taking out of Marconi's English patent, and that of the French patent of 3rd November, that is to say, in the period of priority which makes the new intermediate patent inopposable to the one which comes into being before this patent and terminates subsequently;

Whereas this period being six months, had expired on the 3rd November for the Marconi patent, and took away from it the benefit of priority as against the Tesla patent;

But whereas on the other hand, this period, which is now uniformly extended by the Brussels Conference to twelve months, was according to the 1883 Convention, limited to six months for the countries of Europe, whilst it was seven [fol. 2301] months for oversea countries, and that therefore the question as to whether the second Tesla patent is an admissible, if not an operative anticipation of the Marconi patent of 3rd November, depends upon determining whether or not England is an oversea country;

Whereas although manifestly England is separated by salt water from France and from the Continent of Europe generally, yet she could not on that account, even less than Corsica, Sardinia, Algeria, Tunisia, Morocco, Egypt, etc., be regarded as excluded from the European family and exiled to those remote and mysterious regions recalled by

the somewhat archaic term out of which the difficulty arises;

Whereas the confirmation of this opinion is that the Rome Conference in 1886, having for its object the working out of explanatory regulations as to the 1883 Convention, drew up paragraph 2 of the chapter entitled "Explanatory Provisions"; "As regards the States of the Union situated in Europe, the Extra-European countries which do not border upon the Mediterranean are considered as oversea countries";

Whereas Algeria, Morocco and Egypt are not regarded as oversea countries, and it appears difficult to consider England as an oversea country, being connected with our coast by the various schemes: A submarine tunnel scheme now in preparation, wireless telegraphy and aerial navigation that are actually accomplished facts. And it is all the more difficult in view of the wording set out above, as England not bordering on the Mediterranean, although forming part of the States of the Union situated in Europe, would find herself in the paradoxical position of being to herself her own oversea country;

Whereas, therefore, in this case the period of priority must only be six months, it follows that the Tesla patent of 15th May might anticipate the Marconi patent of 3rd November as well as the first Tesla patent of 20th March;

Whereas, furthermore, the question was not of great importance; indeed, as has already been seen, the Tesla patents could not form an anticipation of the Marconi patent by reason of the profound difference of the application of the two opposed systems: That of Tesla to great industrial operations requiring powerful electric circuits; lighting and power, and that of Marconi having no other objective but telegraphy by Hertzian waves;

Whereas, however, Me. Taillefer maintains the argument of anticipation with great energy; but in order to follow him in his reasoning, supported by fragments of patents, it would be necessary to examine the twenty-four pages of the Tesla patent; whereas Me. Taillefer has himself understood this as his contentions of 12th November thus summarises the arguments of his pleading of the 9th:

[fol. 2302] "It appears from the patent that Tesla had in view the transmission of electric energy to a distance: For this purpose he transmits by induction to an antenna circuit high pressure electric current generated in a first

circuit, which is so arranged that the primary of a transformer, situated in this first circuit, is surrounded by the secondary of the same transformer appear-ng in the antenna circuit.

"At the other end, at the receiving apparatus, the antenna circuit, under similar conditions, excites by induction a second circuit comprising either lamps or motors or any other apparatus for mak-ng use of the transmitted energy. Tesla in his patent indicates in the clearest manner that the various circuits he employs must all be tuned together to corresponding wave lengths; that is to say, syntonized; and that thus, just as with Marconi, the various circuits made use of are arranged in like manner, and are tuned both two and two and all together;

On the other hand, Tesla states that the system that he recommends can be employed for the transmission of intelligible messages to a distance; that he, therefore, certainly has in view the possibility of its application to wireless telegraphy by the aid of high frequency electric waves.

"The object is, therefore, quite the same as that pursued by Marconi and the conditions of carrying the same out are likewise similar; that therefore the Tesla patent of 20th March constitutes an absolute anticipation in all its parts of the Marconi patent."

Whereas these contentions do not go beyond assertions that are at times fairly vague and overlook all the objections doubtless because the very precise mind of their author comprehends the full seriousness of them;

Whereas the contentions of the Société Radioélectrique are bolder, defining, as they do, their points in these terms:

This system consists of the combination of four circuits, one transformer at the transmission, a high frequency oscillation circuit and an antenna circuit; two circuits of one transformer at the receiving station, an antenna circuit and the circuit containing all the translating and registering apparatus; these four circuits are adjusted so as to ensure the synchronising of the oscillations of varying means of capacity and inductance.

Whereas this concise summary could not take the place of the lengthy wording of the specification, which was not translated and which, therefore, evades the examination of the Court, an abnormal position, which is possibly an

avowal of the small degree of reliance placed upon a document, produced at the last moment, and which nobody had [fol. 2293] till then thought of, by the Société Radioélectrique and the other Defendants, which fact should make one very sceptical as to its value;

Whereas, therefore, the Court, being placed in the position of not being able to examine the wording of the patent invoked, restricts itself to noting the profound difference existing between the interpretation of the patent by the Société Radioélectrique and its interpretation by the Société Radiotélégraphique; as nothing in the cited extracts permits of assuming any analogy whatever between the Tesla patent and the Marconi patent;

Whereas, further, it could not well be otherwise; for manifestly, as has already been pointed out, the American patent only has in view a new means of conveying light and power to long distances, without the very costly metallic conductors, in order to be used for industrial purposes properly so called; whereas doubtless vague references are made therein to the transmission of intelligible messages, but the language being, so to speak, with evident intention couched in vague terms, cannot be considered as imparting to the patent the character of a wireless telegraphy invention; moreover it is difficult to see how a device capable of conveying currents at a high voltage, and intended for continuous lighting or motive action, could be made suitable to the special requirements of transmitter and receiver, providing the intermittent but repeated action requisite for the working of wireless telegraphy with manipulators;

Whereas, further, the device of the American patents, as is admitted, comprises neither spark producer nor spark, nor detector nor reflex system, which are the fundamental bases of wireless telegraphy; and whereas it operates by phenomena of conduction, which is entirely different from radiation phenomena, and by means of powerful currents instead of Hertzian waves, which have led to the idea of wireless telegraphy and have ensured its marvellous working;

Whereas the examination of the engravings attached to the patent shows still better, if possible, the absence of any analogy between the Tesla and the Marconi patents;

Whereas certain vague details, sheltered from all examination or investigation, such as the syntonization alleged

to be identical with that of Marconi, cannot support an admission that this document, produced at the last moment, is of the least value for the purpose of assimilation with the Marconi patent.

Whereas this conclusion presses itself with special weight when it is considered that it was in the course of discussion, or rather at the end of the discussion in November, 1912, that these patents, which lay dormant and forgotten in America from 1897, re-awakening in France in 1900, and for twelve years resuming a condition of inertia, have suddenly put in an appearance;

[fol. 2304] Whereas Tesla appears to have been of the same opinion; that as a matter of fact, it is fitting to recall to his honour, that as early as the year 1892, he had pointed out that an arc fed by a continuous current could take the place of the Hertz exciter, if placed within a powerful magnetic field, which phenomenon led to the discovery of wireless telegraphy by means of the singing arc, which is it appears one of the systems of the Société Radioélectrique; and whereas the following year, at a lecture given before the Franklin Institute, Tesla, the first to follow Popoff, had the idea of utilising high frequency currents for the transmission without conductors of intelligible signals and possibly of also energy; and whereas the patent of 1897 transposed matters, being almost entirely confined to the conveyance of industrial energy, and on the other hand relegating the idea of communications by signals to the rank of hypothesis, the interest of which was not foreseen;

Whereas evidently this scepticism of the author with respect to wireless telegraphy set him apart from the very powerful movement that took place with regard to this new science; and thus he restricted himself to the invention of the transformer which bears his name and which precisely was adopted by the one against whom his patents are invoked;

Whereas in the excellent work of Commander Ferrié, nothing else is to be found regarding a scientist of such attainments; and whereas he never made any attempt connected with wireless telegraphy; and he had thus himself repudiated beforehand the character which it is desired wrongly to impute to the American patents;

Whereas further these patents, even if they were foster parents of wireless telegraphy by any process whatever,

would be too distinct from the Marconi patent to constitute even the shadow of an effective anticipation;

Whereas after this last defeat of its adversaries, the Marconi patent stands out as an unassailable monument until new discoveries are made, but which so far from claiming a *de facto* monopoly, must consider the Defendant Companies as meritorious, sympathetic and necessary rivals, inasmuch as they produce the emulation which is indispensable to progress, and is consequently for the public benefit;

Whereas all credit should be given to the intellectual energies which apply themselves to these peaceful struggles without the abuses, the injurious actions and the violence which are so frequently engendered by too passionate rivalries;'

Part Fourth: Cancellation

Whereas Marconi's adversaries invoked against his 1900 patent the trifling objection that it had not been worked within three years of the grant of the patent; whereas the considerable effort devoted to anticipations has caused that [fol. 2305] which ought reasonably to occupy the first rank to be relegated to the second; whereas, therefore, the prominent place given to the discussion of the anticipations should be considered as a actual renunciation of the objection of non-working; whereas, however, this objection being maintained in the submissions and the pleadings, it is necessary to examine the same, however paradoxical it may be; whereas in fact it is well known that hardly had the invention of his genius seen the light when Marconi witnessed its eager and unanimous adoption;

Whereas, therefore, it was almost unnecessary to produce the letter of the Compagnie Générale Transatlantique as follows:

The Compagnie Générale Transatlantique certifies that wireless telegraphy appliances on Marconi's system were installed upon "La Savoie" in 1902, upon "La Lorraine" on 7th March, 1903, upon "La Touraine" on 27th June, 1903, and that these appliances are at present still being worked upon the said mail boats.

Whereas this proves that the patent applied for on 3rd November, 1900, and granted on 1st February, 1901, was

worked within the three years, and that under such perfect conditions, that the powerful Compagnie Transatlantique had no hesitation in equipping their great vessels with same, and that the original device still gives entire satisfaction after the lapse of ten years;

Whereas, indeed, one of the opponents of Marconi objects that the Plaintiffs, acting on the strength of Marconi's rights, only at a recent date established in France works for the manufacture of plates, wires, cables and other articles serving for the working of the patent; whereas the Société Radiotélégraphique even had recourse to a proceeding that Me. Seligmann rightly describes as somewhat barefaced, viz., that they enticed away one of the employees of the Marconi Compa y, who with the aid of subsidies from the young rival company is said to have photographed certain elements of construction which would appear as being of British manufacture;

But whereas, even if the parts which the Marconi Company makes use of to construct their highly important stations and hence to work the patent were wholly obtained from sub-contractors, that would be no matter of reproach to the Plaintiff Company; the Marconi patent being, as a matter of fact (and the opponents have maintained this to the extent of accusing Marconi of being an audacious plagiarist) only a patent relating to the combination of known elements and consequently Marconi has every right to obtain his materials from the firms that manufacture them; and whereas the manufacture, application and working the patent consists of obtaining, wherever the Company may think proper, if it is not thought advisable to undertake the manufacture thereof themselves, the cables, plates, accumulators, coils, &c., which when combined will set up wireless [fol. 2306] telegraphy stations with syntonized circuits;

Whereas this manufacture, and, it may be added, this French manufacture, is proved, especially by the two agreements entered into between the Marconi Company and the Compagnie Transatlantique in 1901 and 1903; and whereas in the former the following is to be found:

The Marconi Company shall instal at their own expense their wireless telegraphy apparatus upon the mail boats of the Compagnie Transatlantique performing the service between Havre and New York, and by mutual agreement the "Savoie" and the "Touraine" have been selected.

Art. 4. The plans shall be submitted to the Compagnie Transatlantique for approval; the Compagnie Transatlantique shall not further have to intervene in the working of the stations installed by the Marconi Company, &c. • • •

The Compagnie Transatlantique shall gratuitously supply the assistance of their staff of laborours and of their workshops for the repairs and future maintenance of these stations, in so far as such assistance may be compatible with the requirements of the service of the Compagnie Transatlantique.

Whereas in the second the following is to be found:

The demonstration to which reference is made in Art. 15 of the contract of 1901 having proved satisfactory to the Compagnie Transatlantique, the two Companies putting into operation the other articles of the contract resolve as follows: • • • The maintenance of the station on "La Savoie," the installation of a second and third station.

Art. 15 The Compagnie Transatlantique shall participate in the expenses incurred by the Marconi Company in equipping electric plant to the extent of 2,500 francs per station; this sum shall be reimbursed to them under such and such conditions, &c. • •

Whereas the foregoing affords evident proof of manufacture in France, by French labour, and which was continued in 1903 by the Compagnie Française Maritime et Commerciale de Télégraphie Sans Fil, which was licensed by the Marconi Company, and which since that time has without interruption been engaged in industrially equipping the fifty or more mail steamers which are at the present time equipped or ready to be equipped with the patented apparatus;

Whereas this proof is in itself sufficient and in denying same the Defendants thereby become Plaintiffs and take upon themselves the onus of proving their assertion, which they have not done;

Whereas it was therefore needless for the Plaintiffs to produce among other documents the invoice of the Société Industrielle des Téléphones, dated 13th February, 1902, and [fol. 2307] proving the supply of special cables, of a special key for the condenser, of a box for the condenser, of a roller and of a piece of mahogany cabinet work for wireless telegraphy in accordance with a model returned.

Part Fifth: Infringement

Whereas the Société Générale Electrotélégraphique and the Société Francaise Radioélectrique, as a matter of course, each on their own part maintain, alternatively to their claims for the cancellation of the Marconi patent, the dissimilarity between the appliances covered by this patent and their apparatus which was seized;

Whereas the Société Radiotélégraphique rely, with regard to the actual seizure effected at Marseilles, upon the interesting statement dictated to the bailiff by the expert whom he took with him:

I ascertained the existence of a wireless telegraphy station, working as stated hereinafter:

1. Transmission (Fig. 1 of the sketch):

The energy in the form of alternating current is produced by a converting group, the alternating current thus produced feeds, through the medium of a Morse key manipulator, the primary P of the static transformer T': the secondary S of this transformer is connected with the coating of a condenser C, forming part of an oscillating circuit called the primary oscillating circuit, comprising in addition the spark producer or oscillator and the self-induction L.

This circuit acts by indirect excitation by derivation upon a second circuit called "secondary circuit or antenna circuit"; this second circuit comprises the adjustable antenna inductance I; the self-induction L', and the earth T. The two self inductions L and L' form a genuine transformer

The self-induction L and the capacity C' of the primary oscillating circuit have suitable values to permit of the establishment of definite periods in this circuit of oscillation; the circuit of the antenna is regulated upon the period selected for the primary circuit by means of the antenna inductance.

2. Receiving station (Figure 2 of the sketch).

The arrangement again comprises two circuits; the antenna circuit and the detector circuit.

The antenna circuit comprises the antenna proper A, which is a real portion of the antenna inductance B, and an adjustable condenser C; the detector circuit comprises the adjustable self induction B2 and the four detectors D', D'', D'', D', and the adjustable condenser B' and B'' form a genu-

ine transformer or first regulates the antenna circuit according to the period of the oscillations.

Whereas it is precisely upon these submissions that the Marconi Company base their accusation of infringement [fol. 2308] against the Société Radiotélégraphique;

Whereas the Marconi Company profess to discover:

(a) In the description of the source, at the transmission station, the regulation of the antenna circuit upon the oscillation circuit; at the receiving station, the regulation of the detector circuit upon the antenna circuit; that is to say, the four circuits of Marconi;

(b) In the transformer, the primary circuit, wherein are inserted the condenser and the spark producer, the primary circuit being thus the well-closed oscillator of Marconi;

(c) The secondary circuit, antenna circuit connected to the primary circuit by a transformer as in the Marconi arrangement;

(d) The two self inductions L and L', forming a genuine transformer;

(e) The two circuits of the transmitter tuned together, the self induction and the capacity of the primary circuit having suitable values, in order to permit of the establishment of definite periods, it being unnecessary that they should be exactly the tone value figures of the Marconi patent, these figures being merely examples, whereas the provisions of the two appliances, the patented one and the seized one, are identical;

(f) The antenna circuit being regulated—and this is the main point—upon the period of the primary by means of the adjustable inductance, which does not exist in any anticipation, and is therefore the characteristic feature of the Marconi patent, and consequently, of its infringement;

(g) At the receiving antenna, also two circuits; That of the antenna and that of the detector connected by a transformer;

(h) Two adjustments: That of the antenna circuit upon the period of the oscillations given by the transmitter, then the circuit of the detector regulated upon the antenna circuit;

(i) To sum up, the four tuned circuits, which are precisely Marconi's invention;

Whereas the submissions of 14th October, 1912, of the Compagnie Générale Radiotélégraphique, in reply to these arguments, have been powerfully developed and commented upon by Me. Taillefer;

Whereas doubtless he duly recognises in the apparatus seized, practically everything that Me. Seligmann discovers therein as elements of infringement, but with scientific negations and important differences; whereas he thus formulates the first point of the defence:

I have already had occasion to point out that this formula is incorrect, and that the period of oscillations of the receiver was never regulated upon the period of oscillation of the transmitter, which is by its side. They are never [fol. 2309] together. Adjustment is effected upon any transmitter such as the one sending the message, that is to say, an attempt is made to perceive by sounding in space; or it may be, if regulation is properly effected, a noise is vaguely heard, and an attempt is made to catch this sound until the maximum physiological sensation is attained, that is to say, the most complete hearing. And I have pointed out that when one thus has electrolytic detectors, it would be impossible to know, otherwise than by rule of thumb, how one is to effect the tuning of the circuits; and I was saying that with the electrolytic detector, when the physiological perception is at its maximum, it never corresponds to an exact tuning of the circuits, for the electrolytic detector possesses this special feature, that it gives maximum effects when the energy transmitted to it is likewise at its maximum. Very well, the energy transmitted when it is at its maximum does not at all correspond to a tuning of the circuits. The result of this is that this tuning of the circuits, in the sense of the rule LC, equals constant, is never accomplished in the incriminated apparatus.

Whereas Me. Taillefer subsequently gives in the following terms the concise but vigorous enumeration of the differences he believes he can find between the two sets of apparatus in question:

Transmitter. In the case of the Radio-Télégraphique, feeding by alternating current; in the case of Marconi, continuous current.

In the case of R.T. the antenna is in derivation and forms a part of the second spark producing circuit; in the case of

The total of the appliances and their connection has lead to the conclusion that their employment must be carried on under the following conditions:

The energy in the form of alternating current is produced by the high frequency converter group; the alternating current thus produced feeds, by the intermediary of a manipulator, the primary of a static transformer; the secondary of this transformer is connected to the coatings of a condenser C, forming part of an oscillating circuit, called the primary oscillating circuit, comprising in addition the spark-producer or oscillator E and the self-induction L; this circuit acts by indirect excitation by derivation upon a second circuit called the secondary circuit or the circuit of the antenna; this second circuit comprises the adjustable antenna inductance I, the self-induction L^1 and the earth T, the two self inductances L and L^1 constitute a genuine transformer.

The self-induction L and the capacity C of the primary oscillating circuit are of suitable values to permit of the establishment of oscillations of determinate periods in this circuit; the antenna circuit is regulated upon the period selected for the primary circuit by means of the antenna inductance I.

[fol. 2311] 2. The existence of an electrolytic receiving system and the general nature of the connection has led us to the conclusion that the employment of this receiving system must be effected under the following conditions:

There are again two circuits.

The antenna circuit comprises the antenna proper A, a variable portion of the antenna inductance B and the earth T; the detector circuit comprises an adjustable inductance B^2, a variable capacity condenser C and the detector D.

The union of the two inductances B^2 and B^1 forms a genuine transformer. In the first place the antenna circuit is regulated upon the period of the oscillation given by the transmitter, whereupon the detector circuit is adjusted upon the antenna circuit.

We have noticed that on the converter group there appears a plate bearing the following inscription: Société Française Radioélectrique, 128, Rue de la Boétie, Paris.

Whereas Mr. Seligmann in his very masterly argument after this quotation discussed certain very important points

of the question, and any possible objections in the course of a dissertation dealing with the two seizures; but whereas it is convenient, before dealing with his argument, to set forth the objections of Me. Sarraute on behalf of the Société Française Radioélectrique;

Whereas the attack opens by charging the Havre Bailiff with having acted improperly; whereas if, in fact, he found an Oudin apparatus, an Oudin resonator at the transmission station, he calls attention to a Tesla transformer at the receiving station; an installation by induction and two separate circuits; whilst there were in reality both at the transmitter and the receiver an Oudin autotransformer as in the Ducretet arrangement, which, again, will be brought forward here, as well as in the question of anticipation, as an argument regarded as decisive against Marconi; but whereas the Bailiff overlooked this second autotransformer by not forcing open the box containing this same, so that acting upon inference and not upon experiment he asserted the existence of a Tesla and two circuits, whilst there was an Oudin and one single circuit; whereas, further, the Bailiff is alleged to have also committed a gross error in referring to an apparatus working by induction whilst it operated by derivation;

Whereas, however, Me. Sarraute acknowledges that the substitution of the Oudin for the Tesla is unimportant as compared with two main facts deposed by the bailiff, which were sufficient to defeat Marconi; an Oudin resonator at the transmission circuit, an electrolytic detector at the receiving circuit, which would make the apparatus a derivative, not of Marconi, but of Ducretet, who would thus find that he had successfully overcome in advance the opponent whose system, being essentially based upon the tuning of [fol. 2312] four circuits, could not be said to be infringed by a system which only tunes three, inasmuch as the Oudin resonator inserted in the transmitter between two circuits which it tunes first together, and then with that of the antenna, would in fact form only three synchronized circuits; whereas indeed the circuit of the detector is not only tuned with those of the transmitter, but, further, cannot be adjusted to resonance, and, therefore, there is no fresh analogy between the apparatus seized and the patented appliances;

Whereas it is sought to explain this difference by the difference alleged to be very profound between the Branly

detector, the only one which existed in 1900, and the electrolytic detector which the Defendants employ;

Whereas this term and this system, which play such a great rôle in this portion of the discussion, require some comments, without which the arguments would be difficult to follow.

Whereas Me. Taillefer began this examination at the outset of his pleading by opposing to the Branly detector, which is particularly subtle and subject to wave influence, another more recent system; the electrolytic detector, which is alone implicated and the crystal detector, which has already been referred to; whereas the electrolytic detector is, according to Me. Taillefer, a species of voltameter of a very delicate character, consisting substantially of two platinum wires, the finer one of which provides by its two ends the two poles of the voltameter, which is very sensitive to external waves; whereas, if it is influenced by the latter, the current readily passes through, but it does not transmit the same unless the intensity of these waves reaches the maximum, so that it does not work if the circuits are tuned;

Whereas under these conditions it may at once be asked whether the system of the Société Radioélectrique is nothing more than misapplied genius, and an endeavor to differentiate itself from the Marconi system, which retains its paramount value and which a detail of this character cannot detract from;

Whereas this opinion appears to be corroborated by the following extract from the excellent work of M. le Commandant Ferrier, who associated himself with Commander Tissot in the present proceedings against Marconi, to whom he had as recently as 1909 rendered striking homage; whereas in fact, on pages 310 and the following of this book, composed with the collaboration of Colonel Boulanger, the following explanation of the electrolytic detector is to be found, following upon that of the metal filing coherer, and the magnetic receiver, which is increasingly adopted by Marconi, and the Stuby and Telefunken receiver:

All the electrolytic detectors and receivers are constructed on the same principle, and are only differentiated by their details.

In the direct action arrangement the detector is put in [fol. 2313] circuit with two telephones, and the resistance of a potentiometer fitted upon a cell. A slider enables the

electromotive power applied to the terminals of the detector to be varied at will.

An adjustable condenser is applied to the terminals of the detector; the detector is directly interpolated in the antenna, to which are added a self-induction and an adjustable condenser, both being for the purpose of obtaining resonance.

This arrangement is rarely employed except in very simplified stations.

For indirect action by derivation the detector is fitted, as in the previous case, with the telephones and the potentiometer. A solenoid has one of its ends connected to the point of the detector, the other end being free. Two sliders can be moved along the solenoid: A is connected to the aerial, B to earth and to one of the coatings of a condenser, which may or may not be adjustable, the other armature being connected to the second terminal of the detector. The primary of the resonator is therefore formed by the turns A B and the secondary by the turns B'. The sliders are sometimes arranged so as to permit of their being rendered interdependent; they are first set in motion one after the other, then together in order to find the position which gives the best receptivity, or which permits of eliminating any kind of disturbance. When the condenser is adjustable, it is necessary to add to the foregoing adjustments that of this condenser. Another adjustable condenser is also sometimes placed at the terminals of the detector to reduce the damping of the circuit of resonance.

Each receiver generally comprises several detectors which are at will placed in circuit by means of a commutator.

The circuits of the detector, and in particular the earth wire, should be disconnected during transmission in order to avoid rapid deterioration of the detector.

Finally, the arrangement for indirect action by induction does not differ from the foregoing except as regards the resonance circuits.

As a rule the secondary is not adjustable. To pass from one scale to the following a change of secondary is made. The waves comprised between those corresponding to two secondaries are brought into resonance by means of adjustable condensers.

The primary is ordinarily adjustable by means of a slider or with the aid of plugs.

The secondary can likewise be set up in the detector circuit.

As a rule, the coupling is regulated by modifying the distance between the primary and the secondary.

[fol. 2314] Superfluous and extraneous signals are successfully eliminated by making use of an intermediate circuit, the coupling of which can be varied with the aerial circuit and the detector circuit.

The purifying function of these intermediate circuits has been pointed out by Mr. Stone in respect of both receiving and transmission. They are subject, however, to the drawback of absorbing a portion of the energy, but in many cases this fact does not give rise to any serious inconveniences, whilst on the other hand it is very important to clearly receive signals which are rendered indistinct by extraneous signals or atmospherical disturbance.

For instance, the mode of erection shown on Figure 167 can be made use of, the various condensers being adjustable as well as the various windings. It is well to arrange a commutator in order to permit of using at option one only of the circuits instead of both.

Whatever may be the mode of erection adopted for putting the electrolytic detector into operation, the apparatus to be made use of can be of any pattern. However, to obtain the maximum efficiency it is advisable to observe the following rules, &c."

Whereas from this long quotation, which in case of need may be corroborated by pages 145 and the following from the same work, several facts are made manifest, the first of which is that the electrolytic detector does not in fact present any serious differences as compared with other detectors; the second is that the processes of induction and of derivation are comprised in the same devices; the third is that the question of adjustment is always the dominant one in wireless telegraphy whatever may be the differences existing in the various parts which combine to produce the common result; whereas, further, one is somewhat surprised to observe in this portion of the contest, which is devoted to infringement, the energy displayed in rejecting the possibility of tuning the circuits, whereas when dealing with anticipations it was sought with equal energy to prove that everybody had known and made use of syntonisation prior to Marconi, who was accordingly merely a plagiarist with his theory and practice of four circuits;

Whereas it is opportune to confirm the foregoing by one of the passages from Me. Taillefer's pleadings:—

In Tesla there are four circuits tuned with a view to the transmission of wireless telegraphy;

By whatever means Tesla's theory is carried out, whether by Marconi waves, whether by Tesla or Hertzian waves, all this is merely a matter of words, and we are compelled to face the facts.

Very well, you acknowledge that in Tesla there are four tuned circuits, tuned not only in pairs, but all four together; that they transmit electric vibration from end to end, and that, as pointed out by Tesla, they can be used for the pur- [fol. 2315] poses of wireless telegraphy. I want to know what there is remaining of the Marconi patent.

Whereas, however, the Defendants seek to demonstrate that there is a sufficient difference between the apparatus seized and that of Marconi, owing to the fact that in the apparatus of the latter the transformer is composed of two entirely distinct coils, whilst the transformer of the seized appliance is formed of one single coil, one portion of which contains the primary circuit in which the current passes; that this single self induction coil also contains the transformed current of the secondary circuit in the shape of radiation current; that thus the action of the primary circuit upon the secondary circuit is alleged to take place not by induction as in the case of Marconi, but by derivation, which is expressed by stating that the apparatus seized is not a transformer like Marconi's, but an auto-transformer, which would suffice to cause the complaint of infringement to fail to the ground.

Whereas these subtleties appear to be irrelevant inasmuch as in the first place the Marconi claims do not define the transformer he proposes to use, but in his improvement patent are made applicable to all systems of transformers, so that he can equally well make use of the Tesla device adopted by him and the Oudin device, which would distinguish the seized apparatus.

Whereas further the contradiction which it is sought to establish between the transformer and the auto-transformer is scarcely more than a dispute about words; whereas, indeed, the term "transformer" was at the outset made use of to designate the apparatus serving to raise or diminish the voltage of an electric current, for instance,

by converting a current of 30 amperes at 100 volts into a current of 10 amperes at 300 volts or *vice versa;* and whereas the apparatus principally used at the outset had two separate windings and the ratio in which the voltage was raised or lowered depended upon the number of windings of the secondary as compared with the number of windings of the primary;

Whereas this apparatus was employed for other purposes than that of modifying the voltage and particularly for the transformation of electric energy into the energy of the magnetic field, the latter in turn becoming transformed into electric energy in another circuit, *i.e.*, in the secondary as an induced current;

Whereas the same effect could be obtained subsequently by an apparatus having one single winding, one portion of which only is common to the two circuits, and the whole or a part of which was placed in one only of the two circuits; whereas the ratio of change in the voltage depended upon that existing between the number of windings of the primary and the number of windings of the secondary;

Whereas this apparatus, which was first called a transformer, received the name of auto-transformer in order to distinguish it from the transformer proper, having two separate windings;

[fol. 2316] Whereas the supporters of a marked difference between the two systems allege that the auto transformer does not act as does the transformer entirely by mutual induction, but partially by mutual induction and partially by what is called inductive derivation; so that they can entirely eliminate mutual induction in order to obtain inductive derivation only, which would constitute a genuine invention;

Whereas there must be pointed out what is of great importance to the discussion, that if in an auto-transformer the whole of the winding is common to the two circuits there is no modification of voltage and consequently no effect by way of transformation of voltage, but the only function of the apparatus is by way of inductive derivation;

Whereas prior to Tesla's experiments upon high-frequency currents and very high potentials, the transformers and auto-transformers were provided with the traditional iron core, offering a more ready passage to the lines of force of the magnetic field; but whereas Tesla in order still

further to increase the voltage made use of transformers without core, which were definitely adopted in his patents of 1898 and 1899 and were, doubtless, also contemplated in the more general description of the 1900 specification;

Whereas the Oudin transformer appears to have been the only apparatus without a core employed prior to Marconi;

Whereas Commander Ferrier, on page 223 of the book already referred to, under the title, "Oudin and Tesla Transformers," examines the two appliances under discussion and which thus appear as possessing very great analogies;

Whereas under such circumstances, it can readily be understood that the learned Me. Taillefer should express himself thus:

I take it that the Oudin resonator is a transformer; it is a further transformer. * * * the adjustment of the aerial is effected by the employment of the Oudin transformer. * * * and this is interesting, for in the device impeached by Marconi we discover precisely the aerial and the employment of the resonator. Oudin uses it with the same object and for the same purpose.

For what purpose, then, is my opponent's lengthy dissertation to demonstrate that the Oudin resonator and the Marconi transformer are the same thing? I am in agreement with him * * * Marconi, in 1900, copied Lodge, Braun and Tesla; he further borrowed from Oudin that which was his characteristic feature * * * in 1898 the transmitter (Marconi) is provided with an Oudin adjustable resonator.

Whereas it is evident from all the foregoing that the substitution of an Oudin for the Tesla in the seized apparatus does not constitute any palliation for those who are charged [fol. 2317] with infringement, as Marconi, as a matter of fact employed the Oudin transformer or auto-transformer prior to 1900 and on the strength of his claims can still do so, seeing that the practical result is the same;

Whereas the excuse of incomplete syntonization in the apparatus seized as compared with the four Marconi circuits also falls to the ground in presence of the foregoing findings of fact; whereas scientific theories, however ingenious they may be, which attempt to make out that Marconi's formula of mathematical syntonization is inappli-

cable, as well as the impossibility of the seized apparatus providing the syntonization of four circuits, also fail in in view of the results of the Marconi invention, the identical working of the seized apparatus, which would not be the case without syntonization, which is the fundamental basis of a practical receiver for Hertzian waves;

Whereas it matters little whether such syntonization be the result of a mathematical formula or of the employment of adjustment by a tentative method, as Nature almost always takes an ironical pleasure in defeating absolute classification as well as any attempt to imprison it within infallible dogmatic formulæ; whereas the supporters of such formulæ, who try to set up Oudin in opposition to Tesla, derivation to induction, and the couplings of the seized apparatus to those of Marconi are entirely routed by Commander Ferrier, to whom the involved Companies appeal, and who, in his learned developments of Chapter VIII. of the work already referred to, absolutely assimilates the indirect processes of excitation, induction or derivation in respect of both the receiver and the transmitter;

Whereas the simplest method in this grave discussion is to quote verbatim concise extracts which will provide an irrefutable argument upon the point in dispute:

Indirect excitation by derivation. . . . This excitation is identical with the equation we have laid down for coupling by induction . . . in both cases the co-efficients representing the ratio of the self-induction of the coupled portion to the total self-induction of the aerial.

We can therefore apply to excitation by derivation all the conclusions which have been laid down for coupling by induction . . . the circuits are in resonance. . . .

To sum up, the following adjustments will have to be carried out:

In the case of the transmitter the two coupled circuits must be brought into resonance and the same thing applies to the two receiving circuits. . . .

It is by tentative methods that these various adjustments are effected. . . . In the case of the receiver preference is given to operating by induction, as the adjustments are far more precise when the circuits are entirely separated [fol. 2318] Whereas in any event, whether the seized apparatus formed a part or a working detail different from

the whole appliance constituting the 1900 Marconi patent, infringement would none the less exist on account of this fundamental law in respect of patents, viz., that any one borrowing the principle of a patented invention cannot evade the consequences of his infringement by introducing unimportant modifications into the invention; and whereas when the invention, as in Marconi's case, covers a combination of parts or a process producing new and useful results, any one producing the same results by making use of the main parts of the combination of the process infringes the invention, even if he has modified the combination of the process by omitting some unimportant part and substituting another equivalent part;

Whereas in the case of the seized appliances, in order to evade the complaints brought against them, it cannot be alleged that they had invented a new process as regards Marconi's process; whereas, as a matter of fact, the latter has not yet been surpassed, as Commander Ferrier acknowledges, not in his statement brought into the discussion in so unexpected a fashion that Me. Taillefer did not think fit to rely upon him, but rather upon the formal declaration to be found on page 403 of his work already referred to and which reads as follows:

It was in 1896 that Mr. Marconi accomplished the first communication by means of Hertzian waves; since that time he has continued to improve his earlier devices, and it may be said that he is still at the present moment, among all the scientists dealing with wireless telegraphy, the one who has caused the greatest advances to be made.

In 1899 the establishment of radiotelegraphic communication was the first real practical application of wireless telegraphy.

The first experiments of syntonized apparatus were made by Mr. Marconi between France and Corsica.

Whereas to sum up, so long as those who profess to obtain the same practical result as Marconi have not discovered fresh processes, but restrict themselves to introducing insignificant variations in his apparatus, they will not be able to escape from the reproach of infringement;

Whereas it is surprising to read immediately afterwards a special notice stating precisely that his system cannot be regarded as an infringement of the Marconi patent; whereas one is still more surprised to observe that the Com-

pagnie Radioélectrique, in view of their contradictory attitude, have not thought of proving that the apparatus seized against them were not their property.

[fol. 2319] Part Sixth: Summing Up. Judgment

Whereas, to sum up, this lengthy examination of the facts and of the arguments of the parties, of the documents which are for the most part very largely quoted from in order to avoid any unintentional colouring of their wording or their intention, has made apparent the unquestionably novel character of the 1900 Marconi patent; whereas doubtless the latter has drawn from the common fund of knowledge the various elements of his invention, which has no pretence to be anything else but the application of known means for the achievement of a new industrial result;

Whereas, however, in spite of the high status of the scientists whose partial discoveries it has been sought to put forward as anticipations fatal to the Marconi patent, the latter is none the less the one who first occupied and maintained an important position not only in the practical utilisation, but also has already been seen in the search for constant improvements;

Whereas, doubtless, the powerful combining process which enabled Marconi to bring the result of all previous scientific and practical research to such a high level is the most valuable testimony rendered to the genius of his predecessors, but does not in any way detract from the operations carried on by him which brought into the domain of the most remarkable industrial application all the efforts which had remained at a standstill on the purely scientific territory of theoretic ideals or on the less attractive ground of incompletely successful inventions;

Whereas in view of the tremendously rapid march of science, which is constantly placing within the reach of all, as a conquest, which quickly becomes commonplace; that which perhaps not long before appeared to be the boldest of vain imaginings, it cannot be doubted that within a short time wireless telegraphy, according to Marconi's patent, will seem but a modest preface to fresh conquests, but whereas this development, the fruit of further efforts, which will perhaps give to the conquerors of new forces, as compared to Marconi himself, the privileged position which he has inherited from his predecessors, does not

detract at all from the glory of the past, which is the common patrimony of all labourers who are early in the field.

Whereas in view of these natural laws which exert a sovereign domination over the mysterious destinies of humanity, it will be safe to relegate to a negligible background the passions which the Hertzian waves appear to have unchained and which will not even be taken into account by those who by their strict duty have only Right and Justice to consider, assisted by a modest but conscientious examination of the opposing submissions and the documents put in evidence;

Whereas these documents have enabled us to reject both the accusation of plagiarism, and the claim of forfeiture [fol. 2620] for failure to work within the legal time limit, which were brought against the patent set up and have further enabled us to investigate clearly the remarkable nature of the apparatus seized at Marseilles and Havre against the Société Radiotélégraphique and the Société Radioélectrique, both of whom are well qualified to look ahead instead of wasting time in rearguard actions, and thus to substitute for proceedings which have given rise to complaint, but which are excusable on account of the subtlety of the problems raised, the fruitful victories which doubtless await them upon new paths and in regions that were unsuspected yesterday, but which are now beginning to deliver up their mysteries;

Whereas, however, the documents put in during the arguments by the Marconi Company do not supply any means whereby the damage for which they claim compensation can be ascertained; whereas the small value of the seizures made by them show how insignificant had been up to then the actions of the Defendants; whereas under these circumstances and specially with regard to the position of the pleading, the Court is compelled to order that this damage shall be ascertained by reference, recommending the referee [illegible] to such a manner as to avoid everything that may appear like a roving commission over the affairs of the two Companies rivals of the Plaintiff Company, younger than the latter, but, perhaps, as deserving as the Plaintiffs and as desirous to serve the interests of science and the good of the public; whereas the referee must also bear in mind the theories which are put forward on both sides and which the high authority of the Counsel for parties has been able,

by considerable effort, to set forth clearly, and which makes the action of the Defendants very excusable:

For these reasons the Court—

In due form, having regard to the connection in the subject matter, consolidates the actions in order to comprise the whole under the same judgment:

Gives to Legru a record that he leaves the matter in the hands of the Court to decide as to the question of infringement:

As to the Substance:

Gives to the Société Générale de Transports Maritimes à Vapeur a record that they reserve their right to claim upon the Compagnie Générale Radiotélégraphique in the event of their working being interfered with by the substitution of the confiscated apparatus:

Holds that the Marconi Wireless Telegraphy Company are properly entitled to the patent granted on the 3rd November, 1900, with regard to improvements in wireless telegraphy; that the same is valid, as it produces an industrial result which is now beyond question:

Holds that the patent has been worked in France within the legal limit both by manufacturing the appliances and by installing them in a series of wireless telegraphy stations:

[fol. 2321] Holds that the electrical installations and apparatus seized at Marseilles from the Société Générale Maritime and the Compagnie Générale Radiotélégraphique, then at Havre from Legru and la Société Française Radioélectrique are infringements of the Marconi patent:

Restrains the Compagnie Général Radiotélégraphique and the Société Française Radioélétrique from constructing, exhibiting, installing and offering for sale appliances which constitute an infringement of the said patent:

Orders the confiscation of the apparatus seized both as regards the two Companies and the Société Générale Maritime de Transports à Vapeur and Legru:

Jointly and severally awards against the Compagnie Générale Radiotélégraphique and the Société Générale Maritime de Transports à Vapeur on the one hand and the Société Française Radioélectrique on the other, an amount of damages to be fixed by a Referee and which will comprise in addition to the claim in respect of acts committed previous to the commencement of the action, all acts of infringement committed since that time:

Appoints, in order to carry out this order, Arnitz as Referee, duly sworn, unless he should be excused from doing so by the parties;

Orders the insertion by extracts of the present Judgment in five papers published in Paris and ten published in the provinces, at the choice of the Plaintiffs, provided that the cost of each insertion shall not exceed 500 francs for the first named and 200 francs for the latter;

Orders the Defendants in the Lower Court jointly and severally to pay the costs in that action and the Defendants in the Higher Court to pay the costs in same, all which costs are to be paid to Me. Haquin in legal tender.

Orders the Société Radiotélégraphique to guarantee and indemnify the Société Générale de Transports Maritimes à Vapeur in respect of the above Judgment given against them in favour of Marconi's Wireless Telegraph Company, Limited, and at their expense to instal fresh apparatus fulfilling the conditions laid down at the time the seized apparatus were fitted up;

Orders the Société Française Radioélétrique to reimburse to Legru the cost of the confiscated apparatus in respect of their value, including expenses of installation, to be settled by Arnitz, designated and appointed as above, and who, as far as required, for this further reference will be Sworn unless the oath is dispensed with by the parties.

Orders the Société Générale Radiotélégraphique to pay the cost of the special claim of Legru, with allowance of costs to Me. Brunet, Solicitor, in legal tender.

States that as far as requisite the legal expenses, double fees and fines which may result from the present Judgment shall be included in the costs to which they reasonably belong, and this, if need be, by way of damages. M. DAYRAS, [fol. 2322] substitute Mes. SELIGMANN, TRAVERS, TAILLEFER and SARRAUTE, Advocates.

NOTE. I. II. As to the two first points, the Judgment recorded applies a principle that is constantly maintained in doctrine and juri-prudence to a particularly interesting invention, viz., that there is a patentable invention in the new combination of known means or elements resulting in a new industrial result or presenting new advantages. *Vide* especially Cass. 4 May, 1901 (Gaz. Pal. 1902. 2315); 23rd June, 1905 (Gas. Pal. 1905. 2141); and the notes, and among more recent decisions which have also applied this principle: Trib. civ. Seine 27th June, 1911 (Gaz. Pal. 1911. 2.50);

12th July, 1911 (Gaz. Pal. 1911. 2.79); with the notes and references to decided cases and authors. *Vide* likewise the cases quoted in Gas. Pal. 1912. 1, Table, reverse side, letters patent No. 15. Adde Pouillet, Taillefer and Claro; Letters patent No. 46.

III. On the third point: Usurpation of the essential idea of a patented process constitutes infringement, in spite of differences in detail; Cass, 16th January, 1912. 2. Degrees. (Gas. Pal. 1912. 1.413); Paris, 11th May, 1904 (Gas. Pal. 1904. 1. 762); 6th March, 1899 (D. 1904. 2. 317); Trib. Civ. Seine, 26th March, 1912 (Law of 4th April, 1912—Gaz. Pal. 1912. 1, reverse side, letters patent No. 31); Trib. Civ. Lyons, 9th February, 1912 (Law of 24th January, 1912 Gaz. Pal. *loc et verb. cit.*, No. 28).

PLAINTIFF'S EXHIBIT 46

NAVY DEPT. OFFICE

CONTRACT.

Contract No. 144

1912

Navy Yard New York

Dr. Bureau

Bureau

General Account of Advances

This Contract. ... the twentieth ... of Septe ber ... 11 ... The Telefunken Wireless Telegraph Company of the United States

... 111 Broadway, New York,

... New York ... party of the first part and the United States ... Department ... Navy Department ... New York, N. Y., party of the second part. Witnesseth, That ... the party of the first part, ... itself ... its ... personal and legal representa... with ... of the parts of the second part as follows, viz: ... it ... the party of the second part will furnish and deliver at ... its own ... Navy Yards hereinafter specified ... the ... wants ... specified ... from the date of this contract ... respectively.

Requisition No. 82. Bureau. Naval Supply Account

Item No.

(1) 1 2-K.W. wireless telegraph set, complete, variometer type, motor generator to be wound for 125 volts, D.C. $345

(2) 1 1-K.W.wireless telegraph set, complete, commercial type, motor generator to be wound for 125 volts

(3) 1 K.W.wireless telegraph set, complete, commercial type, motor generator to be wound for ... volts D.C.

---DELIVERY---

Items 1 and 3 To be DELIVERED to Gen'l.Storekeeper Navy Yard, Brklyn, N.Y.

Item 2 To be DELIVERED to Gen'l. Storekeeper, Navy Yard, Portsmouth, N.H.

EACH WIRELESS TELEGRAPH SET TO CONSIST OF THE PARTS NAMED IN THE LIST BELOW GIVEN:

ITEM NO. 1.

This set will consist of the following:

Complete transmitter (Primary and Secondary Variometers, Spark Gap and Paper Condenser in Teak Case), New Horisontal or C.E.F. type Receiver with two Detectors and Three Telephones, Key, Transformer, Aerial Hot Wire Ammeter, Aerial Switch, Switchboard, Hand Starter, Motor Generator (with spares required by 1678), and high frequency Protecting Board.

DELIVERY:----------FIFTEEN DAYS (15), EXCEPT RECEIVER, WHICH IS TO BE DELIVERED WITHIN NINETY (90) DAYS.

ITEM NO. 2.

This set will consist of the following:

Transmitter (Spark Gap, Condenser, Transmitting Spiral and Aerial Hot Wire Ammeter), new special horisontal type Receiver with two Detectors and one Telephone, Key, Transformer, Aerial Switch, Switchboard, Hand Starter, Motor Generator with five spare sets of Brushes for Motor and High frequency Protector Board.

DELIVERY: ---------- FIFTEEN (15) DAYS, EXCEPT RECEIVER, WHICH IS TO BE DELIVERED WITHIN NINETY DAYS.

ITEM NO. 3.

This set will consist of the following:

Transmitter (Spark Gap, Condenser, Transmitting Spiral and Aerial Hot Wire Ammeter), new special horisontal type Receiver with two Detectors and one Telephone, Key, Transformer, Aerial Switch, Switchboard, Hand Starter, Motor Generator with five spare sets of brushes for Motor and High frequency Protector Board.

DELIVERY: ------ FIFTEEN (15) DAYS, EXCEPT RECEIVER, WHICH IS TO BE DELIVERED WITHIN NINETY (90) DAYS.

One complete set of spare Leyden Jars to be furnished for each of the sets under Items 2 and 3.

The switchboards should have the following:

1 A. C. Voltmeter,
1 A. C. Ammeter,
1 Frequency Meter,
1 Solenoid Switch,
2 Knife Switches,
2 Rheostats,
Fuses,
Wire.

The switchboard equipment for these sets to include the following:

1 A. C. Voltmeter,
1 A. C. Ammeter,
1 Frequency Meter,
1 Solenoid Switch,
1 Starting Switch,
2 Knife Switches,
2 Rheostats,
Fuses,
Wire.

If the sets are furnished with hand starters, no starting switch is required.

Copper coated jars to be furnished under Item No. 3.

All RECEIVERS under this contract TO BE DELIVERED at the Navy Yard, Brooklyn, N. Y., and HOME at the Navy Yard, Portsmouth, N. H.

10 - 9

1. It is hereby mutually and expressly covenanted and agreed by and between the parties hereto that the articles to be furnished or services to be performed under this contract shall conform in all respects to the requirements of the specifications hereunto annexed, which specifications, the "Instructions, Descriptions, and Conditions" printed on the reverse of the said party of the first part, shall be deemed and taken as forming a part of this contract with like operation and effect as if the same were herein recited herein; and, in any case where the specifications do not explicitly provide to the contrary, all workmanship and materials entering into the manufacture or construction of any article or articles under this contract shall be of the very best kind for the purpose and manufacture; and said article, articles, or services shall upon delivery or completion, be subject to inspection and examination by the officer or officers authorized by the said party of the second part to inspect and examine the same, and no article or service performed under this contract shall be accepted until it or they shall have been inspected and approved by such officer or officers; and any article or service not so approved shall be removed by the said party of the first part at its own expense and at its own days after notification.

2. It is further covenanted and agreed, as aforesaid, that time is an essential element of this contract and that in case the said party of the first part shall fail to make delivery of any or all of the articles or materials or to perform any or all of the services contracted for, in conformity with the conditions and requirements of the contract, and within the time or times prescribed, the said party of the second part will be damaged thereby, and the amount of said damages is hereby fixed and agreed upon and shall be deducted from the contract price, the deductions, however, not to exceed in any case 10 per cent of the stipulated value of the articles or materials not delivered, or of the services not so performed. Rejection of deliveries or performance not to be considered as waiving deliveries or performance on any days shall not have been caused by act of the Government, by strikes, riots, fire, or other disorder, delays in transportation on the part of transportation companies, or by other circumstances beyond the control of the contractor, but such circumstances shall not be deemed sufficient delays on the part of subcontractors in furnishing materials when such delays were known to the contractor at the time of the execution of this contract, unless the same be specified herein specifically as excusable delays. That the question whether delays are due to causes herein specified shall be determined by the said party of the second part.

3. It is further covenanted and agreed that if the said party of the first part shall fail in any respect to perform this contract the same may, at the option of the United States, be declared null and void, without prejudice to the right of the United States to recover for damages thereto or violations thereof, or the said party of the second part may purchase or procure in such manner and from such person or persons as he may deem proper, paying such price therefor as may be necessary in order to procure the same, such articles or materials of the kind specified herein as practicable, or procure the performance of such services as the said party of the first part shall fail to deliver or perform as required, and may demand and recover from the said party of the first part the difference between the price so paid therefor and the price stipulated in the contract, and the amount of such difference shall be paid to the said party of the first part to the said party of the second part on demand.

5. It is further covenanted and agreed that the said party of the first part shall indemnify the United States and all persons acting under them, for all liability on account of any patent rights granted by the United States that may in any way affect the sale or use of the articles herein contracted for.

6. It is further covenanted and agreed that in carrying out the provisions of the contract no convict shall be employed while undergoing sentence of imprisonment at hard labor which has been imposed by a court of the United States, any State, Territory or municipality having criminal jurisdiction, that the contract is upon the express condition that no Member of or Delegate to Congress, nor any person belonging to or employed in the naval service of, or shall be admitted to any share or part thereof, or to any benefit to arise therefrom except as a member of a corporation, and that any transfer of the contract or any interest therein to any person or party by the said party of the first part shall annul the same, so far as the United States are concerned.

AND THIS CONTRACT FURTHER WITNESSETH, That the United States party of the second part in consideration of the faithful performance of the foregoing stipulations, do hereby covenant and agree to and with the said party of the first part as follows:

That upon the presentation of the customary bills and the proper vouchers (the latter subject to inspection and examination of the said articles, articles, or services, and within ten days after such evidence shall have been obtained from the Chief of the Bureau of Navigation, Navy Department, there shall be paid to the said party of the first part at the Navy Pay Office, New York, N. Y.,

The Telefunken Wireless Telegraph Company of the United States

or to its order by the Navy Pay Officer at Navy Pay Office, New York, N. Y.,

the sum of Ninety Three Hundred Twenty Dollars -------- ($9320.00) -------

for all the articles delivered or services performed under this contract. Provided, That no payment shall be made for any of the articles or services until the same shall have been inspected and accepted by the officer or officers authorized to inspect the same.

IN WITNESS WHEREOF the said parties hereto have hereunto set their hands and seals the day and year first above written.

SIGNED AND SEALED IN THE PRESENCE OF—

(sd) Frank W. Perkins

(sd) John Morrison, Jr.

Telefunken Wireless Telegraph Co. of the United States.

(sd) [illegible]

as to party of the first part

(sd) F. J. Sinnott

as to Purchasing Pay Officer

(sd) [illegible]

Pay Inspector

U. S. Navy Pay Office, New York, N. Y.

THE TELEFUNKEN WIRELESS TELEGRAPH COMPANY OF THE UNITED STATES

August 22nd, 1912.

The Sets covered by our bid are NOT in accordance with Specification 1676, Except Paragraph 108-113-114-115 and 116 and we are unable to comply strictly with the other paragraphs of Specification 1676 without seriously impairing not only the usefulness, but also the efficiency of the set as a whole.

All spare parts as required under Paragraphs 14a, 16e(12), 26b, 32k, 37d, 55e, 66j, 70b, 100a, and 117 are included except spare parts for the generators under Paragraph 100a, because the machine we use is an Inductor Alternator with stationary Field and armature windings. As no battery is required with our Detectors, no spare primary batteries as for Paragraph 30 are supplied.

The Sets we propose supplying are of our Standard 500 Cycle Quenched Spark System and of latest Switchboard type in which the Spark Gap, Transmitting Spiral and Relay Key and the Aerial Coils, Aerial Variometer, Aerial Hot Wire Ammeter, Aerial Capacity and connections are mounted on Metal frames similiar to switchboard panels and are intended to be set up in a similiar manner, i.e., simply attached to the wall and floor. They are NOT of the Variometer Type but have a range of from 300 to 2000 meters and can be rapidly set for any of five (5) steps within this range as, for instance, 600, 900, 1200, 1600, or 2000 meters.

The transmitting condensers are made up of Standard 10 Glass Plate Leyden Jars in an aluminum porcelain insulated

August 22nd, 1912.

rack. The Leyden Jars we propose supplying will be of our usual high quality and in accordance with Paragraph 16 except e2-e3-e4-and e10 which requirements we consider entirely unnecessary if not impracticable and tending in no way to effect the operation on the durability of the sets.

The Switchboards we propose supplying will be of the simplified type as shown in our attached blueprint No. 200 same as supplied by us on all recent orders.

The Receivers we propose supplying with each set will be as follows:-

(a) Our Standard Upright Type E5 Receiver with a range up to 10000 meters and with interchangeable variable primary and interchangeable variable secondary coils and variable primary and variable secondary condensers with the primary capacity so arranged that it can be connected up with the antenna either in series or parallel by means of a switch.

(b) Same as under (a) but with a range of from 300 to 3000 meters.

(c) Our Standard Horizontal Type E4 Receiver with a range of from 300 to 3000 meters and with a variable primary and variable secondary coil and a variable primary condenser arranged so that it can be connected either in series or parallel with the antenna by means of a switch.

The Detectors we propose supplying will be of our latest form of Iron Pyrites Detectors covered by U.S. Patent dated Sept. 12th, 1911 [illegible] will be mounted on separate stands.

The [illegible] we propose supplying are of our [illegible] Station Type as shown in attached photograph No. 474 with a range of from about 275 to 3000 meters. [illegible]

[illegible] set will consist of [illegible]

August 22nd, 1912.

of apparatus:-

One Motor-Generator.
One Automatic Starter.
One Switchboard with:

- One Frequency Meter (Weston).
- One A.C. Ammeter "
- One A.C. Voltmeter "
- One Lampbracket.
- Two Fused D.P. Knife Switches.
- Two Rheostats.
- One Solenoid.
- One Set Terminals
- Instrument Fuses.

One Transformer.
One Primary Choke Coil.
One Key with Platinum Contacts.
One Transmitter with Iron Frame, including:

- Spark-gap with cover and ventilator.
- Transmitting Spiral with plugs and cords.
- Relay Key.

One Leyden Jar Transmitting Capacity in an aluminum porcelain insulated case.
One Set Aerial Coils and Aerial Variometer in iron frame with connections, aerial capacity and Aerial Hot Wire Ammeter.
One Lightning Switch.
One set of Protective appliances as per Paragraph 117.
Three Receivers as described above.
Three Detector Stands each for and including two Detectors.
Three Double Head Telephones.
One Tone Controller or Tone Tester with detector and cord.
One EKI Wavemeter as described above with

- Variable Tone Buzzer.
- One Lamp.
- One Helium Tube.

One Set of Spares consisting of -

- One Motor Armature.
- One " Field Coil.
- One Set Brushholders.
- One " Brushholder Rings.
- Ten Sets Brushes.
- Ten Set of all fuses in Switchboard.
- One set spider arms.

or -4

TELEFUNKEN WIRELESS TELEGRAPH COMPANY OF THE UNITED STATES

August 22nd, 1912.

Two Double Head Telephones.
Fifteen Telephone Cords.
Six Extra Cups with Crystals for Detectors.
Four Spare Condensers for Protectors.
Forty Spare Fuses for "
Three Helium Tubes for Wavemeter.

THE TELEFUNKEN WIRELESS TELEGRAPH COMPANY OF THE UNITED STATES

Richard Pfund
Gen'l Mgr.

No 474

2701

PROPOSAL FOR SUPPLIES OR SERVICES

U. S. NAVY PAY OFFICE

NEW YORK.

Telefunken Co.

Please return this proposal in duplicate, duly signed, by the above name, AUG 10 1912, with prices entered opposite each item named below, for delivery, free of charges, as specified below, within ____ days from receipt of order subject to the conditions printed on the back of this form.

Respectfully,

Navy Pay Office, U.S. Navy.

WM. JACKSON ARNOLD,

Purchasing Pay Inspector, U.S.N.

Bids to be considered must show unit prices, extensions, and total amount of bid.

ARTICLES REQUIRED.	Price of Items. Dollars	Price of Items. Cents	Per	Price Amount of Bid. Dollars	Price Amount of Bid. Cents
Requisition No. 89 Sm. Naval Supply Account. Item No. (1) Two (2) 2 K.W. 500 cycle, motor generator, reversed gap, radio telegraph sets; complete with spare parts?			Sets.	$N.S	00

To be in accordance with specifications 16-7-8, issued by Navy Dept., except as modified hereby. Bids to be made strictly in accordance with paragraph 118, specification 8, 16-7-8, and paragraph 118 (c) will be strictly observed.

Bids as per paragraph 118 d are subject to approval in each case, and, unless approved, will be required to meet the correspondence of specifications, 16-7-8, when the apparatus is presented for final acceptance.

All bidders must strictly comply with the following paragraphs of the specifications, 16-7-8, which are not to be made subject to modification by the bidders:-

Paragraph 108-Drawings, etc.
113-Tests after delivery.
114-Patents.
117-Interchangeability.
118-Omissions and misdirections.

Spare parts

118 aa-For ventilation of spark gap.
118 B if For condensers of transmitter.
118 h For electrodes of detector.
118 i-For primary batteries.
118 k-For telephone cords.
118 l-li For wave meter helium tubes.
118 e For circuit breaker contacts.
118 j For panel fuses.
118 h- do
118 c-a For motor and dynamo.
118 f For protection appliances.

Special consideration will be given bids offering apparatus in which the transmitting wave length can be continuously and readily changed, as per paragraph 6e of the specifications, over a range from 600 to 1000 meters; also for compact apparatus in accordance with paragraph 6m of the specifications.

The spitting condensers made up of Standard Leyden Jars will be required.

Three (3) receivers to be furnished with each set, as follows:

(a) One highly selective receiver of special design for receiving wave lengths up to 10,000 meters, to be furnished with a variable condenser in primary circuit with leads which can be operated by switches to put this condenser in series or in parallel with inductance or to cut it out.

(b) One highly selective receiver with variable condenser, for primary circuit as required for (a), for receiving waves from 300 to 3,000 meters for ship communication.

(c) One simplified receiver, range 300 to 3,000 meters, to consist of variable primary inductance, variable secondary, with means for varying the mutual inductance between the two circuits, and variable series condenser.

All detectors must be fitted with binding posts for detector mounted as a separate item. Detectors [illegible] mounted as described will be accepted.

Bidders will describe particularly receivers and detectors they propose to furnish.

One (1) wave meter will be required with each set.

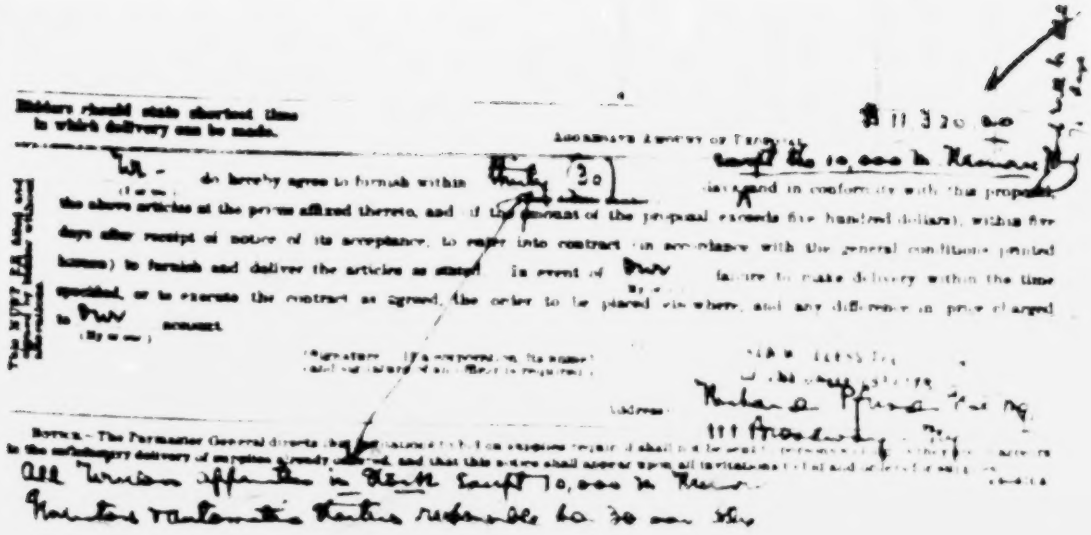
DELIVERY at the Navy Yard, New York, for inspection and test within the shortest possible time after [illegible] a contract is signed and approved.

TO BE ADDRESSED to the General Storekeeper, Navy Yard, N. Y.

2331

2-6

DO NOT PREPARED TO SUBMIT A BID, PLEASE GO BACK over the line dots
& mail bought to your attention; otherwise your name may be de



Bidders should state shortest time in which delivery can be made.

Acknowledge receipt of Telegram

$ 11 320.00

I, [illegible] do hereby agree to furnish within thirty (30) days [illegible] and in conformity with this proposal the above articles at the prices affixed thereto, and if the amount of the proposal exceeds five hundred dollars, within five days after receipt of notice of its acceptance, to enter into contract (in accordance with the general conditions printed herein) to furnish and deliver the articles as stated. In event of PMW failure to make delivery within the time specified, or to execute the contract as agreed, the order to be placed elsewhere, and any difference in price charged to PMW account.

(By whom)

(Signature — If a corporation, the name of chief executive officer is required)

Address [illegible]

Notice.—The Postmaster General directs that [illegible] shall not be [illegible] unless in the unfortunate delivery of [illegible] already delivered, and that this notice shall operate upon all invitations [illegible]

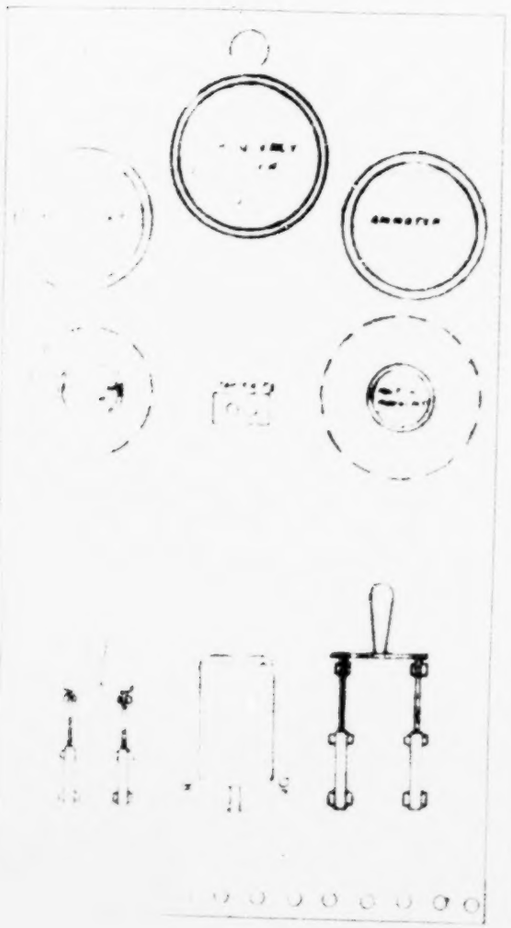
All Terminal offices in Class Tariff 10,000 in Reserve

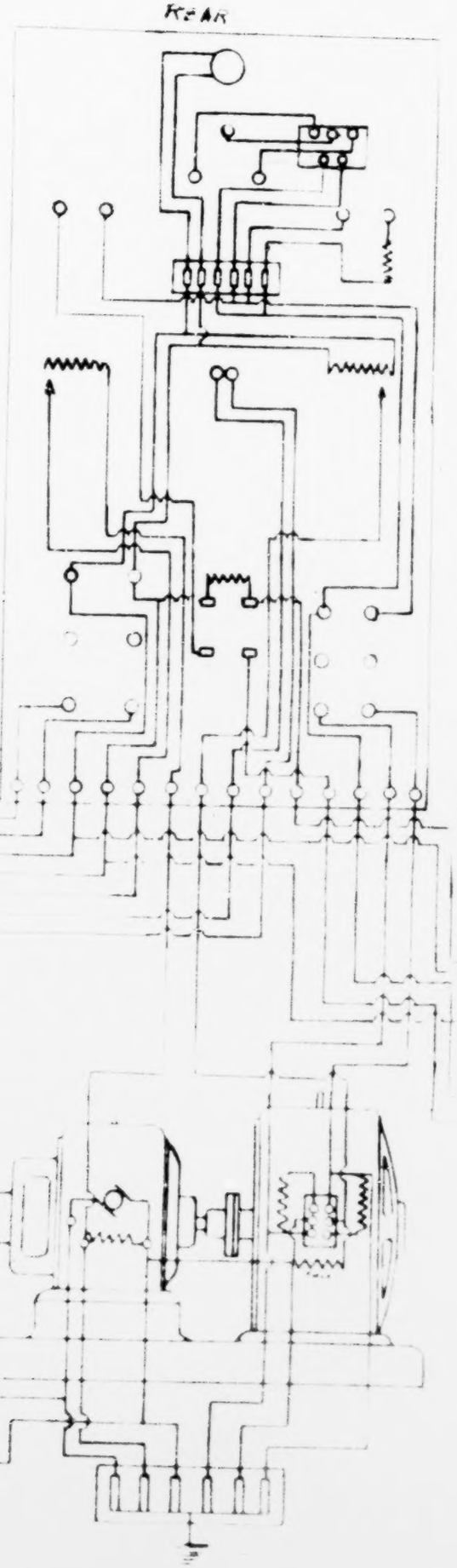
Registered Mail Parcels Returnable to 30 mm Sky

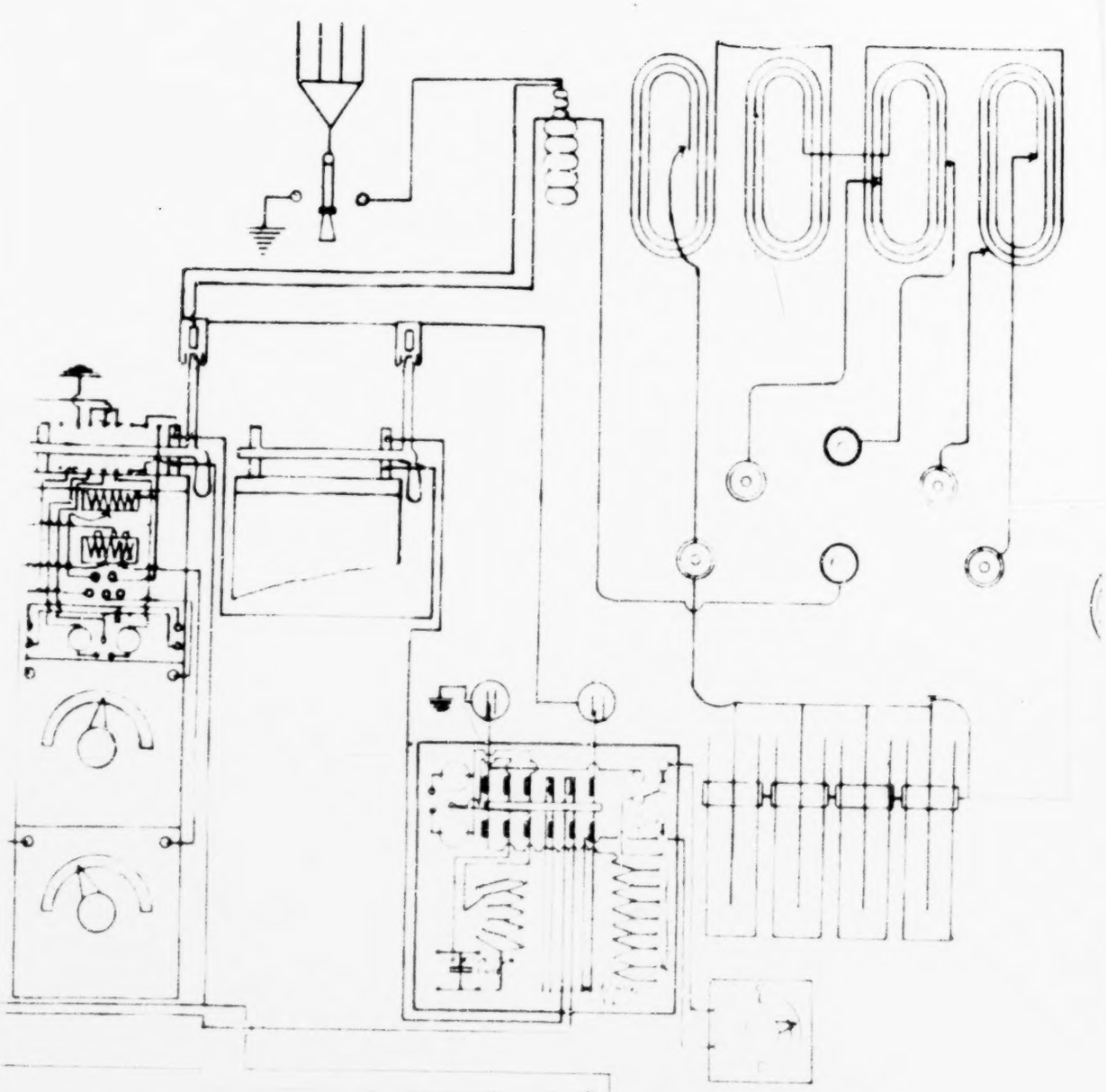
2332

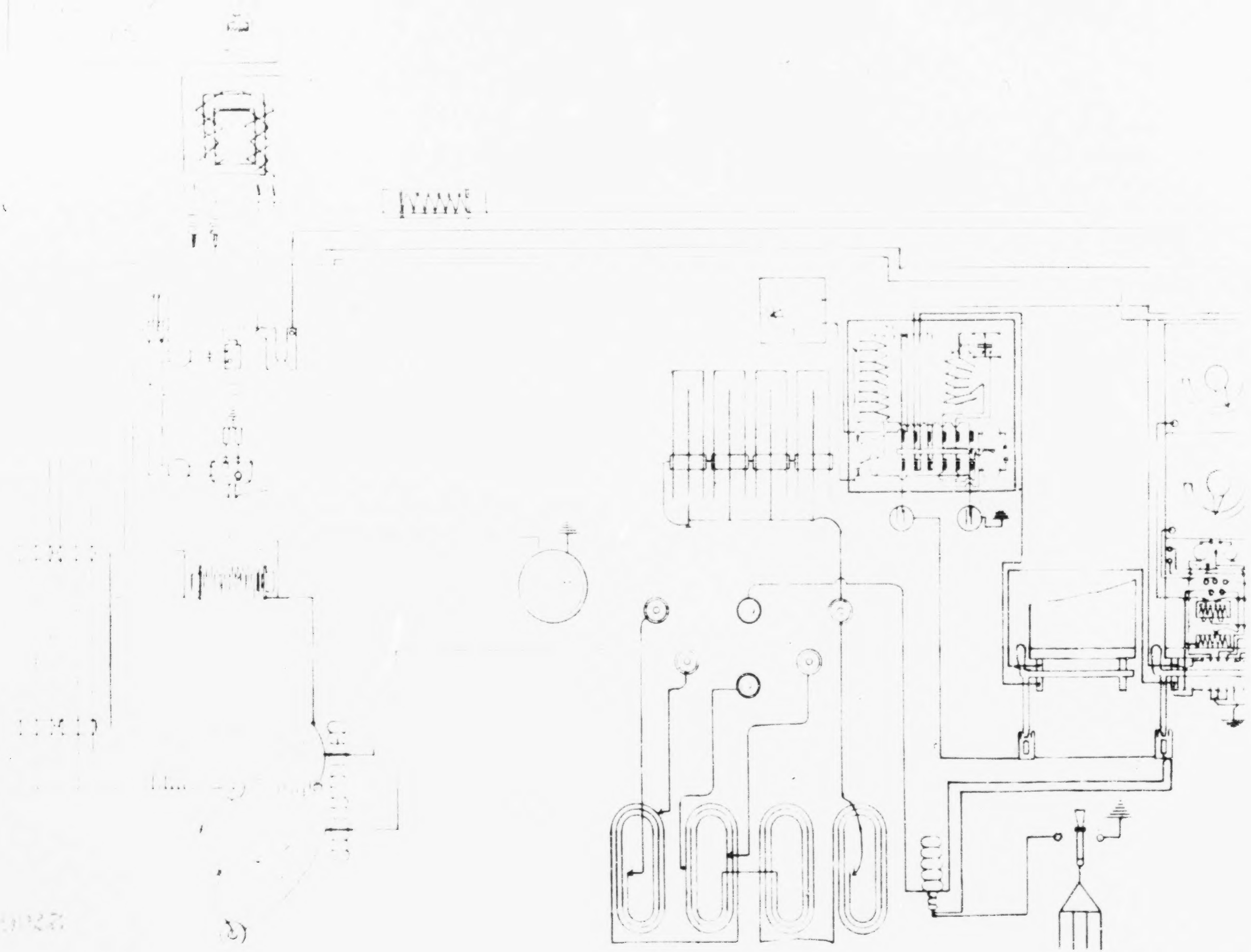
FRONT

REAR









PLAINTIFF'S EXHIBIT 53

2707

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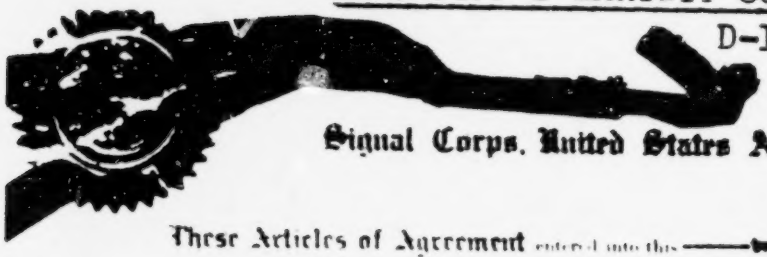

Signal Corps, United States Army.

Plaintiff's Exhibit
1 8 1 23

These Articles of Agreement entered into this twenty-seventh day of June, 1918, between C. DeF. Chandler, Captain, Signal Corps, United States Army, of the first part, and Foote, Pierson & Company, a partnership composed of George L. Foote and Henry O. Pierson, with an office at 100 Duane Street, New York, State of New York, of the second part, Witnesseth, that in conformity with copy of the advertisement, specifications, and [illegible] attached and which, in so far as they relate to this contract, form a part of it, the [illegible] C. DeF. Chandler, Captain, Signal Corps, United States Army, for and in behalf of the United States of America, and the said FOOTE, PIERSON & COMPANY hereinafter designated as the contractor, do covenant and agree, to and with each other, as follows, viz:

ART. I. That the said contractor shall manufacture for and deliver to the United States of America, the following:

EIGHT (8) Field wireless pack sets, complete with storage batteries, in accordance with Signal Corps specification No. 410, part "B," Revised, and sample set furnished the contractor. (Sets to be serially numbered in accordance with instructions contained in the order.)

ORDER No. 6808, copy attached hereto, forms a part of this agreement.

ART. II. That the deliveries of the supplies and material herein contracted for shall be made in the manner, numbers or quantities, and for each number or quantity, on or before the date specified therefor as follows, viz:

Delivery

That complete/shall be made on or before OCTOBER 25, 1918.

ART. III. All supplies and materials furnished and work done under this contract shall, before being accepted, be subject to such inspection as may be appointed on the part of the Government,

A-2

and such as do not conform to the specifications set forth in this contract shall be rejected. The decision of the Chief Signal Officer, United States Army, as to quality and quantity shall be final.

ART. IV. That for and in consideration of the faithful performance of the stipulations of this contract, the contractor shall be paid at the office of ——the Chief Signal Officer—— ——of the Army——, at ——Washington, D.C.—— for all supplies and materials delivered in conformity with the requirements of this contract, on or before the dates above specified (Article II, *supra*) *and accepted*, the following prices, viz:

EIGHT (8) wireless pack sets, at three hundred and seventy-four ($374) dollars each, making a total consideration of two thousand nine hundred and ninety-two ($2,992) dollars.

to be paid as soon as practicable after the acceptance of the same, in funds furnished by the United States for the purpose, reserving ——per cent from each payment until final settlement, on completion of the contract or otherwise.

ART. V. It is further agreed that for all supplies and materials which shall not be delivered in conformity with the requirements of this contract on or before the dates prescribed therefor in Article II, above, but which shall be subsequently delivered and accepted, the prices shall be as follows:

——none——

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NOTICE - Inspectors cannot accept departures from this specification. Indicate exceptions with your bid

SIGNAL

JUN. 9 1919

SPECIFICATION, NO. 610.
(June 20, 1909).

INTRODUCTORY.

This specification covers all of the equipment necessary for the operation of the [illegible] telegraph outfit. The equipment specified herein may be [illegible] in its entirety or by unit parts in the discretion of the Chief Signal [illegible] the Army.

If the order is placed for the equipment in its entirety under this specification, the contractor will be held accountable for the efficiency and proper [illegible] of the unit parts, the inspection covering the completed outfit. The contractor will not be held accountable for the efficiency of the circuit under any condition, but will take great care to see that every detail of the specification is followed out in the construction of the apparatus covered [illegible].

This specification is intended for the information of the manufacturer only [illegible] description of the installation or operation of the equipment. This specification is divided into five parts as follows:

Part A - General Requirements.
Part [illegible] - Antennae.
Part [illegible] - Generating Set.
Part [illegible] - Train Set.
Part [illegible] - Land Generating Set.

This specification will be issued in its entirety only when bids are asked [illegible] the parts mentioned herein.

No changes [illegible] will be allowed [illegible] by the inspector [illegible]

SPECIFICATIONS.

Antenna - 96
Battery Batteries -221
Cable Batteries -368
Carriage -403
Cross Arm Cables -416
Alternating Current - - - - - - - - - - - - - - - - - - -430

DRAWINGS.

The drawings form part of this specification, and when considered [illegible] shall be furnished the contractor with the FULL SET of this specification [illegible] the article to be supplied.

Part [illegible] - [illegible] drawings.
Part [illegible] - Field Set, pack, Wing Kite..... 534a
[illegible] wire reel
[illegible] for kite..... 534b
Field [illegible] release set, pack, hollow
[illegible] sectional mast with [illegible]
[illegible] aerial and counter wire [illegible]..... 649a
[illegible] release set, pack, [illegible]
[illegible] sectional mast, detail..... 649b
Part [illegible] - [illegible] release set, pack, generating
[illegible] set..... 499a
[illegible] Kite set, pack, generating
[illegible], detail..... 499b
[illegible] Balloon set, pack, generating
[illegible], [illegible] wire..... 499c
[illegible] [illegible] set, pack, operating
[illegible], [illegible] [illegible] mast for
[illegible] [illegible] [illegible]..... 499d

NOTICE - Inspectors cannot accept departures from this specification. Indicate exceptions with your

Field wireless set, prek, generating set circuit breaker..... 499b
Field wireless set, prek, generating set, battery and spark coil box for..... 499f
Field wireless set, prek, generating set, cover..... 499j
Field wireless set, prek, generating set, circuits..... 499b

Part V - Standard binding posts..... 510
Field wireless set, prek, cabinet, tuning coil..... 497a
Field wireless set, prek, interrupter.. 549
Field wireless set, prek, induction coil, box..... 558
Field wireless set, prek, induction coil, details..... 558b
Field wireless set, prek, open spark gap..... 566
Field wireless set, prek, sending key.. 560
Field wireless set, prek, terminals for Leyden tube condenser..... 563
Field wireless set, prek, terminals.... 563
Field wireless set, prek, trunk type, wiring diagram..... 741
Field wireless set, prek, tell-tale, lamp mounting..... 631
Field wireless set, prek, linking spiral..... 643
Field wireless set, prek, double throw control switch..... 672
Field wireless set, prek, Leyden tube.. 568
Primary condenser, 2 m. f. for trunk set wireless..... 765

Part W - Packing box for hand generator, field wireless, set prek..... 627

PART A [illegible]
(P.S. No. [illegible])

1. FIELD DUTY:

These general requirements will accompany all [illegible] specification.

2. INSPECTION:

When the order under this specification is [illegible] by the Chief Signal Officer of the Army who will cause an inspection [illegible] shall be the duty of the contractor to remedy any defects pointed out by the ter and the contractor will be held accountable for any imperfections which t ter may have overlooked.

The Chief Signal Officer of the Army reserves the right to [illegible] processes of manufacture if he so desires.

All of the apparatus described in this specification, unless [illegible] may be subjected to the proper tests indicated in these requirements.

It is to be understood that this apparatus throughout must be fully [illegible] cation with absolute fidelity and any material which fails to conform to the est standard of workmanship will be rejected.

(a) TINNING: Copper wire which is insulated with rubber shall be [illegible] conform to the requirements of specification No. 403.

(b) GALVANIZING: All galvanized articles mentioned in this specification shall meet the requirements of specification No. 96.

(c) NICKELPLATING: A drop of nitric acid, specific gravity [illegible] in diameter, applied with medicine dropper to flat surface of nickelplate shall nickelplate in six minutes. In nickelplating surfaces, the nitric test will be [illegible] ticularly careful in buffing so that the nickelplate may be firmly adherent, and in case the nickelplating is rejected, the nickel plating must be buffed off and new plat put on. Any defect in the finished surface which is likely to result in flaking of the nickel after it has been in use for a short time will be considered cause for rejection of the article even though the nickel passes the other requirements of this test.

(d) COPPERING: The residue left on a fine [illegible] shall not be attacked by nitric acid having a specific gravity of 1.1.

(e) RUBBER USED FOR INSULATION: The rubber used for insulating wires [illegible] used in any part of the equipment described in this specification must conform to specification No. 430 herewith.

(f) WATERPROOFING: The compound used for saturating the braided covering for conductors in use out of doors shall be insoluble in water and shall not melt or [illegible] subjected to a temperature of 120 degrees F. nor crack at 0 degrees F. By the term "melt" is meant that it must not form any appreciable ridge of compound when placed on a piece of paper and subjected to a temperature of 120 degrees F. for thirty minutes nor must a preceptibly oily or greasy spot appear on the paper if the compound is of any oily nature.

(g) SOFT DRAWN COPPER WIRE: Soft drawn copper [illegible] shall withstand the following test:

No. 20 B. & S. or smaller — twists in six inches [illegible]
No. 12 B. & S. and not smaller than No. 18 B. & S. twists in six inches — 60.

Samples must show an elongation of 20% before breaking.

(h) Unsatisfactory workmanship will be considered cause for rejection of the equipment even though the specification may be technically complied with.

(i) Special tests will be found hereinafter.

3. MATERIALS:

(a) Hardwood: Where hardwood is specified it must be of first quality thoroughly seasoned live timber absolutely free from checks, cracks, knots, [illegible] of any description. It shall be so put together that in no case is the [illegible] ed spar for holding the apparatus together. All woodwork and interior [illegible] shall be finished to represent light mahogany as hereinafter specified.

(b) Leather: All leather parts shall be vax-tanned, best quality [illegible] sewing being extra strong and rivets being used wherever possible to [illegible] cutting of threads in typical climates. Threads used must be the strongest [illegible] able, thoroughly waxed.

(c) Commercial fittings: Where commercial [illegible]

3. GENERAL REQUIREMENTS---- (2)

(d) Brass: Sheet brass shall be what is commonly known as low brass and shall have a composition approximately as follows:

Copper ---65%
Zinc----35%

Brass for binding posts, etc. shall have approximately the following composition:

Copper----67
Zinc------33

(e) Hard rubber: The hard rubber covered by this specification shall be of the best grade obtainable made up from best Para rubber and sulphur with no other ingredients. Samples will be subjected to chemical and mechanical tests.

(f) Fibre: The fibre covered by this specification shall be red in color and so treated as to be impervious to moisture. Samples shall be subjected to test for mechanical strength and hygroscopic qualities.

(g) Slate: All slate specified herein shall be of the best grade Arnson oil finished dead black. The rear of the slate will also be thoroughly oiled.

(h) Marble: All marble shall be white Italian, free from all flaws whatsoever.

FINISH.

(a) Brass work will be in four standard finishes, as indicated hereinafter. The finishes will be designated as follows:

Standard dark finish.
Standard nickel finish.
Standard telegraph finish.
Dip lacquered.

All brass work will be finished in one of these styles.

(b) The standard dark finish for brass work not a contact surface will be obtained by the use of either of the following methods:

1. By the use of a solution of arsenic made by dissolving common white arsenic, arsenious oxide, in hydrochloric acid.

2. Copperplate the part to be finished, then using an alkaline polysulphide solution such as sodium polysulphide.

Care must be taken in the preparation of the parts to be finished to see that they are entirely free from lacquer or grease. Clear lacquer will be applied to the parts after the desired finish with the above solutions has been secured.

(c) The nickel finish will conform to the requirements of Par. 2.

(d) The standard telegraph finish will conform to that of the best grade telegraph instruments, being polished and lacquered.

(e) Brass parts not ordinarily exposed will be dip-lacquered, care being taken that all parts are thoroughly cleaned before lacquering.

(f) The standard finish for copper parts not forming part of a contact will be obtained by dipping into a solution of alkaline polysulphide, such as sodium polysulphides. Care will be taken to see that the parts to be finished are free from grease or lacquer before dipping in the solution and clear lacquer will be applied to the parts after the desired finish is obtained.

(g) The standard finish for all woodwork is as indicated below. This finish will be accurately followed for all wooden parts of this equipment.

The following applies only to specification No. 410 - Field Wireless Set, which reads:

"All woodwork and interior of pack chest shall be finished in the following manner:

Stained light mahogany and rubbed down after being dried for twelve hours. Three coats of varnish shall then be applied. The wood is shall be rubbed down after each operation with pumice stone and crude oil. The finish when complete shall be smooth but not glossy, and shall present no evidence of open pores in the wood, and shall not be easily scratched or marred."

The following applies to Specifications

Nos. 464—Standard Marine Wireless Telegraph Equipment,
479—Station Wireless Equipment, 10 K. W.
485— Wireless Telegraph Equipment, 1 K.W. Station Set,
516—Wireless Equipment "Joseph Henry,"
518—Station Wireless Telegraph Set, 5 K. W.

Woodwork shall be finished as follows:

Filled with medium grade [illegible] after being [illegible]

AT-14

hours shall be covered with a coat of orange shellac. After being rubbed smooth with sand paper, a coat of rubbing varnish shall be applied and rubbed down with pumice stone and crude oil. The woodwork shall receive two coats of rubbing varnish and shall be rubbed down after each operation. The finish when complete shall be smooth but not glossy, and shall present no evidence of open pores in the wood, and shall not be easily scratched or marred."

The successful bidder will decide upon the color and the quality of the finish from the sample which will be supplied him.

(h) Hard rubber, where exposed, will invariably be polished.

(i) Ironwork will be galvanized to meet the requirements of specification No.96

5-PROPERTY NUMBERS:

The property numbers shall be serial and shall accompany the order. If these numbers are not indicated in the order the manufacturer shall take care to put them and see that they are on the instruments before inspection.

6-METAL WORK:

All metal work shall be provided with a rustless coating of one of the types specified above and it shall meet the test indicated above.

If not otherwise specified, the metal parts, unless magnetic qualities require otherwise, shall be made of brass. All threads and screws shall be U. S. commercial standard.

7-NAME PLATES:

(a) The name plates shall be of brass and shall conform to the drawings of the several instruments.

(b) These plates will in all cases be machine-engraved.

(c) These plates will be ordered in one of two finishes as follows:

Standard dark finish,
Nickel grain finish.

(d) The standard dark finish will be obtained as indicated in Paragraph 4-b and the letters will be filled with white enamel.

(e) The nickel grain finish shall conform to Signal Corps standard and letters shall be black-finish. Sample will be furnished the manufacturer.

8-PACKING:

All articles described herein must be packed with great care. The packing will be made the subject of inspection and if crates are not satisfactory to the inspector, the materials will not be accepted until proper package is provided.

(f) The insulation between the primary and secondary windings shall withstand the application of an alternating current of 40,000 volts for 10 seconds.

The primary winding shall withstand the application of 500 volts alternating current for a period of one minute.

(g) The outside containing case shall receive two coats of hard transparent varnish with rubbed finish. The top side of the case shall have stamped in the wood, in letters not less than 1/4" high, the following words:

INDUCTION COIL
U. S. SIGNAL CORPS.

7-INTERRUPTER:

The interrupter furnished under this specification shall conform accurately to dimensions given in drawing 549 and meet the following requirements:

(a) Material: All materials used must be the best of their kind.

(b) Workmanship: Every part of the work on this interrupter must conform to the highest grade of workmanship.

(c) The base shall be hard rubber polished on all exposed surfaces.

(d) Fittings: Fittings on exposed surfaces shall be provided with gray nickel finish and other not forming a part of the magnetic circuit or not otherwise shown on the drawing, shall be of brass.

(e) Windings: The magnet shall be wound with No. 34 B. & S. gauge single cotton, covered copper magnet wire and shall be thoroughly water-proofed. Magnet heads shall be fibre and a fibre shall shall be interposed between the magnet windings and the core. Windings shall each have a resistance of about 9 ohms. The finished bobbins shall be covered with pebble cloth.

(f) Magnetic circuit: Care shall be taken to make accurate joints in all parts of the magnetic circuit. This will receive special attention at inspection.

(g) Insulation: All materials for insulation, including milled heads for fastening screws, insulation for busser contacts, and the base shall be of the best grade of hard rubber.

(h) Contacts: Contacts shall be of platinum and shall be fully equal to dimensions shown on drawing.

(i) Contact springs: Particular care must be taken in the selection of the contact springs in order that rapidity and certainty of action of the interrupter may be secured. It may be necessary to make several changes before a satisfactory spring is obtained and the contractor will be required to satisfy the inspector in this particular. The dimensions shown in drawings are furnished as a guide, the complete interrupter must equal sample in operation.

(j) Tests: Inspections will particularly include the efficiency of the springs, accuracy of the contacts, insulation of windings and contacts, accuracy of fit of the adjusting screws, general appearance of the completed interrupter as well as such other tests as the inspector may deem necessary.

8-SIGNALING KEY:

The key shall be standard open circuit log telegraph key provided with special platinum contacts as shown on drawing 560, and meeting the following requirements:

(a) Base: The base shall be of brass or other approved non-corrosive metal.

(b) Springs shall be of phosphor bronze.

(c) Levers shall be made of phosphor bronze.

(d) Trunnions shall be of blued steel or phosphor bronze.

(e) Insulation: The switch knob, lever tip, and other insulation shall be of hard rubber.

(f) All metal work shall have a standard dull finish.

(g) Marking: The letters U. S.S. C. shall be stamped on the base.

9-CONTROL SWITCH:

(a) The control switch shall conform to drawing 672 in all details.

(b) The control switch shall be made of the best Lake copper, dead-file finish, to dimensions.

(c) All hard rubber used shall conform to General Requirements, Part A, of this specification.

(d) The construction must conform in general to the requirements of specification No. 360, covering the manufacture of knife switches.

10-TUNING COIL:

The tuning coil furnished under this specification shall conform to the dimensions given for the short coil of drawing 497c and meet the following requirements:

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SPEC. 610 -- Part D---(3)

(a) Cylinders:- Cylinders shall be of hard rubber per General requirements, Part A, of this specification, and shall have a spiral groove with 24 pitch to accommodate wiring.

(b) The cylinder shall be wound with No. 24 B. & S. Gauge hard brass wire. After winding on the cylinder, this wire shall be heavily copper-plated and nickeled. No hot plating shall be used in the plating process and particular care shall be taken to have the completed cylinder entirely free from plating and cleansing solutions.

(c) Contactors and adjusting bars shall be made of brass, grey nickel finish.

(d) All other metal work shall be brass, polished, and heavily dip-lacquered.

11-SILICON DETECTOR:

This shall be the standard silicon detector as made by the Wireless Specialty Co., 71 Nev Street, New York, and shall be furnished with nickel-plated mounting, retaining chain for button, and fittings complete for connection to the wireless receiving set.

12-TERMINALS:

(a) The terminals shall conform to drawing 569.

(b) The lock nut binding posts shall conform to dimensions shown on drawing 569.

(c) All hard rubber used shall conform to General Requirements, Part A, of this specification.

(d) Workmanship and finish must be first-class throughout.

13-TELLTALE LAMP:

(a) The telltale lamps shall be furnished complete with hard rubber mounting as shown on drawing 631. Two spare incandescent lamps shall be furnished with each mounting ordered under this specification.

(b) All hard rubber shall conform to General Requirements, Part A, of this specification.

(c) Binding posts shall be of brass, standard nickel finish.

14-LEYDEN TUBE CONDENSER:

This condenser shall be furnished complete with tubes and shall meet the following requirements:

(a) The Leyden tube terminals shall conform to drawing 568. One pair of terminals ordered shall comprise one set of upper terminals and one set of lower terminals as shown on the drawing.

(b) The spring clips shall be of the best grade of German silver. These shall be carefully formed to outline shown on drawing. Particular attention will be given to forming these spring clips so that the strength of the material will not be impaired in the process of forming.

(c) The base shall be made of hard rubber which shall meet the General Requirements, Part A, of this specification.

(d) The Leyden tubes shall be designed for mounting on the terminals of drawing [illegible] shall be the Tolefunken make or equal. The dimensions shall be about 12 inches by one inch in diameter. The tubes shall be provided with copper strip protection as shown in drawing 568.

(e) The electrostatic capacity of these tubes shall be about .00075 M.F.

(f) Special care shall be taken by the manufacturer in packing the tubes ordered under this specification in order that the breakage in shipment may be reduced to the minimum. 1 spare tube shall be furnished with each condenser.

15-DOUBLE HEAD RECEIVER:

This shall be the double head telephone receiver, H.W.Sullivan make, pattern A, [illegible] resistance of about 2,460 ohms. It will be furnished with a five-foot tinsel cord, silk covered. Three spare cords and six spare ear caps shall be furnished with each receiver.

16-TRUNKS:

The trunks shall be the Leatheroid Trunk Co's. standard make or equal and shall [illegible] dimensions of 21 inches long, 12 inches wide, and 12 inches deep, of which 2-1/4 inches shall be in the cover. The 21 inches by 12 inches inside surface of the cover and the bottom of the trunk shall be fitted with 3/8-inch lining of white pine [illegible] brass screws. The inside dimensions above shall obtain after these linings are in place.

The trunk shall be three-ply, made up with one thickness of poplar between two of leatheroid, the inside being lined with chase-cloth.

All corners shall be reinforced with leatheroid and corners shall have mild [illegible].

The trunk shall be furnished with a good improved type of double hinged trunk lock with duplicate keys [illegible].

The lid shall have a rubber valance [illegible] to prevent moisture from entering [illegible].

2717

AT-18

...l-inch side of the trunk.

...t there shall be secured by means of flat head
...s, 1-1/2 inches x 2-1/4 inches by 5-inches for

...It. two coats of olive drab paint made up according
...pounds of white lead ground in raw linseed oil; one pint
...drier; one quart raw linseed oil, one pound raw umber.

...storage battery meeting the following re-

...plied shall consist of two units of four cells each
...for unit and six amperes charging rate, and shall be

...-spillable, provided with vents, hard rubber screw
...over these caps.
...carrying current shall have hard rubber covering.
...have their polarity stamped on cover.
...shall be of canvas covered with rubber composition to resist

...unit, of four cells, shall not exceed 50 pounds.
...shall be attached to front of containing case. This card
...full directions for charging.

...for reference to drawing No. 765 and shall have a total capacity
...cells shall be the U. S. C. C. #-A or equal. Jars shall be of
...to thoroughly seasoned. Terminals shall be of brass as shown on
...receiver shall withstand a breakdown test of 500 volts D. C.
...resistance of 1K megohms.

...set shall include the following parts in addition to those specified

...for connecting storage batteries to set and to each other and
...trunks.
...set of a J3 Lungen buzzer mounted on 2 4-0 dry cells.
...bond to inside of set for holding head receiver when not in

...compartment for holding the spare parts supplied with the set.
...chart (post) fit, wgt. 1bs.
...key switch.
...for connecting set.
...for detector of 1200 ohms with top off for silicon of 30

...with the following:
...SET PACK NO. ...
...all of the same on both trunks.

JAMES MILLER,
Brigadier General,
Chief Signal Officer of the Army.

PLAINTIFF'S EXHIBIT 59

Signal Corps, United States Army.

RETURN TO OFFICE
RECEIVED
JAN 19 1912
Series 1912 War. Dept.

This Articles of Agreement entered into this ------seventh------ day of December---, nineteen hundred and eleven, between -------R. J. Burt------ Captain,----------, Signal Corps, United States Army, of the first part, and the Wireless Specialty Apparatus Company, one of whose principal offices is at No. 81 New Street, New York City,---------- in the county of --------New York----------, State of-----New York-------, of the second part, WITNESSETH, that in conformity with copy of the advertisement, specifications, and proposal hereunto attached, and which, in so far as they relate to this contract, form a part of it, the said ----------R. J. Burt, Captain,---------- Signal Corps, United States Army, for and in behalf of the United States of America, and the said ----------WIRELESS SPECIALTY APPARATUS COMPANY---------- (hereinafter designated as the contractor,) do covenant and agree, to and with each other, as follows, viz:

Article I. That the said contractor shall manufacture for and deliver to the United States of America, the following:

ITEM:
1. Two (2) Sets, receiving, type 1-P-98, including telephone headsets, Wireless Specialty Apparatus Co. make.

Art. II. That the deliveries of the supplies and materials herein contracted for shall be made in [illegible] and for each number or quantity, on or before the date specified [illegible], viz:

That complete delivery shall be made on or before January 17, 1912.

[illegible] time under this contract shall, before [illegible] be a [illegible] on the part of the Government.

ART. IV. That for and in consideration of the faithful performance of the stipulations of this contract, the contractor shall be paid at the office of ----The Chief Signal Officer--------of the Army----------, at---Washington, D. C.-----, for all supplies and materials delivered in conformity with the requirements of this contract, on or before the date above specified (Article II, *supra*) and *accepted*, the following prices, viz:

ITEM:

1. Two (2) Receiving Sets, at three hundred twenty-five dollars ($325.00) each;

   Making a total consideration of six hundred and fifty dollars ($650.00).

to be paid as soon as practicable after the acceptance of the same, in funds furnished by the United States for the purpose, reserving ____ per cent from each payment until final settlement, on completion of the contract or otherwise.

ART. V. It is further agreed that for all supplies and materials which shall not be delivered in conformity with the requirements of this contract on or before the dates prescribed therefor in Article II, above, but which shall be subsequently delivered and accepted, the prices shall be as follows:

Contract No. 133
Series No. 3

Account of { No. of Station Bureau
A. B. General Account of Advances

Articles of Agreement, Made and concluded this twenty-first day of September, one thousand nine hundred and eight, by and between Frederick Security Apparatus Co. of No. 61 Pearl Street, New York, in the State of New York, party of the first part, and Rear Admiral Charles O'Neil, Chief of the Bureau of Supplies and Accounts, United States Navy, Navy Department, Washington, D.C., acting under the direction of the Secretary of the Navy, party of the second part, witnesseth, that, for and in consideration of the payments hereinafter specified, the party of the first part, for itself and its personal and legal representatives, doth hereby covenant and agree to and with the party of the second part, as follows, viz:

1. That it, the said party of the first part, will furnish and deliver, at its own risk and expense, at such place in the Navy Yard, Brooklyn, N.Y., as the Commandant thereof may direct, within the specified days from the date of this contract, the articles, and at the price set opposite each item, respectively:

Requisition No. by Sm. Naval Supply Account.
Item No.

(1) Two (2) 5 K.W. 500 cycle, motor [redacted] ator, [redacted]nched gap, radio telegraph sets, complete with spare parts, $5499.00 set

To be in accordance with specifications 16-T-5, issued by Navy Dept., except as modified hereby. Bids to be made strictly in accordance with paragraph 118, specifications, 16-T-5, and paragraph 118 (c) will be strictly enforced.

Variations as per paragraph 118 d are subject to specific approval in each case, and, unless approved, the contract will be required to meet the corresponding details of specifications, 16-T-5, when the apparatus is inspected for final acceptance.

All bidders must strictly comply with the following paragraphs of the specifications, 16-T-5, which are not to be made subject to modification by the bidders:-

Paragraph 108-Drawings, etc.
113-Tests after delivery.
114-Patents.
115-Interchangeability.
116-Omissions and misdirections.

Spare parts

14-aa-For ventilation of spark gap.
16-B-12-For condensers of transmitter.
28-b For electrodes of detector.
30-For primary batteries.
33-k-For telephone cords.
37-d-13-For wave meter helium tubes
38-e-For circuit breaker contacts.
38-j-For panel fuses.
70-b- do
100-a-For motor and dynamo.
119- For protection appliances.

Special consideration will be given bids offering apparatus in which the transmitting wave length can be continuously and rapidly changed, as per paragraph 4a of the specifications, over a range from 600 to 8000 meters; also for compact apparatus in accordance with paragraph 8a of the specifications.

Transmitting condensers made up of Standard Leyden Jars will be required.

Three (3) receivers to be furnished with each set, as follows:

(a) One highly selective receiver of special design for receiving wave lengths up to 10,000 meters, to be furnished with a variable condenser in primary circuit with leads which can be operated by switches to put this condenser in series or in parallel with inductance or to put it out.

(b) One highly selective receiver with variable condenser, for primary circuit as required for (a), for receiving waves from 300 to 3,000 meters for ship communication.

(c) One simplified receiver, range 300 to 3,000 meters, to consist of variable primary inductance, variable secondary, with means for varying the mutual inductance between the two circuits, and variable series condenser.

All detectors must be fitted with binding posts for a detector counted as a separate item. Detectors suitably mounted on receivers will be accepted.

Bidders will describe particularly receivers and detectors they propose to furnish.

One (1) wave meter will be required with each set.

DELIVERY at the Navy Yard, New York, for inspection and test within the shortest possible time, time to be a factor in award of contract.

TO BE DELIVERED to the General Storekeeper Navy Yard

12722

ref-3-4

Accepted for material in accordance with the specifications of requisition, except as modified in specifications (copy attached), blueprints, drawings, etc., submitted with bid:

Wireless Specialty Apparatus Co. proposes to furnish apparatus as per the following details:

MOTOR GENERATOR:
Motor -- Volt D.C., shunt interpole, flat speed regulation. 1875 R.P.M. Generator-- 250 volt, 500 cycle, special wave form alternator, designed specially to operate with remainder of transmitting unit. (We reserve the right to furnish our new type, (Patents pending) interpole alternator with variable wave form). Both types have very close VOLTAGE regulation and high over all efficiency. Spares: 4 sets brushes.
PROTECTIVE APPLIANCES, will be supplied.
TRANSFORMER:
Type: Open core, dry, specially designed to operate without exterior resistance with remainder of transmitting unit. Spares: 2 secondary sections.
[illegible] SPARK GAP:
New design, perfect cooling by special central draft. (We reserve right to furnish our new type Tubular gap). This latter having new feature of cooling and perfect sparking alignment with ease of dismantling).
LOW TENSION SWITCHBOARD:
Black slate, angle supports, on which will be mounted:
1. S.E.Hot wire voltmeter,
1. S.E.Hot wire ammeter,
1. S.E.Single phase wattmeter,
1. Hartman & Braun Reed type frequency indicator.
(All instruments calibrated for 500 cycles).
AUTOMATIC MOTOR STARTER:
Special contactors for distant control of A.C., line and field; besides motor control.
Generator and motor field rheostats, etc., as per photographs.
TRANSMITTING INDUCTANCES:
New type, (patents pending) transmitting inductances will be supplied giving continuously variable wave length of 600 to 2000 meters with no switches, exciting and radiating circuits, always in resonance and with maximum coupling. This type of inductance is absolutely new and gives the widest range of inductance variation of any known form of inductance.
TRANSMITTING CONDENSERS:
Standard type W.S.A.Co's. copper deposit jars in Rack. Capacity, .08 Mfd.,
or
We should prefer to furnish our new design plates in absolutely oil tight tanks and cases. This latter type occupies very much less space than the jar type of same capacity.
RADIATION METER:
Hartman & Braun hot wire type, 0-50 amperes, unshunted type.
TRANSMITTING KEY:
Magnetic relay type. A very efficient key capable of operating at a maximum speed of 60 words per minute. Hammer blow type. Signalling accomplished by means of small Morse key.
ANTENNA SWITCH:
Mounted on high tension switchboard panel.
LIGHTNING SWITCH:
As per photograph submitted.
HIGH TENSION SWITCHBOARD:
White marble, same dimensions as low tension switchboard, mounted complete with the following apparatus:
Quenched spark gap.
Wave length and coupling control handles with indicators.

(continued)

(Sheet #2 - continued)

Radiation Meter,
Change-over switch,
(Transformer, condenser and inductances mounted on back of board.)

RECEIVING APPARATUS:

Three Receivers.

(a) New Type 1915, 1-P-76, complete receiver, special design for receiving wave lengths up to 10,000 meters. Highly selective.

(b) New Type 1915, 1-P-76, complete receiver, for receiving wave lengths of 300 to 4200 meters. Highly selective.

(c) New Type 1915, 1-P-76, complete receiver, for receiving wave lengths of 300 to 4200 meters. Simplified type for stand-by conditions.

(b) and (c) will be provided with a Listening-in-key and special phones.

All these receivers are furnished with standard HERTZITE and SILICON ARSENIC detectors and are arranged for very efficient spark group frequency tuning. 3 pairs Pickard adjustable telephones furnished with each set. Telephones can be furnished if desired to be strongly responsive or selective to 1000 sparks per second. Spares as called for in requisition will be supplied.

WAVE METER:

Type P. W. M., will be supplied.

DELIVERY:

One set to be delivered within fifty-three (53) days from date of contract.

One set to be delivered within seventy-eight (78) days from date of contract.

P R I C E:

The price to be $3699.00 per set, making a total of $7398.00.

PLAINTIFF'S EXHIBIT 69

NAVY PAY OFFICE

CONTRACT.

SERIES 1914

Pay Office ...n.....O.

Account of { Req'n No. 186 B. B.&A
Station Bureau Steam Engineering
App'n Genl.Appt.Advances,B.A,(Equipt.of vessels 1914, ...)

This Contract, of two parts, made and concluded this 31st day of ..., A. D. 1916, by and between

...s & Simms Mfg.Co.,
...olumbia St., Seattle, Washington,
... of ..., party of the first part, and the UNITED STATES
...shipping Pay Officer, United States Navy Pay Office, Washn.D.C.,
...der the direction of the Secretary of the Navy, party of the second part, Witnesseth: That
... in consideration of the payments hereinafter specified, the party of the first part,
...E.Smith ... and its personal and legal representa-
...tives, hereby covenant and agree to and with the party of the second part, as follows, viz:

1. That ...the said party of the first part, will furnish and deliver, at its own
...and expense, at such place in the Navy Yard,Mare Island,Cal., & New York, N.Y. as the
...Bureau hereinafter may direct, and within 240 days from the date of this contract,
...the following articles, and at the price set opposite each item, respectively

...the following articles to be omitted from the specifications:
...switch, $12.00 per set
...switch, 8.00 " " Total for 8 sets: $166.00
17.00
Total Cost: $1,186.00

ARTICLES REQUIRED

Requisition No. ...

FOR DELIVERY AT NAVY YARDS MARE ISLAND, CAL. AND NEW YORK, N.Y.

Rec. 186 B.&A.

Item 1. Five (5) S-A... radio sets for ship installations.

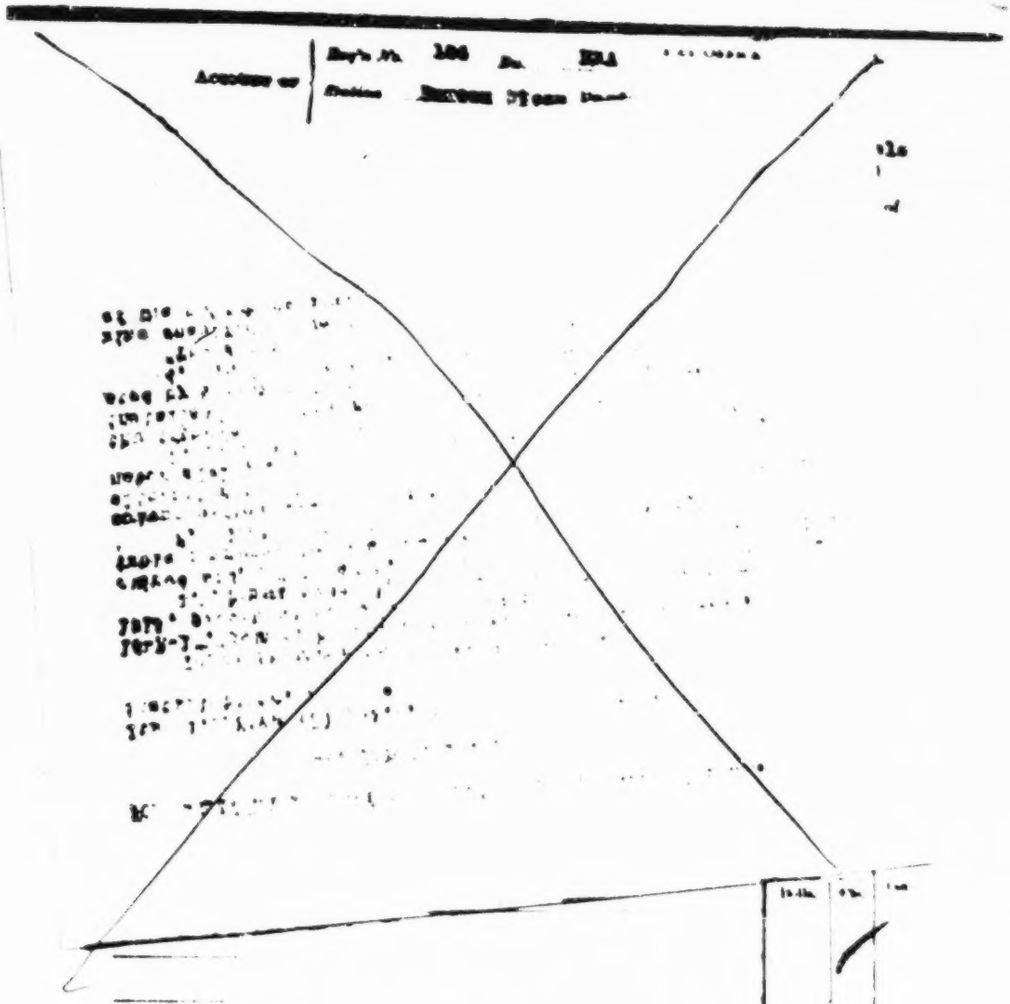
To be in accordance with "Specifications 18-R-1", issued by the Navy Department January 1, 1916, except as modified below:-

1. Panel assembly of the transmitter ... required and, if offered, the different ... table to ready removal and separate ... selector ..., one ... alternator armature circuit and the other ... motor field,

3. The automatic starting ... the transfer switch ... installation in the radio room, ... operated by a push button switch located on ...

4. In lieu of par. 14 (a)(2) substitute the following:

"The set shall ... nine specified were ... of the switch panels.



4. Under par. 24(b) add: "Contract number and requisition number."

5. In lieu of paragraphs 25(f) and 25(g), substitute the following:

"All apparatus, including transmitters and receivers, shall be capable of continuous operation at a room temperature of 50° C. and a humidity of 90% saturation. No part of the transmitting apparatus having cotton insulation shall show a final temperature greater than 90° C. and no other part of the apparatus shall show a final temperature greater than 105° C., nor shall any part of the apparatus show deterioration or faulty operation. Continuous operation shall be based on a test for a period of eight consecutive hours at full power at a sending rate of about 20 words per minute; power to be measured with key depressed."

6. Condenser for protective appliances required by par. 21 (a)(4) shall be of not less than 0.05 mfd. instead of 0.1 mfd. capacity.

8. Paragraph 21(c) of the specifications 16-R-1 required that protective appliances shall be provided for use in the following locations:

(1) Across the terminals of the low tension winding of the transformer, 2 sets, 1 for each transformer.

(2) Across the terminals of the armature of the alternator, 2 sets, 1 for each alternator.

(3) Across the terminals of the fields of the alternator, 2 sets, 1 for each alternator.

(4) Across leads to cooling motor and spark gap.

Paragraph 21(d) requires protective appliances as specified for each D.C. motor of the two motor-generators.

9805.00

Cont -1 a

9. The spare parts, including spare brushes, gaskets, contacts, fuses, quenched gap plates, spares for blower motor, etc., provided with each set, except those for the motor-generator and except the spare condenser units, shall be delivered in a suitable hardwood box with metal hinges and lock. The box shall be suitably fitted to hold the spare parts securely and each spare part shall be readily removable without disturbing the other contents of the box. The spare parts for the motor-generator shall be provided in a separate box.

10. Bidders shall state what reduction will be made from prices offered in case the government, at its option, supplies any or all of the following apparatus.

(1) Lightning switch.
(2) Antenna transfer switch.
(3) Condenser rack.
(4) Wave changing switch.
(5) Oscillation transformer.

11. The unit price for each set shall include all spare parts as required by the specifications and as offered but an itemized list of the spare parts as required by the specifications and so offered must accompany each bid and the unit price of each spare part so offered must be stated. This information is desired for future reference in placing orders for spare parts. The particular attention of bidders is invited to this paragraph, and the preceding paragraph, which must be strictly complied with. Failure to meet the requirements of these paragraphs will render the bid liable to rejection.

12. Liquidated damages for delay in delivery shall be calculated at the rate of [illegible] per day per set for each set not delivered complete at the expiration of the contract period.

Delivery to be made within 240 days from date of contract. Delivery of the first two sets to be made at the Navy Yard, New York, and of the other three sets at the Navy Yard, Mare Island, Cal.

PLAINTIFF'S EXHIBIT 72 27727

[redacted] Navy Yard

Account of [redacted] General Acct. of Advances

This Contract, of two parts, made and concluded this Twelfth day of January, A. D. 1914 by and between Radio Telephone & Telegraph

[redacted]

of 805 Broadway, New York,

in the State of New York, party of the first part, and the UNITED STATES, by the Purchasing Pay Officer, United States Navy Pay Office, New York, N. Y. acting under the direction of the Secretary of the Navy, party of the second part. Witnesseth, That, for and in consideration of the payments hereinafter specified, the said party of the first part for itself and its [redacted] doth hereby covenant and agree to and with the party of the second part as follows:

1. That it, the said party of the first part, will furnish and deliver to its [redacted] risk and expense, at such place in the Navy Yard, Brooklyn, N. Y. as the Commandant thereof may direct and within thirty days [redacted] contract, the following articles, and at the price set opposite each [redacted]

Requisition No. 184, Bureau. Naval Supply Account.

Part 1	Title		
10	Arbon appliances, complete,	400.00	each
1000	Double bulbs for same,	2.50	"
4	sets colors and bulbs for use with Arbon appliances,	50.00	Set
5	Loud-speaking horns for use with Arbon appliances,	50.00	each

All articles to be equal to samples submitted for test at the Navy Yard, Bureau of Steam Engineering, Washington, D. C. and approved by the Commandant, New York, N. Y.

Deliveries to be made to the General Storekeeper, Navy Yard, Brooklyn, N. Y.

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6. It is hereby mutually and expressly covenanted and agreed by and between the parties hereto that the articles or articles to be furnished or services to be performed under this contract shall conform in all respects to the requirements of the specifications hereunto annexed, which specifications the "Instructions, Reference, and Conditions," printed on the proposal of the said party of the first part, shall be deemed and taken as forming a part of this contract with like operation and effect as if the same were incorporated herein; and, in any case where the specifications do not explicitly provide to the contrary, all workmanship and materials entering into the manufacture or construction of any article or articles under this contract shall be of the very best quality and manufacture, and said article, articles, or services shall upon delivery or completion, be subject to inspection and examination by the officer or officers authorized by the said party of the second part to inspect and examine the same; and no article furnished or service performed under this contract shall be accepted until it or they shall have been inspected and approved by said officer or officers; and if not so approved shall be removed by the said party of the first part at its own expense and within ten days after notification.

7. It is further covenanted and agreed, as aforesaid, that time is an essential element of this contract and that if the said party of the first part shall fail to make delivery of any or all of the articles or materials or to perform any work or services herein specified in accordance with the conditions and requirements of the contract, and within the time herein provided (the said party of the second part reserving the right thereby and thereupon to extend the time for delivery), then the said party of the second part may purchase in the open market and thereafter furnish and deliver such articles or materials as may be necessary to complete the amount of such articles or materials undelivered by the said party of the first part, and the said party of the first part shall make deductions on account thereof from the contract price aforesaid, or

8. It is further covenanted and agreed that if the said party of the first part shall fail to perform the work to be performed by it under this contract within the time herein specified, or if the said party of the first part shall fail to perform any of the covenants herein contained on the part of the said party of the first part to be performed, then the said party of the second part may, by written notice to the said party of the first part, declare this contract null and void, and thereupon the said party of the second part may enter upon the premises of the said party of the first part and take possession of all articles and materials which may be upon the premises and which have been purchased or procured by the said party of the first part for the performance of this contract, and may employ any other person or persons to complete the work to be performed under this contract, and the said party of the first part shall not be entitled to receive any further payment under this contract.

9. It is further covenanted and agreed that if the said party of the first part shall fail to perform the work to be performed by it under this contract within the time herein specified, or if the said party of the first part shall fail to perform any of the covenants herein contained on the part of the said party of the first part to be performed, then the said party of the second part may, by written notice to the said party of the first part, declare this contract null and void, and thereupon the said party of the second part may enter upon the premises of the said party of the first part and take possession of all articles and materials which may be upon the premises and which have been purchased or procured by the said party of the first part for the performance of this contract, and may employ any other person or persons to complete the work to be performed under this contract, and the said party of the first part shall not be entitled to receive any further payment under this contract.

10. It is further covenanted and agreed that if the said party of the first part shall fail to perform the work to be performed by it under this contract within the time herein specified, or if the said party of the first part shall fail to perform any of the covenants herein contained on the part of the said party of the first part to be performed, then the said party of the second part may, by written notice to the said party of the first part, declare this contract null and void, and thereupon the said party of the second part may enter upon the premises of the said party of the first part and take possession of all articles and materials which may be upon the premises and which have been purchased or procured by the said party of the first part for the performance of this contract, and may employ any other person or persons to complete the work to be performed under this contract, and the said party of the first part shall not be entitled to receive any further payment under this contract.

11. It is further covenanted and agreed that if the said party of the first part shall fail to perform the work to be performed by it under this contract within the time herein specified, or if the said party of the first part shall fail to perform any of the covenants herein contained on the part of the said party of the first part to be performed, then the said party of the second part may, by written notice to the said party of the first part, declare this contract null and void, and thereupon the said party of the second part may enter upon the premises of the said party of the first part and take possession of all articles and materials which may be upon the premises and which have been purchased or procured by the said party of the first part for the performance of this contract, and may employ any other person or persons to complete the work to be performed under this contract, and the said party of the first part shall not be entitled to receive any further payment under this contract.

12. It is further covenanted and agreed that if the said party of the first part shall fail to perform the work to be performed by it under this contract within the time herein specified, or if the said party of the first part shall fail to perform any of the covenants herein contained on the part of the said party of the first part to be performed, then the said party of the second part may, by written notice to the said party of the first part, declare this contract null and void, and thereupon the said party of the second part may enter upon the premises of the said party of the first part and take possession of all articles and materials which may be upon the premises and which have been purchased or procured by the said party of the first part for the performance of this contract, and may employ any other person or persons to complete the work to be performed under this contract, and the said party of the first part shall not be entitled to receive any further payment under this contract.

13. It is further covenanted and agreed that if the said party of the first part shall fail to perform the work to be performed by it under this contract within the time herein specified, or if the said party of the first part shall fail to perform any of the covenants herein contained on the part of the said party of the first part to be performed, then the said party of the second part may, by written notice to the said party of the first part, declare this contract null and void, and thereupon the said party of the second part may enter upon the premises of the said party of the first part and take possession of all articles and materials which may be upon the premises and which have been purchased or procured by the said party of the first part for the performance of this contract, and may employ any other person or persons to complete the work to be performed under this contract, and the said party of the first part shall not be entitled to receive any further payment under this contract.

14. It is further covenanted and agreed that if the said party of the first part shall fail to perform the work to be performed by it under this contract within the time herein specified, or if the said party of the first part shall fail to perform any of the covenants herein contained on the part of the said party of the first part to be performed, then the said party of the second part may, by written notice to the said party of the first part, declare this contract null and void, and thereupon the said party of the second part may enter upon the premises of the said party of the first part and take possession of all articles and materials which may be upon the premises and which have been purchased or procured by the said party of the first part for the performance of this contract, and may employ any other person or persons to complete the work to be performed under this contract, and the said party of the first part shall not be entitled to receive any further payment under this contract.

15. It is further covenanted and agreed that if the said party of the first part shall fail to perform the work to be performed by it under this contract within the time herein specified, or if the said party of the first part shall fail to perform any of the covenants herein contained on the part of the said party of the first part to be performed, then the said party of the second part may, by written notice to the said party of the first part, declare this contract null and void, and thereupon the said party of the second part may enter upon the premises of the said party of the first part and take possession of all articles and materials which may be upon the premises and which have been purchased or procured by the said party of the first part for the performance of this contract, and may employ any other person or persons to complete the work to be performed under this contract, and the said party of the first part shall not be entitled to receive any further payment under this contract.

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PLAINTIFF'S EXHIBIT 74

(2725)

S. and A. Form No. 204

MAIN BRANCH OFFICE

CONTRACT.

Contract No. [redacted]

Amount [redacted]

Pay Current [redacted]

Date

Req No. 844 Bu BSA

Account of Station Bureau Steam Engineering,

App'n Asst. Asst. Secretary, NAV

Equipt of Vessels, Misc, S.R.

This Contract, of two parts, made and concluded this 27th day of June, A. D. 19 16 by and between

Radio Tel. Phone & Telegraph Co.

of 370 Broadway, New York City

in the State of party of the first part, and the UNITED STATES, by

Paymaster of the Pay Office of the United States Navy Pay Office Washington, D.C.,

acting under the direction of the Secretary of the Navy, party of the second part, Witnesseth, That,

for the consideration hereinafter specified, the party of the first part, for

itself and its executors, administrators, successors, and its personal and legal representatives, does

hereby covenant, promise, and agree with the party of the second part, as follows, viz:

First: That the said party of the first part will furnish and deliver at its own

proper cost and expense at the Navy Yard, Washington, D.C.,

the following articles, viz: to be new and perfect in every respect, and to be delivered within 90 days from the date of this

contract, at the prices set opposite each item, respectively:

Item	1.	30 Ea.	each
"	2.	4 Ea.	"
"	3.	2 Ea.	"
"	4.	2 Ea.	"
"	5.	200 Ea.	"
"	6.	25 Ea.	"
	7.	Total	7,625. 00

Item

1. 30 single ultraudion detectors, complete with 6-volt Hudson filament, double bulb, without telephone receivers,
2. 4 ultraudion detections, complete with 12-volt Hudson filament, double bulb, and telephone receivers
3. 2 receiving cabinets, complete,
   To be specially designed for use with and to include 6 volt Ultraudion detector. Detector and receiving circuits to be in separate cabinets. Range of wave lengths of receivers to extend to 10,000 meters.
4. 2 receiving cabinets, complete. To be specially designed for use with, and to include, 12 volt ultraudion detectors. Detector and receiving circuits to be in separate cabinets. Range of wavelengths of receivers to extend to 10,000 meters.
5. 200 Hudson filament, 6 volt, double bulbs, for use with Item 1
6. 25 Hudson filament, 12 volt, double bulbs, for use with Item 2.

Each bulb supplied under Items 5 and 6 shall be enclosed in a separate container. The container shall be suitably inscribed with a description of the enclosed bulb which will indicate exactly the apparatus with which it is to be used, in order to prevent confusion with bulbs of similar appearance designed for other purposes. Preferably containers for bulbs of different classes should, be readily distinguishable through differences in shape or color of markings.

Each piece apparatus supplied under Items 1, 2, 3 and 4 shall be accompanied with full wiring diagram and detailed instructions for the care and operation of the same.

The best workmanship and material shall be employed throughout.

To be inspected at place of delivery, and subject to approval after inspection.

PLAINTIFF'S EXHIBIT 75

[redacted]

Account of [redacted]

This Contract, of two parts, made and concluded this [redacted] day of [redacted], A. D. 19[redacted], by and between

Radio Telephone & Telegraph Co.,

New York City,

of the State of [redacted], party of the first part, and the UNITED STATES of the Purchasing Pay Officer, United States Navy Pay Office, acting under the direction of the Secretary of the Navy, party of the second part, Witnesseth, That for and in consideration of the payments hereinafter specified, the party of the first part, for [redacted] and [redacted] personal and legal representatives, hereby covenant and agree to and with the party of the second part, as follows, viz:

1. That the said party of the first part, will furnish and deliver, at [redacted] and expense, at such place in the Navy [redacted] as the [redacted] thereof may direct, and within [redacted] from the date of this contract, the following articles, and at the price set opposite each item, to wit:

Cost: Items 1. $450.00
2. 10.00 ALL: $2,350.00

Item
1. 5 20-watt generator Audion sets. To be complete with small high-voltage generator in lieu of B battery, rheostat, switches, impedance, "grid-shunt", etc., but without condensers or inductances. Motor-generator to be adapted to operation on d.c. current supply of 110-120 volts.
Item
2. 10 spare bulbs for above
Inspection after delivery.

P. Cert. 1.

2731

SOUTHERN DISTRICT

PLAINTIFFS

VS

DEFENDANTS

IN EQUITY
No. 12-31.

PLAINTIFF'S EXHIBIT No. 14

PATENTS AND DESIGNS ACT, 1907.

IT IS HEREBY CERTIFIED by the Comptroller-General of Patents, Designs and Trade Marks that on the 16th November, 1904, John Ambrose Fleming, of University College, Gower Street, in the County of London, Doctor of Science, made an application (with provisional specification) for a Patent for an invention the title of which is "Improvements in instruments for detecting and measuring alternating electric currents"; that the application in question was numbered 24,850 of 1904; and that a complete specification (including drawings) was left in connection therewith on the 15th August, 1905.

It is also certified that the said complete specification was accepted and placed open to public inspection on the 21st September, 1905; that a Patent was granted in respect of the said application on the 7th December, 1905, and sealed as of the 16th November, 1904; and that the annexed are true copies of the provisional specification and complete specification and drawings as accepted.

This certificate is issued for use in legal proceedings in the United States of America.

FLEMING BRITISH PATENT #24,850
EXHIBIT #77

WITNESS my hand this 9th day of April, 1913.

Comptroller-General of Patents, Designs and Trade Marks.

THE PATENT OFFICE,
25, SOUTHAMPTON BUILDINGS,
LONDON, W.C.

2358

ERRATUM.

SPECIFICATION No. 24,850 A.D. 1904.

Page 4, line 11, *for* "Figure 7" *read* "Figure 1"

PATENT OFFICE,
22nd February, 1906.

2732

[Second Edition.]

N° 24,850 A.D. 1904

Date of Application, 16th Nov., 1904

Complete Specification Left, 15th Aug., 1905 – Accepted, 21st Sept., 1905

PROVISIONAL SPECIFICATION.

Improvements in Instruments for Detecting and Measuring Alternating Electric Currents.

I JOHN AMBROSE FLEMING of University College, Gower Street, in the County of London, Doctor of Science, do hereby declare the nature of this invention to be as follows:

It is well known that alternating electric currents can only be detected and measured by the use of some instrument, the indications of which do not depend upon the direction of the current. Hence an instrument of which the indication is dependent upon the heating of a wire by the current commonly known as a hot wire instrument is suitable for the above purpose. Also one depending upon the attraction or repulsion of electric current, commonly known as an electrodynamometer, because in both these cases the indication or reading of the instrument is the same even if the current direction is reversed.

On the other hand, an ordinary galvanometer of the movable needle or movable coil type cannot by itself be used for detecting or measuring alternating currents because it only gives an indication with a unidirectional current and is therefore unaffected by an alternating current.

The object of my invention is to provide a means by which an ordinary galvanometer can be used to detect and measure alternating electric currents and especially high frequency alternating currents commonly known as electric oscillations.

The means I employ for this purpose consists in the insertion in the circuit of the alternating current of an appliance which permits only the passage of electric current in one direction and constitutes therefore an electrical valve.

I construct it as follows:—

In a glass bulb, I seal two or more carbon filaments such as are used for the manufacture of electric lamps. These filaments each have their own separate terminals. One or more of these carbon filaments may be replaced by loops of platinum wire, provided at least one carbon filament is used. A high vacuum must be made in the bulb. Two such bulbs are employed and for the sake of simplicity, I may describe the mode of use when a double carbon filament in each bulb is used. The two bulbs are each associated with a small insulated primary or secondary battery of sufficient voltage to bring one of the filaments to bright incandescence of greater intrinsic brilliancy than if used as an incandescent lamp. The bulbs are connected in parallel with each other and inserted in the alternating current circuit, but so that an incandescent filament and a dark or cold filament in each bulb form the electrode or connection for the current to be measured to enter and leave the bulb.

In series with one of the bulbs is placed an ordinary galvanometer. In the two branch circuits formed of the two bulbs, one in series with a galvanometer the local insulated batteries are arranged to ignite carbon filaments at opposite ends. That is to say, the carbon filament nearest to one common terminal is the ignited filament in one bulb and that farthest from the same common terminal in the other bulb.

These bulbs have the property that inside the bulb, negative electricity can move from the hot to the cold carbon filament even under a very low electromotive force but it cannot move in the opposite direction. Hence, owing to the arrangement of the bulbs, the alternating current arriving at the common terminal splits and all the positive alternations pass through one bulb and all the negative through the other bulb. The galvanometer is therefore affected solely by currents flowing in one direction. The bulbs serve the purpose of separating out the two constituents of the alternating current.

In place of two bulbs, one only may be used in series with a galvanometer and then the bulb only allows currents to pass in one direction and the galvanometer gives an indication.

The device is especially applicable to the detection and measurement by an ordinary galvanometer of high frequency electric currents or oscillations, where any form of mechanical or electrolytic rectifier is useless.

I construct the bulbs with two or more sets of carbon filaments.

One set when rendered incandescent forming one electrode of the valve and the other set kept cold, the other electrode.

In place of carbon filament for the cold electrodes I use sometimes, loops of platinum wire or platinum wires with plates on the end.

In making the connections of the bulb to the alternating current circuit it is essential to join one end of the galvanometer wire to that terminal of the hot carbon filament to which the negative end of the local or heating battery is applied.

The other end of the galvanometer and the two ends or all the ends of the cold filaments taken together constitute the terminal of the indicating appliance.

The carbon filament may also be heated by part of the alternating current which is being rectified or measured.

Any other method of heating one or more of the carbon filaments may be employed.

The above described multiple carbon filament bulb and a galvanometer may be used as a receiving instrument in wireless telegraphy.

For this case, the aerial receiving wire has the primary circuit of an oscillation transformer inserted in it and one of the above described electrical valves and a galvanometer are inserted in the secondary circuit.

The feeble alternating currents excited in the aerial by electric waves, then make themselves evident by indications in the galvanometer.

Dated this 16th day of November 1904.

J. A. FLEMING.

COMPLETE SPECIFICATION.

"Improvements in Instruments for Detecting and Measuring Alternating Electric Currents."

I, John Ambrose Fleming, of University College, Gower Street, in the County of London, Doctor of Science, do hereby declare the nature of this invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

Such instruments as the latter are not affected by alternating electric currents either of high or low frequency which can only be measured and detected by instruments called alternating current instruments of special design. It is, however, of great practical importance to be able to detect feeble electric oscillations, such as are employed in Hertzian wave telegraphy by an ordinary movable coil or movable needle mirror galvanometer. This can be done if the alternating current can be "rectified", that is either suppressing all the constituent electric currents in one direction and preserving the others, or else by changing the direction of one of the sets of currents which compose the alternating current so that the whole movement of electricity is in one direction. Many means have been devised and are in use for rectifying low frequency alternating currents, such as are used in electric lighting. There are well known forms of mechanical rectifier, also there is a well known form of electro-chemical rectifier depending on the fact that when a plate of carbon and aluminium is placed in any electrolyte which yields oxygen on electrolysis, an electric current can only pass through this cell in one direction if below a certain voltage.

Both these forms of rectifier are however inapplicable for high frequency currents. I have found that the aluminium-carbon cell will not act with high frequency currents.

I have discovered that if two conductors are enclosed in a vessel in which a good vacuum is made, one being heated to a high temperature, the space between the hot and cold conductors possesses a unilateral electric conductivity, and negative electricity can pass from the hot conductor to the cold conductor but not in the reverse direction.

As the hot conductor should be heated to a very high temperature say near to the melting point of platinum (1700° C.), it should be of carbon preferably in the form of a filament such as is used in any ordinary incandescent electric lamp. The cold conductor may be of many materials, but I prefer a bright metal such as platinum or aluminium or else carbon.

The two conductors are enclosed in a glass bulb similar to that of an incandescent lamp, and I generally heat the carbon filament to a high state of incandescence by a continuous electric current, the electrical connection to the filament and the cold conductor being made by platinum wires, sealed air tight through the glass.

Figure 1 is a full size sectional elevation of an instrument constructed according to this invention, the electrical connections being shown diagrammatically. Figure 4 illustrates the application of the invention to wireless telegraphy.

Figures 2 and 3 show modifications to smaller scales.

In Figure 1 *a* is a glass bulb, and *b* is a carbon filament like the carbon of an incandescent lamp, suitable say for taking a current of [illegible]

c [illegible] is a cylinder of aluminium open at the top and [illegible] surrounds but does not touch the filament. The cylinder *c* is supported by [illegible] and the ends of the filament *b* are connected [illegible] The platinum wires are sealed in the ordinary manner.

A high vacuum should be obtained in the bulb *a* and as a considerable [illegible] are occluded in the conductors these should be heated when the bulb is being exhausted. The filament *b* can be conveniently heated by passing a current through it whilst the cylinder *c* can be heated by surrounding the bulb with a resistance coil through which a current is passed the whole being covered in a box lined with asbestos or the like. When as hereinafter described the cylinder *c* is replaced by any form of conductor which can be heated by passing a current through it this method is usually more convenient than that just described.

The carbon filament is made highly incandescent in the usual way by a continuous electric current produced by the battery *h* the negative pole of which is connected to the wire *e* and the positive to the wire *f*. The wires *e* and *f* are

connected together by a wire *g* which completes the circuit through the secondary winding *k* of an induction coil (such as is ordinarily used in wireless telegraphy) and a galvanometer *l*. *m* is the primary winding of the induction coil having one end connected as is usual to an aerial wire *n* and the other to earth *o*. The arrangement described above operates as an electric valve and permits negative electricity to flow from the hot carbon *b* to the metal cylinder *c* but not in the reverse direction so that the alternations induced in the coil *k* by the Hertzian waves received by the aerial wire *n* are rectified or transformed into a more or less continuous current capable of actuating the galvanometer *l* by which the signals can be read.

Although Figure 1 shows the application of the instrument to wireless telegraphy it will be understood that the aerial wire *n* may be replaced by any circuit in which there is an alternating electromotive force, whether of low frequency or of high frequency.

I may increase the effect in the following manner: I employ two bulbs arranged as shown in Figure 2 each being similar to that shown in Figure 1. *p p* are the two coils of a differential galvanometer connected to the bulbs in such fashion that currents flowing in opposite directions through the two bulbs, flow in the same direction round the two coils of the galvanometer as regards the needle *q* of the galvanometer itself. For this purpose the hot conductor of each bulb is connected to the cold conductor of the other, hence, one bulb permits negative electricity to flow only in one direction and the other bulb permits only negative electricity to flow in the opposite direction through it. The common terminal of the two galvanometer coils *p* is connected to the coil *k* or any source of alternating electromotive force or of electrical oscillations, the other terminal of the said source being connected to the bulbs as shown. Each bulb has its own separate insulated battery *h* for heating its hot filament.

Under these circumstances, alternating electric currents are split into two continuous currents passing through the two bulbs in opposite and, in the two coils of the galvanometer, in the same directions.

By thus using a differential galvanometer I make use of the whole of the energy of the alternating current instead of discarding half of it. In this manner very feeble electrical oscillations can make themselves apparent by the indication which they give on a sensitive mirror galvanometer.

A number of these valves may be associated together in parallel as shown in Figure 3 so that alternating currents rectified by them separately may produce continuous currents which are added together.

In place of using a metal cylinder surrounding a carbon loop filament, I sometimes use a number of carbon filaments. Some of these are heated by means of an electric current, and become the hot conductor of the oscillation valve and the others remain cold and form the cold conductor. Or the metal cylinder may be replaced by a cylinder of meerschaum or the like having wound helically upon it a narrow ribbon of metallic foil.

The galvanometer *l* may be replaced by any other instrument for detecting the oscillations or by a relay for actuating a detecting or recording instrument.

In those cases in which a larger alternating current has to be dealt with, the hot conductor may be a rod of soft graphitic carbon held in suitable supports.

I find it possible by means of the device described above to rectify an alternating current without the use of any auxiliary continuous heating current. Thus, if I pass through the carbon filament an alternating current to bring it to bright incandescence, I find it I connect either terminal of the filament by a circuit outside the bulb with the terminal of the embracing cylinder or other cold conductor, then in this circuit a continuous current flows. Hence, the device may be used for rectifying either high frequency or low frequency alternating currents of electrical oscillations, provided these are of sufficient strength to render a carbon filament brilliantly incandescent.

Instruments for Detecting and Measuring Alternating Electric Currents.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed I declare that what I claim is:—

1. A vacuous vessel having in it two conductors adjacent to but not touching each other, one of them being heated, these conductors being connected by a circuit outside the vessel, such circuit being exposed to some influence tending to produce an alternating current in it and which contains a galvanometer or other instrument for detecting a continuous current substantially as described.

2. In instrumen's such as are covered by Claim 1, heating the conductor by means of a continuous electric current passed through it substantially as described.

3. The application of the instruments covered by Claims 1 and 2 to wireless telegraphy substantially as described.

4. Duplicating the instruments covered by Claims 1, 2 and 3, by connecting the two coils of a differential galvanometer respectively to the heated conductor in one vessel and the unheated conductor in the other, the connection between the two coils being connected to the other pair of conductors substantially as described.

5. Instruments for converting alternating electric currents into unilateral currents substantially as described.

Dated this 1st day of August 1905.

J. A. FLEMING.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.
[G. 9058—125—1/1906.]

27.37

Fig. 1.

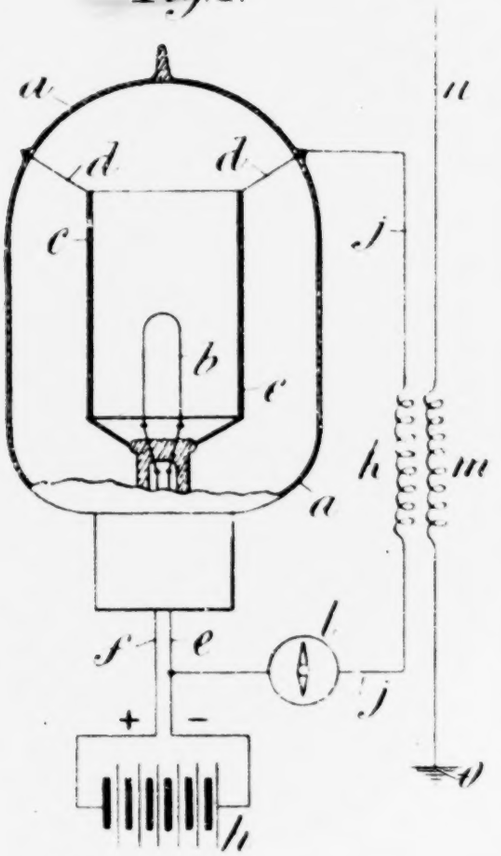


Fig. 2.

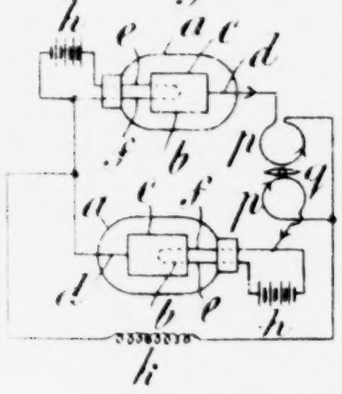
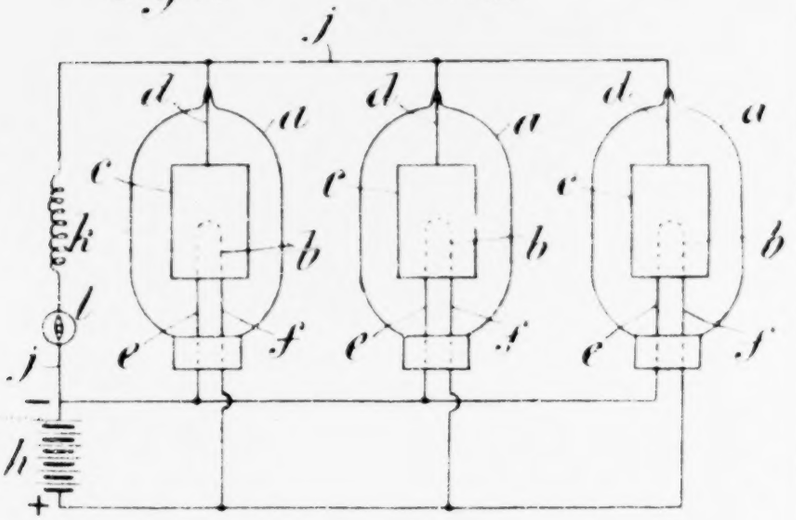


Fig. 3.



PLAINTIFF'S EXHIBIT 78
(1913 Navy Manual)

2738-2740

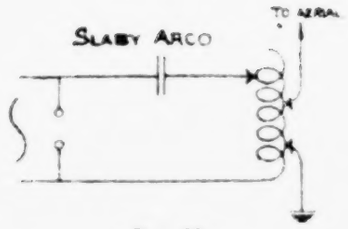


FIG. 29A

FIG. 31

FIG. 33.—Earthed Electric Waves.

2365-2367

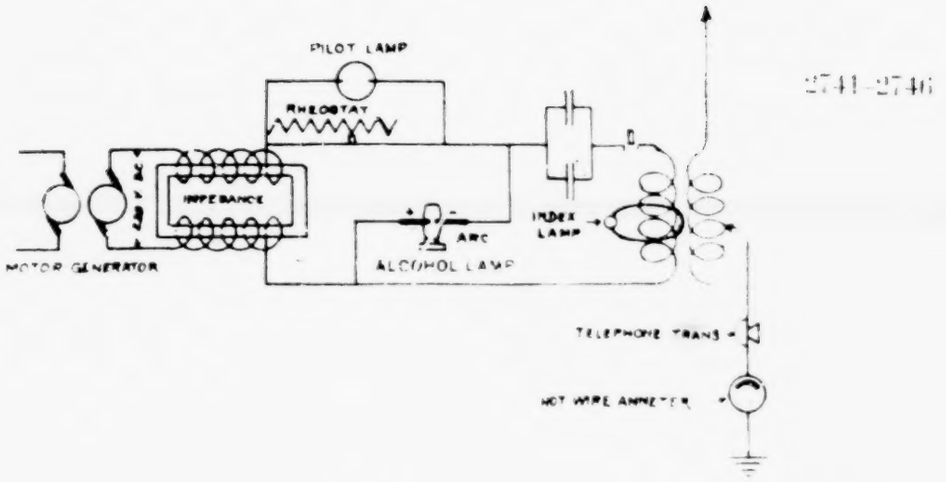


Fig. 52

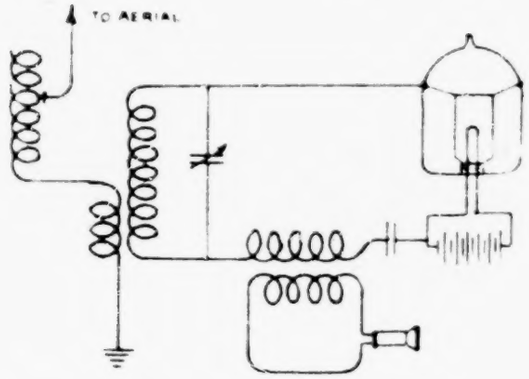


FIG. 53 VALVE RECEIVER - MARCONI

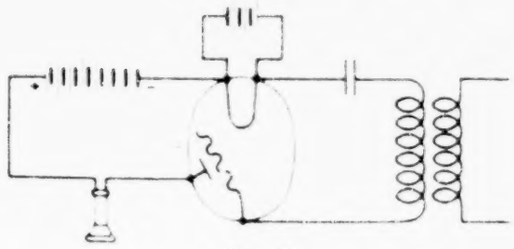


Fig. 55

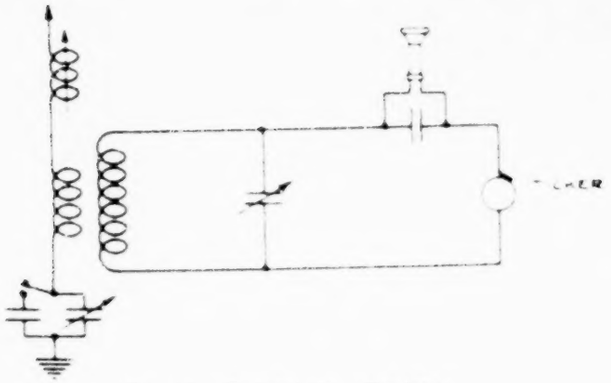
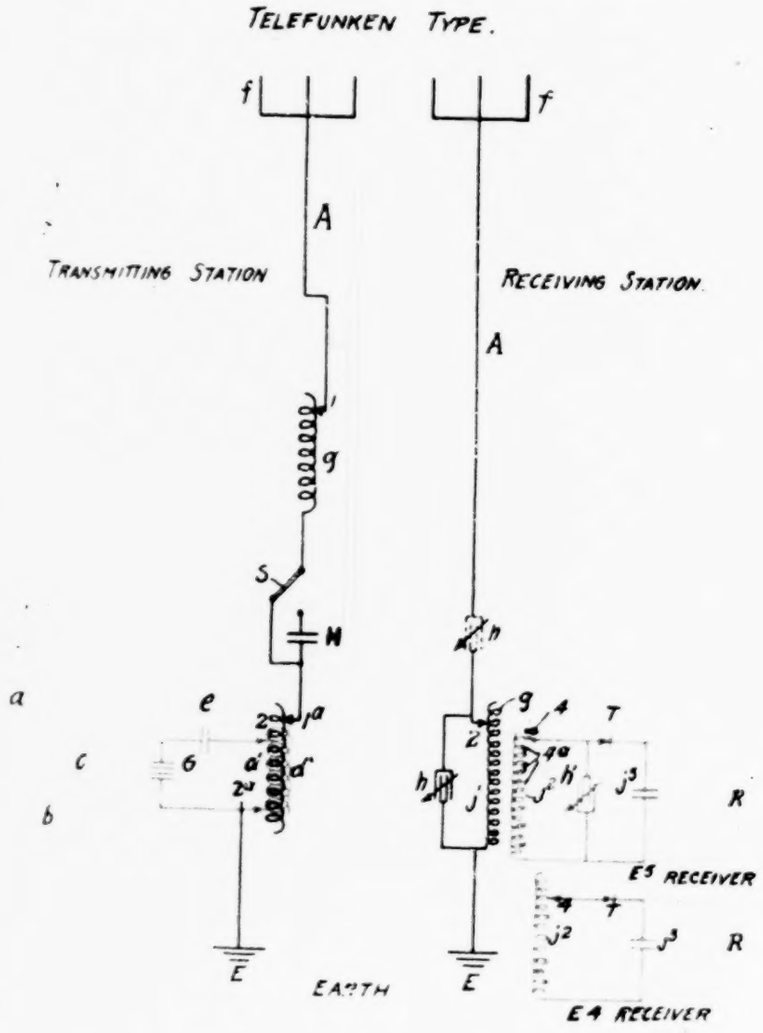


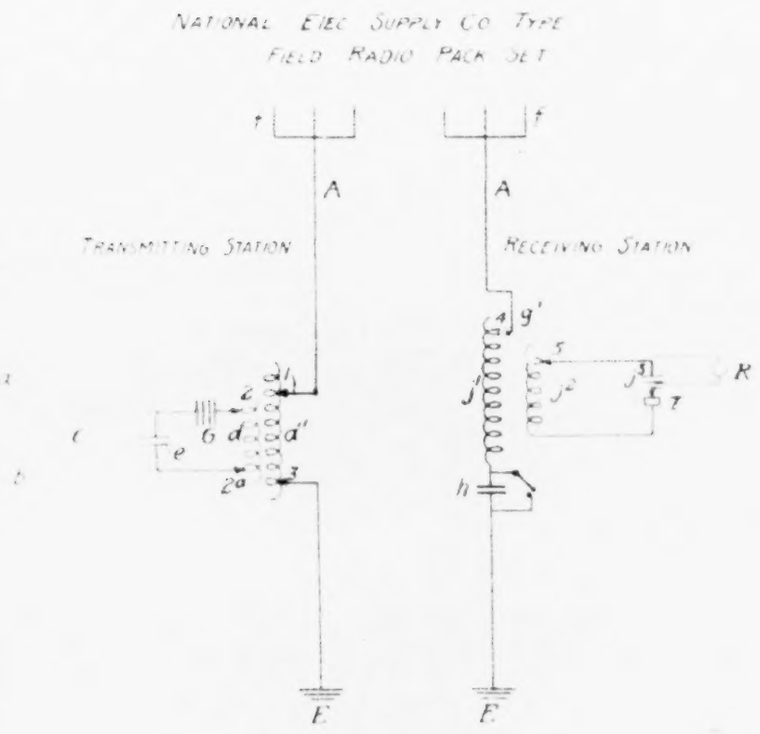
Fig. 59 — Federal Co. (Poulsen)

[fol. 2374] PLAINTIFF'S EXHIBIT, =79, DRAWING TELEFUNKEN APPARATUS



[fol. 2375] PLAINTIFF'S EXHIBIT #80, DRAWING NATIONAL ELECTRIC SUPPLY COMPANY APPARATUS

Plaintiff's Exhibit 80



[fol. 2376] PLAINTIFF'S EXHIBIT #84, OFFICIAL INSTRUCTIONS FOR USE OF ULTRA AUDION

Subject: The Ultraudion—Its use with the various models of the 1-P-76 receivers in the U. S. Navy Radio Stations on board ship and on shore.

1. The Ultraudion, or oscillating audion, is very much more sensitive than the best crystal detector. Its great superiority over the ordinary detector, in both uniformity and sensitivity, more than makes up for the few new difficulties that will be met in learning to operate it. All the connections of the Ultraudion are given in the attached diagram. The three tables at the end of these instruction sheets give the approximate ranges, for the three models of the 1-P-76 receivers, within which the Ultraudion will oscillate, and also the size of the loading coils and parallel condensers that will be necessary when working on the very long wave lengths. The measurements were made on an antenna with a fundamental wave length of 440 meters and a capacity of 0.00126 mfds., which is fairly representative of the ordinary ship's installation. When the audion is connected as shown in Figure 1, it is many times more sensitive than the old audion connection, even when it is not in the oscillating condition. When not oscillating it also preserves the distinctive note of a spark station but will not make sustained oscillations, such as are given out by an arc or a high frequency machine, audible.

Description of the Audion

2. The audion has three elements which are sealed in the bulb. They are the filament, one pair of grids and one pair of plates. The connections to these elements are brought out in four wires, two of which are for the filament, while the other two are one for the pair of grids and one for the pair of plates. The lead to the plates is red while the lead to the grids is green. An easy way to remember the grid connection is that G stands for grid and green. The filament is lighted by a 6-volt storage battery, the voltage being regulated by means of a series rheostat. The filament is rated at 3½ volts and about ¾ amperes.

Description of the Ultraudion Circuit

3. The receiving circuit itself consists of two parts, the primary or the antenna circuit, and the secondary or the

inductively coupled circuit. The primary circuit is the ordinary circuit as found in the various models of the 1-P-76 receivers. A condenser in series with the antenna is shown in the diagram. When used in this position more [fol. 2377] inductions will have to be cut in. It is best to use a variable series condenser with a total capacity of 0.001 mfds. When receiving sustained oscillations the series condenser will actually strengthen the signals, and while it is not so good for spark signals it allows a finer adjustment of resonance than would be possible with inductance varied in steps. For wave lengths longer than the range of the primary inductance it will be necessary to put this condenser in parallel with the antenna, but doing this will decrease the strength of signal especially when the parallel capacity is large.

4. In the 1-P-76 1912 model and 1-P-76 improved model the two leads to the ultraudion circuit are connected to the secondary inductance binding posts which are also common to the condenser. The telephone and the detector connections on the sets are left *open*. In the 1-P-76 1914 model there are two fixed secondary condensers, one for the short wave and one for the long wave coils. These condensers are connected to the slide rods of the two secondaries, and will have to be disconnected and a double pole, double throw knife switch mounted on the end of the receiver case. To one set of clips on the switch connect the slide rods of the short wave secondary; to the other set of clips connect the long wave secondary rods and to the pivots of the switch connect the outside variable tuning condenser of about 0.0018 mf.

5. The ultraudion circuit has two leads running to it. One of them is connected directly to the plate or R binding post while the other is connected to the grid or G binding post through the variable condenser GC of about 0.001 mfds. total capacity. The condenser must be in this lead and not in the plate lead. Six binding posts on the audion box are used. The two marked S_1 S_2, "To tuner," or Ra Re, are not to be used. The R, G, A-, A-, and the two telephone posts are sufficient as the diagram shows. The bridging condenser BC is connected from A- to the R post, and should have a total capacity of 0.002 mfds. and be variable. Connect the telephones in the posts marked "Telephones" on the audion box. The circuit is now ready for use.

Method of Obtaining Oscillations

6. Draw secondary inductance out as far as possible from the primary.

(2) Set secondary tuning condenser C at 0°.

(3) Set bridging condenser BC at 0°.

(4) Cut in 80 turns of secondary inductance for either of the 1912 models of 1-P-76, or 30 or 40 turns of the 1914 model short wave secondary.

(5) Set the grid condenser GC at 40°.

(6) Bring filament to a fair brightness.

[fol. 2378] (7) Vary B battery step by step and tap with the finger on the inductance side binding post of the grid condenser, or at the point shown in the diagram. When the bulb is in the oscillating condition a click will be heard in the telephones when the finger touches the post and another when the finger is removed. The tapping should be very frequent and the condensers should be kept *very* close to the points mentioned above. As you tap vary the A and the B battery voltages. The oscillating point is but very little below the point where the blue arc appears. On wave lengths up to 1500 meters the bridging condenser should never be raised above 10°, neither should the grid condenser be below 15°. On account of the high resistance of the secondary inductance not more than 30° can be used on the secondary condenser with the best bulbs, and often not more than 10°. This applies to the 1912 models of the 1-P-76 where the capacity of the condenser is about 0.0018 mfds. This size of condenser is also large enough for the 1912 model 1-P-76.

7. There are two good ways of determining whether a bulb is in the oscillating condition. The first is by hearing the double click mentioned above. The second method is the use of a testing buzzer. If the bulb is oscillating the cellar note of the buzzer will be roughened. If the oscillations stop they can generally be restarted by bringing the secondary tuning condenser back to 0°.

A Device for the Prevention of Deadening of the Bulb Due to Strong Signals and Static Shocks

8. In figure 1 there is shown a double carborundum contact which connected across the grid and the filament. The object of this contact is to prevent the killing of the bulb

due to very heavy signals and some kinds of static shocks. It will be necessary to use it in stations where strong interfering signals are met with and in fleet work. It is not intended as a static preventer. Any carborundum can be used and the contact need not be light; in fact, there is not much choice in the contact.

Causes of Failure to Produce Oscillations

9. Some bulbs will not oscillate so it is best to try several, remembering to vary the A and the B battery voltages. Vary the condensers *slowly*. Sometimes reversing the R and the G leads of the bulb will clear up the trouble because frequently bulbs are found that have reversed leads. Another trouble is indicated by failure to produce a blue arc. If it is impossible to strike the blue arc the trouble lies in the B battery not having sufficient voltage, or the connections are wrong, or the bulb is improperly exhausted. B battery trouble is located by varying the voltage and if sharp clicks are not heard, provided connections are per [fol. 2379] diagram, the voltage of the battery should be tested, and where the test is not satisfactory look for poor cells, and short circuit those that do not come up to voltage. The cells deteriorate through local action rather than through use, so that old cells are more likely to cause trouble than fresh ones. If the trouble is not in the B battery look over the connections, carefully inspecting them for contact and proper position. For example, if the GC is in the plate lead no oscillations can be produced. The condensers used in this work should have the movable section connected to its binding post by means of a flexible lead so that good contact will be certain.

10. When once oscillations are produced note the settings of the condensers and the inductance. Familiarize yourself with the muffled double click and vary the secondary condenser, tapping all the while to see when the oscillations cease. On short wave lengths B battery must be used at a higher voltage and the A battery voltage also will have to be changed. At the longer wave lengths these two may be reduced, although this depends a great deal on the state of the bulb. It has been found that when a bulb has been burned for some time that it will oscillate more freely than when new. The bridging condenser generally need not be varied much from the 0 setting, the capacity due to the

edge effect of the condenser plates being sufficient except when working long wave lengths. The amount of bridging condenser necessary varies greatly with different bulbs. In the appended tables an average bulb was used, so the values given are fairly representative of general conditions. Do *not* use too close coupling between the primary and the secondary circuits for the oscillations will cease with a click as the coupling is increased. In case close coupling is used while trying to get the bulb to oscillate it is doubtful whether the oscillations can be started on account of the large amount of resistance that is added to that of the secondary inductance due to coupling alone. The closest point that can be safely used without the bulb stopping its oscillations can be found by observation.

11. Audibility readings can be taken by placing two pairs of telephones in series in place of the one pair, the audibility box being connected across the pair of telephones on which the readings are to be taken.

The Ultraudion Used as a Detector for Spark Signals Only

12. Frequently it is desirable to preserve the distinctive note of a spark transmitter when receiving. The Ultraudion, when in the oscillating condition, changes the spark note to a rough note, the roughness of the note depending on the spark frequency and the amount that the receiving circuit is detuned. Although the Ultraudion is [fol. 2380] in its most sensitive condition when oscillating, yet the note produced is difficult to read under static conditions. If either the stopping or the bridging condenser is varied a point will be found where the distinctive spark is brought in. This point can be found by trial. The oscillations are preferably stopped, or prevented, by keeping the bridging condenser large. The Ultraudion in the non-oscillating condition is at least twenty times as sensitive as the audion detector.

The DeForest Amplifone

13. The best place to connect the amplifone is in series with the pair of telephones of the ultraudion circuit. It has been found that one step of amplification is all that can generally be used. Although greater increase can be obtained with two and three steps the corresponding increase

of amplifier noises and static is so great as to more than counterbalance the increase of signals.

14. The binding posts marked S_1 S_2 are the connecting points for the amplifone. Connect one post S_1 directly to one of the telephone binding posts of the ultraudion and connect from the other telephone post through the telephones to the S_2 post. A description of the amplifone and its operation was issued by the Department, September 30, 1914. Audibilities can be taken of the amplified signals by connecting the audibility box across the telephones of the amplifone.

The Telephone Transformer

15. The telephone transformer is used primarily to reduce interference from arc stations operating on about the wave length that is being received. When using this transformer a station can be read when the wave length is only 6% off the interfering wave length. This applies to arc signals. The gain in selectivity is not so great when a spark station is being received. It also helps in reducing static disturbances as the coupling of the transformer can be varied and, although the loudness of the signals is decreased, the static is generally so considerably decreased that signals can be read without the transformer would be too much broken up to read.

16. The transformer (see Figure 2) consists of a primary and a secondary. The primary has a low resistance and will need to be connected in series with the telephones of the ultraudion circuit, that is, the telephones and the primary take the place of the ordinary receiving telephones of the circuit. The secondary of the transformer is tuned roughly by means of a tuning condenser C of from 0.01 to [fol. 2381] 0.10 mfds. capacity placed in series with the secondary of the transformer. This condenser can be a mica dielectric condenser which is variable (x) by 0.01 mfds. steps. The telephones are connected across this capacity with a condenser C_1 in series with them. The series condenser can be from 0.005 to 0.02 mfds. and variable (+0.005

(x) If variable condensers are not to be had, making C about 0.01 mf. and C_1 0.02 mf. will tune the circuit for receiving a tone of about 1,000 vibrations per second.

mfds. steps. The two coils slide on an iron wire core so that the coupling can be varied.

Specifications of the Transformer.

17. Primary spool:—Core is made of fiber tube that is 1 inch inside diameter, $2\frac{1}{2}$ inches long. Heads are $\frac{1}{4}$ inch thick and $3\frac{1}{2}$ inches in diameter. Distance between heads is 2 inches. Wind 40 layers of #28 B&S SCC wire. Bring out the beginning and the end of the winding for connection.

18. Secondary spool:—Core is made of fiber tube that is 1 inch inside diameter, $3\frac{1}{2}$ inches long. Heads are $\frac{1}{4}$ inch thick and $2\frac{1}{4}$ inches in diameter. Distance between heads is 3 inches. Wind 18 layers of #26 B&S SCC wire. Bring out the beginning and the end of the winding for connection. The resistance of the coil is about 50 ohms.

19. Core:—8 inches long and of such a diameter as to allow the two coils to slide easily over it. Iron wire or silicon-steel strips are satisfactory for this core.

Method of Using the D. C. Lighting As a Substitute for the B battery of the Audion

20. The drawback in the use of the ordinary D.C. supply for audion work lies in the fact that the noises of commutation drown out weak signals and otherwise interfere with the reception of signals. These noises can be overcome, for the most part, by means of suitable chokes inserted in the two leads of the D.C. supply. Since the B battery is the chief cause of audion trouble and failure to operate a method of using the D.C. supply has been worked out. Construct the two choke coils in the following manner:

21. The cores are made of fiber tubing $1\frac{1}{4}$ inches outside diameter with $\frac{1}{8}$ inch walls and 3-15 16 inches long. The heads are $\frac{1}{4}$ inch thick and $3\frac{1}{2}$ inches in diameter. [fol. 2382] Fasten two heads to each of the cores, thus making two spools that have a winding space of 3-7 16 inches. On each spool wind 32 layers of #23 B&S DCC copper wire. The layers average 112 turns, making 3600 turns on each coil. The resistance of the coils is 43 ohms apiece. Bring out the beginning and the end of the connections. Mount the spools when wound on a closed iron core that has a square section and a square shape. In this manner the inductance,

or the choking effect, will be increased without an excessive amount of wire being used.

22. Connect the chokes, one in each leg of the D.C. circuit, so that the choking effect will be equalized. Connect the potentiometer across the chokes. The potentiometer should be able to carry $^3/_4$ amperes and give a voltage range of at least 30 volts. The low voltage connections of the potentiometer are connected, one side to the B-binding post of the audion box while the other is connected to the B binding post. Of course, battery B will have to be entirely disconnected from the circuit when the D.C. is being used. The chokes should be connected so that they help each other in magnetizing the core. If the magnetism of the core is weak and one pole is dead the coils are opposing. When the poles are all equally strong the coils are helping and the magnetism is strong.

Tables of the Ranges of the I P 76 Receivers of the U S Navy

23

I P 76 1912 Model.

Lowest number of secondary turns for oscillations is 80.
Wave lengths 700 to 1050 meters.
C from 0° to 15°.
GC from 15° to 40°.
BC at 0°.

160 turns.

Wave lengths 1200 to 1700 meters.
C from 0° to 15°.
GC from 20° to 40°.
BC at 0°.

320 turns.

Wave lengths 2800 to 3100 meters.
C from 0° to 20°.
GC from 15° to 40°.
BC from 0° to 10°.

I P 76 1912 Improved.

Lowest number of secondary turns for oscillations is 80.
Wave lengths 500 to 900 meters.
C from 0° to 30°.
GC from 15° to 40°.
BC at 0°.

160 turns.

Wave lengths 850 to 1850 meters.
C from 0° to 60°.
GC from 30° to 50°.
BC at 0°.

320 turns.

Wave lengths 1250 to 2900 meters.
C from 0° to 60°.
GC from 20° to 40°.
BC from 0° to 10°.

[fol. 2383]

Constants for raising to 5000 meter wave length by means of inductance; secondary 14° of the tuning condenser with 320 turns cut in and a 5.0 milli-henry loading coil in series with it.

Primary circuit: All the inductance of the set and 2 milli-henries in series with the primary circuit. Raising to 5000 meter wave length by means of parallel capacity in the antenna circuit. About 110° of the 0.001 mfd. parallel condenser. With the 5.0 milli-henry coil the secondary will oscillate over the entire range of the capacity of the tuning condenser. Wave lengths are from 2500 to 6400 meters.
GC from 15° to 20°.
BC from 20° to 35°.

Constants for raising to 5000 meter wave length by means of inductance; secondary condenser can be used from 9° to 100° when a 5.0 milli-henry loading coil is cut in series with the 320 turns of the secondary. Wave lengths are from 1800 to 6000 meters. GC 15° to 30°. BC 80° for maximum on the long waves. primary circuit with 2 milli-henry loading coil will tune in 5000 meters. By means of a parallel primary capacity use all the primary coupling coil and 40 turns of the loading coil of the set and about 130° of the 0.001 microfarad capacity. With 8 milli-henries of primary load in addition to the entire primary and a series 0.001 microfarad capacity cut in to 135° strong signals and sharp resonance points can be obtained.

Note. When a series condenser in the antenna circuit is used and the antenna loaded with inductance to produce a stiff circuit the resonance point of the primary and the secondary circuits is found by means of a sharp click as the resonance point is passed in either of the two circuits. This is especially true when the longer wave lengths are being used. On the shorter wave lengths a faint click is sometimes heard although it is not always dependable.

I P 76 1914 Model.
Short wave secondary.

Turns	Wave Lengths	C	GC	BC
30	600-1400	0-70°	10°	0°
40	750-1900	0-100°	15°	15°
50	800-2100	0-80°	15°	20°
60	900-2400	0-80°	15°	25°
70	1000-2600	0-80°	15°	25°
80	1150-2800	0-80°	15°	25°
90	1300-3000	0-90°	15°	25°
100	1462-3500	0-100°	15°	25°

I P 76 1914 Model.
Long wave secondary.

Turns	Wave Lengths	C	GC	BC
20	900-2700	0-80°	25°	15°
30	1650-3500	0-80°	15°	35°
40	2000-4500	0-80°	15°	30°
50	2200-5300	0-80°	15°	30°
60	2500-6000	0-80°	20°	20°
70	2700-6750	0-80°	20°	20°
80	2900-7200	0-80°	20°	20°
90	3150-8000	0-80°	20°	20°
100	3250-8400	0-80°	20°	20°

RE3A101A

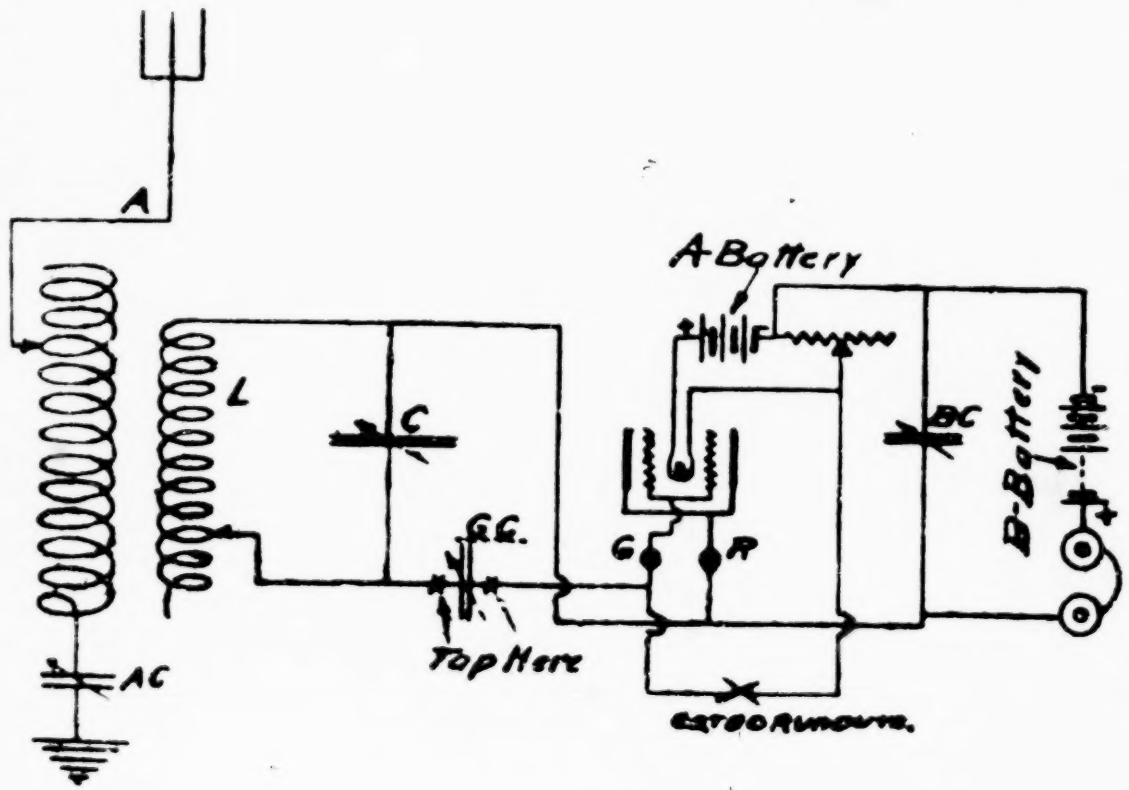


FIG. 1
ULTRAUDION CIRCUIT

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SHEET 9 OF 10

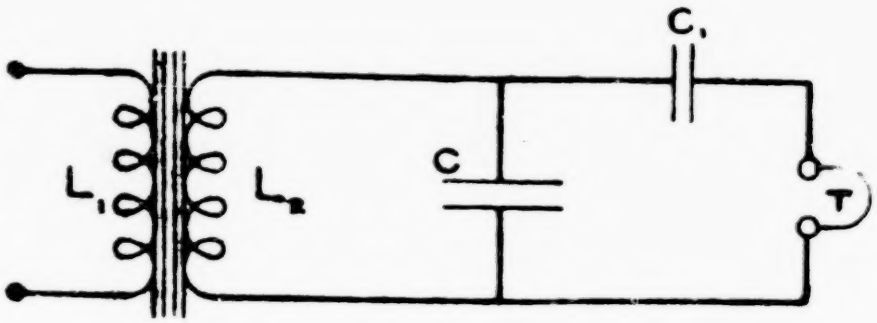
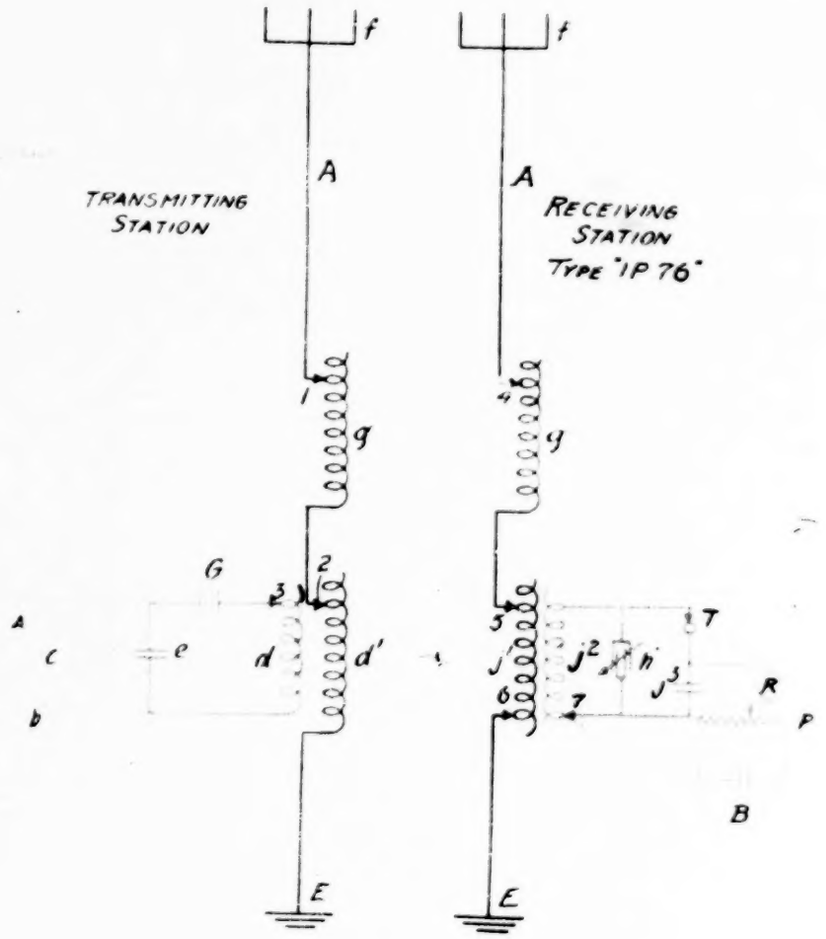


FIG. 2
TELEPHONE TRANSFORMER

Plaintiff's Exhibit 87

WIRELESS SPECIALTY APPARATUS TYPE



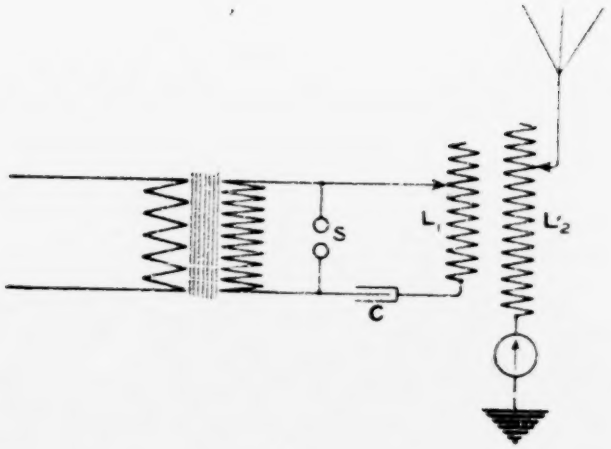


FIG. 36

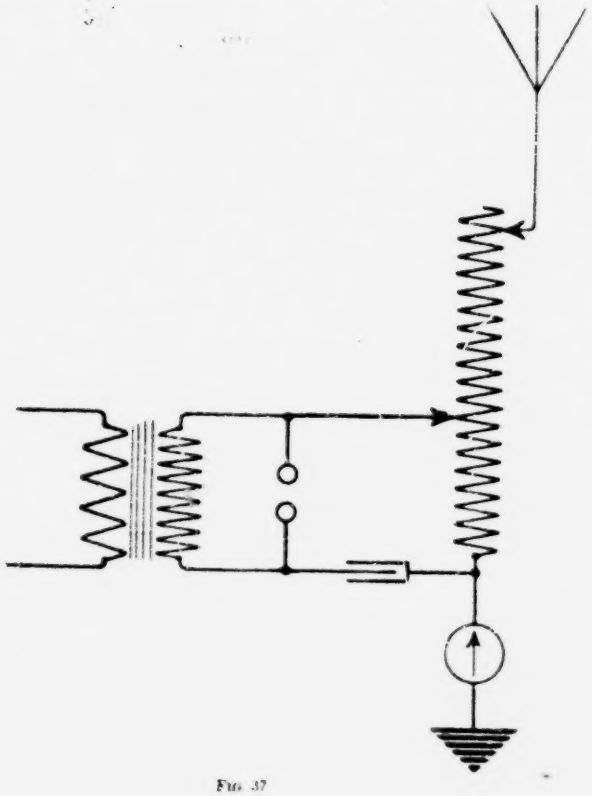


FIG. 37

PLAINTIFF'S EXHIBIT 82

RADIOTELEGRAPHY.

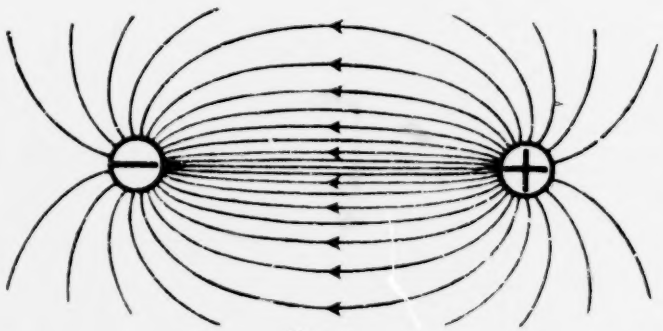


FIG. 1

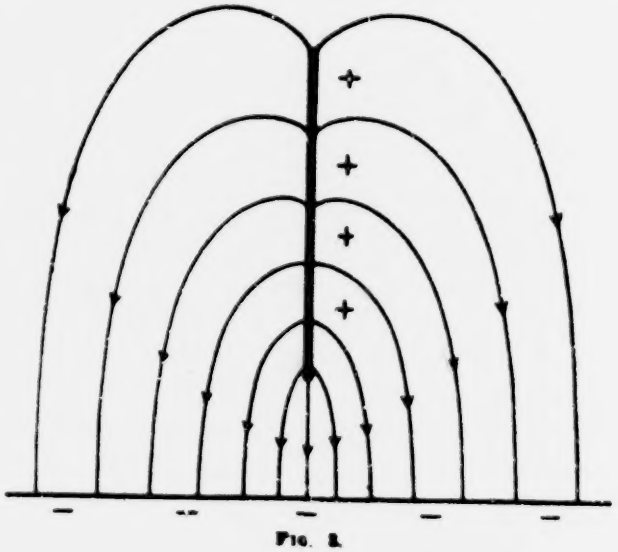
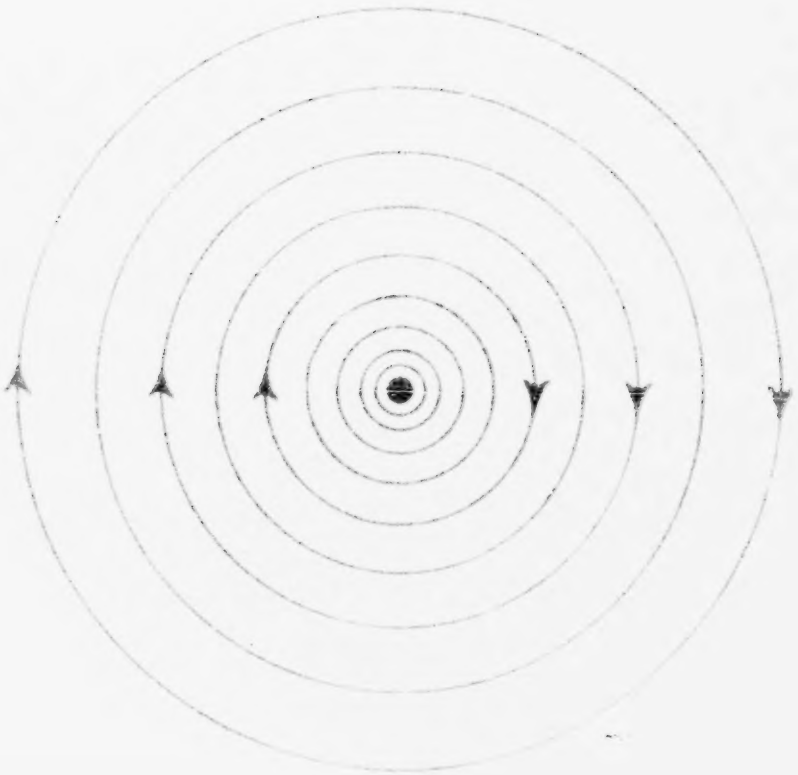
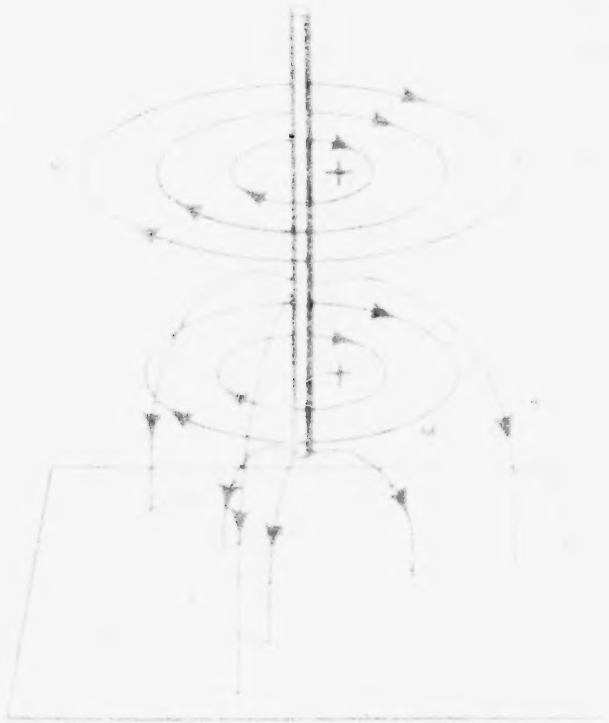


FIG. 2





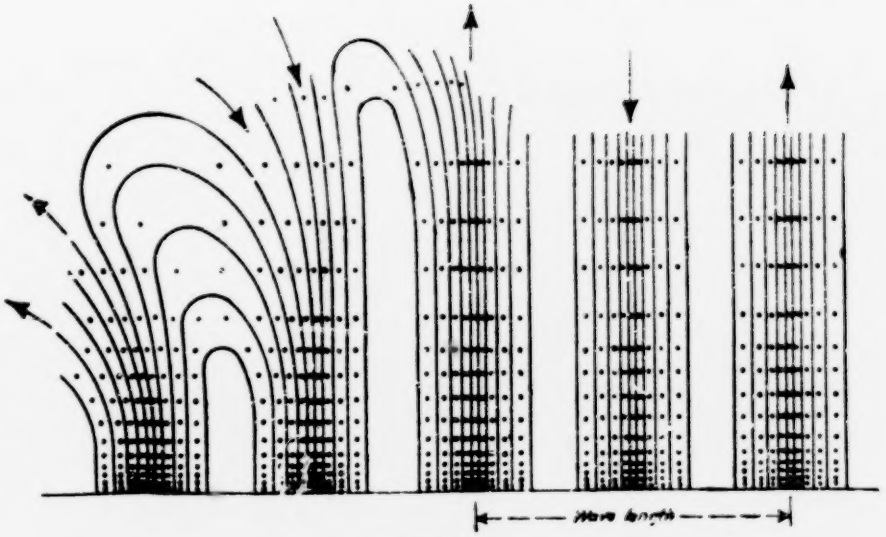


FIG. 9.

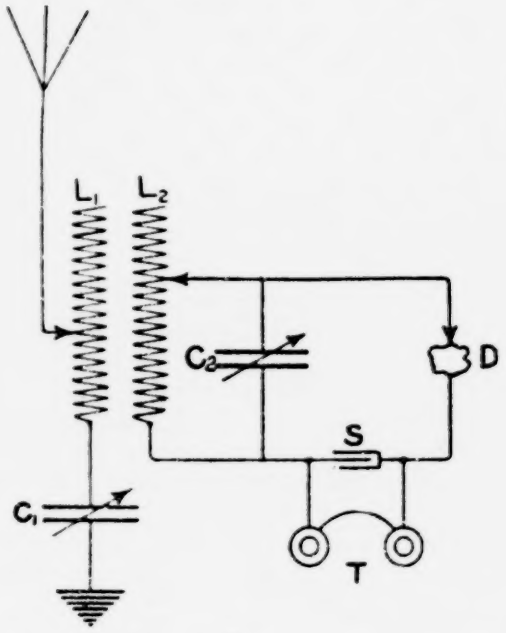


FIG. 82.

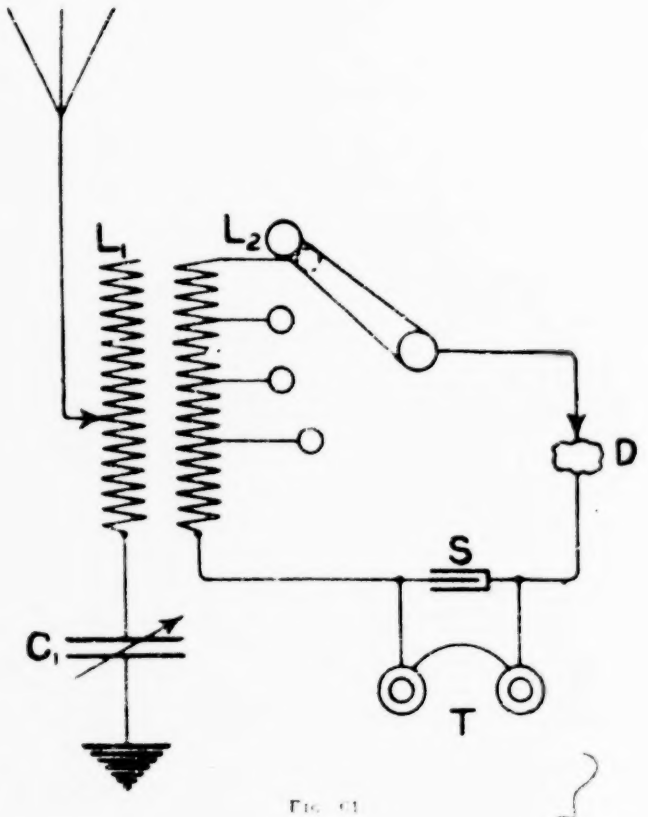


Fig. 1

faces are corroded or pitted, but that when kept air tight they are worn smooth and clean by the sparking action. Sometimes, if there is a flaw in one of the plates or if air leaks into the gap, there will be a noticeable drop in the antenna current, and the note will become poor. When it is believed that the trouble is confined to one or two gaps it is possible to continue sending without dismounting the whole gap by short-circuiting the bad gaps by means of clips provided for the purpose, in which case as many new gaps must be put into circuit by adjusting the movable clip to the right as were cut out by the short-circuiting clips.

The gap should be dismounted *only* when the trouble has been located in the gap and it has been found impossible to remedy it by short-circuiting the different gaps in use. The gap should be dismounted only by an experienced man, who should clean the [illegible] by rubbing them face down on fine emery cloth or paper on a *flat surface*. It is absolutely necessary that both the bearing surfaces and the sparking surface be kept true and plane, as shown by a straightedge.

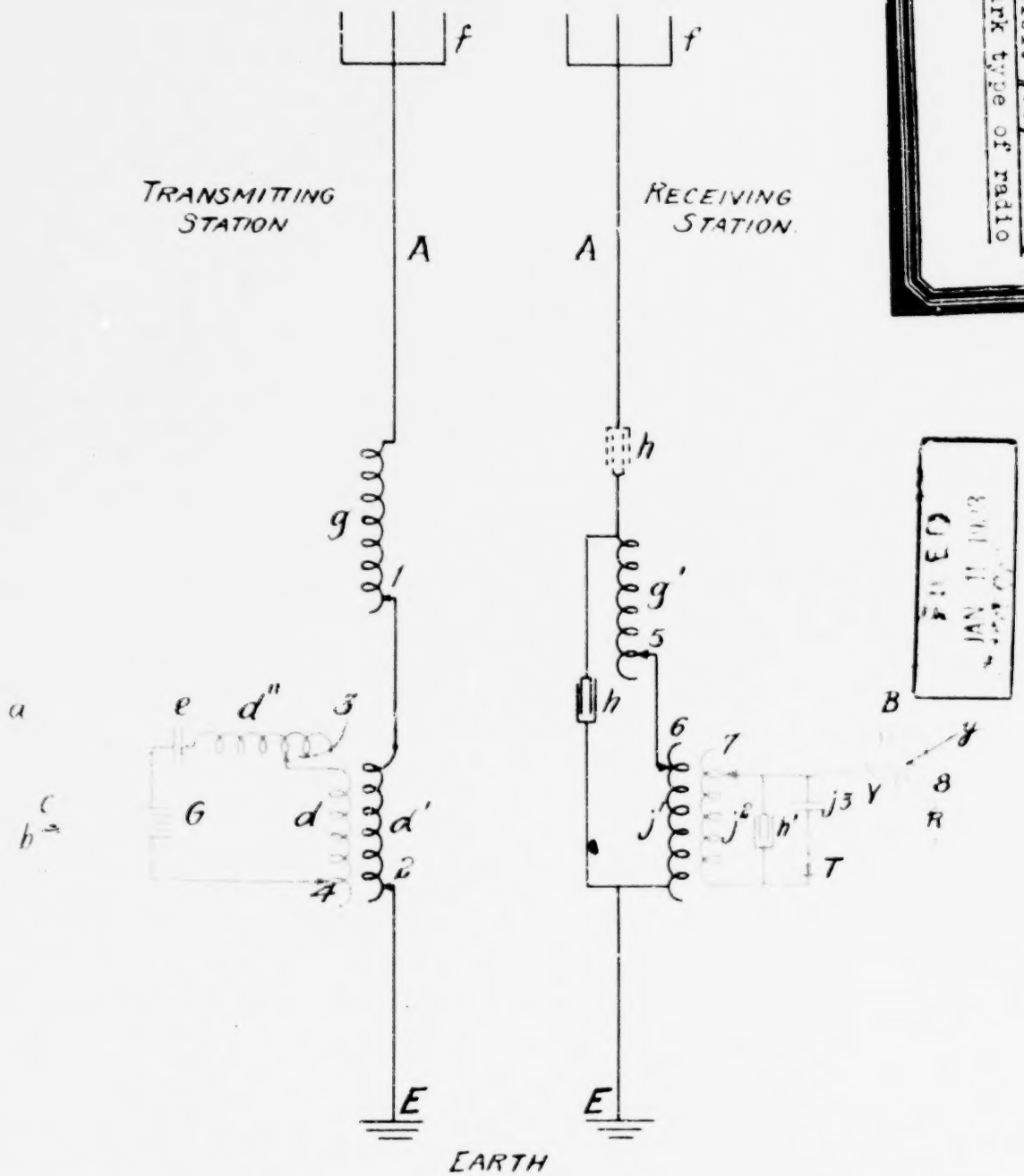
Great care should be exercised in reassembling the gap to set the mica washers accurately on the annular surfaces of the disk and to put on enough tension with the clamping screws to render all of the gap spaces air-tight.

TUNING OF SENDING SET.

The tuning of the closed and open circuits to resonance, and the determination of the correct coupling between them are the two most important adjustments in a quenched spark transmitter. In the present type of directly coupled set with a flat spiral as the oscillation transformer, these adjustments can be made either with or without the help of a wave meter. If made without the meter the adjustments are more difficult and must be found by trial, but they should satisfy the following tests: (1) The number of turns in the closed circuit should be chosen so as to give the desired wave length; (2) the antenna hot-wire ammeter should show the maximum reading that can be obtained by adjusting the number of turns in the open circuit according to the table on page 104; and (3) the note as heard in the telephones of the receiving set should be clear and free from [illegible] of the spark. The [illegible] is to a great degree dependent on [illegible] when an incorrect change in one set will affect [illegible] the result when changing [illegible]

Plaintiff's Exhibit #95, Drawing Kilbourne & Clark type of radio Apparatus.

KILBOURNE & CLARK TYPE



Plaintiff's Exhibit 99

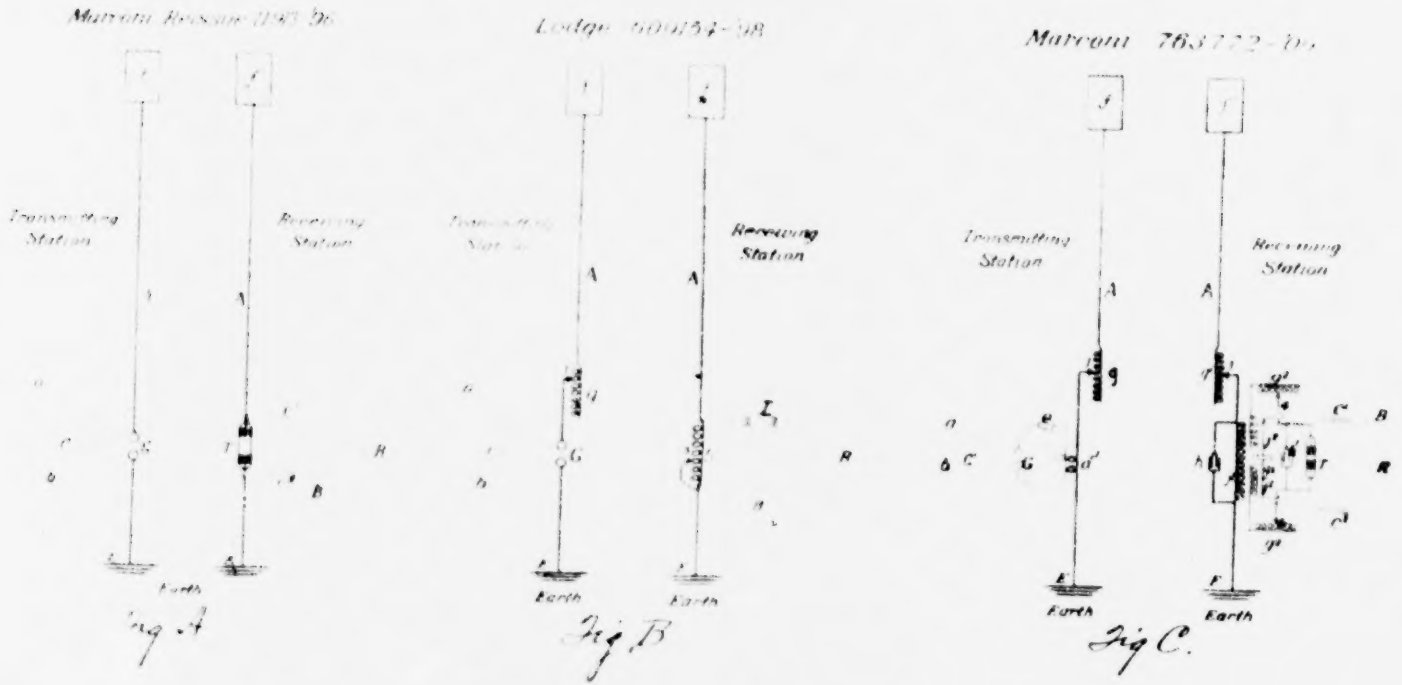


Fig A

Fig B

Fig C.

2405

Pltf. Exhibit 99

PLAINTIFF'S EXHIBIT No. 99 (2)

Marconi Pat. 7877 Transmitting Circuits (Table page 4)

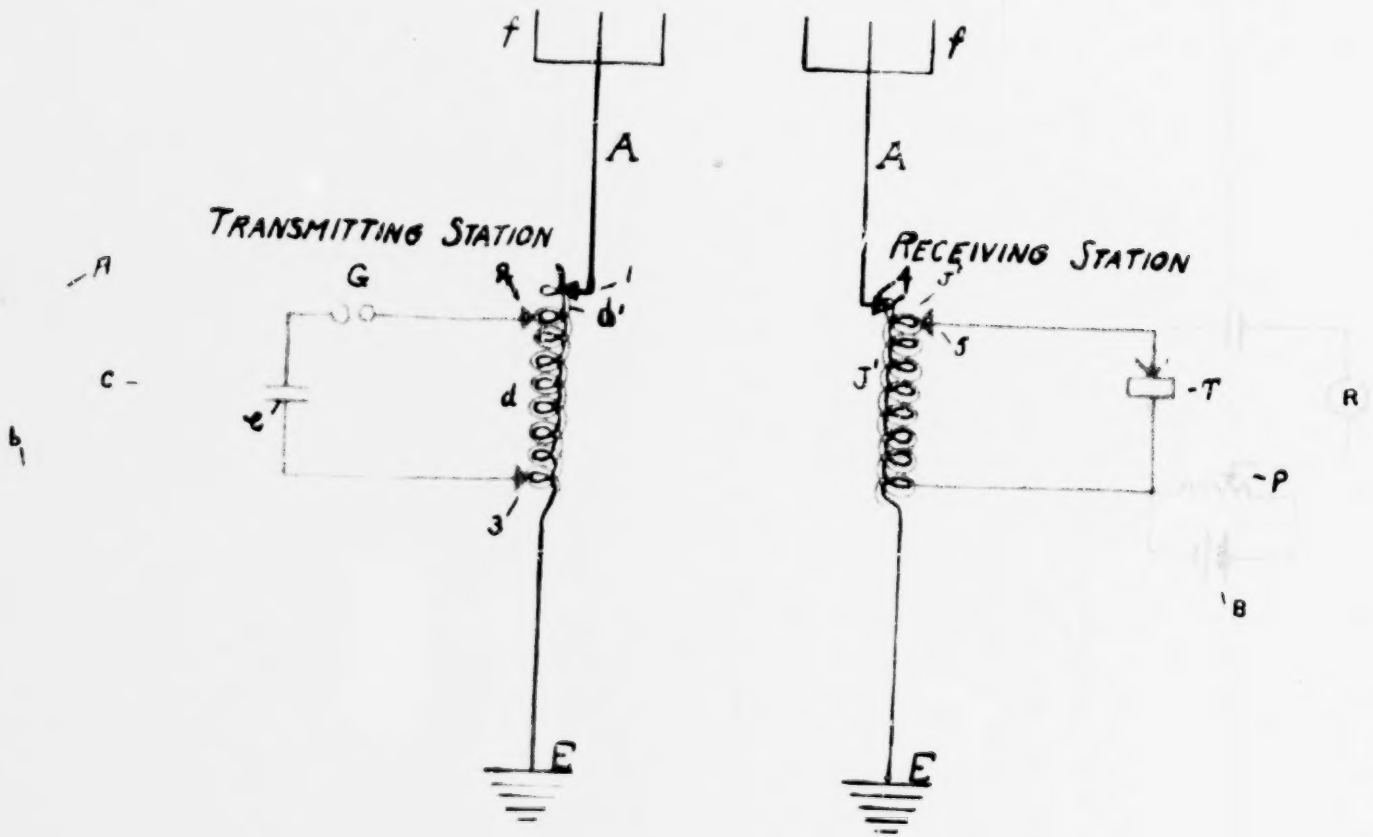
Fig. D

Fig. E

Fig. F

PLAINTIFF'S EXHIBIT NO. (3)

Plaintiff's Exhibit 102



Waterman Sketch—Foote-Pierson Pack Set

[fol. 2407]

PLAINTIFF'S EXHIBIT 102

[fol. 2408] PLAINTIFF'S EXHIBIT 103

Signal Corps Bulletin No. 17.

Instructions For Operating The Field Radio Pack Set, Model 1912.

The 500-cycle, quenched spark radio transmission set and inductively coupled receiver constituting the 1912 model field radio pack set of the Signal Corps, were adopted after extensive investigation of modern methods in the practice of radio telegraphy. The weight efficiency has been more than doubled without decreasing the effective range of radiation. A brief description of the equipment with instructions for the care and operation of the set follows:

Drawings

The following drawings will form part of and illustrate this bulletin:

Field radio pack set, model 1912, receiving circuit diagram 911a
Field radio pack set, model 1912, sending circuit diagram 911b
Field radio pack set, model 1912, poles for shelter tent 911c

Generator

The generator is an 18-pole, alternating current machine of 125 watts capacity at 110 volts and 500 cycles, designed for an armature speed of 3333 R. P. M., the ratio of the gearing being such that this speed is obtained when the crank handles are revolved at 36 R. P. M. A separate direct current exciter is mounted on the main armature shaft for energizing the field magnets.

A double speed clutch is provided on the fly wheel which when properly regulated should engage the armature gear at a speed between 30 and 34 R. P. M. of the crank handles and disengage same when the crank handle speed exceeds 37 R. P. M. Adjustment of the over-speed clutch is made by means of the two radial screws on the periphery of the steel fly wheel which are locked by set screws on the inner face of the wheel; loosening the screws causes the over-speed clutch to operate at a lower speed, and, conversely, tightening this screw causes it to operate at a higher speed.

at each alternation, in which case the fault can be remedied by reducing the number of gaps. If the adjustment is such that the condenser is discharged regularly at every second or third alternation, the note will be even but low pitched, somewhat similar to the note produced by an unquenched spark gap. If the generator speed is constant at 500 cycles, reducing the number of gaps will probably remedy the trouble, although it may be necessary to "loosen" the coupling. By loosening the coupling is meant to reduce the number of turns of the linking spiral (oscillation transformer) common to both the closed and radiating circuits, or, if no common turns are being used, to increase the distance between the sections included in the "closed" and "radiating" circuits.

Damping

When the current in the closed oscillating circuit dies out after a few reversals as already described, the oscillations are said to be "damped". The proper amount of damping is indicated by a high pitched, musical note. Damping is aided by close coupling; however, if the coupling is too close, a retransfer of energy from the radiating to the closed oscillating circuit may occur, with an induced E. M. F. sufficient to again break down the spark gap. This condition can be detected by its effect on the note which will be lower pitched and ragged.

The remedy is to loosen the coupling. In tuning sending circuits, the operator may ascertain the character of the note emitted by listening on the telephone of his own receiving set, which while disconnected at the control switch will be sufficiently energized by the field of the sending helix or oscillating transformer to produce the note.

Receiving Set

The receiving set consists of an inductively coupled transformer, perikon detector, series and stooping condenser, with terminals, switches, etc., mounted in an oak case with hard rubber top and front and is supplied with a Sullivan type, high resistance, double head telephone receiver, as indicated in drawing 911a.

[fol. 2411] The primary coil of the transformer is wound with 170 turns of No. 22 enamelled copper wire divided into two sections, one of 10 turns and one of 160 turns. Each single turn of the small section is tapped off and the leads

connected to the terminals of the dial switch numbered from 1 to 10. The large section is divided into 16 groups of 10 turns each and the leads connected to the terminals of the dial switch marked from 10 to 160. As these dial switches are connected to a common zero point with the switches working in opposite directions from this point, as shown in the diagram, the total number of turns included can readily be determined, being the sum of numbers indicated by the two switch arms.

A condenser of small capacity is connected in series with the aerial and is provided with switch for shunting or short circuiting same when not in use. This condenser is intended for the reception of wave lengths of two hundred meters or less, and is normally short circuited when longer waves are being received.

A small detached buzzer is provided for testing purposes. This buzzer, when operated in the vicinity of the aerial, counterpoise leads, or windings of the coils, excites feeble oscillations which enables the operator to adjust his detector efficiently before tuning the primary and secondary circuits.

Tuning of Receiving Set

After adjusting the detector to a sensitive point by the aid of the test buzzer, move the secondary coil into the primary as far as it will go and set the secondary dial switch on, say 200, which will answer for wave lengths between 250 and 700 meters. Then vary the dial switch marked from 10 to 160 until the signals are heard; this will probably be found near the contact marked 60. When the signals are heard, the adjustment is continued by varying the primary and secondary dial switches and the position of the secondary within the primary coil (i. e. the "Coupling", which for wave lengths approximately 400 meters will be between 10 and 20 on the Coupling scale) until the maximum sound is heard in the telephones. If the incoming wave is found to be short the small 2-point condenser switch may be set at the "On" position which places the condenser in series with the aerial.

Shelter Tent

This tent is similar in dimensions and construction to the standard "Common" tent issued by the Quartermaster's Department, but is made of lighter duck and is not provided with ridge poles nor uprights. Three extra sections are

[fol. 2412] furnished with each 40 foot mast and it is intended that these will be substituted for the tent ridge and upright poles. Two extension pieces are supplied for adapting one extra section as ridge pole and two wood plugs with spikes are supplied for adapting the other two sections for use as uprights. These are shown in the accompanying sketch together with ridge poles and upright assembled for setting up.

Insulating Device

A device is provided for use in insulating the aerial when the shelter tent is used in damp weather, consisting of a square piece of sheet rubber with small marginal holes for lacing into the ventilator at either end of the tent, and a tube attached to the center for admitting the aerial lead. When in use, sufficient slack should be left in the aerial lead to form a drip loop outside of the tent, and if found necessary a piece of heavy insulated wire can be used as a leading in wire.

Packing

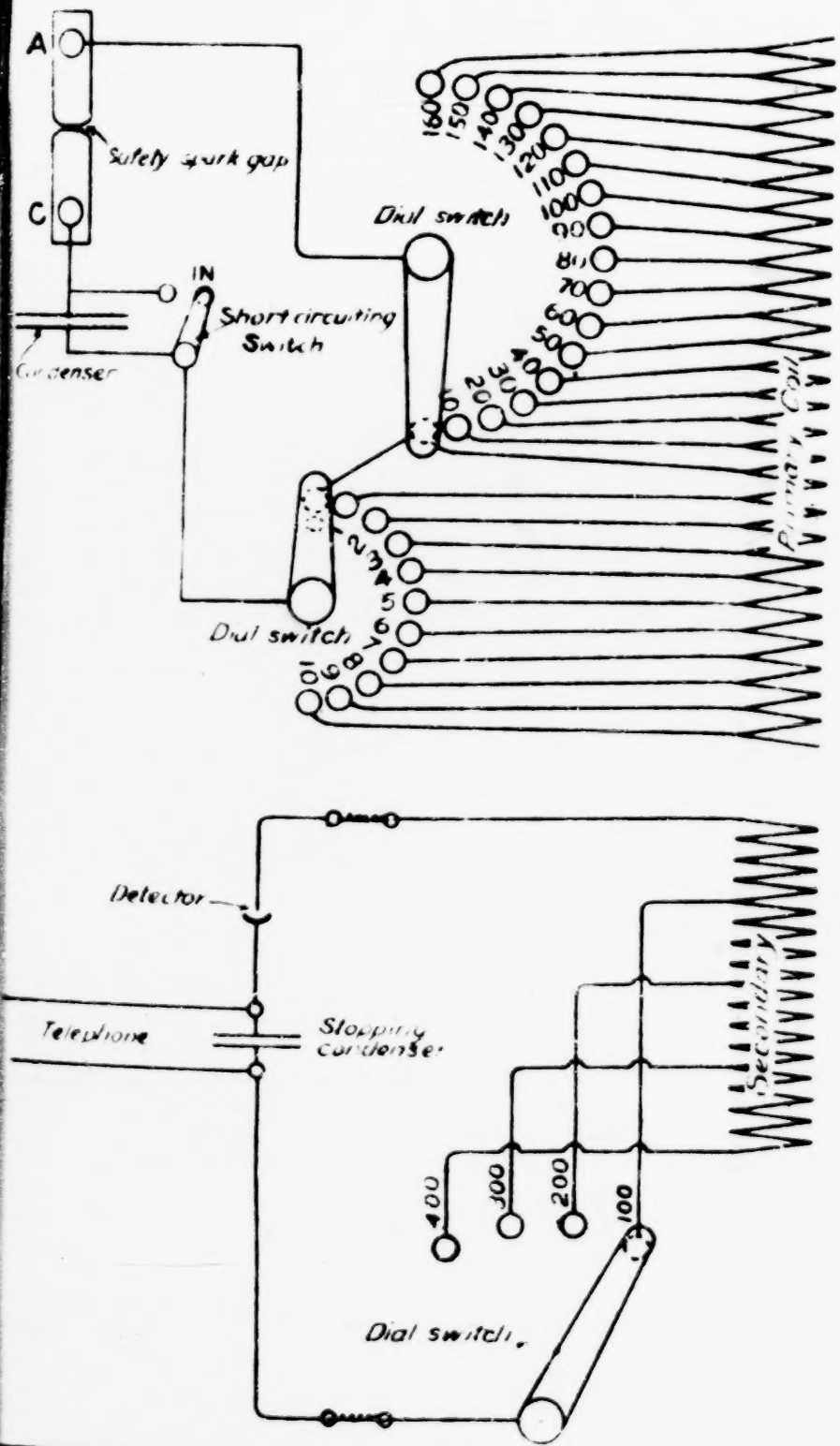
In packing the set on the pack frame, the fourteen wood tent pins and four extension pieces should be folded in with the shelter tent; the insulating device, iron guy pins, hammers, crank handles and oil can placed in the accessory bag. The gear wheel with its leather case, antennae and counterpoises are carried in the large canvas bag. Two end guys are furnished with each tent, which, in case an extra section of mast is broken, will hold the tent in position without using a ridge pole.

The hand generator, generator stand and ten mast sections are carried on one mule; the operating chest, antenna-counterpoise bag and accessory bag on another. The antenna-counterpoise bag is suspended by the "D" rings on the side of the pack frame provided with one set of hooks. The operating chest is hung on the top set of hooks on the opposite side and the small accessory bag beneath it on the lower set of hooks. The tent is carried on top of the frame between the chest and large bag. Two wood foot rests are supplied with each generator stand with sixteen screws for securing them to the adjustable flanges on the base of the stand.

Office of the Chief Signal Officer of the Army, August 15, 1912

FIELD RADIO PACK SET, MODEL 1912

RECEIVING CIRCUIT DIAGRAM



911a-1

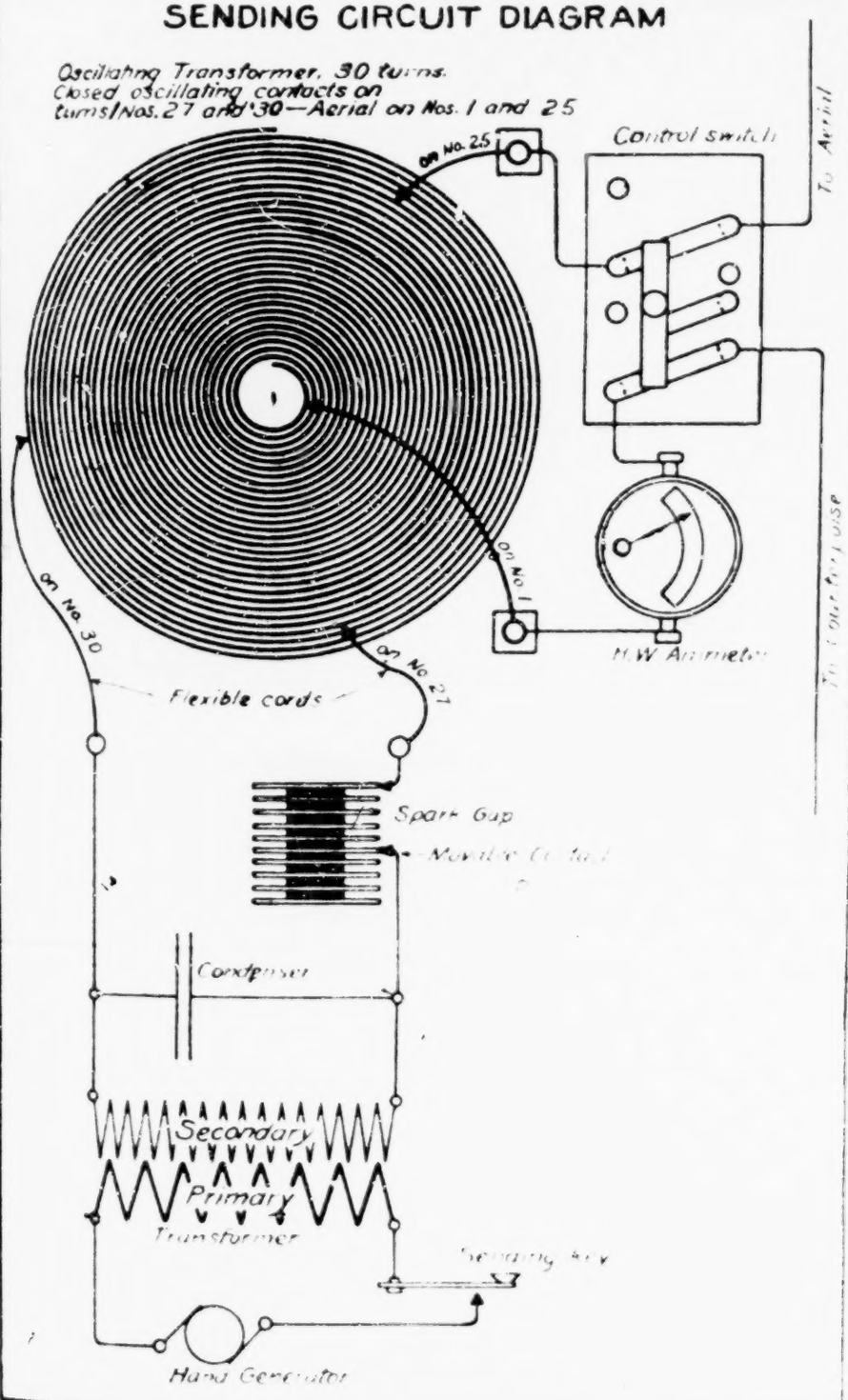
SIGNAL CORPS
U. S. ARMY
Aug. 5, 1912

Ordered	Lt. Col. Chrisfield
Data	H. Dalton
Drawn	P.C. Bowen
Checked	
O.K.	
Approved	

Revised
Nov. 4 1912. changed location of primary condenser (1)

FIELD RADIO PACK SET, MODEL 1912

SENDING CIRCUIT DIAGRAM



911b

SIGNAL CORPS
U.S ARMY
Aug. 6. 1912

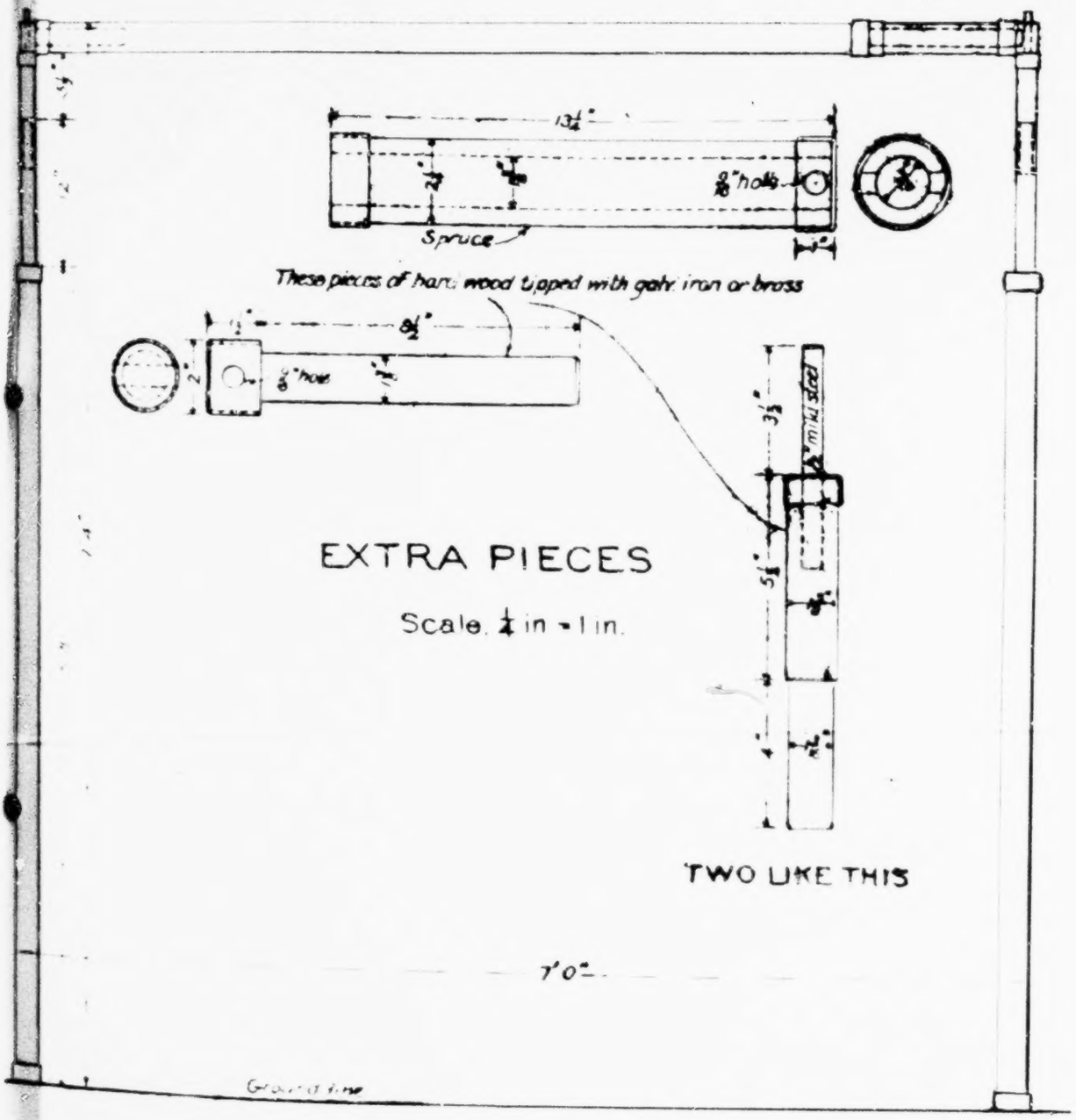
2781

911c

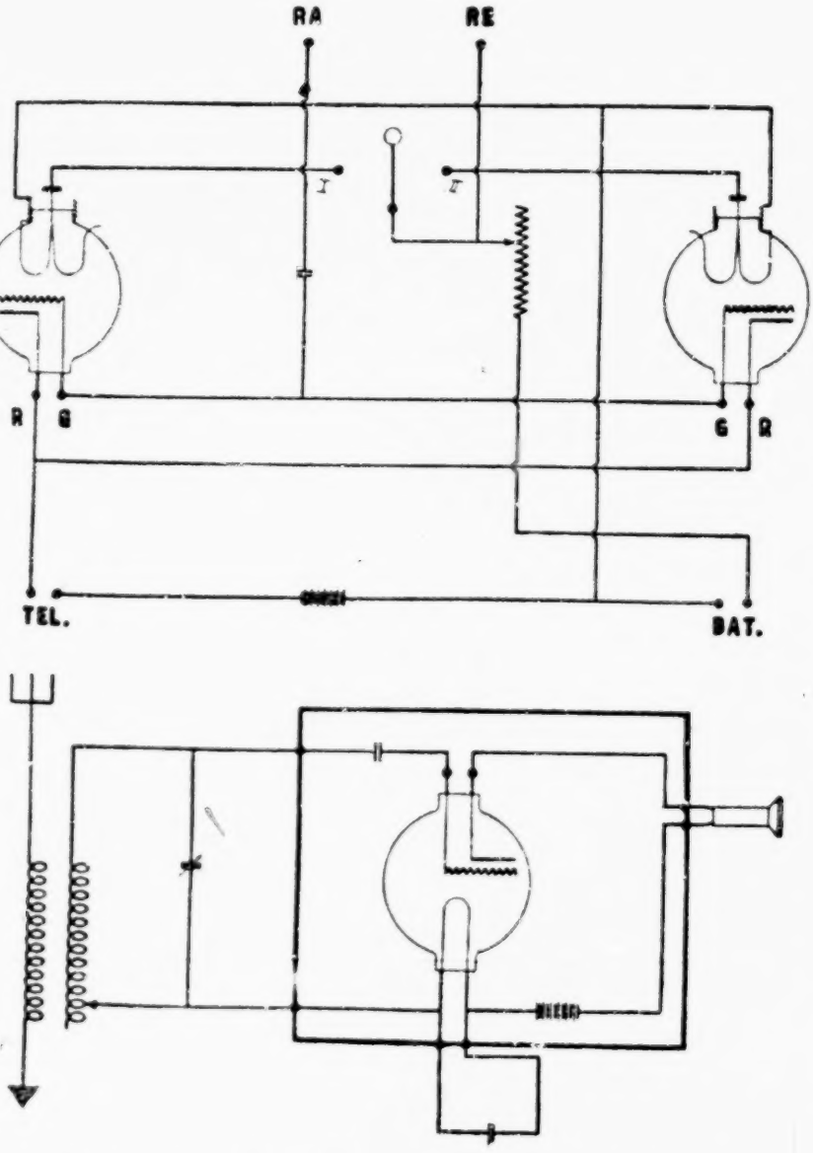
FIELD RADIO PACK SET, MODEL 1912.

POLES FOR SHELTER TENT.

Scale, 1 in. = 1 ft.

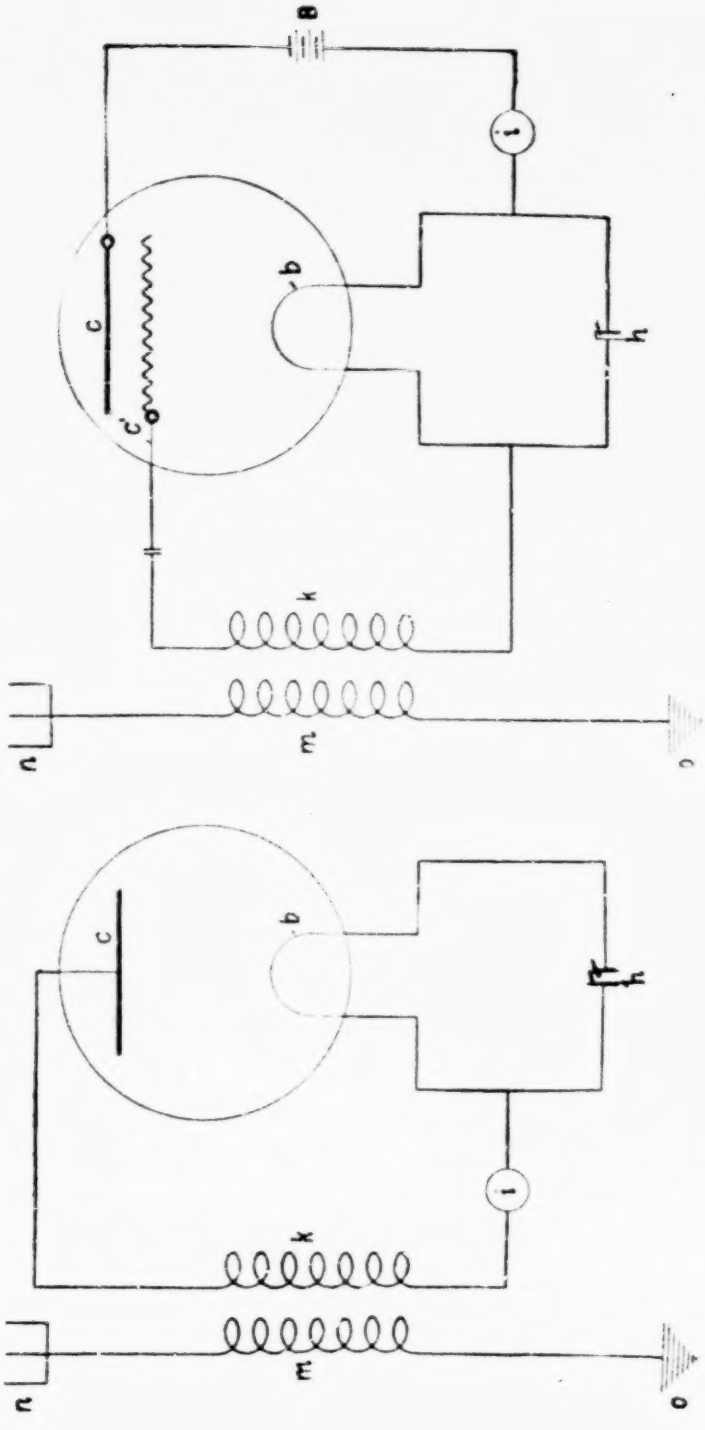


Plaintiff's Exhibit 106



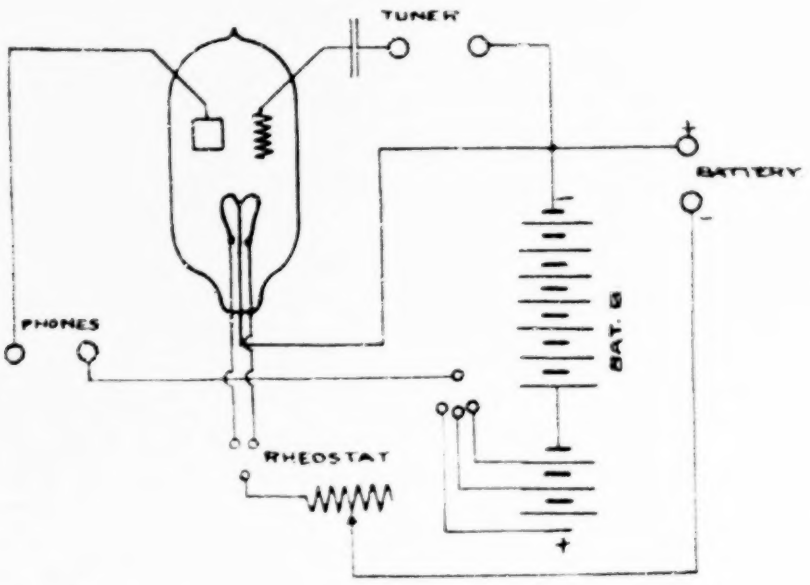
Drawing Simplified Circuits "PN" Detector

Plaintiff's Exhibit 107
Fleming and DeForest Compared



Plaintiff's Exhibit No. 108

Circuit of Type RJ4 Audion Detector



After the first filament has been consumed wind the little copper wire tight around the brass base of bulb underneath the rubber band. This connects the second filament.

Instructions.

Do not connect over six volts Storage Battery to the external binding post marked + and —. Before lighting the filament see that the resistance switch is on "ALL IN" position. Then adjust rheostat until lamp burns at normal brightness. Adjust brightness of filament and the Battery B switch to give maximum sensitiveness.

In connecting up the Audion Detector, connect the grid to G and wing to W as marked below the binding posts. The Grid is the zig-zag wire terminal. The Wing is the plate.

If bulb is capped the green wire leads to the grid, the red leads to the wing.

RADIO TELEPHONE & TELEGRAPH COMPANY

309 BROADWAY, NEW YORK

Concerning the RJ4 Audion Dectector

The Audion has been proven, by scientific and official tests to be from 1.5 to 3 times as sensitive as any crystal detector. With it even in this small and cheap form, telegraphic ranges far greater than those possible with the crystal or electrolytic detectors are easily attained. There is scarcely an amateur who has tried one but will admit this, and consequently has no further use for his crystal detector.

It is reliable, requires no adjustment after the proper voltage and heating currents are determined, it can not be injured by powerful transmitter sparks in the immediate vicinity. If it momentarily loses its sensitiveness by reason of the transmitter spark, it is automatically restored, without the slightest decrease in its sensitiveness.

If too much "Battery B" voltage be applied a blue glow will appear in the bulb, or tube, or may be seen merely around the edges of the "plate" or wing. When this blue glow fills the bulb it is usually not very sensitive, and can be removed by simply reducing the B voltage by the 4-point switch on front of box. The sensitiveness can be instantly restored by merely switching off and on the lighting current. Only one filament should be burned at one time. This doubles the life of the bulb.

Never burn the filament at excessive brilliancy, as full sensitiveness can be obtained at normal brilliancy.

Alway use a storage battery for lighting the lamp, as dry cells run down very quickly when used for that purpose.

Never use more than three cells of storage battery.

Don't let the storage cells run down low and then hook in another fourth cell, because if this is done there is always danger of the run-down cells picking up, or recuperating after a short period of rest and then of burning out the filament when first switched on again.

Connect the secondary of the receiver tuning circuit to the binding posts marked "Tuner."

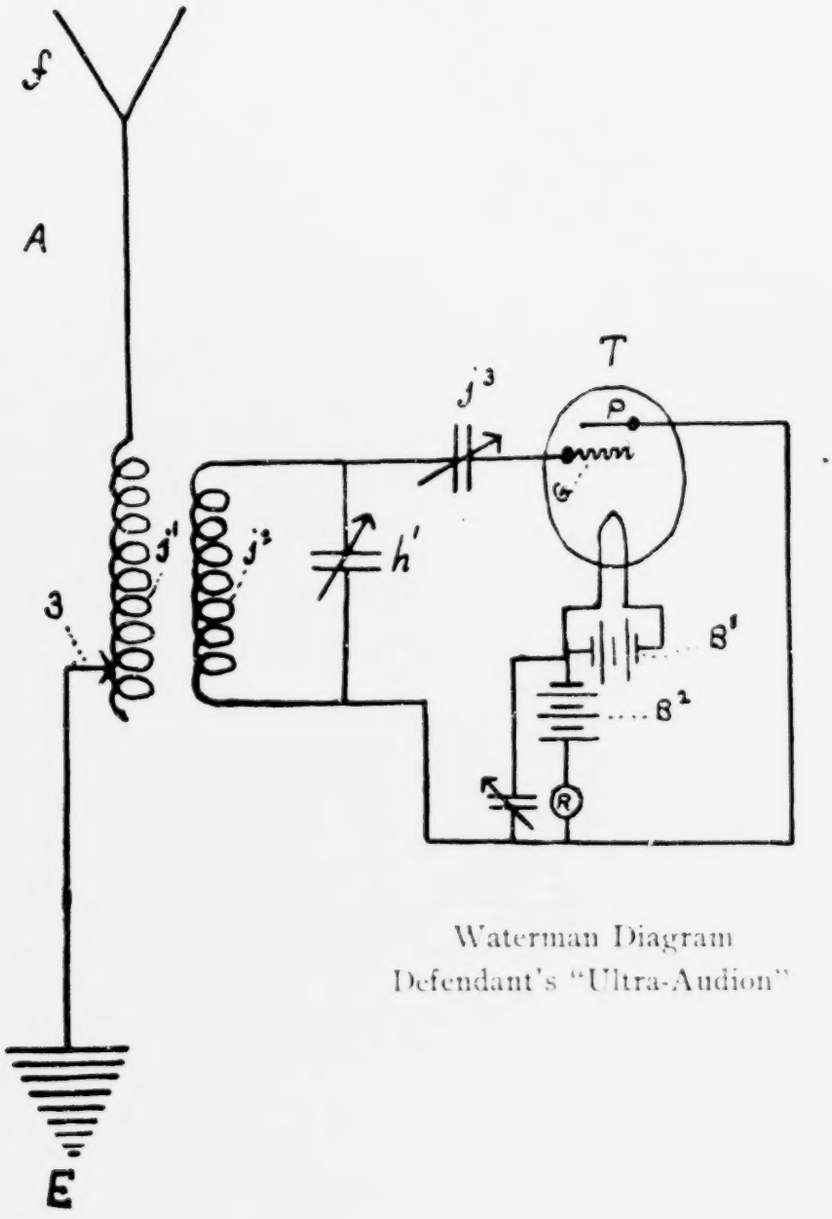
It makes some difference in the results obtained which of these two terminals is connected to one or the other of the two "Tuner" binding posts. The surest way of determining this is to reverse the two connections, and thus observe which gives the louder signals.

The RJ4 Audion set is for **Amateur** work only. It is not under any conditions licensed to be used for commercial work.

RADIO TELEPHONE & TELEGRAPH COMPANY
309 BROADWAY, NEW YORK

Plaintiff's Exhibit 109.

2786



Waterman Diagram
Defendant's "Ultra-Audion"

Plaintiff's Exhibit 110

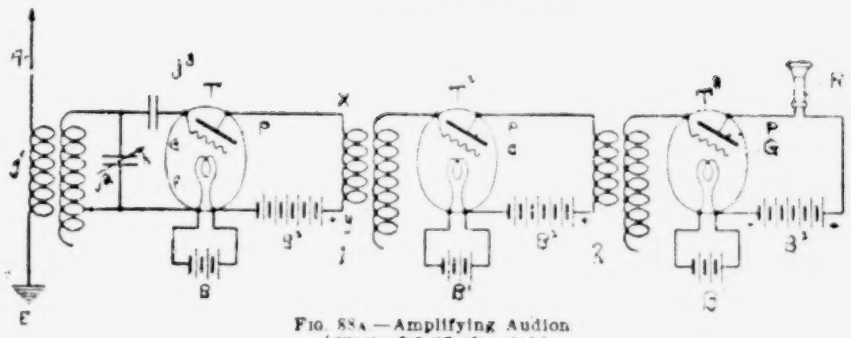
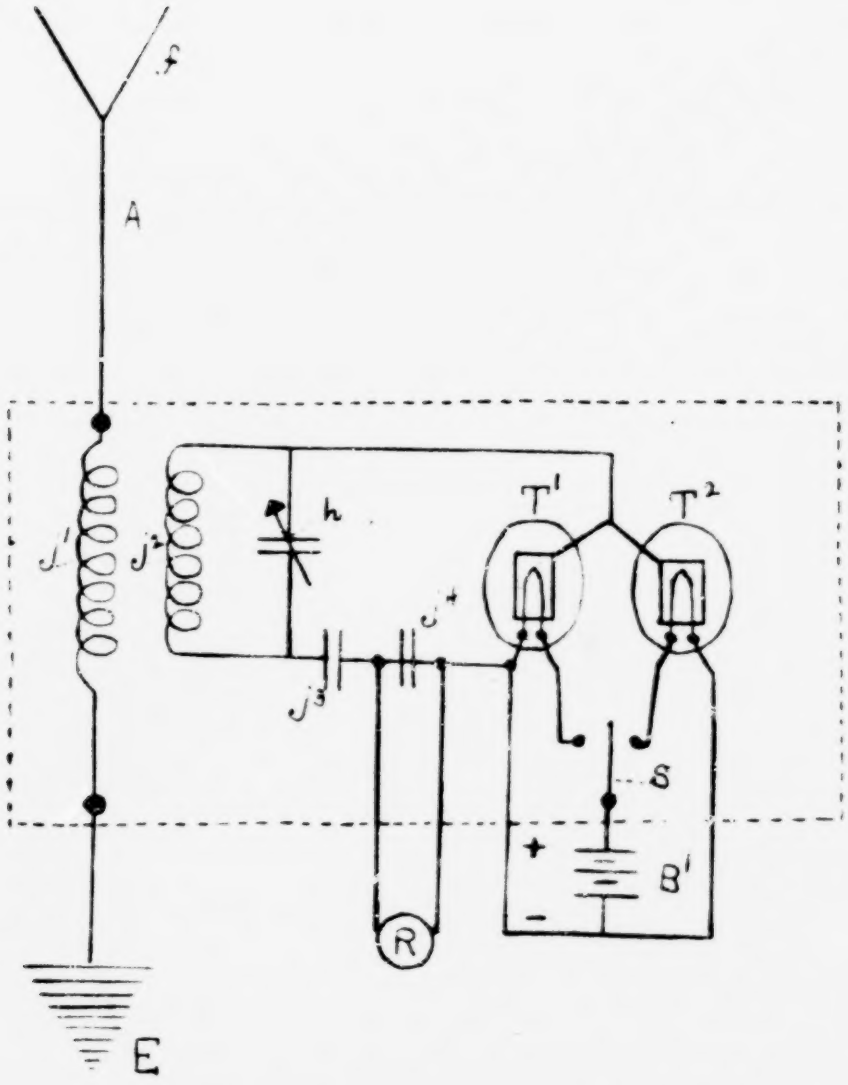


FIG. 88A.—Amplifying Audion
(FROM NAVY MANUAL 1915)

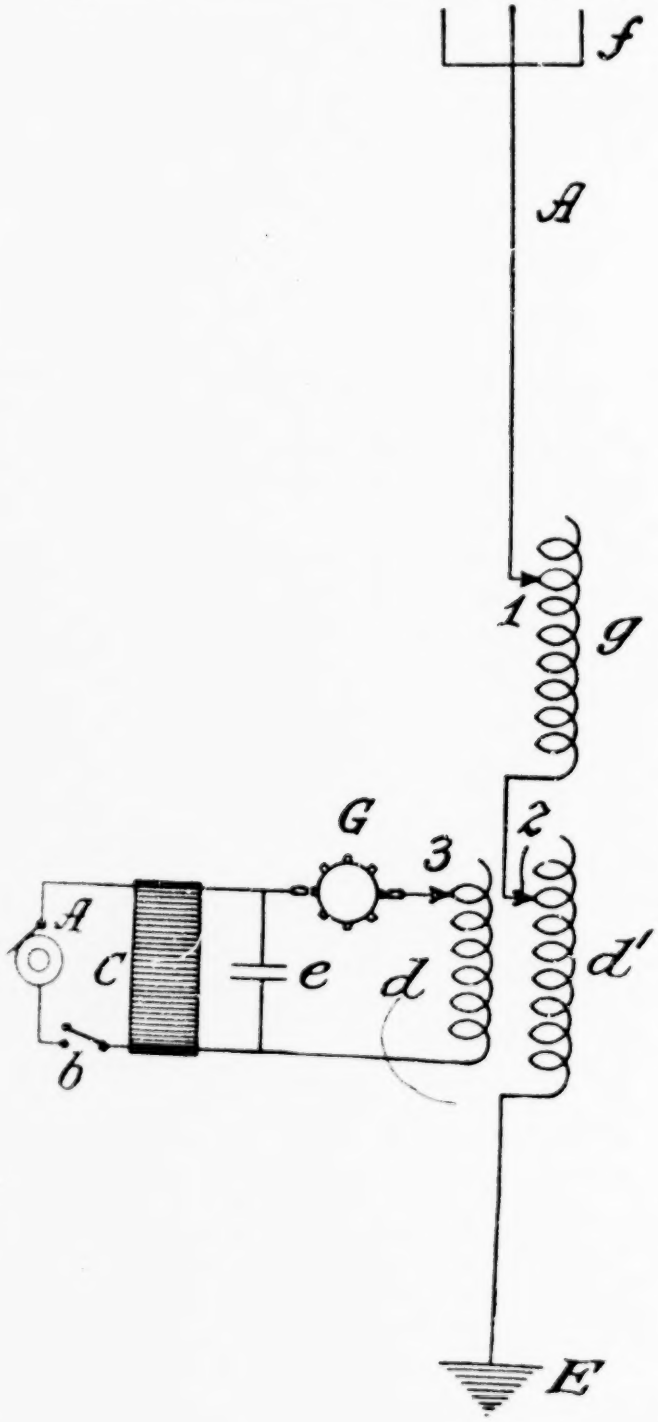
Plaintiff's Exhibit 111



Waterman Sketch Circuits of Plaintiff's Exhibit 28
Fleming Valve Receiver

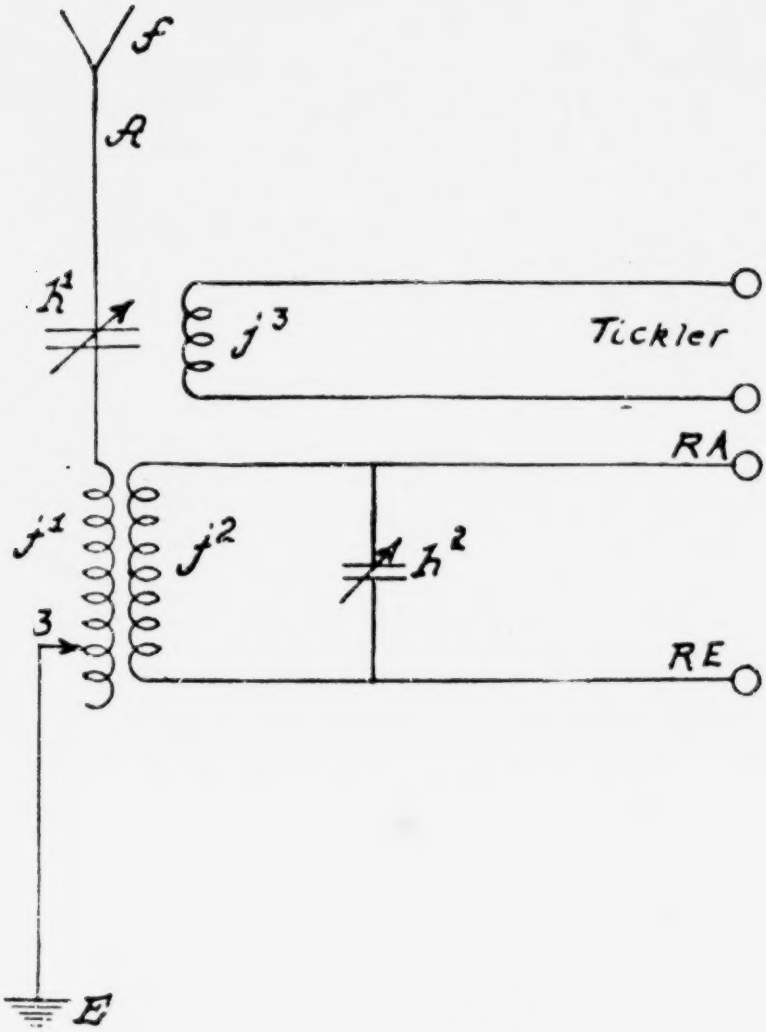
Typical Transmitter with Rotating Gap

Plaintiff's Exhibit 112
Typical Transmitter with Rotating Gap



Plaintiff's Exhibit 113

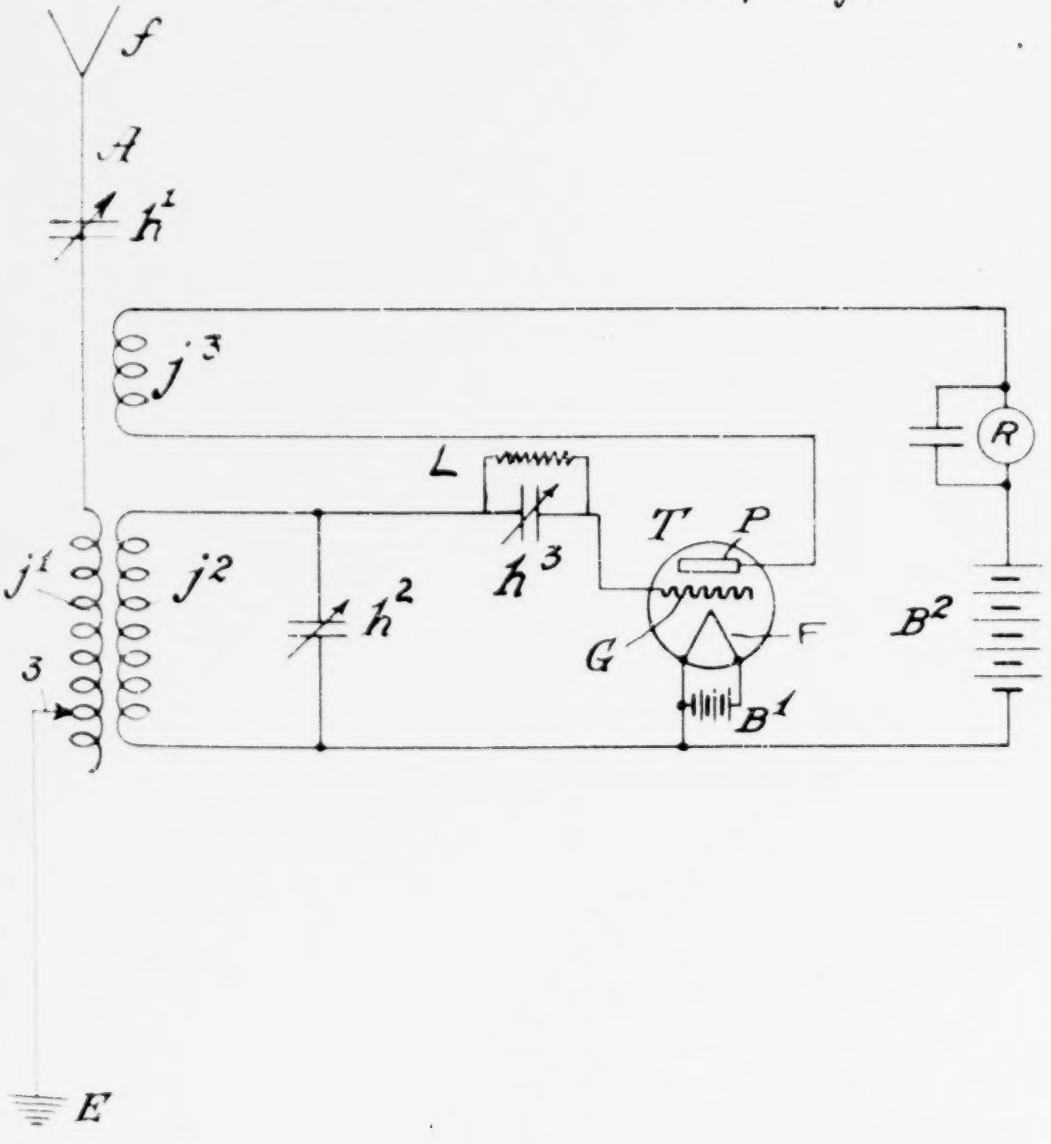
Receiver arranged with terminals for any form of detector



PLAINTIFF'S EXHIBIT 114 2791

VACUUM TUBE RECEIVER.

Arranged for both oscillations and regeneration!
(with inductive coupling)

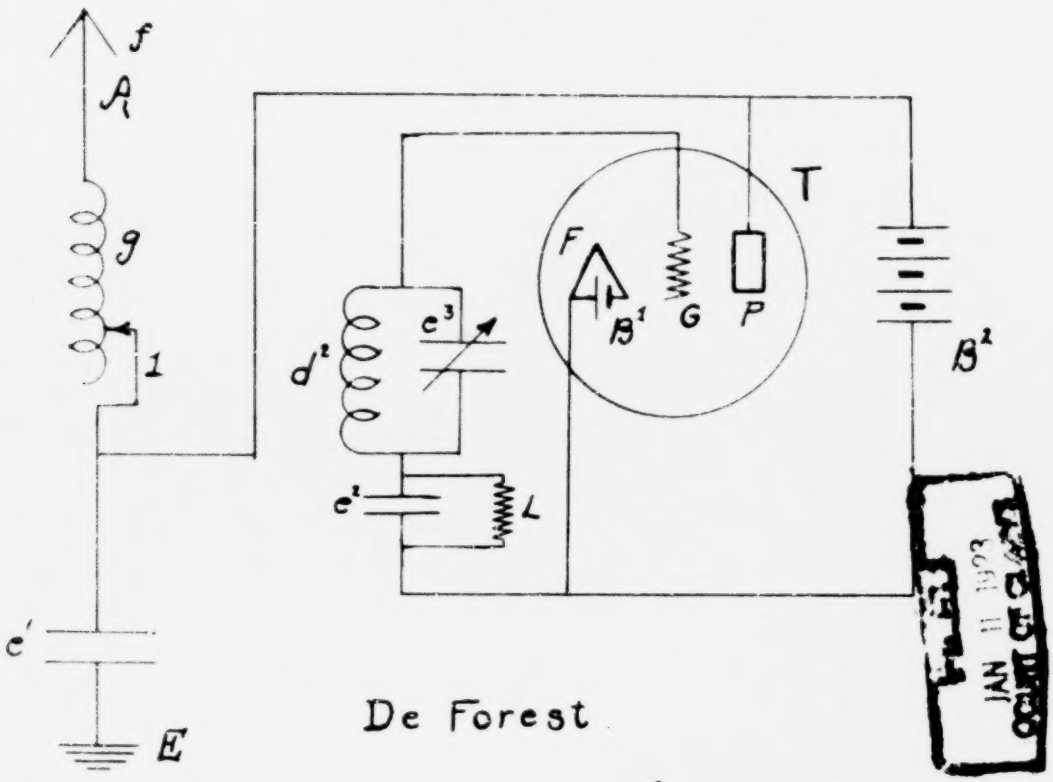


JAN 11 1917

E. L. Chaffee, Commissioner.

PLAINTIFF'S EXHIBIT 116

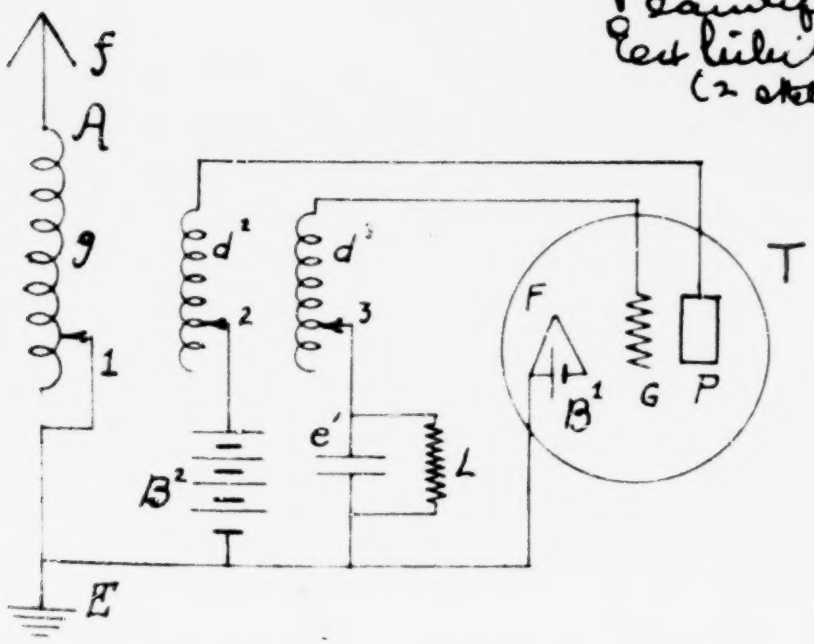
Vacuum Tube Transmitters
for Radio Telephony



De Forest

JAN 11 1923

Marconi vs.
Hle U.S. # 33642
Plaintiff's
Exhibit 116
(2 sketches.)



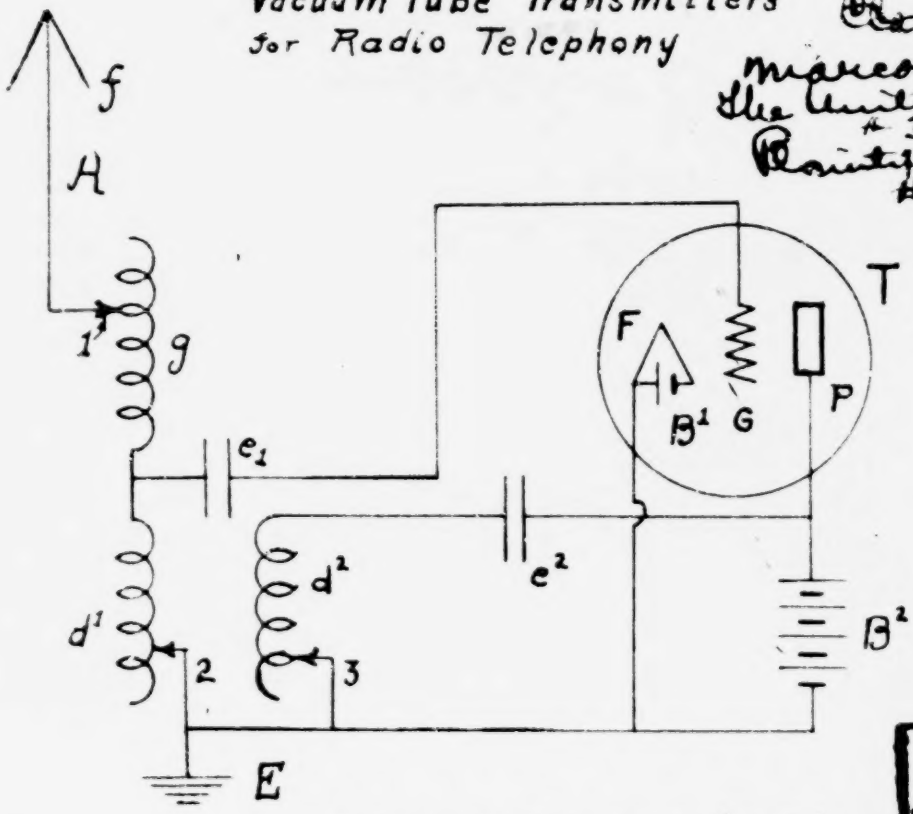
2426

General Electric (No1)

PLAINTIFF'S EXHIBIT 116

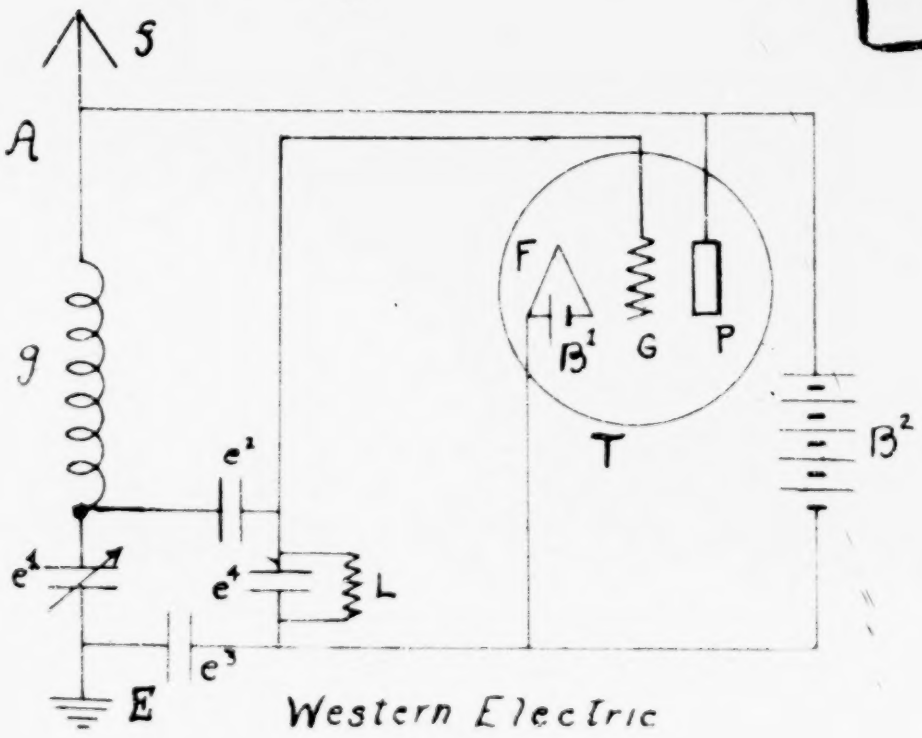
Vacuum Tube Transmitters
for Radio Telephony

Marconi vs
The United States
33, 634
Plaintiff's Ex.
#116.



General Electric (No 2)

FILED
JAN 11 1923
COURT OF CLAIMS



Western Electric

PLAINTIFF'S EXHIBIT 120

~~Please read and send in as full a discussion as possible at earliest date~~

The Canadian Society of Civil Engineers

INCORPORATED 1887.

~~ADVANCE PROOF — subject to revision.~~

~~N.B. The Society, as a body, does not hold itself responsible for the statements and opinions advanced in any of its publications.~~

INTERFERENCE IN WIRELESS TELEGRAPHY

By John Stone Stone

Read before the Electrical Section, 9th March, 1905.

Introduction

Of the various problems which have been presented in the course of the development of the new art of wireless telegraphy, none is of greater interest to the engineer and none is of more far-reaching importance from the industrial and commercial standpoint than that of rendering the receiving instruments of wireless telegraph stations immune from *interference*.

There are two principal kinds of interference:

1st. Interference which arises from electrical charges which accumulate upon the vertical oscillator under various conditions of weather, provided the vertical oscillator has no adequate electrical connection to the earth.

2nd. Interference which arises from such stray electromagnetic waves as are produced by lightning, by magnetic storms, by sparks in neighboring circuits, such for instance as occur in trolley circuits, and also from the electromagnetic waves emanating from wireless telegraph stations other than that with which communication is desired.

Interference Due to Static Charges.

The interference which results from the first of these two sources is readily overcome since the oscillator of a wireless receiving station may always be given a metallic connection to the earth sufficient to maintain it clear of statical charges without in any appreciable degree interfering with its operation as a receiving oscillator.

Thus for instance if the vertical oscillator includes a condenser insulating a portion of the vertical oscillator from the earth, the condenser may be shunted by a coil of inductance so large that

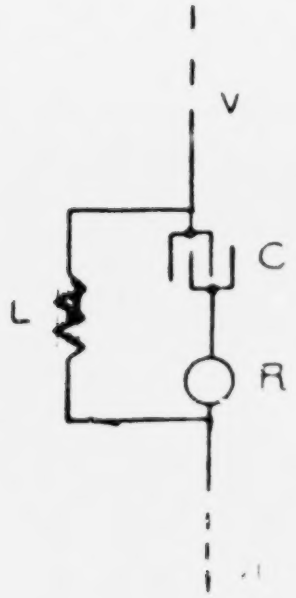


Fig. 1.

for the high frequencies employed in wireless telegraphy it will operate practically as an open circuit, whilst affording a ready path to earth for the electrical charges which, in its absence, would accumulate upon the vertical oscillator and produce disruptive discharges to earth.

Again, if a highly sensitive detector or receiving device be included directly in the vertical receiving oscillator, such an inductance coil may be placed in shunt to the receiver without appreciably affecting its sensitiveness. The coil will then serve as a by-path for the currents due to the passage of the charges of the vertical oscillator to the earth.

Another device which may serve to still further protect the receiver under these conditions is that illustrated in Fig. 1, in which

V and V' are portions of the vertical oscillator system, L is a coil of large inductance, R is the receiving device, and C is a condenser of capacity so large as not to impede appreciably the passage of the high-frequency oscillations of wireless telegraphy while acting practically as an open circuit for the more slowly varying currents by which the vertical oscillator is maintained free of static charges.

The greatest security from this form of interference is however obtained by providing the vertical receiving oscillator with an adequate conductive connection to earth and by placing the receiving device in a local circuit made resonant by a coil and a condenser to the frequency of the electrical oscillations to which the receiver is intended to respond.

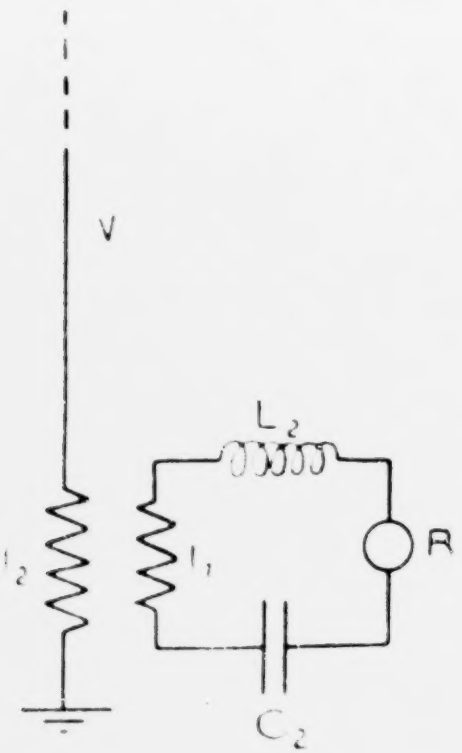


Fig 2

An example of such an arrangement is shown in Fig. 2, in which V L I is the vertical receiving oscillator, I_1 and I_2 are the [illegible] a high frequency transformer, R is the receiver, C [illegible] and L_2 is an inductance coil.

The manner in which the local circuit containing the receiver is made resonant to the frequency of the oscillations to which it is intended to respond will be considered later in this paper. It is

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sufficient here to note that the local circuit being resonant to a frequency sufficiently high for the purposes of wireless telegraphy, will not be appreciably affected by the more slowly varying currents in the vertical oscillator by which the latter is maintained free from static charges.

INTERFERENCE DUE TO ELECTROMAGNETIC WAVES.

Coming now to the prevention of interference by electromagnetic waves such as emanate from other wireless stations than that with which it is desired to hold communication, and to the prevention of interference by stray electromagnetic waves, we find that the solution of the problem depends upon the character of the message-bearing wave, the energy of which it is desired to convey to the receiving device, and also upon the character of the disturbing waves, the energy of which it is desired to exclude or divert from the receiving device.

We can control the character of the waves whose energy we wish to receive, by suitably designing the apparatus to be used at the transmitting station, but we have no control over the character of the disturbing waves except in so far as these arise from wireless stations within operative range of the receiving station.

The simplest solution of this problem is to cause each transmitter to send out its signals by means of *persistent trains of simple harmonic waves* of a frequency materially different from that employed by any other transmitter within operative range of the receiving station with which communication is to be maintained and to make each receiver responsive only to *persistent trains of simple harmonic waves* of the frequency employed by the transmitter with which it is in communication.

By this means the system is rendered selective and becomes a multiple system of telegraphy, permitting the operator at each station to select the station with which he wishes to hold communication to the exclusion of all the other stations, and by which a number of messages may be transmitted simultaneously in a given region without interfering with one another.

Since the stray electromagnetic waves arising from lightning etc., are not persistent trains of simple harmonic waves, but partake more of the character of isolated impulses, the receiver in such a system does not respond to such stray electromagnetic waves and it is therefore also freed from interference which would otherwise arise from such sources.

The manner in which a transmitting station is made to develop persistent trains of simple harmonic electromagnetic waves

of one frequency to the exclusion of waves of other frequencies, though simple in itself, in practice requires the strictest attention to certain details, and these may be best understood by the consideration of a concrete case, this being the manner in which such problems are usually presented to the engineer if not to the inventor.

Transmitter.

In modern wireless telegraphy the messages are transmitted by electromagnetic waves which are horizontally polarized at the earth's surface, and which are developed by electrical oscillations set up in an electrical oscillator whose axis is normal to the surface of the earth and which is connected to the earth at its lower extremity.

The reason for employing waves of this type and so developed, is that such waves have, at the earth's surface, no component of electric force parallel to the surface and no component of the magnetic force normal to or cutting that surface, except in the immediate neighborhood of the base of the transmitting oscillator. As a result they do not tend to induce currents in the surface of the earth as they travel away from the transmitter except where the surface of the earth deviates from the plane of polarization of the waves at that surface. The energy which would otherwise be rapidly dissipated through the production of induced currents in the earth is therefore conserved in the waves. Moreover when a deviation occurs between the plane of the earth's surface and the plane of polarization of the waves at the earth's surface, the currents induced in the surface of the earth are such as to bend the wave front into a position normal to the surface with the result that the waves travel over and around mountains and in fact follow the earth's surface whatever be its contour, instead of tending to travel in straight lines like ordinary light waves and as would be the case with vertically polarized electromagnetic waves.

For a more complete exposition of these points see a paper read by the Author at the International Electrical Congress held at St. Louis, Sept. 12 to 17, 1904, and reprinted in the Electrical Review, New York, Oct. 15, 1904.

There is not space in this paper to discuss in detail the development of the waves described above, but their genesis and mode of propagation is clearly suggested by Figs. 3 to 8. Fig. 3 and Fig. 4 illustrate the development of a wave by free electrical oscillations in a straight wire AoB, the curve lines indicating a line of electric force in its various phases from $t=0$ to $t=\frac{1}{8}$ T, where T is the time of a complete free electrical oscillation in the

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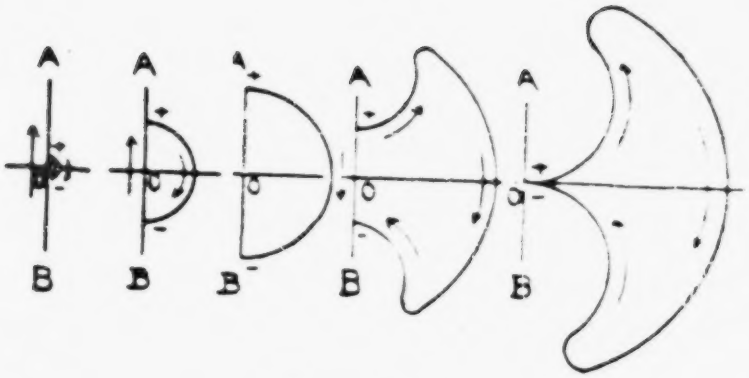


Fig. 3

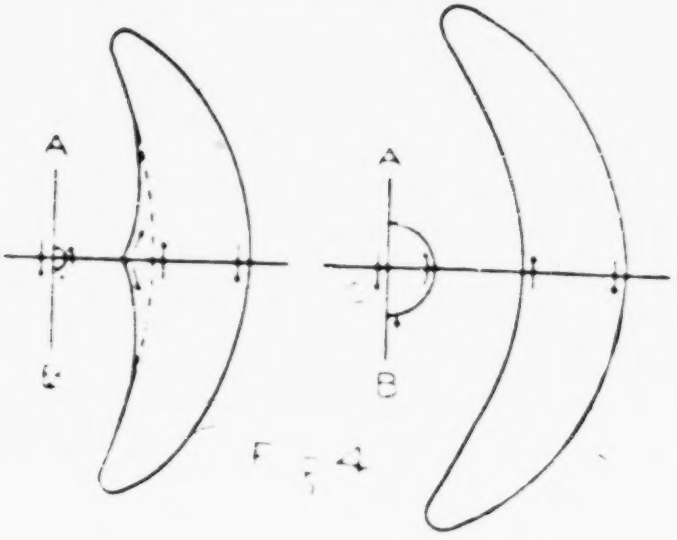
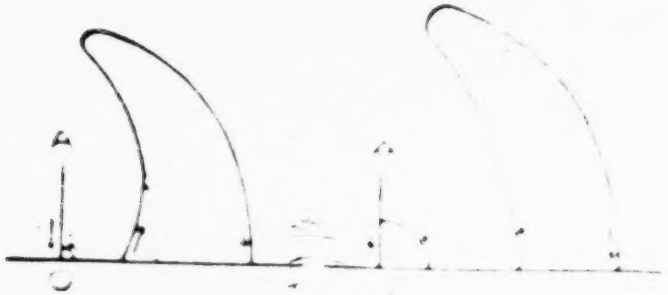


Fig. 5



wire. In Figs. 5 and 6 the genesis of a wave from a vertical linear oscillator Ao earthed at its lower extremity is illustrated, and in Figs. 7 and 8 the effect of an elevation and depression in the surface of the earth upon the wave fronts at that surface is indicated.

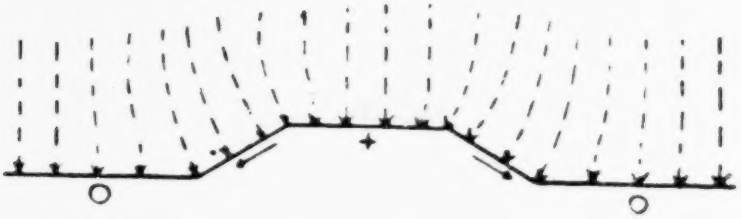


Fig 7

We may next consider the earth connection of the transmitting oscillator and the nature of the support for the oscillator.

Although, by the use of such waves as are described above, normally the current density in the surface of the earth at a distance from the transmitting oscillator is rendered excessively small, nevertheless at, and in the immediate neighborhood, of the base of the vertical oscillator, the current density is in general very great. Moreover since the current is of high frequency, it tends to flow only on the surface of the earth. For this reason the usual

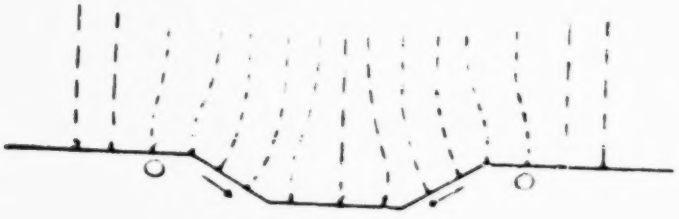


Fig 8

specifications for obtaining a good earth connection, which involves burying a conductor of large area so deep in the ground that it shall be in permanently moist earth, are no longer advantageous, and in a properly constructed wireless telegraph station the conductivity of the *surface of the earth* in the immediate neighborhood of the base of the oscillator is artificially increased by a *superficial ground-plate* composed of sheet metal, or of wire netting, extending radially from the base of the oscillator and covering as large an area about the base of the oscillator as is available for the purpose and consistent with reasonable economy.

Since the waves are horizontally polarized, the supports for the vertical oscillator, such as masts and guy-ropes, should either be of insulating material, or if of metal, they should be divided by insulation into sections short compared to one-half the wave-length of any of the waves to be employed. The reason for this is that the fundamental free period of vibration of a linear conductor is such as to cause it to respond most energetically to waves of twice its own length. For such wave-lengths, therefore, the linear conductor would absorb an undue amount of the energy of the waves and moreover because of the rise of potential which occurs at the ends of the conductor for waves of such length it would be difficult to insulate the conductor from the earth or adjacent portions of the support of the vertical oscillator.

We come now to the vertical oscillator itself. This in general consists of two parts, the elevated conductor *per se* and the devices through which it is connected with the earth.

We shall here consider the relatively simple case in which the elevated conductor is a straight, cylindrical copper wire of length a and radius ρ

Both theory and practice show that the electrical vibrations in such a wire connected directly to the earth at its lower extremity correspond very closely to the transverse vibrations of a heavily damped stretched string.

If such a wire be charged to a high potential and be then permitted to discharge to earth, the electrical oscillations developed in it, and therefore also the electromagnetic waves radiated by it will not be simple harmonic in type and will not be persistent. These waves will not therefore correspond to the sound waves given out by a tuning-fork, but will be of the character of those given out by a heavily damped violin string plucked at its centre.

The fundamental of the waves given out by such an oscillator has a wave-length which very closely approximates four times the length of the wire, and this is accompanied by all the odd harmonics. The oscillations are so much damped by the energy drawn off from the oscillator by radiation as to make the resulting waves more nearly the equivalent of an impulse than of a sustained or persistent train of waves.

If, however, the elevated conductor be not directly connected to the earth, but be connected to it through an inductance coil, both theory and practice show that its electrical vibrations correspond to the transverse vibrations of a heavily damped stretched string with a mass attached to its centre.

The effect of the load at the centre of the stretched string and of the inductance at the base of the vertical wire is to increase the

persistency of the vibrations, to minimize the importance of the harmonics and to lower the frequency of the fundamental. It might therefore seem that in order to cause the vertical oscillator in question to radiate a persistent train of simple harmonic waves of a predetermined frequency, it would be sufficient to charge the

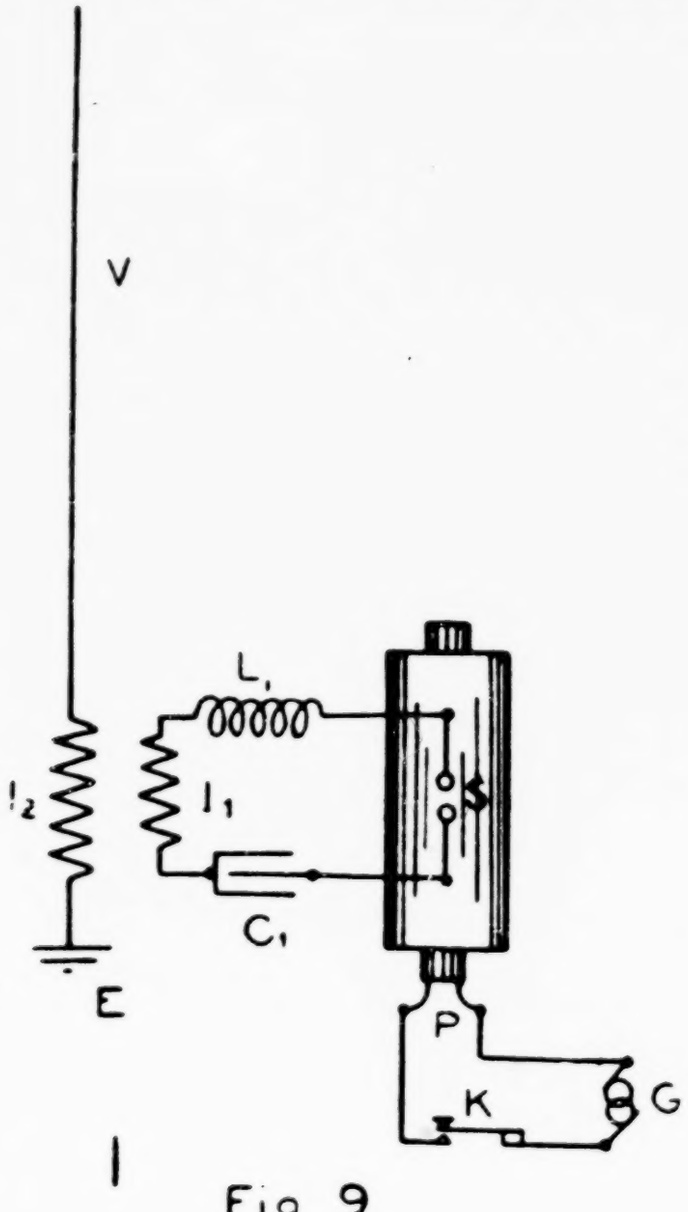


Fig 9

vertical wire to a high potential and permit it to discharge to earth through an inductance coil of suitable dimensions.

This indeed was the plan adopted in the first crude attempts at producing a selective system of wireless telegraphy. This method necessitates the use of waves of much lower frequency than that normally produced by natural vibrations in the vertical wire *per se*.

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The degree of persistency of oscillations so obtained however, is not as great as is required in practice. Such persistency as is obtained is gained at the expense of the amplitude of the current oscillations in the vertical and at the expense of the radiating power of the oscillator, the latter being *cæteris paribus* less for low than for high frequencies. Moreover the spark in the vertical oscillator which normally dissipates an undue amount of the energy of the oscillations, has its resistance enhanced by the reduction of the amplitude of the current oscillations due to the presence of the inductance coil.

This latter difficulty may in a measure be overcome at the expense of any increase of the energy supplied to the oscillator, by shunting the spark gap by a condenser of large capacity. The discharge of the condenser across the spark gap increases the current through the spark and thereby reduces its resistance and damping effect upon the oscillations. The damping effect of the radiation still remains and the persistency is still too much limited for practical purposes.

So far we have considered only the *natural oscillations* of the vertical oscillator which are produced by charging the elevated conductor to a high potential and then permitting it to discharge to earth. When, however, a high degree of persistency, a pure sine wave and a great amplitude of oscillation are desired, the spark gap is removed from the vertical oscillating circuit and a simple harmonic electromotive force is impressed upon the vertical oscillator in its place. The resulting vibrations in the vertical oscillator are then *forced simple harmonic vibrations*. In order that they may be of great amplitude, the frequency of the impressed force is made to correspond to the fundamental of the vertical oscillator or to one of its harmonics, in which cases the reactance of the vertical oscillator is nil.

A simple arrangement for producing forced, simple harmonic vibrations in the vertical oscillator is shown in Fig. 9 in which G is an alternating current generator, k is a key, P shows the connection to the terminals of the primary of a spark coil, S is a spark gap between the terminals of the secondary of the spark coil, C_1 is a condenser, L_1 is an inductance, I_1 and I_2 are the primary and secondary coils of a high-frequency transformer, T is the vertical wire and E is the earth.

There is a variety of ways in which substantially the same result may be accomplished, but there is not space in this paper to consider more than one arrangement.

For the type of elevated conductor which we are here considering, i. e. a cylindrical copper wire of length a and radius r the reactance

of the elevated conductor *per se* is given with a degree of approximation ample for engineering calculations by the expression;—

$$Z = -Lv \cot \frac{na}{v}$$

where $$L = 2 \log_e \frac{4a}{\rho} - k$$

and where $$k = 5{\cdot}584 - 3{\cdot}169\left(\frac{na}{v}\right)^2 - 0{\cdot}3269\left(\frac{na}{v}\right)^4$$ for values of a between 0 and $\frac{\pi v}{2n}$

In these expressions v is the velocity of light and n is the periodicity of the impressed force or $\frac{2\pi}{T}$ where T is the time of a complete oscillation.

The reactance Z therefore vanishes when $n = \frac{2\pi}{T} = m\frac{\pi}{2a}$ where m is an odd integer. The wave lengths corresponding to this condition are therefore $\lambda = VT = \frac{4a}{m}$. The wave-length of the fundamental is therefore 4a and the harmonics are all odd.

For frequencies lower than the fundamental the reactance is negative or a capacity reactance. For frequencies between that of the fundamental and its first harmonic the reactance is positive or an inductance reactance. For frequencies between that of the first even harmonic and the first odd harmonic the reactance is again negative or a capacity reactance. In other words the reactance of the vertical wire measured at the source of disturbance or point of the system is either that of a condenser of capacity $\frac{1}{\quad}$ or of an inductance $\frac{1}{\quad}$ depending upon whether $\cot \frac{na}{v}$ is positive or negative.

The condition for zero reactance in the vertical conductor system is obviously $Z_1 + Z_2 = 0$ where Z_2 is the reactance of the apparatus connected between the vertical wire and the earth. It must therefore be an inductance reactance for frequencies which make the reactance of the vertical wire a capacity reactance and

conversely it must be a capacity reactance for frequencies which make the reactance of the vertical wire an inductance reactance.

The curve shown in Fig. 10 gives the observed apparent capacity of vertical wires 0".08 in diameter varying from 40 to 150 feet in length, when the periodicity of the impressed force is 9.78×10^{5}. In other words it gives the observed apparent capacity of vertical wires for values the angle of $\frac{ns}{v}$ from 0.3976 to 1.790 and for values of the ratio $\frac{4a}{\lambda}$ from 47.520 to 213.800.

The reactance $Z_{"}$ of the apparatus through which the vertical wire is connected to ground may most simply be made negative, when this is necessary, by the insertion of a condenser in series with the coil $L_{"}$, but this result may be accomplished in a variety of ways for the description of which there is not space in this paper.

It will be seen that by making $Z_{"} + Z_{'}$ (or $Z_{"} - Z_{'}$) equal, but opposite in sign to the reactance of the elevated conductor, powerful oscillations of any desired frequency may be developed in the vertical oscillator by means of forced vibrations, whereas when the natural oscillations of the vertical oscillator are resorted to the frequency must necessarily be less than that of the fundamental of the oscillator.

Concerning the arrangement illustrated in Fig. 9, there is much of detail which requires attention in order that the apparatus shall satisfactorily fulfil the requirements of radiating a persistent train of simple harmonic waves. For instance, if a dielectric having considerable electrostatic hysteresis be employed in the condenser, a surprisingly large amount of energy will be dissipated in this dielectric. The magnitude of this loss is due to the fact that the energy dissipated increases both with the potential difference employed at the terminals of the condenser and also with the frequency. Since potential differences developed at the terminals of the condenser amounting to 50,000 volts and oscillations having frequencies of 3,000,000, are not unusual in wireless telegraphy, it is easy to see that the losses in the dielectric of a condenser in a wireless telegraph circuit are of a far greater order than that in the dielectric of condensers employed in the usual power or lighting circuits.

Moreover the specific inductive capacity of most dielectrics is a function of the density of the displacement current in the dielectric, and when such dielectrics are employed in the condenser in an oscillating circuit the resulting oscillations are not simple harmonic in form and are not isochronous throughout the train. in series with the coil $L_{'}$, but this result may be accomplished in

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Air condensers should therefore be used in wireless telegraphy to the exclusion of any other type pending the publication of the results of certain investigations which are being conducted with the view of supplying a dielectric of high dielectric strength and constant specific inductive capacity.

The coils used in wireless telegraphy should not have iron cores except the iron be very finely comminuted and imbedded in a non-hygroscopic dielectric matrix. It has even been found by the author that coils wound on a wooden cylinder do not operate satisfactorily when used in the oscillating circuits of wireless telegraphy. The coils for this purpose are best constructed by winding a few turns of bare copper wire in a single layer on a skeleton frame made of ebonite, care being taken to separate the turns by such an amount that the sum of the air spaces between the wires of the turns is equal to or slightly greater than the sparking distance in air corresponding to the greatest potential difference liable to occur at the terminals of the coil when the apparatus is in operation.

If the local oscillating circuit C_1 I_1 L_1 S of the arrangement shown in Fig. 9 were isolated, its oscillations would be expressed by $i = \frac{e}{L} \frac{1}{\sqrt{\frac{1}{LS} - \frac{R^2}{4L^2}}} \cdot e^{-\frac{R}{2L}t} \cdot \sin \sqrt{\frac{1}{LS} - \frac{R^2}{4L^2}}$ where i is the current, e is the potential to which the condenser C_1 is charged at the time when the spark occurs at S, L is the inductance of the circuit, R is the resistance and S is the permittance or electrostatic capacity of the condenser.

If the oscillator is at all persistent $\frac{R^2}{4L^2}$ is negligible compared to $\frac{1}{LS}$, and the expression reduces to

$$i = e \sqrt{\frac{S}{L}} \cdot e^{-\frac{R}{2L}} \cdot \sin \frac{t}{\sqrt{LS}}$$

The time required to fall to $\frac{1}{e}$ th of their initial amplitude is therefore $t = \frac{2L}{R}$

The number of oscillations per unit of time is $\frac{1}{2\pi\sqrt{LS}}$

The measure of the persistency of the circuit is therefore proportional to $\sqrt{\frac{L}{R'S}}$

For a given frequency, $L_n = \frac{I}{Sn}$ so that the persistency for a given frequency is proportional to $\frac{L_n}{R}$, where n is 2π times the frequency.

An isolated circuit of this type may be made to give extremely persistent simple harmonic oscillations, but if it be given a large co-efficient of mutual induction with another oscillator of relatively low persistency, such as the vertical oscillator V_1E of the arrangement shown in Fig. 9, two things happen. In the first place the oscillations of the circuit are in general no longer simple harmonic, but are broken up into two simple harmonic oscillations of different frequencies, and in the second place the persistency is greatly reduced.

To overcome this difficulty it is necessary either to make the magnetic leakage of the high frequency transformer, connecting the local oscillating circuit with the vertical oscillator, unusually large, or else to add to the local oscillating circuit an inductance coil L_1 with sufficient inductance to swamp by its effect the reaction from the secondary circuit.

When intense radiation is desired, it is necessary to make the capacity S of the condenser C_1 in the local oscillating circuit large compared to S' the apparent capacity of the elevated conductor *per se*, for the frequency employed.

Receiver.

Since the electromagnetic waves to be received at a wireless telegraph receiving station are horizontally polarized at the earth's surface, an electrical oscillator whose axis is normal to the earth's surface is employed at the receiving station. This oscillator may either be connected to earth at its lower extremity or it may be connected to a device having reactance equal for all frequencies to the reactance of the vertical oscillator. It is to be remembered in this regard that at the receiving station we are not concerned with what becomes of the energy which is dissipated by the re-radiation of the energy from the receiving vertical oscillator.

We shall consider again a simple concrete case, and shall assume the elevated conductor to be a cylindrical copper wire of length a and radius ρ as in the case of the transmitter, though it must by no means be assumed that the elevated conductor at the receiving station must necessarily be similar to that at the

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transmitting station, or, in fact, that it must bear any resemblance to that at the transmitting station except in so far as its axis is preferably normal to the surface of the earth

As in the case of the transmitting station, only one simple arrangement of the apparatus sufficient to give the desired result will here be considered. By this arrangement messages transmitted by means of persistent trains of simple harmonic electromagnetic waves of a predetermined frequency may be received to

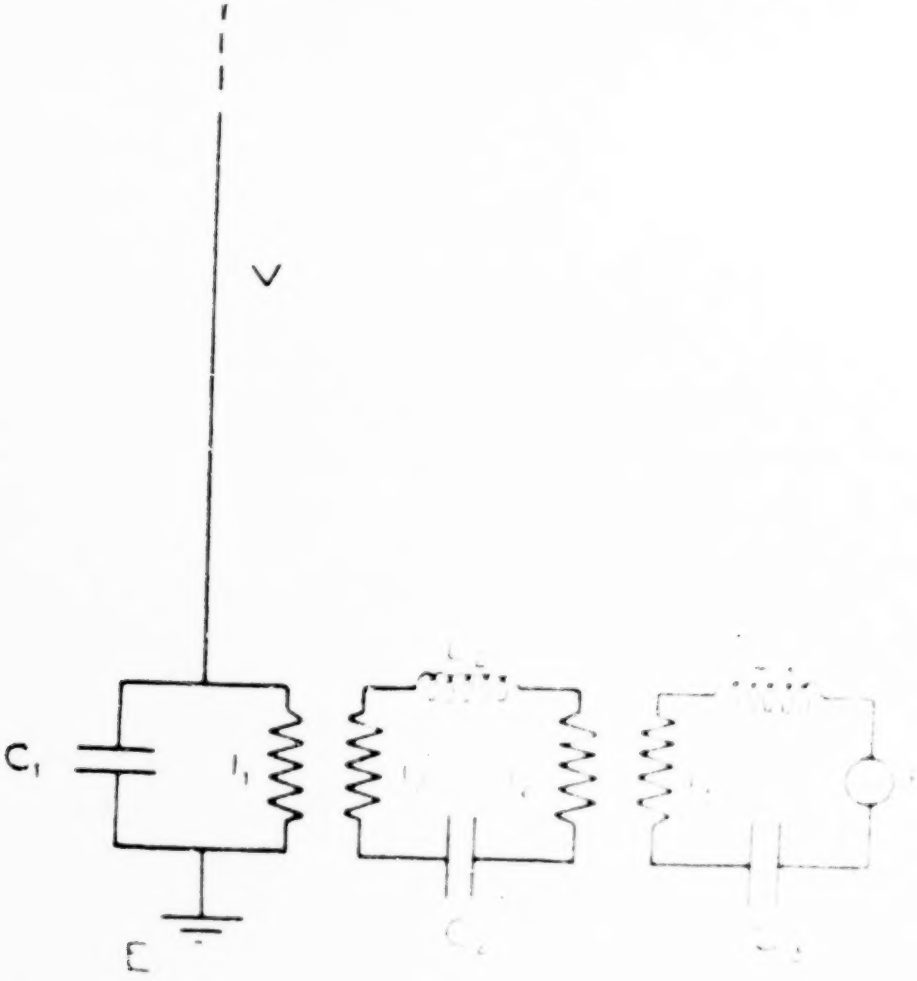

Fig. 1.

the exclusion of messages transmitted in similar ways [illegible] ially different frequencies, and without interference [illegible] waves. Such an arrangement of the [illegible] is shown in the diagram. In this [illegible] device which is indicated at R is [illegible] L, R which is made reasonant to the [illegible] which the station is intended to [illegible]

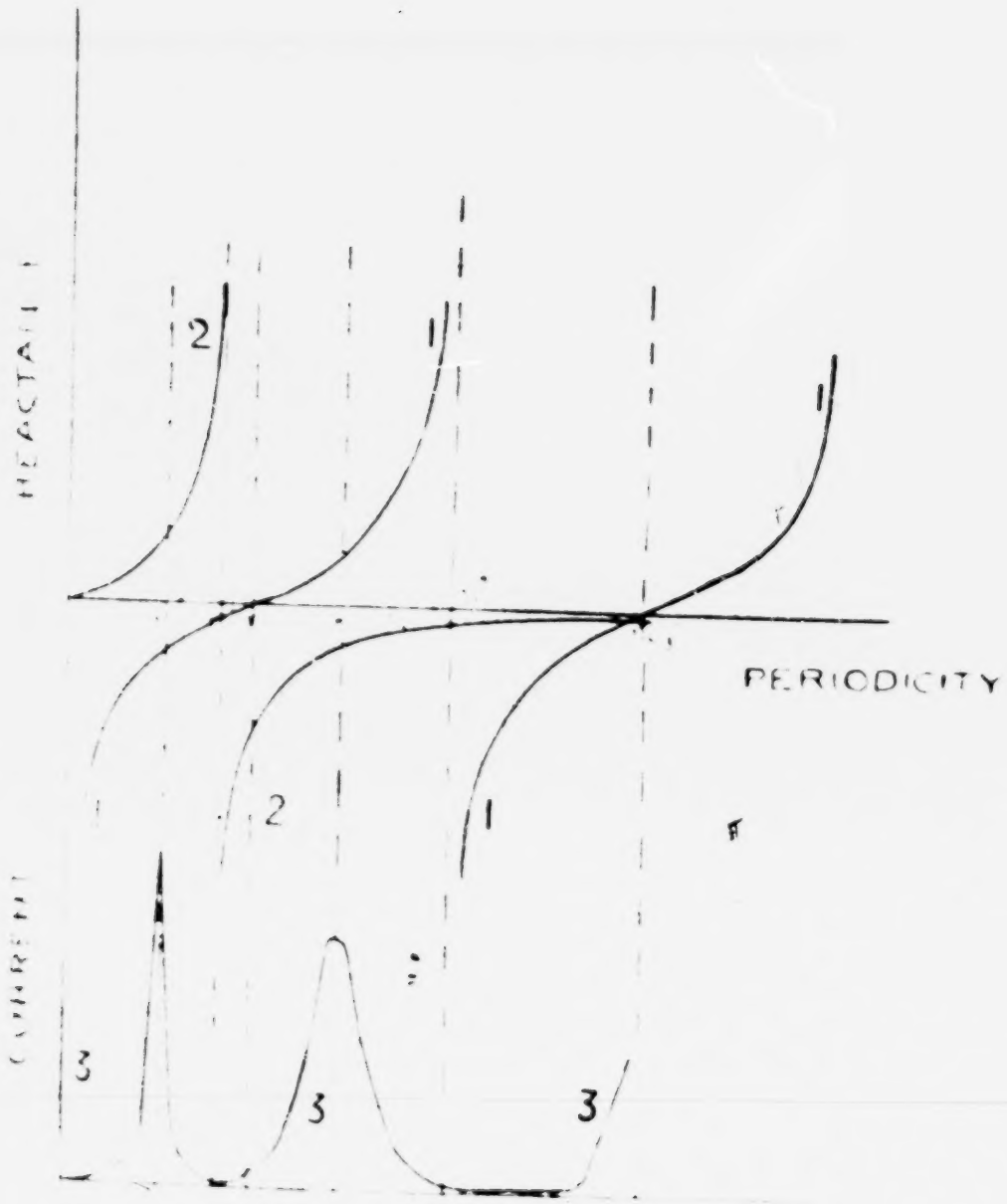

Fig 12

circuit C_2 I_2 L_2 I_2' resonant to the same frequency and called a "weeding-out circuit", is interposed between the first mentioned circuit and the vertical oscillator.

The branch circuit consisting of the coil I_1, and condenser C is not, when taken by itself, resonant to the same frequency as the other local circuits, but is so proportioned that when connected as a branch circuit, forming a part of the vertical oscillator system, the latter shall respond most energetically to persistent trains of waves of that frequency falling upon the vertical wire.

The way in which this is accomplished is perhaps more easily seen by a graphical demonstration than by the use of the analytical solution, though the latter is by no means difficult.

The curves in Fig. 1 illustrate the point in question. Curve 1 represents the reactance of the vertical wire measured at its point of attachment to the loop circuit, for varying periodicities of the impressed force. It will be seen that the periodicity of the fundamental of the vertical wire is at the point n_1'', where the reactance first vanishes. The first even harmonic is at n_2'', and the periodicity of its first odd harmonic is at n_3'', where the reactance again vanishes. Normally therefore curve 3, which is the current curve for varying periodicities of the impressed force on the vertical wire would show maxima at n_1'' and at n_3''. The reactance of the loop circuit for varying periodicities of the impressed force, measured across the points of its attachment to the vertical wire and earth connection is shown in Curve 2. The total reactance of the vertical oscillator measured at the earthed terminal is the algebraic sum of the two reactances shown in Curves 1 and 2, and as a result the current curve 3 shows maxima, not at n_1'' and n_3'', but at periodicities n, n'' and at a periodicity slightly higher than n_3''.

These are the points at which the reactance of the loop circuit is equal, but opposite in sign, to that of the vertical wire.

The periodicity of the local loop circuit *per se* is n; and for this periodicity the current in the vertical wire is practically nil.

The "weeding-out circuit" and the circuit containing the receiver are both resonant to the periodicity n, so that for persistent trains of waves of that periodicity the energy of the oscillations set up in the vertical oscillator is transmitted directly to the receiver, but persistent trains of waves of other frequencies, either produced by slight response in the vertical oscillator or else produced oscillations of the periodicity n'', or of a periodicity slightly higher than n_3'' have little effect on the receiver. To such periodicities the "weeding-out circuit" and the circuit containing the receiver are extremely irresponsive so that the receiv-

ing device receives but an inappreciable amount of the energy of the waves.

In the case of impulsive waves the vertical wire tends to respond only to its own natural rates of vibration as affected by the loop circuit, that is to say, it tends to oscillate at periodicity n'' and to upper harmonics. Such waves acting on the vertical wire, have little tendency to develop oscillations of the natural period of the loop circuit as affected by its connection with the vertical wire, namely n, and the receiver is therefore also protected from the effects of such impulsive waves.

All that has been said regarding the effects of electrostatic and magnetic hysteresis in the description of the transmitting station applies with added force to the apparatus at the receiving station. It is, in fact, much more important to exclude the effects of hysteresis from the receiving circuits than from the transmitting circuits, and it may be laid down as an important rule that under no circumstances shall solid or liquid dielectrics be used in the receiving circuits.

Moreover the injuction in regard to making the mutual inductance small between oscillators at the transmitting station applies in the case of the resonant circuits at the receiving station, since if the mutual energies of the related resonant circuits be not small compared to their self energies, the resonant circuits will modify one another's natural periods and each circuit will respond to more than one periodicity.

Finally it may be said the measure of the selectivity of a resonant circuit is proportional to $\sqrt{\frac{L}{R^2 S}}$, this expression being the same as that found in connection with the persistency of an oscillating circuit. For a given periodicity, therefore, the selectivity is proportional to $\frac{Ln}{R}$

So great is the selectivity of resonant circuits constructed of air condensers and properly designed inductance coils that there is no difficulty in adjusting such circuits to resonance for a given frequency with an error of less than one part in 3,000.

The importance of the "weeding-out circuit" in the receiving station becomes apparent when we observe that the selectivity of the receiving vertical oscillator is greatly diminished by the dissipation of energy, which results from the re-radiation of energy by that oscillator and that the selectivity of the resonant circuit containing the receiver may be greatly diminished by the energy absorbed by the receiver and utilized in its operation.

[fol. 2446] PLAINTIFF'S EXHIBIT NO. 120

IN THE COURT OF CLAIMS OF THE UNITED STATES

MARCONI WIRELESS TELEGRAPH COMPANY, Plaintiff,

vs.

UNITED STATES, Defendant

Copy of Preliminary Report of Interdepartmental Radio Board on Plaintiff's Claim and Accompanying Letter of Oct. 8, 1920. Luella F. Little, Notary Public

INTERDEPARTMENTAL RADIO BOARD,
3341-3343 New Navy Building,
Washington, D. C.

October 8, 1920.

Gentlemen:

There is enclosed herewith draft of preliminary report as to your claim against the United States for compensation for use of your inventions in radio patents. The report is to be understood as involving no waiver or admission on the part of the Government in case a settlement is not reached between it and Claimant. In applying the views expressed in this preliminary report to a review of the radio apparatus purchased or manufactured by the Government, the Board considers that a fair compensation to be allowed in the matter of this claim is $1,063,701.82.

Due steps are being taken to render effective the results arrived at by the Board and the payment of awards finally agreed upon. Meanwhile, an opportunity is offered the Claimant to review the Board's report with a view to reaching agreement between the Board and the Claimant. To this end the Board has set apart Monday the 18th of October, 1920, at 10 A. M., for further discussion of this claim with you and your counsel. Please advise the Board as to whether you will attend on that day. It is pointed out that it has been necessary to set other days of the two weeks beginning 18th October for hearing other claimants, so that it will be difficult to change the date assigned to you, and it

is important, in view of the approaching assembly of Congress, that the matter be disposed of at the time set.

Very respectfully, (signed) E. H. Loftin, Lieutenant-Commander, U. S. N., Chairman.

Marconi Wireless Telegraph Co., Woolworth Bldg., New York City. Copy to Messrs. Sheffield & Betts.

[fol. 2447] CLAIM No. 2

Marconi Wireless Telegraph Co

This claimant is the owner of a large number of patents, a list of which is given in the papers presenting the claim, but pressed its claim only upon the following four patents with the understanding that if a settlement were reached thereon, all claim would be waived as to these other patents:

Re 11,913, Marconi, 609,154 Lodge, 763,772, Marconi, 803,684, Fleming.

Reissue 11,913, to Marconi, granted June 4, 1901, of original patent of Marconi No. 586,193, granted July 13, 1897, on application filed December 7, 1896

This patent expired July 13, 1914. It is the fundamental Marconi patent and has been thoroughly tested by litigation, the result being that while Mr. Marconi's invention was recognized as effecting a most important step in the art, the patent has not been given an effective place by the Courts corresponding to its apparent importance. In the original litigation before Judge Townsend, the first claim of the patent was held to be invalid and it was afterwards cancelled by this claimant. The third claim was held to be valid and to be infringed by the then DeForest structure which included as its detecting element an imperfect contact device operating on the opposite or inverse principle to the Marconi Coherer. The fifth claim involving the use of choke coils was also sustained and held infringed. The claims including the powdered form of the coherer and the provision of an automatic decoherer were held not infringed. The DeForest arrangement, as to the relation between the detector or the spark transmitter and the antenna seems to

have given Judge Townsend no difficulty in this case. (138 Fed. 657, Marconi *v.* DeForest.)

When the patent again came before Judge Townsend (Marconi *v.* American DeForest, 154 Fed. 74) on motion for preliminary injunction, the Court refused an injunction as to DeForest's new apparatus which included a loop radiator and receiver and an electrolytic detector.

When the patent was again tested in the suit before Judge Veeder against National Electric Signaling Co., claim 3 was the only one passed upon and was held to be not infringed on two counts; one, by reason of the removal of the spark producer at the transmitter and the detector at the receiver out of the antenna, and, two, by reason of the employment of a form of detector which was not, in the opinion of Judge Veeder, an imperfect contact such as contemplated by Marconi. Whatever may be the view of the Board as to the Processes whereby Mr. Marconi seems to have been deprived of a result equal to the real scope and value of his invention, the Board does not feel it can go beyond the opinion of Judge Veeder, which has not been modified by any later decision, and as there has been brought to the attention of the Board no instance of a use by the Government which would come in conflict with the [fol. 2448] scope of the claim as defined by Judge Veeder, no allowance can be made on the claim under this patent.

609,154, to Lodge, Granted August 16, 1898, on Application Filed February 1, 1898; Expired August 16, 1915

Reference is made to paper No. 11 in the appendix for the history of the litigation under this patent. Its validity has been uniformly sustained and it is accepted by the Board as the fundamental patent on the use of loading coils in the antenna whether at the transmitter or receiver. A part of the patent which has not been made the subject of claim for infringement but which has been discussed as to its bearing upon the Marconi "four circuit tuning" patent 763,772, is the structure illustrated in Figs 3 and 4 of the Lodge patent and referred to in claim 6. The system here involves, besides the means for synchronizing the radiating circuit, "means for charging it by an aerial disruption or impulsive rush." It is considered that this feature of the Lodge invention is in effect carried out in lesser degree than that specified by Lodge, but still effectively, in those Government stations in which a quenched gap excitation is em-

ployed. (See in this connection opinion of Judge Neterer in Marconi *v.* Kilbourne & Clark, 239 Fed. 328.)

The patent to Lodge, therefore, will be given, in accounting, a weight due both to the synchronizing coils and to the employment of impulse excitation in transmitters employing the quenched gap or other form of impulse excitation, if there be any.

Laches. From the time of grant of this patent, August 16, 1898, or shortly thereafter when radio assumed real proportions, this patent of almost fundamental character was infringed widely and with impunity. The use of loading coils such as contemplated in the patent by the United States Government dates from at least 1902, all without protest on the part of the owners of the patent until after the acquisition of the patent by the Marconi Wireless Telegraph Company of America on March 19, 1912. The defense of Laches which was found good as against this patent by His Honor, Judge Veeder, in Marconi *vs.* National Electric Signaling Co., 213 Fed. 815,863, is applicable with increased force in the case of the United States. The Board is reluctant to apply this rule as to purchases made by the United States after the acquisition of the patent by the Marconi Company and its vigorous and prompt proceeding to protect its rights thereunder, but it is considered by the Board that the rule may be justly applied as against all purchasers made before the acquisition of title by the Marconi Company and which occurred while the then owner of the patent was asleep upon his rights. It is likely that some of these installations purchased before the acquisition of title by the Marconi Company remained in operation after such acquisition of title and that under other conditions the Marconi Company, the claimant here, might be entitled to recover for such use of those installations as occurred while the patent belonged to it. It would, however, be difficult to properly apportion such an award at this late period. The Board is proceeding on a theory of settlement based in all cases on cost price and not extent of use, the use by the Government being for the most part non-commercial and not susceptible of accurate monetary determination. It is thought that full justice will [fol. 2449] be done, recognizing the aversions of the Government to take advantage of a technical defense where it has actually used private property but also bearing in mind the above disabilities, if the award under this patent is limited in all cases to purchases occurring after March 19,

1912, disregarding entirely all installations which may have been made prior to that time whether they remained in use or not.

The Board has not ignored in reaching this view the fact that the patentees' right of injunction is not available against Government infringement and that up till the date of the Act of June 25, 1910, the right of recovery was restricted, but the present claimant delayed its action under that Act for over six years after its passage, the action not having been actually filed in the Court of Claims until over a year after the expiration of the patent. This delay cannot be considered as fully justified by intermediate test cases against other infringers and it is thought that sufficient justice will be done to the claimant by an allowance on the above stated basis.

Stations using dynamos or alternators as radio-frequency generators were not used by the Government prior to the expiration of the Lodge patent and thus do not appear in the accounting thereunder.

763,772, to Marconi, Granted June 28, 1904, on Application Filed November 10, 1900

The history of the litigation under this patent is shown in paper No. 11 of the appendix. It appears to have been uniformly sustained and the Board accepts the patent as having been sufficiently established to cover any wireless system in which at the transmitter effective transfer of energy is obtained between a closed persistent primary circuit and an open non-persistent secondary circuit, with corresponding but reversed arrangement in the receiver. The claims are limited to an open circuit radiator at the transmitter and absorber at the receiver, except claim 2 for the receiver, which, however, has as an element a tuning inductance in the antenna. These specific limitations when taken with the language of the specification, giving an effective meaning to the use of an open circuit as a quick radiator and effective absorber, and with the discussion of Judges Veeder and Neterer would seem to exclude from the accounting to be made by the Government its various loop receiving circuits which cannot come under the term "open circuit" of most of the claims, and which do not include a variable inductance in the antenna as called for by claim 2.

Accounting, however, will be made on all systems having

open antenna whether at the transmitter or receiver coupled with a charging or receiving circuit in such manner that an effective transfer of energy takes place, from one circuit to its coupled circuit by the use of syntony, with modifications expressed below.

Note is taken of the fact that in the litigation heretofore it has not been expressly determined that transmitters employing quenched gaps, and therefore impulse excitation, are included within the terms of the patent. In the case of Marconi *vs.* Kilbourne & Clark, a circuit in which it was argued that there was no effective transfer of energy from the one circuit to the other, the two being substantially energized simultaneously, and in which at any rate there was no effective transfer from one to the other due to [fol. 2450] syntony, was held not to infringe. This, however, is not decisive of the present issue, as to the use of quenched gaps by the Government in which there is a close coupling and a slight or negligible detuning, and in which, undoubtedly, advantage is taken of syntony to secure an effective transfer of energy. The entire period covered by the claim has seen the use of structures of the class at both the transmitter and receiver, and it has taken many forms. The oscillation producer has included open gaps whether stationary or rotary and stationary quenched gaps of various forms. Also alternators of high frequency is current generators have been used in a circuit coupled to the radiating circuit.

A careful study of the various claims of this patent which have been adjudicated and held valid shows claim 10 to be broadest. This claim reads as follows:

"10. A system of wireless telegraphy, in which the transmitting station and the receiving station each contains an oscillating transformer, one circuit of which is an open circuit and the other a closed circuit, the two circuits at each station being in electrical resonance with each other and in electrical resonance with the circuits at the other station, substantially as described."

The language of this claim is on its face, broad enough to include all systems to which there are two circuits either at the transmitter or received and which circuits are in resonance. The only limitation is that one of the circuits must

be an open circuit. The language of this and other claims of the patent is, however, to be construed in the light of the various decisions of the courts and particularly the latest one—the only one going to an appellate court after final hearing—Marconi Wireless Telegraph Co. of America *vs.* Kilbourne & Clark rendered by the Circuit Court of Appeals for the Ninth Circuit.

The Board discusses below whether any of the Government's continuous wave apparatus where tuned coupled circuits are used, come under the patent. The most general exceptions from accounting are the Navy arc transmitters wherein the arc is placed directly in the antenna circuit and the Navy loop receivers in which there are either single circuits or, where a loop is coupled to the secondary, the combination does not include an open circuit.

Accounting will, therefore, be made on all apparatus with the exceptions noted above. But in considering quenched gap transmitters it will be borne in mind that these systems are very closely allied to the impulse excitation systems of Kilbourne & Clark and of Lodge's patent 609,154, and it may be strongly urged that much of the reasoning of the Court of Appeals in the Kilbourne & Clark case would tend to show that these systems are not equivalents of that claimed by Marconi. The specific point is not yet adjudicated, and the patent is not entitled to the weight of an adjudicated patent in this respect.

High Frequency Alternators. The Marconi Company was not understood by the Board to make any claim for compensation for the use of the Lodge and Marconi inventions in these sets, but the Board has of its own motion considered the subject. The question has not been found discussed in any litigation.

In considering the application of the Marconi patent 763,772 to stations having high frequency alternators as a [fol. 2451] source of oscillations, various conditions present themselves. There are three of such stations with which the Government is concerned.

The New Brunswick and Tuckerton stations need no discussion, their temporary use by the Government having been on lease from the claimant—acting in the one case on its own behalf, and in the other case as representative of the foreign owner.

The station at Sayville, Long Island, built by the Atlantic Communication Company, was seized by the Alien Property custodian, either direct or through acquiring the stock of the Company, in April, 1917. At that time the transmitter employed the High Frequency Generator with frequency transformers involved in the defense of Kintner, et al. *vs.* Atlantic Communication Company, 249 Fed. Rep. 73. The property was purchased by the Navy from the Custodian October 11, 1918. Meanwhile the station had been operated by the Navy—but the alternator referred to not having been found efficiently operative, an arc transmitter was put in service about January 1, 1918. It is doubtful whether the Government's mere ownership through the Custodian could under the circumstances be considered an infringement. Furthermore, it is very doubtful whether the system itself infringes on the Marconi patent 763,772. The alternator circuit is so closely coupled to the antenna as to be practically in the antenna. There is no reservoir action and no persistent oscillation of the alternator circuit in the sense of the Marconi patent. The amount of use was small. On the whole, the Board has not felt warranted in conceding any liability on the part of the Government in this case.

Vacuum Tube Transmitters. In the majority of instances, vacuum transmitters employed by the Government have had but a single circuit, the antenna being so connected to the vacuum tube elements that it comprised within itself a part of the oscillating circuit of the vacuum tube generator. In some instances, however, vacuum transmitters have had two circuits, one an oscillating circuit connected to the elements of the vacuum tube and the other an antenna circuit, and where two circuits are so employed, they are in general in tune with each other. The Board is of the opinion, however, that a continuous wave transmitter of this type does not come under the terms of the patent in that no "reservoir action" enters into the principle of exciting the antenna. The oscillations are not damped but continue in constant amplitude and the transfer of energy takes place each cycle without there being any necessity for considering the matter of storing energy in a reservoir circuit to be slowly drawn upon by an antenna or open circuit.

For these reasons the Board is of the opinion that the limited instances of the employment of vacuum tube transmitters having coupled tuned circuits are not cause for accounting under this patent.

893,684, to Fleming, Granted November 7, 1905, on Application Filed April 19, 1905

This is the well-known "Fleming valve patent" which was sustained by Judge Mayer in the suit against the De-Forest Radio Tel. & Tel. Co., 243 Fed. 560. Are further proceedings in this litigation are related in paper No. 11 in the appendix. It may be noted that by the later decisions of Judge Mayer on hearings on supplemental bill, the patent was held to include the DeForest amplifier and oscillion—[fol. 2452] the original decision having held infringement as to the DeForest audion used as a detector. Proceedings are now being had before the master and it has been represented to the Board that an effort is being made by the defendant to exclude from the accounting and take out of the effect of the decision certain types of three-electrode tubes adapted particularly for certain purposes and claimed to operate on a different principle from that on which the tube of the Fleming patent operates.

Basing its action upon the decisions of the Court heretofore rendered, and which go into the matter so fully that it is unnecessary for the Board to express it, the Board will tentatively include in the accounting, subject to any later exclusion therefrom, by the final award in the above suit, of certain types of apparatus, all so-called vacuum tube detectors, amplifiers and oscillions, irrespective of the pressures used.

The Fleming patent includes not merely the tube structure, but the connecting circuits. But the tubes and the circuit are not essentially different from the corresponding parts in the Edison patent 307,031 of October 21, 1884. The novelty claimed lies rather in the application of the invention to radio frequencies than in any particular construction of the tubes or arrangement of the circuits.

The purchases by the Government are largely of tubes independent of the circuit. It is difficult to determine when the tubes were used or in what particular circuits they have been placed. Considering that the use contemplated involved the sooner or later association of the tubes in circuits to constitute the infringing combinations of the patent, the Board has concluded that the award as to these purchases of tubes should be based on their purchase price without undertaking the impossible task of tracing them to the circuits in which they—or some or them—were actually used.

In view of the disclaimer filed by the Claimant on November 17, 1905, tubes in systems employing only low frequency will be omitted from accounting.

[fol. 2453] CLAIMANT'S EXHIBIT NO. 121

IN THE COURT OF CLAIMS OF THE UNITED STATES

MARCONI WIRELESS TELEGRAPH COMPANY, *Plaintiff*.

vs.

UNITED STATES, *Defendant*

Interdepartmental Radio Board's Letter of April 16, 1921
Luella F. Little, *Notary Public*.

Interdepartmental Radio Board

2344 New Navy Building,

Washington, D. C.

April 16, 1921.

Messrs. Sheffield & Betts, 52 William Street, New York, N. Y.

Attention Mr. L. F. H. Betts

SIR:

Claim No. 2—Marconi Wireless Telegraph Co.

Referring to your conference with the Board on Apr. 7 and your further conference with Mr. Knight of the Board on April 13 in the matter of the above claim, the Board has decided that it can not make any change in its method of accounting such that due weight will not be given the Lodge patent after its expiration in 1915. The Board believes its position in this respect is sound and the only one that should be followed.

It is realized, however, that you are not interested in the method of accounting adopted by the Board provided it arrives at a figure which will be acceptable to your clients, but unfortunately the Board can not be governed in its methods by the indifference of claimants as to such methods, but feels that they must be founded on the rules laid down by the courts in patent accountings.

A review of the accounting shows that the weight given by the Board to the Arco-Rendahl patent on quenched gaps, owned by the Government, reduced the allowance to your clients by $194,967.20. The Board is willing to revise its accounting so that this patent is not considered, which additional sum would increase the recommended allowance to your clients to $1,253,389.02.

[fol. 2454] The Board has found that its settlement with others on the contracts in which your clients had warranted the Government amounts to approximately $75,000.00. In other words, this amount should be added to the amount above to arrive at the total value to your clients of this proposed settlement, or $1,328,389.00.

You intimated to Mr. Knight that you are prepared to recommend to the committee of the Marconi Company handling this claim that it accept a figure equivalent to 5 per cent of the cost of apparatus involving some or all of the Marconi Company's patents. You handed to Mr. Knight a sheet showing that you had estimated the cost of apparatus to be $28,425,413.79, and that 5 per cent of this sum is $1,421,270.68. A review of the Board's accounting shows that your estimated cost of apparatus is in error, the actual figure being $26,399,490.60, 5 per cent of which is $1,319,974.53.

It is believed that you arrived at your figure from the data listed on page 3 of your brief of Feb. 2, 1921, when you were heard by the Board. It is pointed out that in the item of "Arc Transmitters", more than two million dollars of this amount involved apparatus purchased after the expiration of the Lodge patent, which amount is practically equivalent to the discrepancy between your figures and the Board's figures.

Reviewing the above, it is pointed out that the Board's herein-proposed recommended allowance plus the saving on warranted contracts is in excess of a 5 per cent allowance on the total cost of apparatus involving the Marconi Company's patents by approximately $9,000.00.

It is suggested that you submit this revised proposed recommendation to the committee of your clients at an early date. If acceptable, the Board's recommendation to the several heads of department will be an award to the Marconi Telegraph Company of $1,253,389.02.

Very respectfully, E. H. Loftin (Signed) Lieut. Commdr., U. S. N., Chairman.

PLAINTIFF'S EXHIBIT 121

2824

No. 767,984. PATENTED AUG. 16, 1904

J. S. STONE.

SPACE TELEGRAPHY.

APPLICATION FILED NOV. 25, 1903

NO MODEL. 2 SHEETS—SHEET 2.

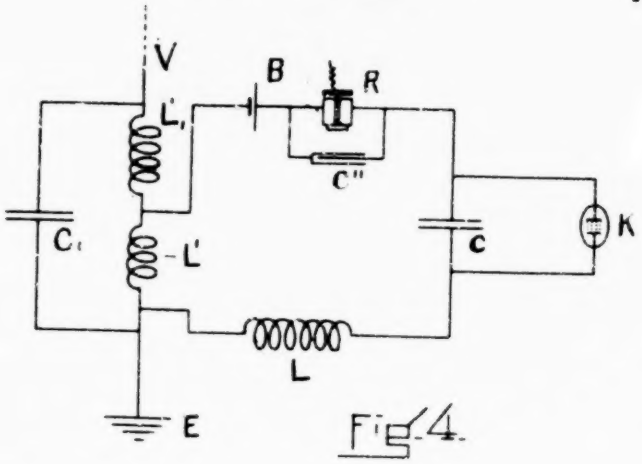

Fig. 4.

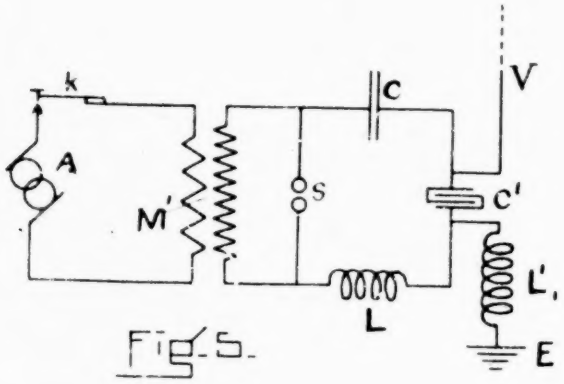

Fig. 5.

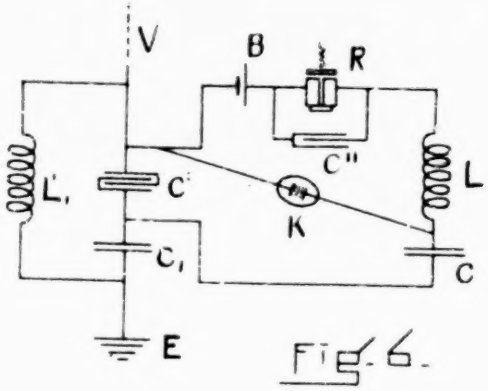

Fig. 6.

WITNESSES.

Francis P. Gaskins

B. Tomlinson

INVENTOR.

John S. Stone

2825

No. 767,984. PATENTED AUG. 16, 1904.

J. S. STONE.

SPACE TELEGRAPHY.

APPLICATION FILED NOV. 25, 1903.

NO MODEL. 2 SHEETS—SHEET 1.

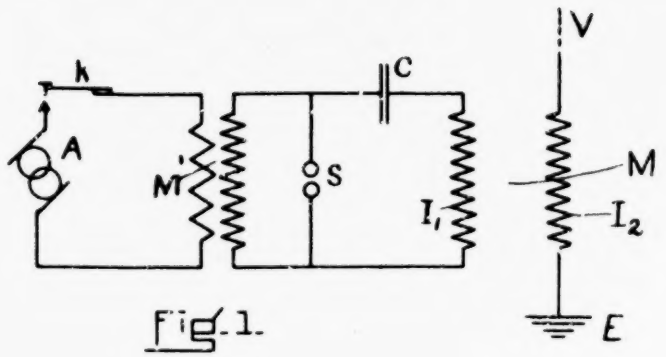

Fig. 1.

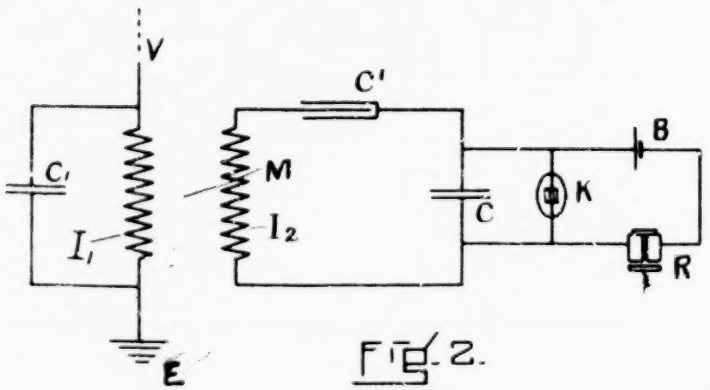

Fig. 2.

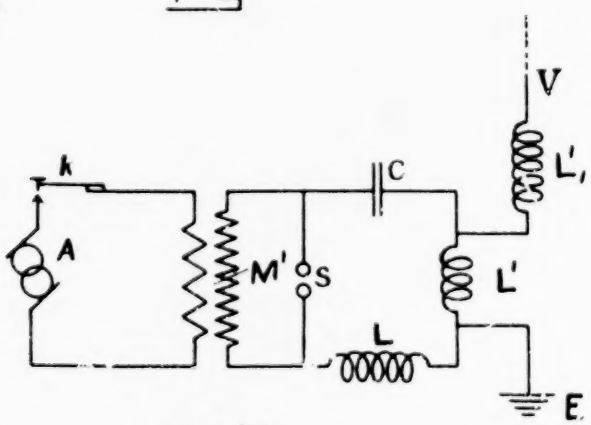

Fig. 3.

WITNESSES.

Raymond D. Jackson

INVENTOR.

John S. Stone

2456

No. 767,984. Patented August 16, 1904.

UNITED STATES PATENT OFFICE.

JOHN STONE STONE, OF CAMBRIDGE, MASSACHUSETTS, ASSIGNOR TO WILLIAM W. SWAN, TRUSTEE, OF BROOKLINE, MASSACHUSETTS.

SPACE TELEGRAPHY

SPECIFICATION forming part of Letters Patent No. 767,984, dated August 16, 1904.

Application filed November 25, 1903. Serial No. 182,832. No model.

To all whom it may concern:

Be it known that I, JOHN STONE STONE, a citizen of the United States, and a resident of Cambridge, in the county of Middlesex and State of Massachusetts, have invented a certain new and useful Improvement in Space Telegraphy, of which the following is a specification.

My invention relates to the art of transmitting intelligence from one station to another by means of electromagnetic waves without the use of wires to guide the waves to their destination, and it relates more particularly to the system of such transmission in which electromagnetic waves are developed by producing electric vibrations in an elevated conductor, preferably vertically elevated.

In my Letters Patent Nos. 714,756 and 714,831, dated December 2, 1902, and in other Letters Patent I have described systems of space telegraphy in which electromagnetic waves substantially simple harmonic in form are transmitted by creating substantially simple harmonic vibrations or oscillations in a sonorous circuit or system of circuits and impressing such vibrations or oscillations upon an elevated conductor. In order that the electric vibrations so impressed upon the elevated conductor, and consequently the electromagnetic waves radiated therefrom, may be simple harmonic in form, I have employed means whereby the individual circuits of a complex of interrelated circuits are made capable of vibrating as circuits of a single degree of freedom. In my Letters Patent Nos. 714,756 and 714,831, and in my Reissued Letters Patent No. 12,149, reissued August 25, 1903, I have described and broadly claimed means whereby such complex of interrelated circuits may be reduced to the equivalent of a number of circuits having a single degree of freedom. I have also specifically claimed therein one of the means whereby this result may be accomplished. The means broadly described and claimed consist in providing each circuit with sufficient auxiliary inductance to render the mutual inductance between it and an associated circuit small compared to the square root of the product of the inductances of the circuits. The specific means therein claimed was an auxiliary inductance-coil in each circuit, whereby the mutual inductance between said circuit and an associated circuit is rendered small compared to the square root of the product of the inductances of the two circuits. Another specific means whereby the same result is accomplished is fully set forth by me in my Letters Patent Nos. 714,832 and 714,833, dated December 2, 1902, wherein I have shown that the function of the auxiliary inductance-coil may be performed by the primary of the transformer connecting the sonorous circuit with the elevated conductor by so proportioning said primary that it shall supply the auxiliary inductance, which in the other specific form of my invention was supplied by means of the auxiliary inductance-coil. This is accomplished by so designing the transformer that the ratio $\frac{M^2_{12}}{L_1 L_2}$ is small compared to unity, which is the opposite course from that in general pursued in constructing a step-up transformer, and is only resorted to in the construction of the so-called "constant-current" transformers, and it may also be accomplished in a plurality of ways set forth in my Letters Patent Nos. 717,467 and 717,515 in the art of wire telegraphy.

In the present specification I confine myself and limit my claims to one of these means, namely, that of so designing the transformer connecting two associated circuits that the ratio $\frac{M^2_{12}}{L_1 L_2}$ is purposely made small compared to unity. In other words, the means herein claimed whereby the complex of circuits is reduced to the equivalent of a system of circuits each of a single degree of freedom is different from that previously claimed by me in that the ratio $\frac{M^2_{12}}{L_1 L_2}$ is made small compared to unity by making the transformer a constant-current transformer, whereas in the other patents I have claimed means for rendering this ratio small compared to unity consisting of auxiliary inductance-coils. In this case the circuits at the transmitting-station

the closed sonorous circuit or closed oscillator, which is a persistently oscillating poor-radiating circuit, and an elevated transmitting-conductor or linear oscillator, which is a good radiating circuit, and therefore a poor oscillator. At the receiving-station the circuits are an elevated receiving-conductor or linear oscillator, which is a good absorbing-circuit and a poor oscillator, and a closed resonant circuit, which is a persistently oscillating circuit, and therefore a poor absorbing-circuit, except for the energy of currents of the frequency to which it is attuned. The particular means employed for reducing the aforesaid system of interrelated circuits to the equivalent of a system of circuits each having a single degree of freedom is a transformer designed as aforesaid, so that the ratio $\frac{M}{L\ L'}$ is made small compared to unity, so that the transformer will have sufficient magnetic leakage to effect the desired result.

In my Letters Patent Nos. 717,467 and 717,545 in the art of wire telegraphy I have described and claimed several specific means of reducing a complex of circuits to the equivalent of a system of circuits each of a single degree of freedom. The underlying principle for accomplishing this result is in all instances that the mutual energy of each circuit with all of the interrelated circuits of the system shall be small compared with the self-energy of said circuit.

The relation of the specific invention herein to be claimed to the broad principle hereinbefore stated may be best understood by having reference to the drawings which accompany and form a part of the present specification.

In the drawings, Figure 1, 3, and 5 represent in diagram apparatus and arrangements of circuits constituting transmitting systems. Figs. 2, 4, and 6 represent in diagram apparatus and arrangements of circuits constituting receiving systems.

In the figures: V is an elevated conductor. M M are transformers. L L L' are inductances. C C C C' are condensers. L_1 L_2 are respectively the primary and secondary windings of the transformer M. s is a spark-gap. A is an alternating-current generator or other source of periodically-varying electromotive force. B is a battery. R is a relay. K is a receiver, herein illustrated as a coherer. k is a key.

In the system illustrated in Figs. 1 and 2 the sonorous circuit s C L and the resonant circuit C C L are each associated with an elevated conductor V by means of a transformer M with magnetic leakage—that is, a transformer in which the primary and secondary windings L and L have such spatial interrelation as to so reduce the mutual inductance between the associated circuits that the ratio $\frac{M'_{12}}{L_1 L_2}$ is small compared to unity, where L L represent the self-inductances of the associated circuits and M the mutual inductance between said circuits. It will be found that when the primary L is in close inductive relation with the secondary L and is then separated therefrom the amplitude of the oscillations developed in said secondary gradually rises to a maximum and that at this point any further separation of the transformer-windings will have the effect of decreasing this amplitude.

The operation of the apparatus shown in Fig. 1 is the same as that of the apparatus shown in Fig. 5 of my hereinbefore-mentioned patent, No. 714,756, and reference may also be had to the description of the operation of the apparatus shown in the figure of my Letters Patent No. 714,832, the function of the auxiliary inductance-coil (designated by the letter L shown in those drawings) being performed by the primary coil L_1 of Fig. 1 of the present case. Similarly the operation of the apparatus shown in Fig. 2 is the same as that of the apparatus shown in Fig. 6 of my Letters Patent No. 714,756, the function of the auxiliary inductance-coil (designated by the letter L in that drawing) being performed by the secondary coil L_2 of Fig. 2 of the present case.

In Fig. 3 the elevated conductor is conductively associated with a sonorous circuit s C L L. In order to impress a simple harmonic electromotive force upon the elevated conductor V, electrical oscillations are produced in the sonorous circuit. These give rise to a corresponding difference of potential at the terminals of the inductance-coil L' in the elevated-conductor system V L' E, and corresponding forced simple harmonic electric vibrations result therein. The inductance of the coil L' being small compared to that of the coil L the oscillations in the sonorous circuit are not materially affected by the association of this circuit with the elevated-conductor system.

In Fig. 4 the elevated conductor is conductively associated with a resonant circuit C L L'. When simple harmonic electric oscillations are set up in the elevated conductor, a corresponding difference of potential is set up at the terminals of the inductance-coil L', and corresponding forced simple harmonic electric vibrations result in the resonant circuit. If the frequency of these vibrations is the same as that to which the resonant circuit is attuned, said resonant circuit responds energetically and has electrical oscillations of relatively great amplitude developed in it, whereas if the frequency of these vibrations be different from that to which the resonant circuit is attuned the resonant circuit responds but feebly and has electric vibrations of relatively small amplitude developed in it. The inductance of the coil L' being small compared to that of the coil L the oscillations in the resonant cir-

but are not materially affected by the association of this circuit with the elevated conductor.

In Fig. 5 the elevated conductor is again conductively connected to a sonorous circuit s C L. In order to impress a simple harmonic electromotive force upon the elevated conductor V, electrical oscillations are produced in the sonorous circuit. These give rise to a corresponding difference of potential at the terminals of the condenser C'' in the elevated-conductor system V C'' L' E and corresponding forced simple harmonic electric oscillations result therein. The capacity of the condenser C being large compared to that of the condenser C', the oscillations in the sonorous circuit are not materially affected by the association of this circuit with the elevated-conductor system.

In Fig. 6 the elevated conductor is conductively associated with a resonant circuit C' L C'. When simple harmonic electric oscillations are set up in the elevated conductor, a corresponding difference of potential is set up at the terminals of the condenser C'' and corresponding forced simple harmonic electrical vibrations result in the resonant circuit. If the frequency of these vibrations is the same as that to which the resonant circuit is attuned, said resonant circuit responds energetically and has electrical oscillations of relatively great amplitude developed in it, whereas if the frequency of these vibrations be different from that to which the resonant circuit is attuned the resonant circuit responds but feebly an has electric oscillations of relatively small amplitude developed in it. The capacity of the condenser C'' being great compared to that of the condenser C', the oscillations in the resonant circuit are not materially affected by the association of this circuit with the elevated conductor.

No mention has heretofore been made of the function of the condensers C''', as these condensers are not essential to the tuning of the circuits in which they are placed, but merely serve to shunt the relays R out of the resonant circuits. In order that these condensers may not appreciably affect the tuning of the circuits in which they are included, and thereby lower the resonant rise of potential at the plates of the condenser C, they are so constructed as to have large capacities compared to the capacities of the condenser C'.

No mention has heretofore been made of the function of the condensers C' and inductance-coils L', as the functions of these elements have been fully described in my applications Serial Nos. 193,371 and 193,372, filed February 13, 1904, and as they form no essential part of the present invention.

I claim—

1. In a system of space telegraphy, an elevated transmitting-conductor serially connected with one winding of a transformer and a sonorous circuit including the other winding of said transformer, said windings being so spatially interrelated as to reduce the complex of interrelated circuits to the equivalent of a system of circuits each having a single degree of freedom.

2. In a system of space telegraphy, an elevated receiving-conductor serially connected with one winding of a transformer, and a resonant circuit including the other winding of said transformer, said windings being so spatially interrelated as to reduce the complex of interrelated circuits to the equivalent of a system of circuits each having a single degree of freedom.

3. In a system of space telegraphy, an elevated conductor serially connected with one winding of a transformer and a persistently-oscillating circuit including the other winding of said transformer, the separation of said windings being sufficient to reduce the complex of interrelated circuits to the equivalent of a system of circuits each having a single degree of freedom.

4. In a system of space telegraphy, a transmitting system comprising a sonorous circuit inductively associated with an elevated conductor by means of a transformer, in combination with a receiving system comprising a resonant circuit attuned to the frequency of the electric oscillations developed in said sonorous circuit and inductively associated with an elevated conductor by means of a transformer, the windings of each of said transformers being so spatially interrelated as to reduce the complex of interrelated circuits constituting the transmitting and receiving systems each to the equivalent of a system of circuits having a single degree of freedom.

5. In a system of space telegraphy, a good oscillator connected with a good radiator or absorber by means of a transformer having sufficient magnetic leakage to reduce the complex of circuits to the equivalent of a system of circuits each having a single degree of freedom.

6. In a system of space telegraphy, a persistently-oscillating circuit, a good radiating or absorbing circuit, and a transformer inductively associating said circuits, the mutual inductance between the windings of said transformer being sufficiently small to reduce the complex of interrelated circuits to the equivalent of a system of circuits each having a single degree of freedom.

7. In a system of space telegraphy, a persistently-oscillating circuit, a good radiating or absorbing circuit, and means for so associating said circuits that the mutual energy of each circuit with its interrelated circuit is rendered small compared with the self-energy of each circuit.

8. In a system of space telegraphy, a persistently-oscillating circuit, a good radiating or absorbing circuit, and means for so in-

ductively associating said circuits that the mutual energy of each circuit with its interrelated circuit is made small compared with the self-energy of each circuit.

9. In a system of space telegraphy, a persistently-oscillating circuit, a good radiating or absorbing circuit, and means for so associating said circuits that the complex of interrelated circuits is reduced to the equivalent of a system of circuits each having a single degree of freedom without the interposition of auxiliary means.

10. In a system of space telegraphy, a persistently-oscillating circuit, a good radiating or absorbing circuit, and means for so inductively associating said circuits that the complex of interrelated circuits is reduced to the equivalent of a system of circuits each having a single degree of freedom without the interposition of auxiliary means.

In testimony whereof I have hereunto subscribed my name this 24th day of November, 1903.

JOHN STONE STONE.

Witnesses:
G. A. HIGGINS,
BRAINERD T. JUDKINS.

Correction in Letters Patent No. 767,984.

It is hereby certified that in Letters Patent No. 767,984, granted August 16, 1904, upon the application of John Stone Stone, of Cambridge, Massachusetts, for an improvement in "Space Telegraphy," an error appears in the printed specification requiring correction, as follows: On page 2, line 66, the symbol "L^1" should read L; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 11th day of July, A. D., 1905.

[SEAL.]

F. I. ALLEN,
Commissioner of Patents.

[fols. 2461-2462] PLAINTIFF'S EXHIBIT 122

RADIO PATENTS

Settlement Of Claims Against Government For Use Of Radio Patents During The World War

Hearings

Before The

Committee On Military Affairs

House Of Representatives

Sixty-Seventh Congress, First Session

Monday, May 23, 1921

Statements of

Commander Stanford C. Hooper, U. S. N.

Lieut. Commander Edward H. Loftin, U. S. N.

Capt. Guy Hill, U. S. A.

Mr. Harry E. Knight, Department of Justice.

Mr. Edward G. Curtis, Special Assistant to the Attorney General.

[fol. 2463] Radio Patents

Committee on Military Affairs,
House of Representatives,
Monday, May 23, 1921.

The committee met at 10:30 o'clock a. m., Hon. Julius Kahn (chairman) presiding.

The Chairman. I have called this meeting of the committee this morning to consider a letter which I received, through the Speaker, from the Secretaries of War and Navy and the Attorney General of the United States regarding the settlement for patents which the Government used during the war for the benefit of the country. They have suggested a bill for that purpose, to which I have made a slight amendment. I will ask the clerk of the committee to read the letter.

(The clerk read the letter, as follows:)

Departments of War, Justice, and Navy,
Washington, D. C., May 14, 1921.

DEAR MR. GILLETT: We have the honor to invite attention to the situation that exists as a result of the use by the Government of patented inventions relating to radio communication and the development in that art.

Prior to the war with Germany the Government, principally the War and Navy Departments, found it necessary, because the validity of many patents relating to wireless telegraphy had not been judicially determined, to use wireless apparatus of various kinds without strict regard to the rights claimed by patentees, and during the war both departments used any and all apparatus, principles, and methods of known value without consideration of questions of infringement or proprietorship, giving where necessary its warranty to contractors to protect them from litigation for infringement.

The development of this art has been very rapid and the patent situation with respect thereto is exceedingly complicated. There are many patents relating to the subject and a large number of claims for compensation for alleged use and infringement of patented inventions, among which there is much conflict, have been filed with the War and Navy Departments.

Realizing that the use by the Government had infringed the rights of many patentees, while some of the claims possess little or no merit, and that a fair and reasonable determination of the whole matter would be difficult, long drawn out, and expensive to the Government as well as to the claimants if an adjustment were not arrived at by a reasonable and businesslike consideration of the interests of all parties concerned, a board designated "Interdepartmental Radio Board" was appointed by ourselves consisting of experts from the War Department, Department of Justice, and the Navy Department to consider all such claims, each with reference to its own merits and the merits of all the others. Such board has been considering the matter for nearly three years, giving all questions connected therewith careful, intelligent, and exhaustive consideration.

The claims presented to the board totaled many millions of dollars. Out of the 24 claims brought only 7 stated the amount of the compensation desired, and the total of those 7 was $14,860,000, the rest aggregating probably a much larger sum.

The board, giving due weight to matters of infringement, validity of patents, values of inventions, the circumstances of use by the Government, and the entire value of up-to-date wireless apparatus as the product of all inventions [fol. 2464] combined, has determined a sum of money that the Government should fairly and reasonably pay to the different patentees in proportion to the value of their respective inventions. Such sum will not exceed $2,500,000, which is only a small percentage of the aggregate sum claimed.

The owners of the various patents affected have been informed of the board's determination, and many or all of them have signified a willingness to accept the amounts allotted to them. The work of the board has been most painstaking and careful, and its conclusions and determinations reflect great credit upon its members. If settlement with the various patentees can be effected on the basis of the board's determination, a situation fraught with troublesome consequences would be disposed of to the great advantage of the Government and to the ultimate satisfaction of the claimants, and it is highly desirable, therefore, that provision be made for such settlements.

Therefore it is urgently recommended that the War, Justice, and Navy Departments be empowered to adjust and pay said claims on the basis of said board's determination.

Transmitted herewith is a draft of a provision that it is believed covers the matter adequately, and is suggested as an amendment to the act entitled "An act to provide relief in cases of contracts connected with the prosecution of the war, and for other purposes," approved February 2, 1919, commonly known as the Dent Act.

If at an early date payment could be tendered to all the claimants of the respective amounts found in their favor by said board, it is believed that all claimants having claims of substantial merit would accept settlement and release the Government, and it is earnestly requested that this

matter be given favorable and prompt consideration by Congress.

Very sincerely, John W. Weeks, *Secretary of War.* H. M. Daugherty, *Attorney General.* Edwin Denby, *Secretary of the Navy.*

Hon. Frederick H. Gillett, *Speaker of the House of Representatives.*

(The bill above referred to is as follows:)

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the act entitled "An act to provide relief in cases of contracts connected with the prosecution of the war, and for other purposes," approved February 2, 1919, and the same is hereby amended by adding thereto the following section:

"SEC. 6. That the Secretary of War, the Attorney General, and the Secretary of the Navy, acting jointly or severally, as in their judgment the circumstances of each case may require, are hereby authorized to adjust, pay, and discharge any and all claims against the United States for or on account of the use or manufacture by or for the United States of any patented invention relating to radio communication in cases in which such patented invention was used without agreement with the owner as to compensation therefor, such settlement of claims to cover both past whether prior to, during, or after the war) and future use where practicable in all cases, and to be based on the determination by such agency as the said Secretaries and Attorney General have designated or established or may designate or establish of all questions of infringement, validity of patents, and value of inventions: *Provided*, That this provision shall not be so construed as to deprive owners of patents who shall not accept settlement under this act of any rights of action conferred by the acts for protection of the owners of patents, approved June 25, 1910, and July 1, 1918, respectively, and for the payment of such claims the sum of $2,500,000, or so much thereof as may be necessary, is hereby appropriated out of any money in the Treasury not otherwise appropriated."

The CHAIRMAN: I have asked the officers representing these three departments to come before the committee this morning for the purpose of explaining the matter to us. I

understand that officers representing the Navy Department will make the opening statements, and we will be very glad to hear them.

[fol. 2465] Statement of Commander Stanford C. Hooper, Officer in Charge, Radio Division, Bureau of Engineering, Navy Department

Commander Hooper: Mr. Chairman, the application of radio-telegraphy for practical purposes is but 20 years old. It is highly scientific, most intricate, and because it is the only practicable means of communication where land wires are not possible, it is most valuable for military purposes. Its growth in these 20 years has been marvelous, of such rapidity that if the military services were to make quick application of the various developments in order to keep abreast of competing nations, there was no time, with the limited skilled force available both in the military branches of the Navy and the Patent Office, to pay proper attention to the patent side of the art.

Today approximately one-tenth of the cable business of the world is being handled by radio. Great improvements in signaling the fleets has been made so that flag commanders are able to give an order on the bridge of the flagship to cause their fleets to turn right and left or about, almost instantly by radio signaling. Prior to this application, maneuvering by flag signaling was slow and uncertain, due to smoke and distance obscuring the flags. Similarly an airplane flight commander is able to telephone by radio his orders for maneuvering his squadrons of airplanes. By virtue of radio the heads of departments on shore are able to give orders to the fleets and individual ships in any part of the world by our wireless system at great increase of efficiency and great saving of cable tolls. Admirals at sea are able to spread their scouts out at great distances apart, keeping in touch by radio, whereas formerly they must cruise in limited areas in order to sight each other and make reports at definite time intervals. This decreases the number of ships required for scouting. The spotting of fleets and of shore batteries has been increased in efficiency hundreds of per cent due to spotting by aircraft which locates the fall of shots with great accuracy due to better observation methods, which would be impossible were it not for the radio with which to communicate the fall of shots.

By means of radio compass instruments, or radio direction finders, it is possible to get an accurate bearing of any ship or station which is transmitting by radio. The Navy has installed for naval ships and for mercantile ships in addition some 70 radio lighthouses on the Atlantic, Gulf, and Pacific coasts, by means of which ships at sea are able to merely call up these stations, and within five minutes be given accurate positions of their locations. This is of greatest assistance to navigation in rainy or foggy weather and the saving of many ships from grounding, and expediting others in reaching a port, whereas, due to fog, etc., they might be delayed for days. Similarly aircraft are aided in reaching their landing fields, where in foggy weather this might be impossible without great risk. The Navy is handling about 60,000,000 words a year in radio traffic. Last year the amount of tolls saved to the Government by means of the Naval Communication Service was in the neighborhood of $7,000,000.

This summary is merely for the purpose of showing that the application of radio is bringing the Government great value in a financial way, as compared to expenditures made for this service.

[fol. 2466] To date there has been no radio company which has reaped great profit from its patents, through which these various developments have been made. In fact, practically all the profits have gone into new developments and new construction, and most of these profits have been purely manufacturing profits.

Two or three times before the war efforts were made to commence the clarification of the complicated radio patent situation in order that royalties should be arranged for to the various companies which owned radio patents. Each time has brought down to the Government department an avalanche of inventors with so many overlapping patents that it was found impossible to determine just who owned the different patents and what the royalties should be. There was no personnel in any Government department capable of handling this matter.

The war came on, and it was universally agreed among the radio companies that they would put aside patent matters until the war was over and give the Government free hand to proceed as best it could to purchase apparatus. This the Government did and with the good will and cooperation of all.

After the war, conferences were arranged between the various departments of the Government interested, principally the War, Navy, and Justice Departments, to discuss methods whereby remuneration might be given those who were justly entitled to royalties on radio apparatus purchased by the Government. The ultimate result was the forming of an interdepartmental radio board, which has for two years constantly been in session with a view to adjusting this matter.

The general policy which governed the board was, first, justice to all concerned; second, the desire to increase incentive to inventions and advance the Government's position in the art of radio telegraph; third, economy for the Government; and fourth, an arrangement for prompt recompensation to all parties.

A list of radio patents purchased by the Government has been compiled, and a list of radio apparatus purchased has been compiled, and the board has worked out a plan to reimburse inventors. In all there are about 500 patents, and that number has been reduced to about 27. That has been accomplished through negotiations with the claimants, and the value of the claims has been reduced to about $2,500,000.

Lieut. Commander Loftin, who has been the head of the board, can give you full information in reference to the board and its method of arriving at its recommendations.

The Chairman: We would be glad to hear the lieutenant commander.

Statement of Lieut. Commander Edward H. Loftin, assistant to the Officer in Charge of the Radio Division, Bureau of Engineering, Navy Department, in Charge of the Patent and Research Sections, with Additional Duty as a Member of the Interdepartmental Radio Board.

Commander Loftin: Mr. Chairman and gentlemen of the committee, I think the first matter I will call to your attention is the authority under which the Interdepartmental Radio Board has been acting, and we have that in the form [fol. 2467] of a precept from the Secretary of War, the Attorney General, and the Secretary of the Navy.

The Chairman: When was that issue?

Commander Loftin: This precept was not issued until February 12, 1921. The reason for that was that that board was informally brought together by orders from the heads

of each of the departments to its own representatives, ordering them to meet with such a board. In our proceedings we found that the situation was quite embarrassing in that we often had inquiries from various claimants as to what our authority was, and what authority we were going to show when we reached our conclusions for having acted as such a board. So we then reported to the several heads of the departments our embarrassment and asked them to give us a formal precept.

Mr. Morin: When were the members of the board originally brought together?

Commander Loftin: The members of the board were originally brought together in August, 1918. Nothing was acted upon until February, 1919. The officers who were originally made members of that board all had duties in the departments. It was during the period of the war, and it was practically impossible for them to undertake the consideration of a situation such as this was.

The Chairman: You mean that the officers representing the Navy all had duties under the Navy Department?

Commander Loftin: Yes, sir; and the officers representing the War Department all had duties under the War Department.

The Chairman: What about the representatives of the Department of Justice?

Commander Loftin: At that time there was only one attorney in the Department of Justice handling patent matters. There were many suits pending against the United States, and he was thoroughly occupied at that time.

Mr. Morin: Has not this board been conducting its business with the approval of the three members of the Cabinet, heads of these three departments, War, Justice, and Navy.

Commander Loftin: Yes, sir; this request was signed by the three members of the Cabinet representing these three departments. The precept says:

Whereas the operations of the War Department and the Navy Department during the war, relating to the furnishing of adequate supplies for radio communication, developed the fact that the patent rights of greatly needed supplies were diversely held, which rendered quantity production by the employment of all the available manufacturing facilities difficult, which situation made obvious the neces-

sity for proceeding with production, without regard to the existence of patent rights, orders for which procedure were issued by both departments, wherein the United States Government directly assumed responsibility for the proper compensation for the unauthorized use of patent rights; and

Whereas large claims were presented to the United States flowing out of such procedure, in addition to others which already had accumulated, and for which suits had been filed against the United States in the Court of Claims; and

Whereas the situation thus produced made obvious the advisability of creating a board of experts in patent law and radio science for the purpose of determining scientifically the measure of liability in which the Government became involved; and

Whereas the Secretary of War suggested the creation of such a board to the Secretary of the Navy and the Attorney General, in which suggestions they concurred, and out of [fol. 2468] which was created by separate appointment representatives of the Secretary of War, the Secretary of the Navy, and the Attorney General, to constitute the Interdepartmental Radio Board, which board has been heretofore organized and has made considerable progress in the discharge of the duties the problems presented seemed to require

Now, therefore, it is directed that the officers and representatives of the several departments heretofore appointed, to wit: Commander Stanford C. Hooper, United States Navy, and Lieut. Commander Edward H. Loftin, United States Navy, representing the Navy Department; Capt. Guy Hill, United States Army, and Robert H. Young, Esq., representing the War Department; Harry E. Knight, Esq., representing the Department of Justice; and any successors of any of said members who shall hereafter be from time to time appointed shall continue as a board, designated the Interdepartmental Radio Board, to investigate, hear, and examine the questions relating to the liability involved in the use by the Government of patents on radio apparatus and similar devices and render to the several heads of the departments mentioned their conclusions and recommendations therein.

Such assistance and information as the board may require will be rendered to it by the officers of the respective departments familiar with patent and technical matters involved in those departments.

Newton D. Baker, *Secretary of War.* Josephus Daniels, *Secretary of the Navy.* A. Mitchell Palmer, *Attorney General.*

To Interdepartmental Radio Board, *Navy Building, Washington, D. C.*

Washington, D. C., *Febraury 12, 1921.*

The Chairman: As I understand it, from the reading of that precept, the Government practically asked these inventors to allow the Government to use their patents, they ultimately to look to the Government for pay for these inventions. That was the purpose of this precept, was it not?

Commander Loftin: Of this order?

The Chairman: Yes.

Commander Loftin: The negotiations were really instigated by several of the main patent holders. During the war we insisted that in all litigation in reference to these patents that the Government was interested and litigation should cease. A number of letters were written to the district courts practically saying that the Government would not tolerate the continuance of litigation on radio patents during the war, and a number of those cases were—in fact, in three cases in which we took such action the cases were set over. The real purpose of that was this: Litigation requires the attention of the engineers of the companies. We had taken a number of the engineers into both services for war purposes, and those who remained with their companies were urgently needed in the production and development of radio apparatus for use during the war.

The Chairman: Was that notice to the inventors in writing?

Commander Loftin: It was to the courts; I am not certain about that; I think we can produce some letters to the companies.

The Chairman: Will you kindly do that and put them in the hearing for the benefit of the members of the committee?

Commander Loftin: I will do that, sir.

[fol. 2469] (The letters referred to are as follows:)

Interdepartmental Radio Board,
Washington, D. C., May 25, 1921.

Hon. Julius Kahn, *Chairman Committee on Military Affairs, House of Representatives, Washington, D. C.*

SIR: Referring to my hearing before the committee on May 23 in connection with the proposed amendment to the Dent Act for the settlement of claims against the Government under patents in the art of radio communication, I am inclosing copies of a number of Navy Department letters which show the department's policy in the matter of suspending litigation on radio patents during the war. This is done in accordance with your request after my reference during the hearing to this particular policy.

Very respectfully,

Edward H. Loftin, *Lieutenant Commander, United States Navy, Chairman.*

January 18, 1918.

GENTLEMEN: From information received by the department from the Bureau of Steam Engineering, it appears that the Government's interests are indirectly involved in the suit of the New York Patents Exploitation Co. against the Mallory Steamship Co., on account of alleged infringement of the Seibt patent, No. 1216615, relating to quenched spark radio apparatus, and that certain information of record in the department or within the knowledge of experts in the department's employ will be of considerable value in connection with the trial of said cause.

In view of the demands made on the entire force of the department's employees under existing conditions, it is not possible that the Government's interests, as affected by said suit, can be given the attention requisite to a proper disposition of the matters in issue, and, as the department's interests will be affected by the outcome of the case analogously with those of the defendant, it is requested that you,

in the public interests, ask the court to stay all proceedings for the duration of the war.

Very respectfully,
Franklin D. Roosevelt, *Assistant Secretary.*

Messrs. Sheffield & Betts, *Counselors at Law, 52 William Street, New York City, N. Y., Attorneys for Mallory Steamship Co.*

April 27, 1918.

Gentlemen: The bureau has received information that you are pushing the suits against E. J. Simon and the Kilbourne & Clark Co. It is believed to be in the interests of the Government to have this litigation stopped.

Please inform the bureau what arrangements you propose to make.

Very respectfully,
H. P. Le Clair, (By direction Chief of Bureau.)

Marconi Wireless Telegraph Co., *Woolworth Building, New York, N. Y.*

December 14, 1917.

Attention of Mr. E. J. Nally.

Gentlemen: The bureau has received information that the patent suit pending against the Government is being pushed by the Marconi Co. You are undoubtedly aware of the fact that in order to defend itself properly, many of the radio experts now with the Government would be required as witnesses for the defense. In view of the fact that we are now prosecuting a war which requires constant attention of all the Navy's experts, it would be impossible for them to take time away from their other important [fol. 2470] work to testify in this case. Thus an injustice would be worked the Government. It is hoped therefore, that the Marconi Co. will be able to see its way clear to a postponement of this suit until after the present war.

Very respectfully,

R. S. Griffin, *Engineer in Chief, United States Navy, Chief of Bureau.*

Marconi Wireless Telegraph Co., *Woolworth Building, New York, N. Y.*

April 7, 1917.

From: Bureau of Steam Engineering.

To: Solicitor.

Subject: Suspension of patent suits during war.

1. There are a number of radio patent suits now in the courts and in prospect which the department is either directly or actively interested in, the principal one being a suit by the Marconi Wireless Telegraph Co. filed in the Court of Claims against the Government. It is impracticable under present conditions, owing to the rush of work, for the bureau to devote any attention to these matters of litigation without taking the attention of the experts from the efficient conduct of its duties in providing and supplying radio sets to the fleets. It is therefore recommended that suitable arrangements be made whereby all litigation of the nature described above be suspended until after the war.

Griffin.

July 11, 1918.

SIR: From information received by the department from the Bureau of Steam Engineering it appears that the Government's interests are involved in the suits of Samuel M. Kintner and Halsey M. Barrett against the Atlantic Communication Co. on the reissue patent No. 12168 and patents Nos. 1050441 and 1053728, relating to the so called heterodyne and sustained wave, now pending before Judge E. Henry Lacombe as master, and that it may be found advisable for the department to intervene and to furnish information and testimony in said matter.

In view of the demands made on the entire force of the department's employees under existing conditions, it is not possible that the Government's interests as affected by said suit can be given the attention requisite to a proper disposition of the matters in issue, and as the department's interests may be affected by the outcome of the case, it is requested that you, in the public interest, ask the court to stay all proceedings for the duration of the war.

W. S. Benson, *Acting Secretary of the Navy.*

Mr. Dean S. Edmonds, *35 Nassau Street, New York, N. Y.*

August 23, 1918.

SIR: Replying to your letter of July 30, 1918, on the subject of the suit between the American Telephone & Telegraph Co. and Mr. Peter Cooper Hewitt.

The suit is apparently not a patent infringement suit and probably does not directly involve wireless. It is further appreciated that you would not under any circumstances press a suit that might embarrass the Government to the slightest degree in the prosecution of the war.

In view, however, of the far-reaching effect of a decision unfavorable to the American Telephone & Telegraph Co. and the importance which they would naturally attach to a proper defense of the suit this bureau is of the opinion that it would be necessary to call upon experts who are now employed on important war work, and that this would necessarily be very objectionable to the Government.

For this reason it is believed inadvisable for the Government to withdraw or modify its request to Hon. Julius M. Mayer to have the suit postponed. The request of the [fol. 2471] Government, however, is not to be construed as making it unnecessary for the telephone company's counsel to use every effort to obtain the services of satisfactory experts who are free to undertake the work.

Very respectfully.

R. S. Griffin, *Engineer in Chief, United States Navy, Chief of Bureau.*

Mr. Drury W. Cooper, *55 Liberty Street, New York, N. Y.*

July 20, 1918.

SIR: This department is informed that a suit is pending before you in which Peter Cooper Hewitt is claiming that the vacuum tubes furnished by the American Telephone & Telegraph Co. embody certain inventions owned by him, and that you desire to be informed as to whether or not the experts available to the American Telephone & Telegraph Co. for consultation and presenting the situation to the court are free to take up this work, or whether, on the contrary, their services are required by the Government.

For the war necessities now existing this department requires and is obtaining the services of all of those who are skilled in vacuum-tube matters in the organizations of the American Telephone & Telegraph Co. and of the Western

Electric Co. (Inc.), as well as those connected with other organizations. It would be prejudicial to the public interests to permit anyone having such knowledge of the operation of these devices in telephony and allied work as would fit him to assist the court and the defendant in the presentation of this case to devote to the case the time which would be necessary for this purpose.

Moreover, the experts of the American Telephone & Telegraph Co. and of the Western Electric Co. (Inc.) and others are engaged in cooperation with this department in highly confidential work involving vacuum-tube operations along lines deemed to be of the highest importance in connection with the prosecution of the present war. This work must be proceed; any testimony given by persons having knowledge of this confidential work, even though not specifically directed to it, would be inadvisable.

For these reasons this department requests that no further steps be taken in this litigation during the present emergency.

Copies of this letter are being forwarded to Mr. Drury W. Cooper and Mr. Charles Neave.

Respectfully,

Josephus Daniels, Secretary of the Navy.

Hon. Julius M. Mayer, United States District Court, New York, N. Y.

January 18, 1918.

Gentlemen: From information received by the department from the Bureau of Steam Engineering it appears that the Government's interests are indirectly involved in the suit of the National Electric Signalling Co. against the Marconi Wireless Telegraph Co., of America, on account of alleged infringement of two patents to Reginald A. Fessenden, Nos. 918306 and 918307, covering improvements in high group frequency radio apparatus, and that certain information of record in the department or within the knowlege of experts in the department's employ will be of considerable value in connection with the trial of said cause.

In view of the demands made on the entire force of the department's employees under existing conditions it is not possible that the Government's interests as affected by said

suit can be given the attention requisite to a proper disposition of the matters in issue and as the department's interests will be affected by the outcome of the case analogously with those of the defendant, it is requested that you, in the public interest, ask the court to stay all proceedings for the duration of the war.

Very respectfully,

Franklin D. Roosevelt, Assistant Secretary.

Messrs. Sheffield & Betts, Counsellors at Law, 52 Williams Street, New York City, N. Y., Attorneys for Marconi Wireless Telegraph Co.

[fol. 2472] April 20, 1918.

Sir: I had the honor to address you under date of February 13, 1918, in regard to the suit of the International Radio Telegraph Co. (formerly S. M. Kintner and H. M. Barrett, receivers of the National Electric Signaling Co.) against Marconi Wireless Telegraph Co., now pending before you in the United States District Court for the District of New Jersey. In this letter it was stated:

"The department does not wish to be understood as requesting a stay of proceedings that would interfere with the making up of the record up to the point where testimony of Government witnesses already of record is incorporated in the case, but in view of the stress of present activities of the department, the absence of some of its experts in foreign waters, and the heavy burden of duties now engrossing the entire time of others, it is believed that the Government's interests would be materially prejudiced, unless given the opportunity after the termination of the war to have incorporated into the record such further testimony as it may deem appropriate and relevant to the patents in suit."

It is the understanding of the department that the record in this case has been now made up to the point where testimony of Government experts already of record has been incorporated therein, but in view of the stress of present activities of the department and the absence of some of its experts in foreign waters and the heavy burden of duties now engrossing the entire time of others, it is believed that the Government's interest would be materially prejudiced, unless given the opportunity after the termination of the

war to have incorporated into the record such further testimony as it may deem relevant and proper to the patents in suit. Hence, it is for the public interest that further proceedings in this cause be suspended for the duration of the war.

Josephus Daniels, Secretary of the Navy.

Commander Loftin: Mr. Chairman, I will take up the general situation first, and then I think the details can be brought out by questions put to me and other members of the board who have been working on this proposition for several years.

Congress and the heads of the several departments are not interested directly in the details of the hundreds of patents which have been considered by this board, and must, of necessity, abide by the opinion of this board or any similar organization; but they are interested in what, in fact, is accomplished by such a board.

There are approximately 2,500 United States patents in this art, all of which were living during the period covered by the board. All of these have had to be considered in one way or another; if not directly as patents under which claims are made, then as to their bearing on patents under which claims were made. In addition, hundreds of foreign patents and hundreds of United States and foreign publications have been sought out and considered in relation to their effect on those patents presented in the claims.

The claimants did not know precisely just what the Government had used, and many of them brought claims under all patents, with the result that the board had to laboriously proceed through several hundred patents, pick out those under which it was evident there was no infringment, and then by hearings with claimants, long drawnout, eliminate the chaff.

The board finally came down to a real serious consideration of 149 patents. This consideration involved searches of the art, writing of long reports, receipt of briefs from claimants, hearings, more briefs, revised reports, and then an accounting on those patents considered good, which were 27 in number, with much discussion following as to the methods of accounting and the effect of decisions thereon.

[fol. 2473] The final number of patents found by the board to be of substantial value was 27. This does not mean there

were not other patents which had been used in small ways, but most of the claimants, recognizing the scope of such an investigation, and realizing that it would draw out the investigation to such an extent by considering minor patents, agreed in advance, if they succeeded in getting a settlement on some of their basic patents, that they would then lump them all and release to the Government all minor patents.

The Chairman: Of these 2,500 patents claimed, were a goodly number allowed before the board was organized?

Commander Loftin: Allowed where?

The Chairman: Or approved by the Government as being valid patents?

Commander Loftin: They were allowed by the Patent Office; yes, sir.

The Chairman: About how many of those patents were there, of the 2,500 that were allowed?

Commander Loftin: Actually about 2,500 were allowed by the Patent Office, but only 27 major patents were allowed by the board as having been used by the Government. We were not asked to consider some minor patents; they were thrown in, if settlement could be reached on the major patents.

Mr. Parker: That is to say, there were minor patents owned by the owners of the major patents?

Commander Loftin: Yes, sir.

Mr. Parker: Then there were a lot of outside patentees who were getting nothing under this settlement?

Commander Loftin: We have asked practically everybody who was suspected of owning a radio patent to come before the board and present evidence.

Mr. Parker: Will they all be released?

Commander Loftin: They will be released, those that have been favorably considered by the board.

Mr. Parker: There are a number which have not been favorably considered; are they going to be released?

Commander Loftin: Most of them will be included in the releases, along with the major patents. For instance, the Marconi Co. has about 350 patents. They presented only four patents finally to the board. The board allowed three of those four patents. They will include in their release to the Government all of the 350 patents that they own, and also the one not allowed by the board, so that it will be a complete and sweeping release of that company on practically 350 patents.

Mr. Parker: What about the Deforest Co.; that was a rival company?

Commander Loftin: We have not succeeded in reaching a settlement with the Deforest Co. In 1917 the Deforest Co. sold to the American Telephone & Telegraph Co. the exclusive rights under their patents. Most of the apparatus bought, which was covered by those patents was bought during the war; if it was prior to the war it was bought from Deforest himself, so there would be practically no allowance to Deforest prior to the time he made this sale to the American Telephone & Telegraph Co. He has contended that he [fol. 2474] has a claim subsequent to such transfer to the American Telephone & Telegraph Co. That matter was submitted to the Attorney General by the board for an opinion as to whether or not he had a legal claim. So far he has failed to convince the Department of Justice that he did have a legal claim. He had many hearings there, and he finally decided that the question involved was so difficult that he would withdraw his claim from the board and submit it to the Court of Claims, later on, if he so desired. So he stands now with his claim withdrawn from the board on a technical, legal question.

Mr. Parker: Can we not force him into the Court of Claims so that we can have done with the question for good?

Commander Loftin: There is no necessity to force him into the Court of Claims; he will go there if he thinks he has any substantial claim.

The Chairman: In the draft of the bill which the departments sent to me I have suggested to one or two of my colleagues on the committee, with whom I have talked, that we put a limitation in there compelling them to present all their claims within a comparatively short length of time, or lose their rights altogether, and that is the only way to handle the question, otherwise the matter would be pending for years, and no committee of Congress at this time wants that kind of a condition to prevail.

Commander Loftin: I might add here that we have already obtained a release from the American Telephone & Telegraph Co. for all claims that they have on the Deforest patents, under which they acquired exclusive rights on March 17, 1913.

The Chairman: About how many claims are included in this bill out of the 2,500 patents that were filed?

Commander Loftin: This will settle all claims which have been presented to the board, except that of the Deforest Co., which has been withdrawn, and one or two minor claims, which were not found by the board to have substantial merit.

The Chairman: What was the value of the Deforest claims as presented by them?

Commander Loftin: He has filed suit in the Court of Claims in which he puts the value at $2,000,000.

The Chairman: So then, as I understand you, claims to the value of $14,000,000 in the aggregate, or thereabouts, were filed with you. Of that $14,000,000 how much is unrepresented in the report you now make?

Commander Loftin: Deforest has $2,000,000, and there is one other claim for $150,000.

The Chairman: So that in making a settlement of these claims and paying $2,500,000 you are practically wiping out approximately $12,000,000 worth of claims?

Commander Loftin: But that $14,800,000 only represented the statements of 7 out of 24 claimants. The other 17 did not state any particular sums, or have not filed suits in the Court of Claims from which we could arrive at figures.

The Chairman: Then you assume that the $2,500,000 which you propose to be paid in settlement, will cover a much greater value than $14,000,000?

Commander Loftin: Easily double that.

[fol. 2475] The Chairman: You may proceed.

Commander Loftin: Such a task has been stupendous, and has required a force of experts—expert to begin with, but which became more expert daily in its specific task as it gained knowledge from experience.

Consider the chaos that would have existed if such a task (the serious consideration of 149 patents of a difficult art) had been presented to a number of courts in different places and at different times; for a single patent could be the cause of half a dozen suits in order to reach the numerous contractors for the Government; and then, after the patents had been sustained, the long drawn out procedure of accounting in each case, each accounting duplicating in many respects accountings in other jurisdictions.

I predict that under our judicial system, and with the extreme difficulty in presenting patent cases, that the task could not have been covered in the courts in 25 years, in the same comprehensive but centralized method of the board.

Patent litigation is a parasite on the development of the

art. Every patent attorney has to be assisted by a whole corps of experts, and I could cite you examples of several recent cases, apparently very simple, which in effect practically stopped the operations of several companies because their engineers were being used by the lawyers as experts.

This art is just coming to the point where it is to justify its inception as one of the blessings to mankind, and nothing should be allowed to interfere with the commercializing plan mapped out. It has proved its value from a military point of view during the war. It has had a great commercial value in the past, but its future is almost without limit, and should be realized, by subsidy, if necessary, rather than by placing useless stumblingblocks in its path.

I could easily make you a table showing how just one of the patents considered by the board could be the subject of seven or eight suits, with reasonable hope of substantial recovery, and when we take all the patents which would have the same reasonable hope of recovery, and show the combinations of suits which could be brought, it would easily reach the hundred mark.

The Chairman: Would it be very difficult to make that kind of a table?

Commander Loftin: No, sir.

The Chairman: The House wants to know about that. If you could take one of these claims and show just exactly what could be done under the patent law, and insert it in the hearing, I am sure the committee will appreciate it very much.

Commander Loftin: That matter is really very simple. For instance, we can take just one of the patents that the board has found to be good, and we can say that the Government has bought apparatus from at least eight contractors employing that particular patent. For that patentee to reach those contractors and get from them what the law allows him—their profits—he would have to file a suit against each one of them, in most cases in different jurisdictions.

The Chairman: If the United States court found that a patent was valid and rendered a decision in favor of the [fol. 2476] holder of the patent, would not the other contractors immediately confess judgment, because the opinion in the one case, affirmed, of course, by the higher courts, would be a precedent in the other cases?

Commander Loftin: That always has an influence on the fellow who is subsequently being sued; but in most of these cases the Government has saved the contractors harmless, so that we would really have to go out into the district courts and watch those suits and see that the contractor who was being sued did not throw up the case (he having been saved harmless by the Government), leaving a situation wherein he could come back to the Government and say, "Reimburse me; I have lost in this court on that particular contract," and the patent owner then having secured judgments in the district courts, could come to the Court of Claims and file a suit against the Government for the use of that apparatus. So that it easily runs up in some cases to 7, 8, 9, or 10 suits. If we take the 27 patents and multiply that number by 5, allowing a factor of safety on the number of suits being brought, that would easily total over a hundred suits.

The Chairman: That would make 135.

Commander Loftin: Yes. That table is not very difficult to make. I could name specific patents and specific apparatus which was involved, and specific contractors if it would be of any value to the committee.

The Chairman: We will appreciate it if you will kindly put that in the hearing.

Mr. Morin: The validity of these patents is not questioned, is it?

Commander Loftin: In this bill?

Mr. Morin: There is no question as to the validity of the patents?

Commander Loftin: On some of them we did question the validity and made no allowance on them, and our figures have been accepted by the claimants.

Mr. Morin: The allowance has been based on the use of the patents that have been found valid?

Commander Loftin: Yes; and the manufacture also. This whole settlement includes the contractors for the Government as well as the Government, the particular necessity for that being that the Government has agreed in many cases to save the contractor harmless. Now, under the act of 1918 we have the entire responsibility anyway.

Mr. Morin: You have not allowed any claims where the validity of the patent is in doubt?

Commander Loftin: No, sir; unless the doubt was such that it could reasonably be resolved in favor of the patentee.

I might say here that I am informed that the courts generally lean over backward to sustain a patent, but I do not think we have gone quite that far. We have required them to come somewhere near the middle ground before we have held that the patent is good. But the courts are very liberal with inventors and will generally resolve a very strong doubt in their favor.

The Chairman: The men who own patents think that the infringers have things all their own way. You may proceed with your statement.

Commander Loftin: The Government has largely held the contractors harmless, through war necessity, and would [fol. 2477] naturally have to defend all the suits to keep indifferent contractors from forfeiting them, and I believe this would mean new quarters for the Attorney General, with a patent department as large as his whole present organization.

In practice, then, this robs patent attorneys of a most promising, lucrative field of occupation for years to come, and saves untold expense in litigation, both to the Government and to patent owners. It practically frees the entire field of prospective litigation and allows the engineers of the companies to go about their legitimate business of improving and perfecting, rather than trying to save from the scrap heap what has been done before. It would practically ruin the Government organization, as radio experts are extremely few, and the Department of Justice would commandeer everyone for litigation.

The Chairman: Have you heard from the patent attorneys?

Commander Loftin: We have had many of them before us.

The Chairman: Are they in favor of this report?

Commander Loftin: Yes; they are quite reasonable about it.

It encourages an art for it to from time to time see that some compensation is being paid for the work being done. The Government has no too good reputation as to its relation to inventors, and yet this method does not encourage the undeserving, as every claim has been sifted down to its real merit.

This board has not aroused any hard feelings. Litigation always does. In our dual status of being court and defense,

we have had to keep open minds, and I believe we have won the confidence of every claimant who has been before us.

By our work the Government knows just where it stands in the radio-patent situation, and through this knowledge has been enabled to negotiate some very desirable patent arrangements for the future; yet all of this good work could be readily stultified if no settlement was had out of this board's efforts and the whole field thrown into litigation.

The Government stopped all litigation during the war by appeals both to litigants and courts. The board stopped it during its work in order to leave the situation in status quo, as it would have been impossible to deal with a situation constantly changing.

I have no knowledge of any substantial reward to any patent in this art. There have been many suits, but the operators heretofore have been financially weak and the judgments have not meant anything.

The Chairman. Did I understand you to say if they had secured judgments when you make this settlement those possible judgments will all be wiped out?

Commander Loftin. Yes, sir; as far as the Government apparatus is concerned. It does not seem that, as far as some commercial company is concerned, which has been operating commercially.

The Chairman. It is only the Government we are interested in.

Commander Loftin. We feel that the operations have been so small that if they settle with the Government it will stop the other suits and allow those men to go ahead in the matter of development. While great advance has been made, there are many problems to be solved, and all that can be done to help solve those problems is going to be of value.

(tol. 247s) It may be of particular interest to know that while the interallied communications conference was in session here in Washington last fall a number of representatives of the British Government at that conference, who were also radio men in Great Britain, learned that such a board was in progress here. They came to us and said they had quite a similar situation in Great Britain, and having learned of our board they would like to have the details as to procedure, what we proposed to do, and how far we had gone, etc., so that they might inform the British Govern-

ment of this form of procedure. After they returned home we learned informally that they had organized such a board in Great Britain.

The Chairman: That was subsequent to the time when they were here?

Commander Loftin: Yes, sir. We had our naval attaché in London inquire as to whether or not that was a fact, and we had a brief report saying that such a board had been organized, but with a personnel much more widely known than the personnel who compose this board.

The Chairman: That shows that they learn things from other countries.

Commander Loftin: They are using what we call in the Navy "deep draft" men—big men.

The Chairman: We can probably learn from other countries, too.

Commander Loftin: Such a board is in progress, and they intend to go further than merely the radio art and are going into other arts in an endeavor to settle numerous claims which have been brought.

The Chairman: Do you think that was the reason why they came to no agreement whatever in this matter of cable transmission—telegraphic transmission?

Commander Loftin: You mean while the conference was in session here?

The Chairman: Yes.

Commander Loftin: They came to many agreements on many points.

The Chairman: On the principal point they did not come to an agreement, or rather they determined to leave the matter to their ambassadors, and they have come to no conclusion yet.

Commander Loftin: They are to proceed again this summer.

The Chairman: And the next summer, and the summer after that, I imagine. You may proceed.

Commander Loftin: The claims which have been stated are $14,800,000, by 7 out of 24 claimants. If all of them had stated an amount, it would probably have been thirty or forty million dollars.

We think it represents a good showing as to the accuracy of our work to pare these claims down to approximately

$2,500,000 and still keep the claimants happy. They are all with us now; you will find them probably putting in a word for themselves, as they have an opportunity, and we certainly see no objection to that. They have worked hard with us and have met every request that the board has made, and we think it is only fair that they should have an opportunity to state their side of the case from time to time, as considered advisable.

The Chairman: Are the Deforest Co. and the other company which you named the only two that are out of this settlement now entirely?

[fol. 2479] Commander Loftin: No, sir; not entirely.

The Chairman: I think the committee would like to know, and it is desirable that we tell the Members upon the floor of the House, just how many claimants are willing to stand by this agreement.

Commander Loftin: I will go through the list of claimants and tell you just what we have done in each case.

In the case of the Vreeland Apparatus Co. we have not made any recommendation as to their claim.

The Cairman: Have you considered it?

Commander Loftin: We have considered their claim very fully, and their claim has also been considered in part—not all their patents—but two out of four of their patents were also considered by the Munitions Patents Board along with us, and their claim was rejected also by that board.

The Chairman: Was it rejected by your board?

Commander Loftin: Our board and the Munitions Patents Board, as far as they considered their claim, which included two out of four patents. We considered four patents, but two of them for special reasons went to the Munitions Patents Board also.

The Chairman: You have rejected it, so far as you are concerned?

Commander Loftin: Yes, sir; we have rejected it.

Mr. Parker: Might I ask you this question, and that is, whether you will settle if the Government used any of the machinery? If they sold the machinery, of course they can not charge for its use.

Commander Loftin: No, sir; they were not a manufacturing company.

Mr. Parker: But suppose the Government simply used the machinery?

Commander Loftin: They were a patent holding company. Now, take the case of the Marconi Wireless Telegraph Co. We reached a settlement with this company and will secure an absolute release from that company under their entire patent situation, which includes some three hundred and fifty and odd patents up to the time that company transferred its holdings to the Radio Corporation of America.

Mr. Wright: Would it not be well to have the amounts of the claims set out, Mr. Chairman, and also the amounts allowed?

Commander Loftin: Where the amounts have been stated we can do that.

The Chairman: Will it take a great length of time?

Commander Loftin: I have sent to you, Mr. Chairman, a draft of the preamble of our report to the several secretaries. That goes into the general phases of the board's work, including the proposed allowances to the several companies. That is not quite complete, but I see no objection to its going into the record, if you desire to have it printed.

Mr. Garrett: Does that include the list of the amounts claimed, and also the amounts allowed?

Commander Loftin: Yes, sir.

The Chairman: You have that in the report, a copy of which you sent to me?

Commander Loftin. Yes, sir.

Mr. Morin: Have you a list of the awards made?

Commander Loftin: Yes, sir.

[fol. 2480] Mr. Morin: It seems to me if that is included in your statement, it would be well to include the entire matter.

Commander Loftin: That is included in the statement which I sent to the chairman, and that will cover the whole matter, unless these amounts stated would bring out some points you would want to ask questions about.

Mr. Parker: Does your statement show whether the machinery was purchased, or whether you made your own machinery?

Commander Loftin: Practically all our apparatus has been made by commercial concerns. We have made a small amount in the Government navy yards.

Mr. Parker: Was any of it made by the patent companies themselves?

Commander Loftin: In a good many cases; yes.

The Chairman: That would all be shown in the statement which you have?

Commander Loftin: We have not shown in our statement which companies are manufacturing and which, apparently, are straightout patent holding concerns, or individuals, who have no facilities for manufacturing.

Mr. Parker: What I meant was, if these people furnished you the machinery and you bought it, you would be free from any royalties.

Commander Loftin: We have taken care of that; we have made no allowance where they have furnished the apparatus themselves.

The Chairman: If there is no objection, the report you refer to may be included in the hearing at this point.

(The report referred to is as follows:)

Report of the Interdepartmental Radio Board as to Claims Against the United States by Owners of Radio Patents

Washington, D. C., *May 31, 1921.*

The Secretary of War,
The Attorney General of the United States, and
The Secretary of the Navy.

This board is comprised of representatives appointed by the Secretary of War, the Attorney General, and the Secretary of the Navy, and constituted as follows:

Lieut. Commander Edward H. Loftin, United States Navy, president, and Commander Stanford C. Hooper, United States Navy, representing the Navy Department.

Robert H. Young, Esq., recorder, and Capt. Guy Hill, United States Army, representing the War Department.

Harry E. Knight, Esq., representing the Department of Justice.

(See "Precept," Paper A.)

History

The steps leading up to the appointing of this board were the following:

Prior to the entry of the United States into the war a single suit involving radio patents had been brought in the

Court of Claims against the Government, namely, that of the Marconi Wireless Telegraph Co. of America against the United States, filed July 29, 1916. At this period the contracts of the Government, in general, including those relating to radio apparatus, required that the contractor should indemnify the Government from any loss arising out of claims for infringement made by reason of the infringing of the contractor's apparatus, and the responsibility of the Government was specifically stated by the act of June 25, 1910 (ch. 423, 36 U. S. Stats., 851).

In January and February, 1918, the Western Electric Co., prior to final decision by the Supreme Court in the Cramp [fol. 2481] and Simon cases below mentioned, had insisted, as to its contracts with the Government, that it (Western Electric Co.) be held harmless in any patent litigation. In one such contract, for example, relating to a radio apparatus designated as an audio frequency amplifier, the supply officer at the navy yard in New York was instructed to award the contract to the Western Electric Co., subject to the following condition:

"The apparatus mentioned herein being required without delay by the United States Government said apparatus is furnished in this emergency without investigation of outstanding patents, upon the condition (to which the United States, in placing its order, agrees) that the United States will save the Western Electric Co. (Inc.) harmless from all claims for infringement of patents on account of the apparatus so furnished, the Government assuming with the patentees direct all responsibility for said patent infringement."

On March 4, 1918, the United States Supreme Court, in the cases of William Cramp & Sons Ship & Engine Building Co. *v.* International Curtis Marine Turbine Co. (246 U. S., 28) and Marconi Wireless Telegraph Co. *v.* Simon (246 U. S., 46), having rendered the opinion that in certain cases contractors with the Government were not protected by the act of 1910 from independent liability, it was represented to the Government, and particularly to the War and Navy Departments, that contractors could no longer safely undertake the warranty against infringement. See in this connection the letter from Deforest Co., dated March 14, 1918. Similar letters were received from the National Electrical

Supply Co., the Wireless Improvement Co., Emil J. Simon, the Wireless Specialty Apparatus Co., Kilbourne & Clark Manufacturing Co., and the Sperry Gyroscope Co.

The contracts with the Western Electric Co., referred to in said letter, had been made prior to the rendering of the decisions in the Cramp and Simon cases, the Western Electric Co. having (as already stated) made their bids in certain cases only on condition that such warranty be given. At this time there had been called to the attention of the Government claims of various companies owning patents for radio apparatus, particular stress being laid upon claims arising under adjudicated patents of the Marconi Wireless Telegraph Co. of America, the International Radio Telegraph Co., and the Deforest Radio Telephone & Telegraph Co.

On March 29, 1918, the Acting Secretary of the Navy caused to be addressed to the Deforest Radio Telephone & Telegraph Co. a communication accepting certain responsibility on the part of the Government for the protection of contractors against patent claims and by direction of the Secretary, the Bureau of Supplies and Accounts, Navy Department, was, on April 3, 1918, notified that letters of similar purport to that sent to the Deforest Co. would be sent by the department from time to time to other contractors where it appeared that such action was necessary, in addition to those mentioned in the first indorsement of the Solicitor for the Navy Department on April 3, 1918.

The Secretary of War issued similar orders and the Secretary of the Navy did likewise in several additional instances.

In order to ascertain and define the obligations which were being assumed by the Government under these guaranties, conferences looking to the reaching of an amicable agreement were had with the several companies and particularly with the Marconi, Deforest, and International Cos.

On June 14, 1918, a conference was held between a representative of the War Department and the Marconi Co.

Negotiations also proceeded with the Deforest and International Cos., and the claims of other patentees which had arisen or might arise were brought to the attention of the War Department and Navy Department and litigation began or was threatened involving the Government directly or indirectly.

In order that the action of the War Department and the Navy Department in reference to claims made to them and the action of the Department of Justice in regard to the litigation pending or proposed might be coordinated, it was, on the 13th of July, 1918, proposed by the patent section of the Bureau of Aircraft Production to the Secretary of War that a letter be addressed to the Secretary of the Navy and the Attorney General proposing the appointment of a board representing the three departments to investigate and negotiate settlement; and favorable responses having been given and action taken thereon, the present board was constituted, and, after various changes in personnel, it is composed of the representatives above stated.

Among considerations influencing the constitution of a board to which might be submitted all claims under radio patents were the following:

It was considered that under the conditions established by the acts of 1910 and 1918 the Government would be in- [fol. 2482] volved in a multiplicity of suits under patents and that these would be different in character, depending upon the time at which the infringement complained of occurred and, in some cases, upon the question of whether the Government or the contractors with the Government were original or contributory infringers. The varying conditions of warranties affecting different contracts, some warranties being by the contractor and some by the Government, in so far as liability of patent infringement is concerned, introduced a serious complication. Under these warranty contracts the Government naturally became interested in suits pending anywhere in the United States involving alleged infringement of letters patent under which claims might be made against the Government.

These questions became particularly important in the radio art, which involves considerable difficulty in understanding its principles and in making them clear to any court not technically trained. The art is, furthermore, new and rapidly developing, so that the condition of patent protection is in a state of flux, and the entire field of accounting is embraced by still living patents. The number of claimants in this line and the patents involved were numerous, the contractors were also numerous, and the variation in forms of apparatus was and the conditions of the contracts were such that a claimant for compensation under a patent was in the position in some instances of being a warrantor

to the Government under all patents but his own. The great importance of the radio art to the conditions of modern war and the necessity for ignoring everything but efficiency and speed in securing equipment produced an amount of infringement upon radio patents in the last few years all out of proportion to what would have occurred in ordinary times.

A board comprising representatives of the several departments involved would consolidate the accounting into a single process which, in other event, might have had to have been repeatedly repeated for proceedings involving different departments of the Government, different patents and different jurisdictions. It would enable the coajoint consideration of the various claims and the various patents and thus protect the Government from having to pay multiple compensations for the same installation, for each patentee could be counted upon to urge in court the exclusive importance of his invention, and if each were granted compensation without the consideration of the claims of other patentees, the Government would undoubtedly be involved by successive suits in a total amount out of all proportion to what would be involved if all claims were presented to a single tribunal and each compelled to take his fair proportion of a total sum, for it must be admitted that the compensation due to a patent can not go beyond the value which the invention of that patent has added to preexisting art, and that value is most safely measured by the profit that can be made upon the improved machine, whether by the patentee or by the purchaser as compared with what can be made with prior machines. This sum, being determined either accurately or roughly as the circumstances of the case admit, must be allocated to all patented inventions contained in the machine and properly between them with some attempt of relative valuation and after deduction, also accurately or roughly as the case permits, of the share that is due to old or unpatented parts of the machine.

The saving by such a proceeding of delays and expenses of numerous litigations in numerous courts is obvious, and it may be assumed that if the Government by such a proceeding can ascertain the amount acceptable to claimants and substantially equivalent to what they could expect by continuance of litigation, the Government will have been fully justified by reason of the saving of the time of its personnel and the expenses involved in litigation.

The Interdepartmental Radio Board thus constituted held its initial meeting and organized on August 16, 1918, and began the preparation of a complete detailed statement of the radio apparatus which had been bought, constructed, and used by the War and Navy Departments, segregating the apparatus as much as possible with relation to the patent art as it has progressed.

Prior to the signing of the armistice in November, 1918, the operation of the board was interfered with by the detailing of its members in war operations. On February 12, 1919, a letter was addressed to each of a list of patent owners.

The Wireless Improvement Co., J. S. Stone, Cutting & Washington, and Cooper Hewitt Electrical Co. submitted no claim. The following parties responded that they had no claims to be satisfied or negotiated: Federal Telegraph Co., General Radio Co., Liberty Electric Corporation, Moorhead Laboratories (Inc.), American Radio & Research Corporation, Westinghouse Electric & Manufacturing Co., Kilbourne & Clark Manufacturing Co.

[fol. 2483] Claims for compensation were made by the following:

1. Vreeland Apparatus Co.
2. Marconi Wireless Telegraph Co.
3. International Radio Telegraph Co.
4. Deforest Telephone & Telegraph Co.
5. Louis Cohen.
6. E. H. Armstrong.
7. Emil J. Simon.
8. Sperry Gyroscope Co.
9. American Telephone & Telegraph Co.
10. Reginald Fessenden.
11. Clapp-Eastham Co.
12. Wireless Specialty Apparatus Co.
13. Lowenstein Radio Co. (Inc.).
14. Dubilier Condenser Co.

The following claims were added later:

15. General Transmission Co.
16. John Firth.
17. H. M. Horton.
18. National Electrical Supply Co.

19. Joseph Raes.
20. Title Insurance & Trust Co.
21. Peter E. Stogoff.
22. J. Harris Rogers and H. H. Lyon.
23. J. Harris Rogers.
24. American Mechanical Improvement Co.

An additional circular letter, inquiring as to the condition of cross licenses affecting the patents involved, was sent May 15, 1919, to the several claimants.

The answers to this second circular letter were before the board when the individual claims were considered.

The board thereupon proceeded to consider the several hundred patents set forth in these claims, and on September 25, 1919, had progressed so far with this examination that a letter was sent to the several claimants appointing hearings.

Later notices were sent to the remaining claimants and in due course the claimants all appeared before the board and hearing was had orally in each case. During the discussion of the claims with the various claimants, numerous patents were eliminated by withdrawal of claims thereon, so that there were left for consideration by the board claims based only on the following:

	Number of Patents
1. Vreeland Apparatus Co.	4
2. Marconi Wireless Telegraph Co.	4
3. International Radio Telegraph Co.	29
4. Deforest Radio Telephone & Telegraph Co.	62
5. Louis Cohen	1
6. E. H. Armstrong	1
7. Emil J. Simon	1
8. Sperry Gyroscope Co.	2
9. American Telephone & Telegraph Co.	70
10. R. A. Fessenden (not formally presented).	
11. Clapp Eastham Co.	1
12. Wireless Specialty Apparatus Co.	12
13. Lowenstein Radio Co. (Inc.)	2
14. Dubilier Condenser Co.	4
15. General Transmission Co.	1
16. John Firth	1
17. H. M. Horton	1

	Number of Patents
18. National Electrical Supply Co.	2
19. Joseph Raes	1
20. Title Insurance & Trust Co.	1
21. Peter E. Stogoff	1
22. J. Harris Rogers and H. H. Lyon	2
23. J. Harris Rogers	5
24. American Mechanical Improvement Co.	1

This board has not in its consideration of the various claims that have been brought before it assumed to exercise a judicial function. It has had in view its position as a [fol. 2484] governmental agency, acting on the part of the Government, for ascertaining such reasonable compensation as may be allowed to the various claimants on a basis of settlement without suit, and in each of the conclusions it has reached upon controversial points it has given proper weight to the consideration that both the Government and the claimants will by acceptance of the board's conclusions avoid the expense, delays, and uncertainties of such litigation, and any conclusions which it may reach favorable to any claimant are not to be considered as binding upon the Government, nor as an expression of the Government's or of the board's conclusions on any of these controversial points, in the event that the action of the board does not lead to a final settlement without further litigation.

It also has been had in mind by the board that settlement for the amounts determined to be due the several claimants is to dispose of all claims of infringement arising out of the purchase, use, and sale of patented apparatus and methods, whether against the Government or against contractors with the Government.

The figures arrived at necessarily have been merely approximate. In some cases figures have been estimated from data in hand. In others, on account of lack of specifications or inaccessibility of apparatus for examination, the board has had to reach a conclusion based on verbal reports of officers.

The ascertainment of reasonable compensation has involved various difficulties.

Difficulty is found in determining the period of life and usefulness of individual instruments, and it is not known

and can not readily be ascertained in individual instances how long the period of usefulness is. It is difficult, therefore, to say whether an instrumentality purchased in 1914 may have gone out of use by 1915, at which time it may be there first issued a patent which covers it. It also is difficult of ascertainment whether the article purchased in 1914 was actually put in use in that year or was not actually put in use until 1917, or was ever put in use. This problem can be satisfactorily solved only by awarding the compensation upon the purchase of the article independently of the time and actuality of use, and this method has, in the main, been followed.

It has been ascertained by the board that while a proportion of the cost which might be allotted for compensation by way of royalty can be determined in individual instances of orders of specific instruments, in a large proportion of cases the relative cost of that instrument is not accurately ascertainable where it is incorporated in complete sets or parts of sets.

The board in arriving at a determination of the proper weight of the several patents, infringement of which has been declared, and of the value thereof in affecting reasonable compensation to the claimant, has had, in the first place, to consider whether the specific invention was general in character in so far as its use affected the value of the operation of the entire system or was so local that it involved merely the substitution in one part of the system of a device having for its reason for selection a mere improvement in convenience, cheapness, or other characteristic not involving a modification in operation of the system regarded as a whole. While an improvement might seem, so far as its claims are concerned, to be limited to the specific arrangement of certain elements in the entire wireless installation, where the result of this combination has been so important in affecting the successful operation of the entire system that an adequate return to the inventor would not be secured by awarding to him the proportion of the cost of that specific part of the apparatus, recognition is given by the board to this fact in determining that in such cases the royalty to be allotted to the claimant is to be as widely distributed in the apparatus as is the result of his improvement, or where the improvement is local the allotment of the royalty is equally localized.

In determining the proper amount of royalty in these two cases the board has had recourse to the several decisions of the Court of Claims in determining on what had been considered in individual cases the fair amount of royalty, and has also had in view the practice in commercial establishments in fixing a fair amount of royalty in individual cases, recognizing that the determination of a specific royalty in any individual case is largely an empirical matter and that the conclusions herein represent only a consensus of the opinion of the members of the board derived from the circumstances affecting each individual case.

Copies of all patents and publications referred to are made a part of the files of the board, being too numerous to be made a part of this report.

[fol. 2485] A list of prior litigations on radio patents, approximately complete, is found in paper No. 11.

A list of cases pending against the United States on radio patents in the Court of Claims is found in paper No. 12.

The claim in which amount claimed has been stated are as follows:

Marconi Wireless Telegraph Co. of America	$6,000,000
Deforest Radio Telephone & Telegraph Co	2,000,000
Dubilier Condenser Co	60,000
Emil J. Simon	100,000
John Firth	50,000
Wireless Specialty Apparatus Co	6,500,000
Title Insurance & Trust Co	150,000
Total	14,860,000

The following claimants, while not expressing the definite sum of their claim, demanded a monetary award:

Vreeland Apparatus Co.
International Radio Telegraph Co.
Louis Cohen.
Edwin H. Armstrong.
Sperry Gyroscope Co.
Lowenstein Radio Co.
General Transmission Co.
H. M. Horton.
National Electrical Supply Co.
Joseph Raes.
American Telephone & Telegraph Co.

R. A. Fessenden (not proceeded with).
Clapp Eastham Co.
Peter E. Stogoff.
Dubilier Condenser Co. (on one patent not included in suit in Court of Claims).
J. Harris Rogers & H. H. Lyon.
J. Harris Rogers.
American Mechanical Improvements Co.

As the total purchases and manufacture of radio apparatus, during the period covered by the accounting—as will appear later in this report in discussing the accountants' figures—amounted to $40,425,404.36, the total claims, considering the figures mentioned in discussion by the claimants not presenting definite figures, represented fully 50 per cent of the total cost of apparatus.

The various patents involved will be found more particularly identified in connection with each of the following reports. In the case of each claimant the various patents have been carefully examined with the aid derived from briefs or oral arguments submitted, and the board has, where necessary, examined the history of the patent as disclosed by the Patent Office record and reports of litigation, and has made as extensive a search of the prior art as has seemed necessary in each case. It has also made an extensive inquiry into the radio apparatus purchased or manufactured by the Government, examining the various apparatus where necessary and securing information as to actual details of their construction and operation from Government employees best acquainted therewith.

Résumé

The following claims are denied by the board:

Marconi Wireless Telegraph Co., reissue patent 11913, coherer as receiving device.

International Radio Telegraph Co.:

742780, 752895, 1074423, 1092049, 1059666, 1156677, 1184843, interference preventers.

727331, reissue 12145, eletrolytic detector.

706,745, receiver arrangements, stiff circuits.

730753, charging aerials from direct current source without interruption.

979144, 1020632, 1101914, 1101915, horizontal antennae of small elevation.
1050728, absorbing circuit, claim 9 of patent.

[fol. 2486] Wireless Specialty Apparatus Co.:
1118228, noncopper compounds.
876996, loop antenna.
1213250, detector circuit.
893811, Leyden jar.
1127921, tap tuner with micrometer variation.
904222, chemical compounds.
1104065, cat whisker (nonuse).
1104073, cat whisker.

National Electrical Supply Co., design patent 48638, hand generator.

Joseph Raes, 1099861, portable tower for radio field station.

Vreeland Apparatus Co.:
829447, 829938, oscillion circuit.
1245166, combination of continuous wave transmitter with signals controlled by change of frequency and a heterodyne receiver.
1239852, heterodyne receiver.

Dubilier Condenser Co., 1279850, buzzer transmitters.

General Transmission Co., 1216615, quenched gap circuit.

Title Insurance & Trust Co., 1315197, low frequency system.

Peter E. Stogoff, 1343165, submarine radio system.

J. Harris Rogers and H. H. Lyon, 1220005, 1322622, buried-wire antennae.

J. Harris Rogers:
1315862, underwater antenna coil.
1316188, loop antenna.
1303750, 1349103, 1349104, specific forms of buried-wire antennae.

The following claims have been settled or withdrawn: American Telephone & Telegraph Co., Clapp-Eastham Co., De Forest Radio Telephone & Telegraph Co., Dubilier Condenser Co. (mica condenser patents).

The board recommends that an offer of settlement be made to the following claimants:

The Marconi Wireless Telegraph Co. of America, under letters patent of Lodge No. 609154, Fleming 803684, and the Marconi patent 763772.

The International Radio Telegraph Co. (National Electric Signaling Co.), under patents of Fessenden, Nos. 706742, reissue 12168, 706746, 706747, 727830, 753863, 1050441, and 1050728. (No instances of infringement have been found upon this claimant's patents 846081, 950781, 1158112, and 1182946.)

Dr. Louis Cohen on his patent 1123098.

Emil J. Simon on his patent 1253103.

Lowenstein Radio Co. upon its patents 1258423 and 1305816.

E. H. Armstrong on his patent 1113149.

John Firth on his patent 1018769.

National Electrical Supply Co. on its patent 1145966.

Sperry Gyroscope Co. on its patents 1287116 and 1362753.

H. M. Horton on his patents 1165412.

American Mechanical Improvement Co. on its patent 1238838.

Wireless Specialty Apparatus Co. on its patents 836531, 912613, 933263, and reissue 13798.

Settlements having been made with the American Telephone & Telegraph Co. and the Dubilier Condenser Co., no recommendation is made as to these claimants. R. A. Fessenden having failed to formally present his claim, no recommendation is made as to it.

Considering that the value of the respective inventions to the Government can not be ascertained from returns from commercial uses of the inventions, the Government's use having been largely noncommercial; that great difficulty exists in ascertaining whether in an individual case an apparatus has been put to use; that great divergence occurred in methods of purchase of apparatus; and that other circumstances lead to indefiniteness of any other method of approaching the problem of ascertaining the exact figures, it has been concluded that 15 per cent on the cost price comes as near to being a fair and accurate figure on which to base the board's calculations as can be reached. In applying this percentage it has not always been possible to ascertain what proportion of the cost price is directly assignable to radio apparatus per se, and the board has in doubtful cases often leaned in favor of allowance to the claimant where the records obtainable have not enabled it to segregate such items. In some cases the utmost investigation has not enabled the board to ascertain the exact construction of

apparatus and the board has had to proceed in such matters more or less by inference from surrounding circumstances. [fol. 2487] Note is taken in the accounting of the different terms of expiration of the several patents, of the diminutions in royalty due to the articles having been furnished by the claimant or its licensee, and an average period of three months has been allowed between the date of requisition of apparatus and their delivery in considering whether such apparatus comes within the terms of the accounting. The fixing of a reasonable compensation at 15 per cent where the patents involved have been fundamental has called for a lesser allowance under the authority of the Westinghouse, Dowegiac, and other cases,[1] where other elements enter in limiting the proportion, as, for example, the expiration of one or more of the fundamental patents, its conclusion in the cost price by reason of the article having been furnished by the patentee, or the necessity of apportioning a compensation between a number of claimants. In the case of apportionment of a total royalty regard has been had to the relative importance of the invention in the individual cases. Where the invention is not fundamental but has referred to an individual part or piece of apparatus used as an improvement on or substitution for a previously used device, a basis of compensation at the rate of 10 per cent has been allowed, with suitable apportionment, where several patents are concerned in the article; and in certain cases of minor importance the compensation has been limited to a less percentage. The board has not pretended to reach mathematical exactitude, nor does it consider this necessary. (Underwood Co. v. Stearns & Co., 227 Fed., 74.)

In subdividing the subjects matter of radio apparatus purchased it has been convenient to take them up under the following heads:

1. Complete transmitters and receivers.
2. Receivers.
3. Transmitters.
4. Detectors (crystal)
5. Arc transmitters.
6. Receiving tuners.
7. Vacuum tubes.

[1] See Garretson v. Clark (111 U. S., 120); Westinghouse v. Wagner (225 U. S., 604); Dowegiac Manufacturing Co. v. Minnesota Co. (235 U. S., 641); Dehoning v. Fox Typewriter Co. (251 Fed., 584).

8. Wave changers.
9. Wave meters.
10. Decremeters.
11. Quenched gaps.
12. Direction-finding apparatus.
13. Audion detectors.
14. Condensers.
15. Radio telephones.
16. Amplifiers.

As a rule no deductions have been made for patents owned by the Government or patents or inventions not before the board as claims. Departure from the rule has been made, however, in the case of the quenching-gap inventions. These inventions are of such importance in their relation to quenched-gap transmitters that it has not been thought reasonable to exclude them because several patents covering this feature came into the possession of the Government during the later part of the period of the accounting.

Another exception has been made in the case of the Poulson arc patents for similar reasons.

Complete transmitters and receivers.—The transmitters of these sets have been (1) with open-gap excitation, either fixed or rotary; (2) with quenched gap excitation; (3) with pure impulse excitation; (4) vacuum-tube excitation. (Arc transmitters and alternator transmitters are separately considered.)

The receivers of these sets have as a rule had two tuned circuits. Reference to the accounting sheets will indicate that each separate item constituting an order has been separately estimated with dissociation of the costs of the transmitter and receiver and with application of the several patents, first, to the transmitter; and second, to the receiver cost.

(1) *Open-gap transmitters.*—The foundation patents involved have been Lodge, Marconi, and Stone,[2] the basis being 15 per cent, 5 per cent each.

(2) *Quenched gap transmitters.*—The foundation patents involved are Lodge, for loading coil and impulse excitation; Marconi, for tuning and the quenching gap inventions, the basis being 10 per cent for the Marconi Co. patents and 5

[2] Loose coupling is for convenience identified with Stone's name, although no award is made here to owners of those patents.

per cent for quenching gap inventions. Specific allowances deducted from these sums, however, have been made for the Simon individual quenched gaps. (No Lowenstein type gaps are found in these sets.)

(3) *Pure impulse excitation.*—All patents before the board involved in this form of transmitter had expired before any purchases were made.

[fol. 2488] (4) *Vacuum-tube excitation.*—Only a few sets of this kind were found under this heading, and the compensation was distributed among the Fleming valve patent, the Deforest tube patents, the heterodyne patent, and the Lodge patent, the rates varying according to the uses to which the sets were put.

Receivers of complete transmitters and receivers.—The basis of arrangement is shown more fully when orders comprising receivers alone are reached, the only difference in this case being that the cost of receivers of these sets have been estimated where no information was available as to the cost of the receiver *per se*.

Receivers.—These are divided into three heads:

(1) Receivers arranged with terminals for any form of detector.

(2) Receivers having built-up accommodations for vacuum tubes (*a*) arranged for both oscillations and regeneration, or (*b*) arranged for oscillations only.

(3) Radio compass receivers.

(1) *Receivers arranged with terminals for any form of detector.*—The foundation patents are Lodge, Marconi, and Stone. Where the Lodge and Marconi patents are involved the full 15 per cent has been allowed to Marconi, diminished by 5 per cent for the Stone loose coupling patents when they were in question and diminished by a further 5 per cent on the expiration of the Lodge patent. Where mountings for crystal detectors were included, an amount of $1 per mounting has been deducted for the Wireless Specialty Apparatus Co.

In a few instances of statically coupled receivers of the Cohen type, an allowance was made the Cohen static coupling patent at the rate of 3.75 per cent. It has not been overlooked by the board in reaching this figure that a larger amount has in some instances been paid to Mr. Cohen by contractors—an amount based, in part at least, on en-

gineering services. A proper apportionment of credit has resulted in fixing the above percentage, and credit has been made in these few instances without disturbing allowances already made on these sets to other patentees.

(2) *Receivers having built-in accommodations for vacuum tubes.*—(*a*) Arranged both for oscillations and regeneration: The inventions involved were Lodge, Fleming, Marconi, Beforest tube and Stone loose coupling, the Armstrong regenerating circuit and the heterodyne, and allowance made (Lodge having expired) at the rate of 5 per cent for Marconi and 2½ per cent for each of the remaining claimants.

(*b*) Arranged for oscillations only: The patents involved are Fleming, Marconi, Deforest, Stone, and heterodyne. On account of the relative importance of the heterodyne invention in these sets, the allowance has been at the rate of 4 per cent for Marconi and Fleming patents, 4 per cent for the Deforest and Stone patents, and 4 per cent for the heterodyne patents.

These are the main subdivisions. Still other somewhat different forms are found in which some variation has been made, depending upon the arrangement of the structure and the use to which it is put.

Transmitters.—There are (1) spark transmitters (open gap); (2) quenched gap transmitters; (3) vacuum-tube transmitters; (4) buzzer transmitters. The apportionments of royalties are the same as in transmitters of complete transmitters and receivers.

Detectors (crystal).—Allowance for the crystals themselves and their mountings has been made at the cost or estimated cost price thereof at the rate of 10 per cent to the Wireless Specialty Apparatus Co., where their patents were involved.

Arc transmitters.—These have included stations in which long waves were employed and those in which short waves were employed, and the patents involved are the Fessenden long wave, the Fessenden inductance shunt key, the Fessenden heterodyne patents, the Lodge patent, and the Poulsen arc patent, with an allowance of 7½ per cent, as a rule, to the International Radio Telegraph Co., 2½ per cent to Marconi Co., and 5 per cent to the Poulsen patent. In cases omitting the inductance shunt key the allowance to

the International Radio Telegraph Co. has been reduced to 5 per cent. In the case of the New Brunswick station allowance was made at the rate of 10 per cent to the International Radio Telegraph Co., based on the amount paid for the maintenance of the station during the Government occupancy. No allowance has been made for the Tuckerton Station, this matter being in litigation.

In the accounting no reference is made to the Bordeaux (Lafayette) Station, erected by the Government on French soil, with radio material furnished from this country, under the doctrine of Bullock *v.* Westinghouse (63 C. C. A., 607). Furthermore, this station was not completed during the time of this accounting.

[fol. 2489] *Vacuum tubes.*—The equal rate of 5 per cent has been allowed to the Fleming valve and the Deforest patents, following the rule which was generally adopted of allowing a total compensation of 10 per cent where the patents related to an individual part of the apparatus rather than to the whole system.

Wave changers.—The only patents involved are the Lodge and Marconi patents, and the allowance varied from 5 to 15 per cent, depending upon the use of quenched gap and the period of purchase. The device itself is not an infringement, but allowance has been made on the assumption that these wave changers were purchased for incorporation in sets involving one or both of these patents.

Wave meters.—Allowance has been made at the rate of 10 per cent of the cost of detectors for the Wireless Specialty Apparatus Co. and 10 per cent of the cost of the condensers for the Lowenstein Co. (where the condenser is logarithmic type) and at the rate of 5 per cent of the total in the case of special wave meters involving the heterodyne patents. On the special uni-polar detectors of the Midgley type an allowance of 7½ per cent has been made to the Midgely patent.

Decremeters.—An allowance of 10 per cent of the cost of the condensers per se of a decremeter has been made for Lowenstein's logarithmic condenser patent.

Quenched gaps.—These have been bought as replacements of other gaps, and it is not considered that compensation on the system patents should be allowed. Where the Simon gap has been used allowance has as a rule been made to Simon at the rate of $10 less depreciation where the purchase has occurred before the date of his patent, but where

the individual units have been purchased the allowance has been at the rate of 5 per cent of the cost. In one instance in which the set was furnished with the Lowenstein switch allowance has been made to Lowenstein at the rate of $10 per set less depreciation for purchase prior to grant of his patent. Such gaps have averaged $200 each purchase price.

Direction finding device.—Where the patents involved were Fleming, Deforest, Armstrong, and heterodyne, $3^3/_4$ per cent has been allowed to each claimant.

Audion detector and Audion control boxes.—Allowance of 5 per cent has been made to Marconi for the Fleming patent and 5 per cent to the Deforest patents, except in one instance in which tickler coils were used, when the allowance has been at the rate of $3^3/_4$ per cent to Marconi for the Fleming patent, $3^3/_4$ per cent to Armstrong, $3^3/_4$ per cent to the heterodyne patent, and $3^3/_4$ per cent to the Deforest patents.

Condensers.—An allowance to Lowenstein is made in the instances in which his logarithmic condenser invention is employed at the rate of 10 per cent less depreciation prior to the grant of his patent.

Radio telephones.—The patents involved were Fleming, both transmitter and receiver as a rule, the Fessenden telephone patents, the Armstrong regenerating circuit, and the Deforest patents. The allowances have varied according to the importance of the patents to the set, being in the main at the rate of 6 per cent to Marconi, 3 per cent to the International Radio Telegraph Co., and 3 per cent for the Deforest patents at the receiver, and $3^3/_4$ per cent to each of these claimants at the transmitter, the allowance to Armstrong varying from 2 to $2^1/_2$ per cent where his invention was involved, with corresponding reduction of the other allowances in these cases.

Amplifiers.—The allowance has been at the rate of 5 per cent for the Fleming patent and 5 per cent for the Deforest patents, no allowance, however, having been made for the Fleming patent for vacuum tube amplifiers constructed for purely low frequency or "TPS" conductive signaling.

Receiving tuners-variometers.—Allowance is made to the Marconi Co. at the rate of 5 per cent for the Marconi tuning patent.

Heterodyne method.—The allowance for primary radio stations is fixed to average $2,000 per station, and for

secondary radio stations $500 per station under the heterodyne method patent of the International Co.

Arco fans.—An allowance of 10 per cent has been given where such fans fall within the terms of Slate patent 1,238,838. The Sperry patents have been made the subject of a special recommendation for a part and future license for a fixed sum.

Airplane radio.—The Horton patent has been made the subject of a special recommendation for a past and future license for a fixed sum.

[fol. 2490] The complete list of apparatus taken from Government records by the accountants is shown in the sheets filed among the board's records and not attached to this report. Tables estimating the compensation due the several claimants as estimated by the board on each order are annexed thereto.

The total amount due from the Government to patent owners is found by the board to be $2,869,700.27, apportioned as follows: By the Army, $1,050,179.58; by the Navy, $1,819,520.69; total, $2,869,700.27, and divided among the claimants as follows:

Marconi Wireless Telegraph Co. of America	$1,253,389.02
Wireless Specialty Apparatus Co.	[3]22,449.69
American Telephone & Telegraph Co.	615,333.57
Sperry Gyroscope Co.	5,000.00
E. H. Armstrong	89,624.74
E. J. Simon	30,273.31
International Radio Telegraph Co.	711,451.85
H. M. Horton	75,000.00
Lowenstein Radio Co.	22,892.80
National Electrical Supply Co.	8,875.00
Dubilier Condenser Co.	18,194.31
American Mechanical Improvement Co.	383.80
Louis Cohen	1,271.25
John Firth	15,560.93

The claims of the American Telephone & Telegraph Co. and the Dubilier Condenser Co., so far as included in the above amounts, have been waived or released to the Government under agreements between the claimant and the United States recently consummated, leaving as the net

[3] Determination not yet final.

amount of the total of the claims considered valid and outstanding $2,236,172.39, of which the Army's pro rata is $658,871.11 and the Navy's pro rata is $1,577,301.28.

Precept

[Paper A]

Whereas the operations of the War Department and the Navy Department during the war relating to the furnishing of adequate supplies for radio communication developed the fact that the patent rights of greatly needed supplies were diversely held, which rendered quantity production by the employment of all of the available manufacturing facilities difficult, which situation made obvious the necessity for proceeding with production without regard to the existence of patent rights, orders for which procedure were issued by both departments, wherein the United States Government directly assumed responsibility for the proper compensation for the unauthorized use of patent rights; and

Whereas large claims were presented to the United States, flowing out of such procedure, in addition to others which already had accumulated and for which suits had been filed against the United States in the Court of Claims; and

Whereas the situation thus produced made obvious the advisability of creating a board of experts in patent law and radio science for the purpose of determining scientifically the measure of liability in which the Government became involved; and

Whereas the Secretary of War suggested the creation of such a board to the Secretary of the Navy and the Attorney General, in which suggestion they concurred and out of which was created by separate appointment representatives of the Secretary of War, the Secretary of the Navy, and the Attorney General, to constitute the interdepartmental Radio Board, which board has been heretofore organized and has made considerable progress in the discharge of the duties the problem presented seemed to require.

Now, therefore, it is directed that the officers and representatives of the several departments heretofore appointed, to wit, Commander Stanford C. Hooper, United States

Navy, and Lieut. Commander Edward H. Loftin, United States Navy, representing the Navy Department; Capt. Guy Hill, United States Army, and Robert H. Young, Esq., representing the War Department; Harry E. Knight, Esq., representing the Department of Justice; and any successors [fol. 2491] of any of said members who shall hereafter be, from time to time, appointed shall continue as a board, designated the Interdepartmental Radio Board, to investigate, hear, and examine the questions relating to the liability involved in the use by the Government of patents on radio apparatus and similar devices and render to the several heads of the departments mentioned their conclusions and recommendations therein.

Such assistance and information as the board may require will be rendered to it by the officers of the respective departments familiar with patent and technical matters involved in those departments.

Newton D. Baker, *Secretary of War.* Josephus Daniels, *Secretary of the Navy.* A. Mitchell Palmer, *Attorney General.*

To the Interdepartmental Radio Board,
Navy Building, Washington, D. C.

Washington, D. C., *February 12, 1921.*

Mr. Garrett: What do you mean by a patent-holding concern? Is that a concern which simply holds the patent rights and does nothing else, and is seeking to get certain awards?

Commander Loftin: It is a straight out exploiting of patents—selling licenses for patents.

Mr. Garrett: And the only investment they have is the patent itself?

Commander Loftin: We have not many of those to deal with; but sometimes capital will financially back an inventor, and it takes money to do that. They equip laboratories and sometimes arrive at something that is valuable.

Mr. Garrett: What you mean by a patent holding concern is one that includes the original patentee with his financial backers—that is, he usually takes in a lot of people with him and they finance his project? Usually an inventor is a rather poor fellow and has not much money, and he gets some people to go in with him, and they put the patent on the market.

Commander Loftin. The Vreeland Apparatus Co. is the only company of that kind that we have a claim from. They may make a small amount of apparatus, but they do not make any radio apparatus. We have a number of individuals, of course, who have made inventions themselves.

Mr. Wright: Under the war power the Navy Department had the right to use any of these patents, even without the consent of the patentee?

Commander Loftin: Without the war power we have always had it, and it was not until the passage of the act of 1910 that we have had to pay for those things.

Mr. Wright: It is because of the use of these patents that these claims have been made?

Commander Loftin: Yes, sir.

Mr. Garrett: You say prior to 1910 the Government did not have to pay for them?

Commander Loftin: No, sir; the inventor had no way of reaching the Government, up to 1910, for the use of his invention. The act of 1910 gave him the right to make a claim in the Court of Claims, and the act of 1918 modified that act so that the Government takes all the liability; the [fol. 2492] contractor does not take any liability, as I understand the act, so that from now on we have to watch our step and take care of inventors.

Mr. Wright: You mean that up to the time of the war the Government could use any patent without the consent of the patentee?

Commander Loftin: That simply means the patentee can not enjoin the Government from using it.

Mr. Wright: You have compensated him?

Commander Loftin: We have recommended compensation where we have done that.

Mr. Garrett: Before that the Government exercised its function as a sovereign and did not concede that, having granted a patent to one of its citizens, the citizen possessed a greater right than the Government possessed when it wanted to use a patent for its own purposes?

Commander Loftin: There has been no provision made for it. The only way an inventor could make any claim at all was where the Government in some way implied or made a contract.

The Chairman: Is there anything further you desire to present to the committee?

Commander Loftin: There is one other point I would like to make as to the practical effect of what this board has been doing. We supplied thousands of ships of the Shipping Board with radio apparatus. The Shipping Board does not know that a patent situation exists in radio apparatus. They have had one or two letters from people who did not know that this board was functioning. So through this board we have allowed the Shipping Board to go ahead undisturbed in this complicated field of patents without knowledge of or interference from patent owners. They have all been coming to us.

If there had not been such a board as this, the Shipping Board would have been swamped with claims from the different patentees. I think they would have gotten to a point where they would have been glad to have thrown the apparatus overboard rather than to have used it under the annoyances they would have had if we had not been handling the situation for them.

I have recently had occasion to talk to some of those people about this general situation, and they thoroughly appreciate what has been accomplished for them. They know there is such a situation, but they have never felt its full purport.

Another point as to the seriousness of this proposition. Admiral Griffin, who is the chief of the Bureau of Engineering of the Navy Department, was greatly disturbed about this situation all through 1918, in the middle of the war, and I was in France at that time very much occupied in the development of the high-power radio system we were arranging for in case the cables were cut and we should be denied communication by that means.

It was very important work, and there were many details to be arranged with the British and French as to a real working communication system to take the place of the cables.

I was one of the few officers who had the advantage of having had a postgraduate course in this particular art, and Admiral Griffin desired that I should come back and take up this patent situation, and he made many urgent requests prior to the signing of the armistice for my release from [fol. 2493] the other side, but that was not approved by Admiral Sims on the other side because of the urgency of that work until after the signing of the armistice. I merely mention that to show that a man as busy as Admiral Griffin

was during the war had this on his mind, deeply imbedded in his mind, to the extent of trying to interfere with Admiral Sims's organization on the other side at a very crucial moment.

Mr. Parker: You say some of these patents, what they call pioneer patents—some patents are merely subsidiary patents; is that not so? I mean that the pioneer patent for radio communication was claimed by Marconi, was it not?

Commander Loftin: Yes, sir; we had that one before us.

Mr. Parker: Were there any conflicting claims for the basic patent between the Deforest and the Marconi Cos.?

Commander Loftin: No, sir.

Mr. Parker: I remember at the beginning of the war there was a great deal of trouble because the Deforest Co. wanted to stop our use of radio altogether.

Commander Loftin: The Marconi Co. has sued the Deforest Co. two or three times for use of the early Marconi patent and the second Marconi patent, which is well known in the art, and several others.

Mr. Parker: I am glad to hear that the Deforest Co. does not claim the basic patent, as against Marconi.

Commander Loftin: Not as to a wireless system. Deforest made a very important invention in what is known as an amplifier, the little vacuum tube which they use with the receivers, which has proved of such great value in intensifying the weak signals, allowing a certain amount of power to reach a much greater distance because of the greater strength at the receiving end.

Mr. Parker: I wanted to get at this—whether the Deforest claims were such that if the Marconi claims were allowed, the Marconi Co. would guarantee us against the Deforest claims. You say they claim different things?

Commander Loftin: They have had a claim on this particular tube. Both of them have very important patents in that particular tube, but they have no conflicting claims on a wireless system.

Mr. Parker: Have they conflicting claims on this vacuum tube?

Commander Loftin: They do not conflict; they are specific inventions which are easily separated.

Mr. Parker: Do they claim that either one infringes the other?

Commander Loftin: The Marconi Co. claims that the patent on the tube which involves the Deforrest invention

infringes the patent which they own, and the courts have so held.

Mr. Parker: In that particular case, as to that particular article, ought we not to receive from the Marconi Co. as a part of their settlement, a guaranty against claims of the other company on that device?

Commander Loftin: It so happens in connection with that particular device that during the period when Deforest had a claim, without any legal question, he made all those devices. The Marconi Co. has a claim for those devices, but Deforest has not; he having furnished them, he has no claim, but the Marconi Co. has a claim. During the war, [fol. 2494] which was after the time when the Deforest Co. transferred such rights to the American Telephone & Telegraph Co., there was grave doubt as to whether or not it (Deforest Co.) had any legal claim.

Mr. Parker: I understood that. The question I put to you, which you have not answered, is whether it ought not to be a part of the Marconi release that they guarantee us against a claim by the Deforest company for things that are identical with the things they gave us?

Commander Loftin: There will be no claim by the Deforest company, because they made the apparatus and the license goes with the sale of it.

Mr. Parker: To the United States?

Commander Loftin: To the United States.

Mr. Garrett: Where we are buying them outright it is simply a question of settlement with them for their original apparatus that they invented themselves?

Commander Loftin: The license goes with the sale.

The Chairman: Commander, do you speak for the members of the board from the other departments in this matter?

Commander Loftin: No, sir; I have been chosen by my coworkers on the board as chairman of the board.

The Chairman: Are the other members of the board here to be heard?

Commander Loftin: They are here, and I will be glad to have them asked to verify anything I have said; they may think what I have said is a little bit off in some respects.

The Chairman: We will be very glad to hear from your coworkers.

Statement of Mr. Harry E. Knight, Special Assistant to the Attorney General of the United States, Delegated to Represent Him on the Interdepartmental Radio Board.

Mr. Knight: Mr. Chairman and gentlemen of the committee, the questions of some of the members of the committee have indicated the possibility of a lack of full knowledge on the part of some as to the history of these litigations in which the Government may be involved.

The Government, of course, being sovereign, can only be sued by its own consent. After a long consideration of the matter, the Government consented to be sued in certain cases, and the Tucker Act was passed, which enabled the Government to be attacked under a contract. For a long time the question of litigation against the Government in matters involving tort was subject to much controversy. Actions were brought directly against the Government and dismissed because being laid in tort; the Government being claimed by the claimants to have proceeded without right from the claimant, but against his rights, those actions were dismissed as being not properly covered by the law.

There was very considerable doubt often on those points, and there is one very early case of that kind in the Supreme Court of the United States, in which one of our leading ju- [fol. 2495] tices dissented strongly from the opinion of the Supreme Court, saying he considered that the grant of a patent by the Government and the use of the invention covered by that patent by the Government implied a contract, and he would recommend that the Supreme Court proceed with judgment in favor of the patentee in case the patent were sustained, and as if it had been used on an implied contract. That, however, never became the ruling of the Supreme Court.

Other cases were brought against officers of the War Department or other departments trying to stop their use of a thing for the Government, but on the supposition that they might be reached as individuals. Thus in some cases the article was an invention which was used for the Government, and the people using it were working as officers of the Government. There was, however, the conclusion reached that these officers could be prevented from future acts by injunction, but the Government could not be interfered with in the use of material that it had purchased or

constructed, but the officers could be restricted from further infringement.

That caused a good deal of commotion among patentees, and finally the act of June 25, 1910, was passed, in which a right was given against the Government direct in favor of a patentee when the Government had, without license or authority of the patentee, used the invention. There was no expression in the act which excluded action also against the contractor with the Government.

It was quite a general opinion that the effect of this act was to make the Government a licensee, so that a contractor with the Government would be free, for if he were dealing with a licensee he could not be attacked. It was the general opinion at that time that the Government had appropriated a license. Contractors during the war went largely on that hypothesis, that by the act of June 25, 1910, they were protected. They were dealing with a licensee, and the Supreme Court had used expressions which indicated that. They went ahead and continued to contract with the Government as they had in the past, warranting the Government against any suit of all other patentees. In 1918, however, the Supreme Court rendered two decision, which entirely changed the view of patentees and other persons. Those were the cases of Cramp and Simon. The result of those, briefly, was that while the Government could be sued a contractor could also be sued, unless, as found in the Simon case, there were such relations as to make the contractor a mere contributory infringer. In other words, the Government was the real infringer and should have been the one primarily attacked.

Before that time, and fearing that that might be the outcome of the suits, various contractors of the Government, and the Deforest Co. was one of them, had represented to the Secretary of War the dangers that they were getting into by these large orders given out by the Government, and their warranties that were given to protect them against an unknown situation, because radio patents, being a new art, were coming out constantly. There were hundreds of applications in the Patent Office and thousands of patents were being issued. The contractors became very nervous and they asked that they should be relieved of this situation, and that the Government should assume the burden of it. The Government then assumed a different attitude in mak-

ing its contracts. The Government was at war and did not [fol. 2496] want its contracts held up, didn't feel that it could seize all these factories and have its matters held up; it wanted the individual initiative and help of the factories. So it began itself to assume the responsibility and warrant the contractor, and then came along the act of 1918 and made the Government the sole infringer and relieved the contractor.

Before the war started, the situation in radio patents begun to be somewhat distinct from that of patents generally. Of course, in a country like this which depends so largely on industrial progress and has given so much favor to its patent system, all the different devices which had been used by the Government had been affected by patents, and had been for years affected by them. But radio was a different situation. It was practically a new art, Marconi's early experimenting was in 1895, some 25 years ago, and his fundamental patents have only recently run out. Indeed, one that he has claimed as fundamental only runs out this year.

Here is a situation that presented a constant development on a great many different lines, interweaving lines, lines which if they had been sent to a court would have necessarily been taken up by piecemeal. Take for instance one of the cases cited by one of you gentlemen. If Marconi had attacked one of these contractors in southern New York district and Deforest had attacked along the same line another contractor in the State of New Jersey, and so on throughout the United States. Of course the courts give a good deal of leeway to the Department of Justice in defending the Government in such cases where the rights have been so split up, but inevitably even if sufficient time had been given the Government to defend all these litigations, we should have had before we got through hundreds of accountings, and with the difficulty that each accounting would have taken very little cognizance of what had taken place before. Accounting is a very technical thing, and it is handled along a very unusual way.

There was a case recently in New York where a suit had been brought under three different patents—two claimants, three patents—three claimants against one victim, and the patents were sustained, and the case went to a master. Both cases were referred to ex-Judge Lacombe, a judge who has had tremendous experience in this class of litigation. He

was appointed to hear and determine the case. He reached a basis of accounting which went in two or three very peculiar directions, but he worked it out very thoroughly and then it was brought before a court, and the way he reached his conclusions—and his conclusions were all attacked—and without entering at all into the merits of the case (the matter is still subject to judicial determination).

Judge Mayer has used a very different method from that that was reached by Judge Lacombe. Different judges have very different views of what should be done on accountings, and back of all that is the question of what a patent really means. We find, for instance, in Marconi's four circuit toning patent an entirely different decision reached in the second circuit from that reached in the far western coast circuit. So that if this had gone up, we should have encountered numerous accountings and copending cases. And this is much more difficult because of the unusual number of claims pending. There had been brought in 1918 a large number of claims, but we knew that there [fol. 2497] would be many more, because patents were issuing constantly. We have had brought before this board patents that were of very recent issue. So that the principal claimants, the Marconi Co. and the Deforest Co. and the International Radio-Telegraph Co., all urging their claims before the War Department, agreed that the matter might be referred to some joint conference of representatives of the War, the Navy, and the Justice Departments, they being the principal ones concerned, to see whether some satisfactory result could not be reached without litigation. They all had their claims that they could present through the Court of Claims and all through the country in the district courts. But they were willing to submit their claims to a board, and I must say that these patentees and these concerns interested with the patentees, have shown throughout a most conciliatory attitude toward the Government. In nearly all instances there has been no disposition shown to press the Government unduly, or take any advantage of it, or to ask for an unreasonable amount.

The Chairman: There has not been a case of gouging.

Mr. Knight: In no case whatever has there been any gouging or any attempt at it.

So, members of the War Department, the Navy Departmentment, and the Department of Justice came together

and called themselves the interdepartmental board, just to have a name to do business with, and to forestall future controversies they sent notices to every one who might have a claim.

The Chairman: Have you a copy of that notice?

Mr. Knight: Yes, sir. It is among the papers here.

The Chairman: Will you kindly give it to the reporter.

Mr. Knight: I think the chairman intends to file all of those papers.

The Chairman: Very well.

Mr. Knight: A number of them responded.

The Chairman: You need not take the time now, Mr. Knight. You can give it to the reporter afterwards.

(The notice referred to is as follows:)

February 12, 1919.

SIR: The board considering the claims of owners of patents for radio inventions asserted to have been used by the Government has been referred to so large a number of patents that unless the field of investigation be narrowed materially the work of the board will be greatly protracted and a satisfactory adjustment extremely difficult or impossible to reach.

Since it is the purpose of the board to expedite its work and reach a conclusion with the least possible delay, and this also being the desire of the patent owners concerned it has concluded to ask these patent owners to cooperate in reaching that object by giving due consideration and answers to the following questions in such manner as they think will render the most assistance to the board:

(*a*) What patents owned or controlled by you are basic adjudicated patents or are nonadjudicated patents that you consider are generally recognized as basic and which you regard as having been employed in standard practical apparatus that has been actually used by the Government? (Identify the patent or patents by number, date, name of patentee, and identify as definitely as practicable, the type of apparatus in which you consider said patents involved, and how involved.)

(*b*) If you should obtain a settlement based on the patents named in answer to (*a*), will you lump all other patents owned and controlled by you in that settlement without further claim for royalty on these other patents so lumped? [fol. 2498] (*c*) What patents owned or controlled by other

companies or individuals do you regard as basic adjudicated patents or as well-recognized basic nonajudicated patents that should be taken into account by the board in considering the general settlement of royalties? (Give name, number, and date of patents, by whom owner or controlled, type of apparatus in which said patents are involved, and how involved, so far as information on the subject will permit.)

The board is of the opinion that only by a response to the subject matter of the foregoing inquiries given in the most liberal spirit with due consideration for the patents and claims of others can it hope to arrive at any early conclusion or settlement of the matters involved and begs you to have these considerations well in mind and earnestly cooperate with the board toward reaching an early settlement.

Mr. Knight: A number made no answer. A number said they had no claims against the Government. Those were these: The Federal Telegraph Co., General Radio Co., Liberty Electric Corporation, Moorehead Laboratories (Inc.), American Radio & Research Corporation, Westinghouse Electric & Manufacturing Co., and Kilbourne & Clark Manufacturing Co. These companies all stated that they had no claim for infringement. There were 25 claimants, however, who put in claims for patents. Of these we refused to consider one because we didn't consider it radio at all, leaving 24.

(The papers referred to are as follows:)

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(*c*) What patents owned or controlled by other companies or individuals do you regard as basic adjudicated patents or as well-recognized basic nonadjudicated patents that should be taken into account by the board in considering the general settlement of royalties? (Give name, number, and date of patents, by whom owned or controlled, type of apparatus in which said patents are involved, and how involved so far as information on the subject will permit.)

The board is of the opinion that only by a response to the subject matter of the foregoing inquiries given in the most liberal spirit, with due consideration for the patents and claims of others, can it hope to arrive at any early conclusion or settlement of the matters involved and begs you to have these considerations well in mind and earnestly cooperate with the board toward reaching an early settlement.

May 15, 1919.

Referring to your recent letters to the Interdepartmental Radio Board concerning the matter of claim for infringement of radio patents owned by you, the board now requires additional information, and requests that the following questions be answered at the earliest possible date:

(*a*) Have you granted any licenses, now expired or still existing, under the patents listed in your letter?

[fol. 2499] (*b*) Are the licenses of such a nature as to permit the licensee or sublicensees to manufacture and to sell to the Government for its use without royalty?

(*c*) Names of such licensees.

(*d*) Effective dates of such licenses (dates beginning and dates expiring).

(*e*) Are you a licensee under any patents owned by others, which license permitted you to manufacture and sell to the Government for its use (past and existing)?

(*f*) By whom granted?

(*g*) Effective dates of such licenses (dates beginning and dates expiring).

(*h*) Under what patents?

(*i*) Will you kindly furnish a copy of any license above referred to?

This information is necessary to the board in order to avoid making allotments on royalties to the wrong parties.

It is desired that the response shall be as of April 15, 1919.

Mr. Frothingham: You sent these notices to all the 25 claimants?

Mr. Knight: No, sir. We sent them to all that we supposed might make a claim.

Mr. Frothingham: And you thought there would be some likelihood of recovering if they went before the Court of Claims?

Mr. Knight: Yes, sir. I might say this, that those of us who have been devoting our consideratoin to this art have estimated, but only roughly, whom the principal patentees are. We know who the patentees are, of course. We know those who have patents of merit. For instance, no one would think of omitting the Marconi Co., or the Deforest Co., and so on. So we sent out this list and the result was that it was trimmed down to 24 claimants. And I would like briefly, if it please the committee, to revert to these several claimants, because it will bring this thing up to what it will result if settled in this way rather than by litigation.

The Chairman: The committee would be very glad to have you state that.

Mr. Knight: First, the Vreeland Apparatus Co. (we have these numbered just as they appear on our books, the order does not show when the claim started or the importance of the claim) made claim under four patents. Their cla m was one of very considerable difficulty. The Government was more or less involved by their claim. Most of you

remember that during the war the Atlantic Communication Co., representing in this country the German Wireless Corporation, was succeeded in this country by the custodian. Among its effects was found an agreement with the Vreeland Apparatus Co. for the use of its invention, and that was seized or bought by the Government custodian among other claims. It was considered by the Munitions Patent Board that that contract (the Government having taken this license over), that that license had lapsed on account of failing to continue to make payments for license fee. So the claimant came to our board to ascertain whether the patents were valid, whether the Government was bound to respect them by reason of this patent, or otherwise, and whether the Government had used the apparatus and the patents. Two of the patents concerned were subject to broad patents controlled by the International Radio Co.

I will not bother your committee by going over the months-long study by the board of the patents, but we reached the conclusion finally that the situation was not so clear that the committee could recommend the Government make any payment on this part of the claim. The remainder of the claim was under patents relating to oscillators. The patents had lain idle for a number of years, and were [fol. 2560] only brought up before our board as an afterthought, and we didn't feel under those circumstances that we should be the first to say that the Government should pay something for such patents, and we rejected the claim in toto, and it will go to the Court of Claims.

This is one case of a claim where the board was not able to settle. It was a claim so large under facts of such doubtful merit that we haven't thought it wise to prejudge before it goes to the court.

The next one on our list is the Marconi Wireless Telegraph Co. They have numerous patents, but they offered to waive all their claims if we made a satisfactory claim on a few, and they brought to our attention four as of particular merit. Those four patents are all fundamental.

They have all been sustained by the courts, and the Marconi Co. made very pointed representation to this board that they should have a special position because they were the only company holding claims that had been held to be fundamental, and they have all been sustained.

The Chairman: Lieut. Commander Lofton said that your board sustained three, and one had not been sustained.

Mr. Knight: Yes. I mean sustained by the courts. They had all been sustained by the courts. One was called the Marconi reissue patent, which is the fundamental patent for wireless telegraphy. The second was his improvement for tuning the two circuits at each end. The third was Lodge's patent for tuning the antennae and adjusting it by means of a coil. I speak of it in as simple terms as I can, because I imagine we are not all familiar with radio language. And the other was in connection with the Fleming patent, what is known as the Fleming valve. These were all important patents, but the first of them, while sustained by the court and held fundamental, had been held not infringed by the modern wireless systems. So we found no possibility of going beyond the courts in that, and we refused to allow the Marconi Co. on that. The other claims involved finding what the Government had done. They were evidently valid. They had been defended by various companies at enormous expense and held infringed.

(Thereupon a recess was taken until 2 o'clock p. m.)

After Recess

The committee met, pursuant to recess, at 2 o'clock p. m.

Statement of Mr. Harry E. Knight—Resumed

Mr. Knight: It has been suggested during the recess that in the Dent Act, to which this bill is proposed as an amendment, in order to avoid certain difficulties in the comptroller's office, who is the one man in the United States who must be obeyed by everybody, the words "on a fair and equitable basis" were inserted in the act after the words "to adjust, pay, and discharge," and the suggestion is that that addition be made to this bill also so as to prevent any too rigid interpretation by the comptroller of the actions of the heads of departments that are taken under this act.

Before taking up a little further in detail the various claims, I want to say one word about the number of the [fol. 2501] claims. I think, perhaps some confusion has been created in the minds of some members of the committee as to the number of claims. It has been stated there were some 2,500 patents.

The Chairman: Two thousand seven hundred.

Mr. Knight: Or perhaps 2,700. Each of these patents has what is called a number of claims in it so that there might have been brought before us, perhaps, 10,000 claims to separate elements of radio apparatus. A very large proportion of those patents, of course, have no relation to anything the Government or anybody else ever did, and I should say fully half of them nobody ever did anything with at all. Fifty per cent of all patents are merely unsuccessful dreams and probably the usual proportion of radio patents is the same. The committee has, however, examined all of these patents. Most of them it discarded from any further thought. Those that seemed to be important it has proceeded upon, and of those that were important, where it has received a claim on invitation, it has taken action on the claim, either favorably or adversely, except as to one or two cases not yet determined. After hearing from claimants, there were several hundred patents still before the board which the board had to consider of more or less importance.

Those were reduced, after much discussion, to about 150 patents, and by a further process of elimination, either by agreement with the claimant or by direct action of the board, those were all reduced to some 27 patents as the ones that were worth while passing upon at all. But with regard to the question of matters that may hang over, which has been the subject of some discussion here, the board is fully convinced that by this settlement, not only shall we save the Government much money, as to the details of which I think the Special Assistant to the Attorney General here, who is in charge of patent matters generally of the Government, can give the committee better information, but we shall have settled every claim capable of settlement either now present or which may become present on all of the activities of the Government in radio matters since the year 1910, which is the time of the beginning of any possible claims.

Mr. Hull: Right there, I thought you said this morning there were some claims not included in this settlement.

Mr. Knight: There are. Those are claims we have, with our best judgment, gone over and considered not capable of settlement; that is, not ready to settle, and they will have to go into court. I do not mean to say we have settled every claim on which suit may be or will be brought, but every-

thing on which we think a suit can justly be brought with a rendition of a verdict favorable to the claimant.

Mr. Hull: The Deforest people never came to you at all?

Mr. Knight: Yes, sir; we have had perhaps 25 arguments from them. Their claim has been in the Court of Claims since 1919.

Mr. Hull: You do not think they can justify their claim?

Mr. Knight: We do not. I do not mean to say in toto. They undoubtedly have a claim to some extent, but to the extent that they claim we were absolutely unable to reach an agreement with them. The question with some of these people is whether they have any claim at all. The question with others is, admitting they have some claim, how much can they justly be settled with, and where, for instance, with the Deforest Co. asking for $400,000 and we thinking [fol. 2502] the total sum they should have is $20,000, we are so far apart that we can not make a settlement with them. I do not instance those figures as the exact sums, but simply as an illustration.

The Chairman: But you contend that if they have any claim they can go to the Court of Claims and have that adjusted?

Mr. Knight: Yes. There is no attempt here to deprive a claimant of his rights in the Court of Claims. Our only attempt is to make settlements which will save the Government money and at the same time give these claimants their money within a reasonable space of time.

Mr. Hull: It is not exactly true that you have settled all claims?

Mr. Knight: No, sir.

The Chairman: Mr. Hull, they did not say this morning that they had done that.

Mr. Hull: No; but I understood him to say just now that this would practically settle all claims.

The Chairman: Except those of the Deforest people and one other company.

Mr. Knight: If I said that, then my language is incorrect.

Mr. Hull: Now, you say, "for all time." Let me clear that up in my own mind. You, of course, do not mean to say that you have settled a claim against the Government for an improvement that has not been made?

Mr. Knight: No; all claims that can be made for anything that has happened up to the date stated in the settlement.

Mr. Hull: Will this settlement give the Government the right to go ahead and use all these patents that we have settled for in this bill in the future?

Mr. Knight: In the future; and the bill provides that we shall have the right to do that, if possible. Of course, it is not always possible to make an arrangement for a future right. Sometimes the patentee is uncertain in his desires. He will want more than the Government is willing to give him, and the Government may finally say, "See us in the Court of Claims."

Mr. Hull: We are settling with the Marconi Co. under this bill?

Mr. Knight: Yes.

Mr. Hull: Does that give us the right to go ahead and use those patents in the future?

Mr. Knight: No, sir.

Mr. Hull: We have to pay for that in the future?

Mr. Knight: Yes, sir.

The Chairman: This only enables you to settle up to the time this agreement is finally acted upon by the President of the United States.

Mr. Morin: You have allowed for every case where there can be any substantial recovery made, have you not?

Mr. Knight: That is our judgment; yes. We have even gone so far, in some cases, as to allow something on account of the loss of the Government in litigation expenses; that is, we have had that in mind. It is a thing you can not reckon in exact figures, but it is always a thing we have had in mind. Where there is some doubt as to whether the claimant can sustain his patent, but we think the court may resolve those doubts in his favor, we have also had the fact [fol. 2503] in mind of the saving that the Government is making in litigation expenses.

Mr. Hull: Do you base your settlement on basic patents or do you base it on the service that the man rendered in getting up a new combination?

Mr. Knight: We have considered the size of the invention in its several aspects; the size so far as it may involve expensiveness of apparatus; its size so far as it relates to its position in the art. Where it is a very important patent we have paid much more regard to it, as we think the court

would, than to a less important patent. Indeed, our whole process of mind has been to try to find out, as far as we could, what the Court of Claims, which would be the tribunal hearing these cases against the Government, would do in the way of awarding fair and just compensation under the present acts of Congress.

Mr. Hull: They never award anything except for a basic patent.

Mr. Knight: Oh, yes.

Mr. Hull: They do?

Mr. Knight: Yes; wherever the Government has without right or license from the inventor used an invention, they make an award.

Mr. Hull: Whether he had a basic patent or not?

Mr. Knight: Yes, sir; the law of 1910 says nothing about basic patents. It says that wherever the United States has used an invention without right or license or authority, whatever the words are, from the inventor, etc.

Mr. Hull: As I understand it, and I may not be right about it, most patents are not basic at all, but are simply combinations of old principles.

Mr. Knight: You might almost say that all patents are combinations.

Mr. Hull: Not all; there are some basic patents, as I understand it. A manufacturer could manufacture any of those patents that are not basic, and the man who has the patent can not prevent the manufacture unless he has a basic patent.

Mr. Knight: No; that is not the law, sir. Within the limit of his right, the owner of a limited patent is as fully protected as the man who owns a patent as broad as the earth. The measurement is not of the quality of his right, but the extent of it.

The Chairman: And if anybody infringes that improvement of a basic patent, he is liable for that infringement?

Mr. Knight: Absolutely; if the owner of a basic patent should copy—supposing he is not merely a patent owner, but a manufacturer—Smith's patent for some little improvement and the court held, however small that improvement was, that it was still an invention, then the owner even of the basic patent will have to pay him.

Mr. Hull: But if the man could prove that the patent which he was copying was not fundamental, that it was

just simply an old principle applied, he certainly would have the right to use it.

Mr. Knight: No. It that goes to the extent of finding——

Mr. Hull (interposing): That is, as I understand patent law.

Mr. Knight: If it goes to the extent of finding that the patent is invalid on that account, yes; but a court can not find, first, that the patent is valid, however limited; second, that the defendant has used it, and still refuse to find the [fol. 2594] defendant guilty, and find him guilty in damages if they can be ascertained.

Mr. Hull: I do not understand why the Government should reimburse, unless it would be necessary, under the same circumstances, for a private corporation to do the same thing.

Mr. Knight: That is perfectly true; and there is no award that would be made without that.

Mr. Hull: Most manufacturers, or a great many of them, simply go and steal another man's patent right along, and if they have enough money they can get away with it, especially if it is against some poor fellow. They can do it right along, and they do do it.

Mr. Morin: Are you not doing the same thing that you would do with a private corporation?

Mr. Knight: Our findings, of course, are based on precisely the rulings that would be made against any corporation or any user of an invention.

Mr. Frothingham: You are acting under something that Congress passed in 1910.

Mr. Knight: Yes; in 1910 and 1918.

Mr. Frothingham: And it is up to Congress if anyone is to blame.

Mr. Hull: I think when that act or an act similar to that was passed I was not here; and they contended that the Government should reimburse the men holding the patent for the value of the improvement to the art, irrespective of whether he had a fundamental patent or not. I have always thought we should not do that. If a man, of course, has a fundamental patent, we are liable for damages. If he has not, I do not see how he can set up a claim for damages, because, as a matter of fact, when you examine the cases where the corporations have fought them out, the courts have ruled right along that unless a man can prove

he has a fundamental, basic patent he can not recover damages.

Mr. Knight: I think, perhaps, the cases you have in mind are those in which the courts have given less value to improvement patents.

Mr. Hull: I will cite the cases in reference to the internal-combustion engine—the Selden patents and all those cases.

Mr. Knight: That is a very good illustration. The Selden patent was held in the final decision by the court of appeals to be limited to a specific form of engine. It was held to be so limited a claim that the modern automobile had drifted away from it and the patent did not cover them. It was not held that because the patent was limited a defendant infringing it did not have to pay, but it was held that the defendant did not use it because the invention was so limited.

Mr. Hull: What he used was not an infringement; that is what they held.

Mr. Knight: Exactly.

Mr. Hull: That what he used was not an infringement because the principle was old.

Mr. Knight: Yes.

Mr. Hull: And that the patentee did not invent anything.

Mr. Knight: There is the distinction. You see the narrower you make the claim the less chance there is that the defendant will have used it; but however limited the claim, [fol. 2565] if the defendant has used it, then there has never been a decision that he does not have to pay for it.

Mr. Hull: But the claims of a lawyer in getting a patent are always very broad. He makes them as broad as he possibly can.

The Chairman: The basic patent is not always the most important. You will remember that the steam engine was a very valuable basic patent. Then George Westinghouse came along and patented a little airbrake, which made it possible to run that train at an enormous rate of speed. He became very rich. His patent was a comparatively simple thing, and yet that patent was as valuable, if not more valuable, than the basic patent.

Mr. Knight: This question of basic patents is largely an unprofitable one for discussion, because a basic patent may be basic for a few minutes and then is set aside by another basic patent. We had an instance of that in this art. For example, Fessenden had made his very valuable and very clever improvements in electrolytic detectors, which he

called a liquid barator. It was thought to be the only thing that was a substitute for the old forms of insensitive and difficult working detectors.

Mr. Hull: I do not want to go into a discussion of the basic patents and all that. I am not lawyer enough to do that. The point that I want to get at is this: In the settlement of these claims are we paying for patents or supposed-to-be patents, which they claim are patents, but they are not really patents, but they are registered and all that? I am pretty sure, if I remember aright, that Secretary of War Baker argued that we should do that; if anybody improved anything and had spent his time on it, we should pay for it—that is, if he had patented anything that could be sustained in the courts.

Mr. Knight: We have examined to see whether he had a valid patent, and then we have examined to see how broad that patent was, what its scope was, and we have tried to find out how many and what apparatus the Government had made which were under patent. That gave us some basis of estimating what payment should be made. If we thought the patent invalid or insignificant, that the improvement was not worth paying for, we have so declared; but if it was a substantial improvement and the Government used it and had the advantage of the invention and it was a legal claim which the Court of Claims would allow, we have, in that case, favored the claim.

Mr. Hull: That is all.

Mr. Wright: As to the Marconi patent, just how did you arrive at what was the proper amount of award to give for the right to make?

Mr. Knight: A wireless set has two very well-defined things. We have the transmitting end and the receiving end. There may be one transmitter and a number of receivers. Some inventions are peculiar to the transmitter and some to the receiver. Also, there are fundamental patents to each that go to the entire structure and some that simply deal with parts of the structure. You take, for instance, an ordinary radio installation and take the Marconi 4-circuit tuning patent. Marconi, before this other invention came up, had devised radio telegraphy. He now removed the spark gap, the device that put the oscillations into the vertical wire, from the vertical wire and put them in a side circuit and then tuned those two circuits together, [fol. 2506] so that the power would be efficiently trans-

mitted from one to the other. Of course, you can tune two electric wires just the same as you can tune two wires in a piano, so that when you touch one the other one responds. He took a patent for that.

We had to consider how much of those were used in our transmitters and how much were used in our receivers, and then we had to find out what other inventions were in it, because there were other inventions also that related to the entire transmitting set and some that related to parts of the set. The Court of Claims has been somewhat arbitrary in its fixing of awards that should be made to inventors. In ordinary cases against a private individual or corporation the court ascertains the entire profit that has been made by the defendant or the entire loss that has been suffered by the plaintiff or the damage that may have been caused to the plaintiff, finds out the biggest figure and gives it to the patentee. This board does not proceed exactly on that basis. It is not a question of damage to the plaintiff or what profit—the Government makes no profit. The law says that the court shall investigate and determine what shall be due and proper compensation. The law does not use the word "damages" nor "profits." Proceeding on that basis the board investigated and took testimony to ascertain what would be a fair amount.

We went on the basis that the general run of Government contracts during the war were made on a cost-plus 15 per cent basis. As a rule, the courts, outside of the Court of Claims, when they determine the amount that shall be awarded for profit, allow the whole profit, to go to the inventor unless there is some particular reason for diminishing it. In this case we had a number of reasons for diminishing it. We had a number of other awards to consider. Taking the total profit to the contractor dealing with the Government at 15 per cent on his cost price we had to fix a sum that we could deal with for dividing among these patentees. Having found, say, that such and such a set would have cost the Government a million dollars and that the profit on it was, say, $150,000, and the patents to be considered were Marconi's 4-circuit tuning, telephony patents, and so on, then we determined the relative value of these patents in the set. It varied some in different sets. In some sets the principal part of the thing would be the heterodyne, in others the principal object was to use it for

telephony, and so on, and so we had to give different weights to different patents at different times.

The Chairman: What does heterodyne mean?

Mr. Knight: What is ordinarily meant in music by beats. That is a very interesting patent. They had long desired to use in wireless what is known as the continuous wave, but when a continuous wave came over there was no means of receiving it unless you had some mechanical or other interrupter, and thus you lost a lot of the energy. Prof. Fessenden solved the problem by working with these high-frequency electric waves, so that if you were sending at 100,000 frequency per second and you put in your local circuit, going over the same wire, say 99,000 per second, then you would have traveling on this wire those two frequencies, one of 100,000 oscillations and one of 99,000, and the differences between the two, namely, 1,000, would be the frequency heard over the telephone. That is just about the [fol. 2507] natural frequency of the telephone diaphragm. He got a broad patent for that. In many of the systems used by the Government that is a very important means of receiving. In a great many of these cases, where it was so important for receiving the continuous wave, we have allowed a larger proportion to the heterodyne. In other cases, where the principal object was to use it for the telephone, we have allowed the telephone patent a greater weight. They have all had to split up the 15 per cent between them, because that is the limit we have been willing to go.

Mr. Hull: Fifteen per cent of the cost of the article?

Mr. Knight: Yes, sir; of the cost to the Government.

After all, the courts have always said that when it comes to these questions we must do a lot of guessing. We have exercised the privilege of the court in guessing once in a while. We have sometimes had to guess what the article was that the Government used. We have taken the best evidence we could get. We have pulled up sailors, officers, soldiers, and everybody else to try to find what this particular thing was, and we have found it.

The Chairman: Is it 15 per cent of the amount that the company or the corporation or the individual has put in a claim for?

Mr. Knight: Where the Government has bought an installation, say, for $100, we have estimated $15 of that was

profit to the contractor, and an amount similar to the profit to the contractor has to be divided between the inventors whose inventions he used.

The Chairman: That is exactly in line with what Mr. Hull suggested.

Mr. Knight: We have not always done that, because in some cases we have found that the prior art, as it is called—that is, the old art that everybody has a right to use—should receive its share. Thus the Marconi Co. was very much troubled because, having allowed them a percentage during the period of the life of the Lodge patent to their profit, we continued to take off that same percentage, but to the profit of the Government, after the Lodge patent expired.

The Chairman: It has been very interesting and we thank you very much.

Statement of Capt. Guy Hill, Officer in Charge of Radio Development Section, Office of the Chief Signal Officer of the Army, and Member of the Inter-Departmental Radio Board.

Capt. Hill: The problems of the War Department in radio are very similar to those of the Navy Department, except, of course, our work is different in not having practically any ship radio. We have aircraft, tanks, and a large number of portable sets for the Army. The inventions that have been used in the War Department apparatus are practically identical with the inventions that have been used in the Navy Department apparatus, except that we have not used them to as great an extent.

I think Commander Loftin, Commander Hooper, and Mr. Knight have summed up the work of the board and the way that the board has used these patents, so I have not anything definite to add, unless you have some specific questions.

[fol. 2508] The Chairman: You have heard their statements?

Capt. Hill: Yes, sir; I have been here all during the hearing.

The Chairman: And you concur in their findings?

Capt. Hill: I concur in the findings and in the statements which they have made before the committee.

Mr. Wright: You also concur in the statement that there has been a great deal of detail involved in the board's investigations?

Capt. Hill: I certainly do.

The Chairman: Is there any member of the committee who would like to ask any questions? [After a pause.] If not, we thank you very much.

Capt. Hill: I should also add, Mr. Chairman, that Maj. Young, the other member of this board from the War Department, is in full accord with the statements of Commander Hooper, Commander Loftin, and Mr. Knight.

The Chairman: I understand that he has been called away on account of the death of a member of his family. Otherwise he would have been glad to have been here and give his evidence along the same line?

Capt. Hill: Yes, sir. He was here a while this morning, but had to leave.

The Chairman: We are much obliged to you.

Statement of Mr. Edward G. Curtis, Special Assistant to the Attorney General, in Charge of the Defense of the United States in Patent Litigation.

The Chairman: How long have you held your present position, Mr. Curtis?

Mr. Curtis: Two years, Mr. Chairman, approximately. In that connection, with your permission, I might state how I came to be connected with the Department of Justice, and what my work has been there, so you may understand exactly the basis on which I found the statements that follow.

The Chairman: We shall be glad to hear you.

Mr. Curtis: Following my return from military service I was asked to come to Washington by Attorney General Palmer, to take charge of the defense of the United States in its patent cases.

A great number of patent cases against the Government had accumulated not only under radio patents, but under a great many other patents, and the Department of Justice at that time was not prepared to meet the situation. I came here and formed a department of patent defense, which consists of some 20 or 25 patent attorneys.

During these past two years I have participated in no less than 100 different pieces of litigation involving alleged

infringement of patents by the United States. In the course of these two years I have come into intimate contact with every branch of the departments of the Government which has any particular interest in or dealing with patent matters. Now, there is a foundation for the few remarks I have to make.

First, something has been omitted from the testimony given before you. The modesty of the members of the board [2509] has prevented them from saying what I can. I have watched the board from what might be called an outside position. They have worked with a high degree of intelligence and skill with this very difficult problem, and when they say, without any explanation, that the patent claimants have been docile, be assured the reason for it is that claimant after claimant has been obliged to concede the care and efficiency with which this board has examined the problems before them.

Speaking for the Department of Justice, I am impressed with the business aspect of the situation. It would cost the Department of Justice probably no less than $500,000 in counsel fees, expert fees, and other expenses to fight through the courts these various claims that this board has succeeded in getting to this point of settlement.

Secondly, I have no doubt whatever that should the efforts of this board fail and the cases go to trial in the Court of Claims, the sum of the awards by that court would exceed the findings that have been made by the board.

Putting these points together, therefore, it is hardly controvertible that if this committee passes the recommendation which is before you, a direct and demonstrable saving of considerable extent will have been vouchsafed the Government.

As to the details of the operations of the board, the complicated wireless instruments which they have studied and analyzed. I do not feel qualified to speak; these matters have already been put before the committee; but I shall be glad now or at any time to answer, so far as I can, any questions which you have to ask.

The Chairman: Does any member of the committee desire to ask any questions at this time?

Mr. Hull: Just one question. What do you estimate is the amount of claims that are not settled by this?

Mr. Curtis: You have touched a very difficult problem there, and I will have to do a little guessing. The situation is this: There are, roughly speaking, two classes of claims, good claims and bad claims. This board has sifted out the wheat from the chaff, so far as it can be done outside of a court, and has determined that certain claims are good and ought to be settled and that certain claims are either bad or at least so doubtful as to make settlement inadvisable. Speaking by and large, these latter claims will probably come up in court, but they are the claims we do not particularly fear. The board has made peace with most of those who had good patents that were infringed, and for the most part has declined to settle only with those who had patents apparently invalid or patents which were not infringed. If those who have been discredited by the board are disgruntled and proceed in the Court of Claims, we have good hopes of confronting them with effective defenses. As to these unsettled claims, I hardly know what to say; they involve claims of some millions of dollars. But, as I said, we feel that in most instances we have defenses against them and look forward with considerable assurance to defeating the majority of those plaintiffs who have not been wise enough to submit to the recommendation of the board. Of course a claimant denied by the board can go to the Court of Claims if he desires. If he does, he will meet the combined strength of the board and counsel for the United States, who will be provided with what we believe are good defenses.

[fol. 2510] Does that answer your question?

Mr. Hull: Yes, sir. Along that line, what as to the future of these claims, does it take into consideration the future use by the Government? Of course, by doing this we admit that the party had a claim against the Government.

Mr. Curtis: Possibly; but I should suggest that you let Commander Loftin answer that question, because it is a phase about which he knows more than I.

Commander Loftin: Do you desire me to say something on that point?

Mr. Hull: Yes, sir.

Commander Loftin: In that connection I am acting in a dual capacity as representing the Bureau of Engineering in radio matters and this board. The Bureau of Engineer-

ing, as you know, purchases the material for radio for the Navy. Now, using the knowledge that this board has gained of the patent situation, we have succeeded in bringing together many of these patents into several of the larger companies and we have succeeded in having those companies practically take care of the Government for the future. For instance, the American Telephone & Telegraph Co. has purchased the Deforest patents—some very important patents to the radio art—and the General Electric Co. has formed the Radio Corporation of America to go into the business of manufacturing radio apparatus and operating radio stations. In doing that they purchased all the Marconi Co.'s interests and combined with those the development of the General Electric Co. and bought out here and there a number of other patents. The International Radio Co., which had a large claim, sold their rights to the Westinghouse Co., so that most of the important patents are held within large organizations and not distributed as they were prior to the commencing of this war. The Radio Corporation and the General Electric Co. and the American Telephone & Telegraph Co. have made an agreement that as far as the Government is concerned any one of those companies can manufacture apparatus for the Government under the patents owned by them, so that gives us at least three competitors from whom we can buy and to expect reasonable prices for the apparatus under a very large group of patents. We also understand that there is in progress an arrangement which will include the Westinghouse Co., so that as far as the future is concerned we feel pretty safe on Government purchases that we will be able to buy from four large companies and can get competition on our proposals for bids.

The Chairman: And at a moderate price?

Commander Loftin: At a modern price; yes, sir; competition from four companies, and in our dealings with them we have always found them willing to supply the Government with apparatus at a very reasonable price.

There are a few other patents that the board has found the Government may be likely to use in the future which are not included in the arrangement among these large companies. In those cases we have secured an arrangement under this settlement proposed to take care of the Government for the life of those patents for a nominal

amount. So, I think it can be safely said that this settlement [fol. 2511] will take care of the future as far as patents which exist to-day are concerned.

Of course, we can not attempt to say as to things which will come after that, but we anticipate, as far as these companies are concerned, that they will give us the benefit of their development: that is, as far as the competition on the part of the four companies is concerned.

The Chairman: I would like to ask you a question. The Dent law, as I remember, provides that a man, in order to get the advantage of that law, had to file his claim before the elapse of a certain amount of time. This provides for a new section passed after the Dent Act was enacted, and there is a doubt in my mind whether that time allowance would apply to this last section, section 6. Do you think it would be advisable to put in the law as we consider it in the House or in the committee a provision that any claim under this section must be submitted to Congress or the proper authorities not later than, say, six months from the date of the passage of the bill? I think the original Dent Act provides for six months.

Commander Loftin: That would include everybody irrespective of time, and I think that should be sufficient, from a practical side. We have practically had before us—and have had for some time—every claim that we anticipate will be brought. The last one of those was probably after that date in the Dent Act.

Mr. Knight: That time ran out in 1919.

The Chairman: I remember that very well. I was one of the conferees on that bill.

Commander Loftin: We have a few claims that were filed after that date, and if that date is going to limit the claims before this board it should be fixed so it will not.

Mr. Knight: Six months after passage of the act would be an abundance of time.

The Chairman: Have you any other suggestion? Could you say three months. These are all war matters and for God's sake let's get rid of the war as soon as possible.

Commander Loftin: I understand, Mr. Chairman, it was four months in the Dent Act, and I think three months in this case would be quite adequate. I do not think there are any more claims and I think three months would be enough.

The Chairman: I thank you very much. What is the name of that case that you referred to?

Commander Loftin: That is the Dent Act.

The Chairman: What is the name of the book?

Mr. Davis: This is volume 1 of Decisions of the War Department Board of Contract Adjustments. That was the board that acted in a semijudicial capacity in enforcing the Dent Act.

The Chairman: This is referred to in that volume as you have suggested?

Mr. Davis: Yes, sir. The Dent Act is printed in this as part of War Department Supply Circular No. 17.

The Chairman: I just want to identify it in the record so that if the committee want to see it we would know just where to find it.

Commander Loftin: Just one other matter. You mentioned this morning some anticipated change in this bill of requiring claimants who do not accept the board's recommendation of proceeding into the Court of Claims within a certain time.

[fol. 2512] The Chairman: That is what I had in mind just now.

Commander Loftin: I thought you meant in the Court of Claims.

The Chairman: If a man does not file his claim in these branches of the Government within the time mentioned in the act I suppose the law provides how soon he may proceed in the Court of Claims.

Commander Loftin: As I understand, there is no limit on that. But he can only claim six years back in his damages.

The Chairman: I presume the moment you begin to interfere with that right in the Court of Claims you immediately enter into trouble, and we have troubles enough on our hands now.

Commander Loftin: The reason we mention that is that we have understood with our claimants right along that whatever happened in the board would be without prejudice, and I was going to suggest if there were an intention of limiting the time they could go into the Court of Claims, it should not be done, as we have never proposed to them that not accepting our recommendation would prejudice the claim.

Mr. Curtis: May I leave you this one thought: That regardless of what may happen in the future, and regardless of the pleasing fact that probably the future is largely taken care of—even if it were not, it would be highly advanta-

geous to the Government in every way to see that this bill passes, since it will undoubtedly insure to the Government a very large saving of money.

The Chairman: We are very much obliged to you gentlemen.

Thereupon, at 3.10 p. m., the committee adjourned until Tuesday, May 24, at 10 o'clock a. m.)

Plaintiff's Exhibit 142.

French Patent for Invention No. 305,060, for "Improvements in Wireless Telegraphy", granted November 3, 1900, to la Société Marconi's Wireless Telegraph Company.

The original exhibit is in the French language. The French patent No. 305,060 is substantially the same as British patent No. 7777 of 1900, granted to Guglielmo Marconi and Marconi's Wireless Telegraph Company, Ltd., (Plaintiff's Exhibit 34 herein) with the following exceptions:

The French patent, page 2, line 3, refers to French patent No. 261,602; the British patent, page 2, line 48, refers to British patent No. 12,039 of 1896.

The French patent, page 5, line 10, refers to French patent No. 283,521; the British patent, page 3, line 28 et, refers to British patents Nos. 12,326 of 1898, 6,982 of 1899, and 25,186 of 1899.

The French patent, page 7, gives figure numbers as 5 to 8, whereas the British patent, page 3, line 48, gives figure numbers 5 to 11.

The matter appearing at the following places in the British patent are omitted from the French patent: page 3, lines 54-55, inclusive; page 5, lines 35-54, inclusive; and page 7, lines 12-14, inclusive, and line 22.

Tunes Nos. 7, 8, and 9 of the Table entitled "Transmitting Station" on page 6 of the British patent are omitted from the corresponding Table in the French patent. Tunes Nos. 7, 8, and 9 of the Table entitled "Receiving Station" on page 7 of the British patent are omitted from the corresponding Table in the French patent.

Figs. 9, 10, and 11 of the British patent are not found in the French patent.

The claims of the two patents differ from each other; those of the British patent appear in Plaintiff's Exhibit 34 and those of the French patent appear in Plaintiff's Exhibit 36.

Claimant's Exhibit No. 150

PLAINTIFF'S EXHIBIT ~~No. 85~~ H 1

~~Dept E Ref~~ June 30th 1899

My dear Parker,

One chief limitation to the utility of the vertical wire of our telegraphy system is that the pedestrian animals in all directions from the transmitting wire so that within the sphere of influence of our vertical wire, all other vertical wire stations are affected by the signals sent from this wire and may not only receive the signals sent from it, but will be interfered with by it in the process of receiving signals from any other vertical wire station from which they may be attempting to receive communication.

This difficulty may be overcome by using transmitting wires giving forth simple harmonic signal waves and receiving stations respond waves or stations only capable of receiving simple harmonic signal waves.

In the existing vertical wire stations, the waves sent out and used to receive messages are complex harmonic waves owing to the fact that the vertical wires are not simple resonators but are capable, upon receiving electrical equilibrium disrupted, of developing oscillation of a

Receipt Exhibit #2

considerable number of different frequencies and also an equal # corresponding more or less perfectly to a corresponding, large number of different frequencies.

Instead of utilizing the vertical wire itself at the transmitting station or the oscillator, I propose to impress upon this vertical wire, oscillations from an oscillator which oscillations should be of a frequency corresponding to the fundamental of the wire. Similarly at the receiving station, I shall draw from the vertical wire, only that component of the complex wave which is of lower frequency.

If now the fundamental of the wire at the receiving station be the same as that of the wire at the transmitting station, then the receiving station may receive signals from the transmitting station, but if it be different from that of the transmitting station, it may not receive those signals.

By such an arrangement it is obvious we shall be enabled to have a large number of vertical wire stations or number

Plaintiff's Ex N 3
~~Dfts Ex Ft 1~~

Boston, July 22, 1890.

Mr. John Stone Stone,
Phillips Building,
Boston, Mass.

My dear Stone:-

Your letters of July 18th and ~~week~~ June 20 last were received in due course, and have been read with great interest. The "selective" methods of space telegraphy therein described I believe I understand sufficiently to set up and operate them.

Allow me to add that this specialization of the work which Marconi's experiments to date leave in rather primitive condition, is very important, and should be prosecuted without delay by way of further development, and protection by letters-patent.

Yours very cordially,

Jno. L. B. Bates

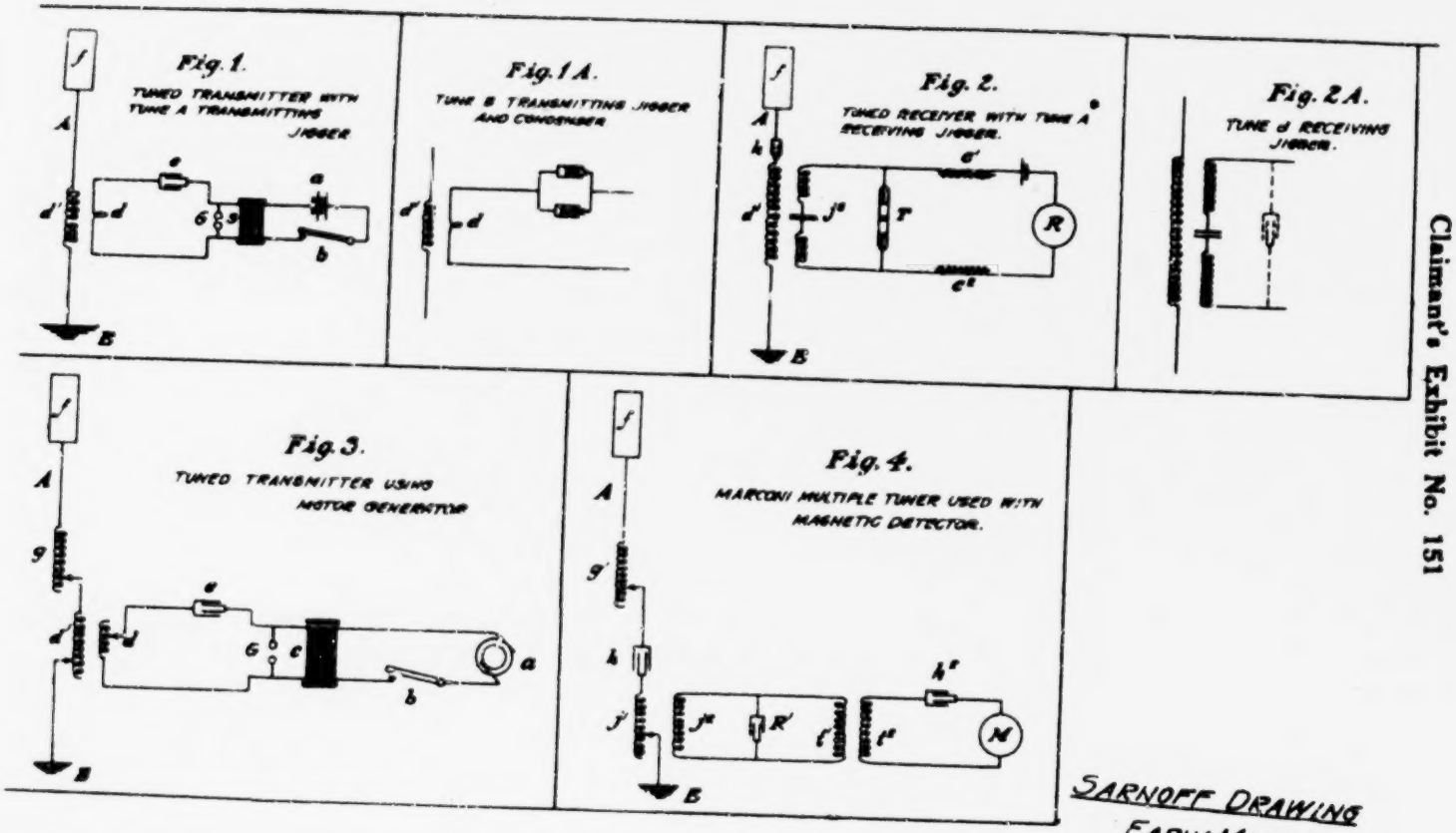
June 20

ly 18th and ~~20th~~ last were

June 30th.

Plaintiff's Ex. N 4

him limitation to the



Claimant's Exhibit No. 151

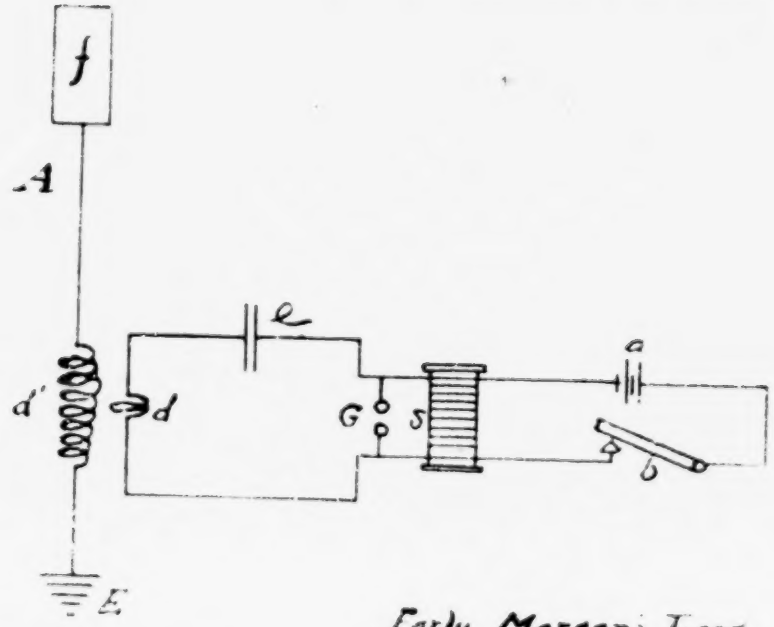
SARNOFF DRAWING
EARLY MARCONI
TUNED TRANSMITTERS
AND RECEIVERS.

Receiver's Exhibit No 39 I

Claimant's Exhibit No. 157

FIG 1

TUNED TRANSMITTER
WITH TUNE A TRANSMITTING JIGGER



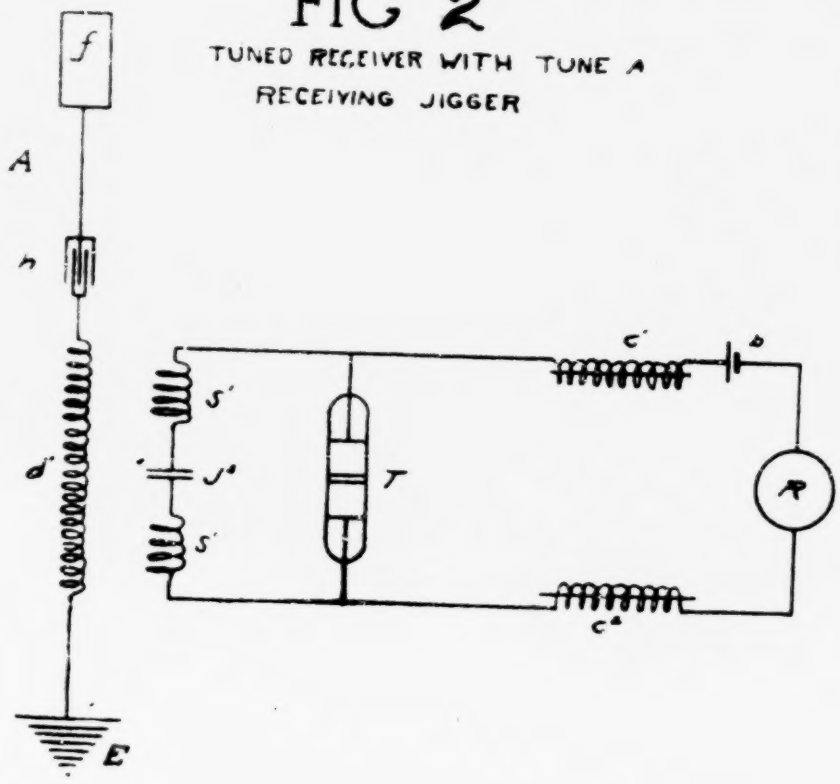
Marconi Exhibit 27 (?)

Early Marconi Tuned Transmitters

Claimant's Exhibit No. 158

FIG 2

TUNED RECEIVER WITH TUNE A
RECEIVING JIGGER

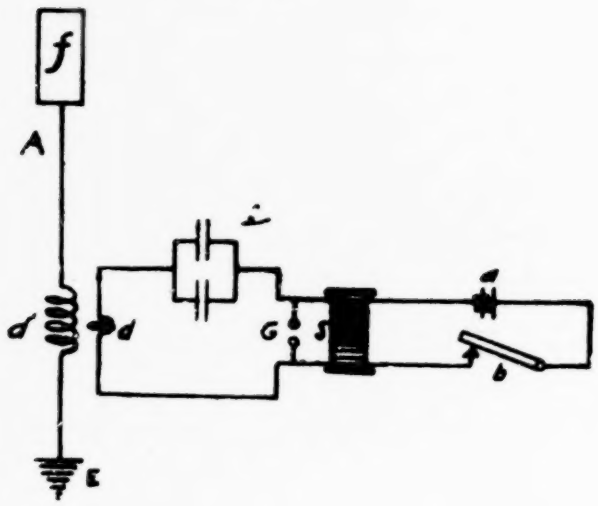


Plaintiff's Exhibit 29 π²

4-7-16

Claimant's Exhibit No. 159

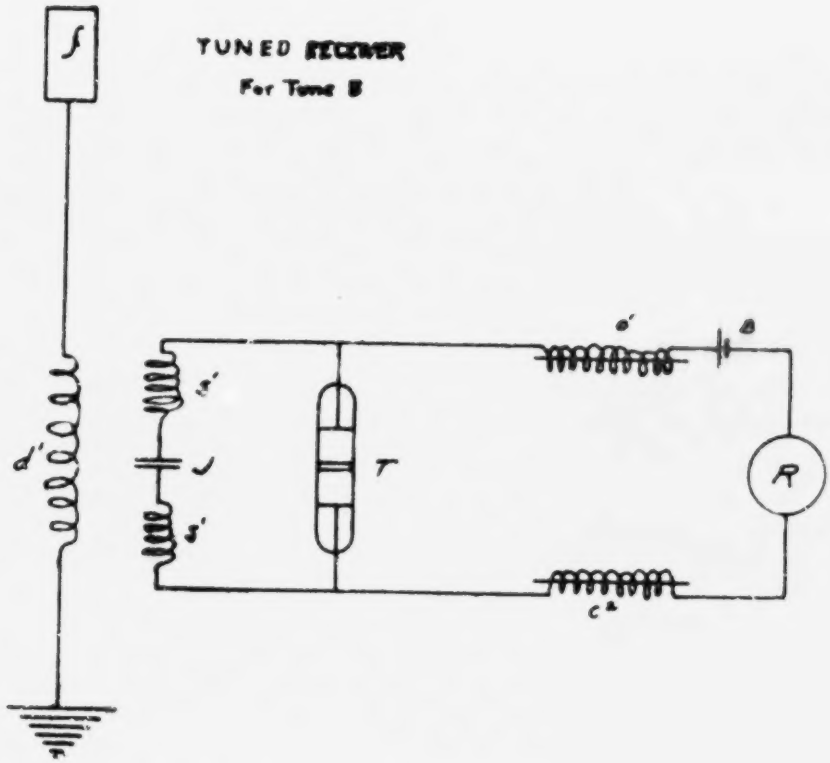
TUNED TRANSMITTER
For tube B



Plaintiff Exhibit 27 T 3

23120

Claimant's Exhibit No. 160



Plaintiff's Exhibit 27 ***

[fol. 2527] PLAINTIFF'S EXHIBIT 171

UNITED STATES DISTRICT COURT, SOUTHERN DISTRICT OF NEW YORK

Equity No. 12/31. On Fleming Patent No 803,684

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA, Plaintiff,

vs.

DEFOREST RADIO TELEPHONE & TELEGRAPH COMPANY, Defendant

PLEADINGS AND EVIDENCE UNDER SUPPLEMENTAL BILL

Sheffield & Betts, Solicitors for Plaintiff. Darby and Darby, Solicitors for Defendant.

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[fol. 2529] UNITED STATES DISTRICT COURT, SOUTHERN DISTRICT OF NEW YORK

In Equity No. 12 31. On Fleming Patent No. 803,684

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA,
Plaintiff,

vs.

DEFOREST RADIO TELEPHONE & TELEGRAPH COMPANY,
Defendant

SUPPLEMENTAL BILL

To the Honorable the Judges of the District Court of the United States for the Southern District of New York, in the Second Circuit:

The plaintiff above named, alleges as follows:

First: That the Plaintiff, Marconi Wireless Telegraph Company of America, is a corporation organized and

existing under and by virtue of the laws of the State of New Jersey, and a citizen of said State and a resident of the District of New Jersey within said State.

Second: On information and belief, that the defendant above named, DeForest Radio Telephone & Telegraph Company, at the time or times of the acts of infringement hereinafter complained of was and now is a corporation organized and existing under and by virtue of the laws of the State of Delaware, and a citizen of said States, and at the said time or times had and now has a regular and established place of business in the Borough of Manhattan, City of New York, Southern District of New York, within the State of New York, where it has committed and is now committing some of the acts of infringement hereinafter complained of.

Third: That the above-named plaintiff filed its original amended bill herein against the above-named defendant and another on or about the 28th day of November, 1914, wherein it alleged, among other things, ownership of United States Letters Patent No. 803,684, issued November 7, 1905, to the above-named plaintiff for improvements in Instruments for Converting Alternating Electric Currents into Continuous Currents, upon the invention of John A. Fleming, and charged that the above-named defendant had infringed upon said Letters Patent, and prayed for a discovery, accounting, payment of profits and damages, and for an injunction restraining said defendant from said infringement; that the said defendant duly appeared herein and filed its answer to said original amended bill, alleging, among other things, the invalidity of said Letters Patents, denying the infringement thereof, and setting up other defenses usual in suits for infringement of Letters Patent for inventions; that thereafter issue was joined, a trial on the merits thereof was had in open court, at which a large amount of evidence, [fol. 2530] both expert and fact, was taken by both parties herein on the issues raised; that after further and due proceedings were had, and on or about October 9, 1915, an interlocutory decree was entered herein decreeing, among other things, that claims 1 and 37 of said Letters Patent No. 803,684 were good and valid in law; that said defendant had infringed upon said claims, and granting a perpetual injunction restraining said infringement and an ac-

counting of profits and damages by reason thereof; that subsequently the defendant appealed from said decree and on or about May 8, 1916, the Circuit Court of Appeals for the Second Circuit, after argument on the merits, affirmed said decree; that subsequently and on or about May 28, 1916, an order was entered herein on the mandate of said Circuit Court of Appeals affirming the said interlocutory decree, which orders and decrees remain in full force and effect and unreversed, and all of which will more fully and at large appear by reference to records of this Court and of the said Circuit Court of Appeals, in this suit and to which the plaintiff refers and makes a part of this supplemental bill.

Fourth: That the plaintiff has been, ever since the date of said Letters Patent No. 803,684, and now is, the sole and exclusive owner thereof and of all claims for damages and profits for any infringement thereof.

Fifth: Upon information and belief and by way of supplement: That the aforesaid defendant, since October 1908, and prior to the execution of this supplemental bill, has unlawfully and wrongfully made, sold and caused to be used within the Southern District of New York and elsewhere within the United States, and is now making, selling and causing to be used within said Southern District of New York and elsewhere within the United States, and threatening to continue so to do, devices or wireless telegraph instruments known as "Oscillions" or "Audion Oscillions", containing, embodying or employing the inventions of said claims 1 and 37 of said Letters Patent No. 803,684, or contributing to embodiment and infringement of the inventions of said claims of said Letters Patent and the rights of the plaintiff thereunder.

Sixth: Upon information and belief and by way of supplement, that the said "Oscillions" or "Audion Oscillions" were made and sold and caused to be used as aforesaid, subsequent to the filing herein of the said original amended bill and pending the aforesaid proceedings herein; that the plaintiff, prior to and at the time of filing said original amended bill, was ignorant of the manufacture and sale of said "Oscillions" or "Audion Oscillions" and of the construction and arrangement of said devices and the circuits thereof, and did not acquire any knowledge or sufficient knowledge thereof on which to base any claims in respect

thereto until subsequent to the aforesaid trial under the issues raised by the said amended bill and answer thereto.

Seventh: Upon information and belief and by way of supplement, that said "Oscillions" or "Audion Oscillions" are substantially or essentially the same in construction and mode of operation as the audions, amplifiers and devices adjudged by the aforesaid interlocutory decree to be an infringement of said claims 1 and 37 of said Letters Patent No. 803,684, as the same has been construed by this Court and by the Circuit Court of Appeals for the Second Circuit.

[fol. 2531] *Eighth:* Upon information and belief and by way of supplement, that the defendant has derived and received, and is still deriving and receiving from the said manufacture, sale and use of said "Oscillions" or "Audion Oscillions", great gain and profit, but to what amount the plaintiff is ignorant and cannot set forth, and that by reason of said manufacture, sale and use the defendant has deprived the plaintiff of great gains and profits, but to what amount the plaintiff is ignorant and cannot set forth at present.

Ninth: That by reason of the premises the plaintiff has suffered great loss, damage and injury, and unless said wrongful and unlawful manufacture and sale by the defendant of said "Oscillions" or "Audion Oscillions" is enjoined by the decree of this Court, will continue to suffer great loss and be irreparably injured and damaged.

Wherefore, the plaintiff prays:

1. That it may have the benefit of the evidence and proceedings heretofore had herein, and of any decisions, orders, decrees or injunctions heretofore entered herein or granted against the defendant herein.

2. That the defendant be required to make full, true, direct and perfect answer (but not under oath, an answer under oath being expressly waived) to this supplemental bill of complaint, and that the defendant be required to pay the costs, charges and disbursements of the proceedings under this supplemental bill.

3. That the defendant and its associates, attorneys, clerks, servants, agents, workmen and employees may be provisionally and perpetually enjoined and restrained by the

decree of this Court from directly or indirectly making or causing to be made, using or causing to be used, leasing or causing to be leased, selling or causing to be sold, advertising or offering for sale, use or lease, or causing to be advertised or offered for sale, use or lease, agreeing or contracting to sell or lease, or causing to be agreed or contracted for sale or lease, supplying or causing to be supplied, installing or causing to be installed, or threathening to make, use, lease, sell, supply or install and threatening to offer or contract for sale, lease or supply, or disposing of in any manner, any devices, known as "Oscillions" or "Audion Oscillions", or substantially similar devices embodying or employing, or contributing to the embodiment or employment of said inventions and improvements or discoveries of claims 1 and 37 of said Letters Patent No. 803,684.

4. That the defendant may be decreed to account for and pay over unto the plaintiff all such gains, profits and advantages as have accrued to or have been earned or received by the said defendant, and all such gains, profits and advantages as would have accrued to or been earned by the plaintiff but for the infringement of the said defendant complained of herein, and also all damages the plaintiff has sustained by said infringement of the defendant, and that the Court will assess the same or cause them to be assessed under its direction, and will increase the same, in its discretion, as provided by law.

5. Or that the interlocutory decree heretofore entered herein and the injunctions heretofore issued herein against the defendant be extended to apply to the aforesaid "Oscillions" or "Audion Oscillions" and substantially similar devices.

[fol. 2532] 6. That the plaintiff may have such other and further relief as the premises and the equity of the case may require and as to the Court may seem just.

Marconi Wireless Telegraph Company of America,
by E. J. Nally, *Vice-President.*

Sheffield & Betts, *Plaintiff's Solicitors.* L. F. H. Betts, *of Counsel.*

STATE OF NEW YORK,
County of New York, ss:

On this 14th day of September, 1917, before me came E. J. Nally, to me personally known, who being by me duly

sworn did dispose and say that he is the Vice-President of Marconi Wireless Telegraph Company of America, the plaintiff named in the foregoing supplemental bill of complaint; that he has read the said supplemental bill subscribed by him and knows the contents thereof and that the same is true of his own knowledge except as to matters which are therein stated to be alleged on information and belief, and as to those matters he believes it to be true. That the reason why this verification is not made by the said plaintiff personally is that said plaintiff is a corporation.

E. J. Nally.

Sworn to before me this 14th day of September, 1917.
Walter S. Jones, *Notary Public*, New York County.
(Seal.)

[fol. 2533] IN THE DISTRICT COURT OF THE UNITED STATES FOR THE SOUTHERN DISTRICT OF NEW YORK

In Equity No. 12/31. On Fleming Patent No. 803,684

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA,
Plaintiff,

vs.

DEFOREST RADIO TELEPHONE & TELEGRAPH COMPANY,
Defendant

ANSWER TO SUPPLEMENTAL BILL

The Answer of DeForest Radio Telephone & Telegraph Company, the Defendant herein, to the Supplemental Bill of Complaint of Marconi Wireless Telegraph Company of America.

This defendant, answering, says, as to the following correspondingly numbered paragraphs of the Supplemental Bill:

First: It admits the allegations of Paragraph First.

Second: It admits the allegations of Paragraph Second as to its incorporation and citizenship; but it denies that it has any place of business in the Borough of Manhattan and that it has committed or is committing any of the alleged acts of infringement complained of.

Third: It admits the allegations of Paragraph Third, save that the dates given therein as 1915 and 1916 are erroneous and should be 1916 and 1917 respectively.

Fourth: It has no knowledge as to whether plaintiff was, at the date of the Supplemental Bill, the sole and exclusive owner of the patent sued on or of any or all claims for damages and profits for any infringement thereof.

Fifth: As to the allegations of Paragraphs Fifth and Sixth concerning the alleged infringement, it denies that at any time or at any place it has made, sold or caused to be used, any devices or wireless telegraph instruments known as "Oscillions" or "Audion Oscillions" containing, embodying, or employing the inventions of claims 1 or 37 of Patent 803,684 in suit, or contributing to embodiment and infringement of said claims or either of them or any of the rights of the Plaintiff thereunder; and it avers that the limits of said patent, excluding any and all Oscillion apparatus, are and have been definitely fixed by the Court of Appeals of this Court, by this Court, by the face of the patent itself, and by the prior state of the art; and it further avers that it is doing no business save under its own patents covering the subject matter of the alleged infringement and not previously considered in the prior litigation under the patent in suit.

Sixth: As to the allegations of Paragraph Sixth, concern-
[fol. 2534] ing Plaintiff's knowledge of the alleged infringement, Defendant has no knowledge, and leaves Plaintiff to its necessary proof thereof.

Seventh: As to the allegations of Paragraph Seventh, that the alleged infringements are substantially or essentially the same in construction and mode of operation as the apparatus heretofore adjudged to be infringements of the patent in suit, as the latter has been construed by this Court and by the Court of Appeals of this Circuit, the Defendant denies the same, and in support of its denial refers to the decision of this Court of July 11, 1917, subsequent to the decision of the Court of Appeals, denying an injunction as to the matters now complained of, although extending in other respects the scope of the injunction previously issued and approved by the Court of Appeals.

Eighth: As to the allegations of Paragraph Eighth, it denies that it has derived or received, or is deriving or re-

ceiving from any manufacture, sale or use of "Oscillions" or "Audion Oscillions," any gains or profits; but as to deprivation of the plaintiff of aay gains or profits, it is without knowledge.

Ninth: It is without knowledge as to the allegations of Paragraph Ninth.

Wherefore, Defendant prays that the Supplemental Bill of Complaint be dismissed with costs.

Philip Farnsworth, Solicitor for Defendant, 149 Broadway, New York City, N. Y.

Dated New York, N. Y., October 4, 1917.

[fol. 2535] UNITED STATES DISTRICT COURT, SOUTHERN DISTRICT OF NEW YORK

In Equity 12/31

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA, Plaintiff,

vs.

DEFOREST RADIO TELEPHONE & TELEGRAPH COMPANY, Defendant

New York, N. Y., March 11 and 12, 1919.

Before Hon. Julius M. Mayer, District Judge

March (1919) Term

APPEARANCES:

Messrs. Sheffield & Betts, by L. F. H. Betts, J. Edgar Bull, of Counsel, for the Plaintiff. Samuel E. Darby, Esq., Samuel E. Darby, Jr., Esq., for the Defendant.

PLAINTIFF'S PRIMA FACIE PROOFS

Mr. Bull: Will counsel for the defendant admit that the defendant at the date of the commission of the acts of infringement alleged in the supplemental bill herein, had a

regular and established place of business within the Southern District of New York?

Mr. Darby, Jr.: Yes.

Mr. Bull: Will you admit that this DeForest radio telephone apparatus, bulletin D-16 was issued, published and generally distributed by the defendant subsequent to the filing of the original bill herein and prior to the filing of the supplemental bill herein?

Mr. Darby, Jr.: We admit that the publication was issued and distributed by the DeForest Company prior to those dates, but how generally they were distributed of course I do not know; I am not prepared to state at this time.

Mr. Bull: That is between the date of the filing of the original bill and the date of the filing of the supplemental bill.

Mr. Darby, Jr.: Yes.

Mr. Bull: Will you admit that all the apparatus illustrated and described in said catalogue was manufactured and sold by the defendant within the Southern District of New York [fol. 2536] subsequent to the filing of the original bill herein and prior to the filing of the supplemental bill herein?

Mr. Darby, Jr.: We admit it was offered for sale; I do not know whether it was sold or not.

Mr. Bull: Will you admit that the supplemental bill may be amended *nunc pro tunc* as of its date of filing by inserting paragraph 3, seventh line from the bottom, page 2, "1916" for "1915", and lines 2 and 5, page 3, "1917" for "1916"? Those are clerical errors in the bill.

Mr. Darby, Jr.: These appear to be merely typographical errors and we admit it.

Mr. Bull: Will you admit that the plaintiff is now and has continuously been the sole owner of the Fleming patent in suit since the date of the filing of the original bill herein?

Mr. Darby, Sr.: We have no knowledge as to that; we have no reason to challenge it.

Mr. Bull: Will you admit it for the purposes of this proceeding?

Mr. Darby, Sr.: As far as I know, yes.

Mr. Bull: It is a fact; it will simply save calling a witness.

Mr. Darby, Jr.: If it is a fact we admit it.

Mr. Bull: Your Honor remembers that on the motion an affidavit by Mr. Waterman was filed, a first affidavit, and then a reply affidavit, and a part of those affidavits related to this oscillion matter.

The Court: Yes.

Mr. Bull: If it meets with the approval of the court I will have Mr. Waterman take the stand, have him read what he said in those affidavits as his depositions in this case, simply as a quick way of getting at it.

The Court: I have approved that method on a number of occasions; I think it is satisfactory.

FRANK L. WATERMAN, a witness called on behalf of the plaintiff, being duly sworn, testifies as follows:

Direct examination.

By Mr. Bull:

Q. 1. You have testified as a witness in the trial of the original bill in this case?

A. I did.

Q. 2. Will you explain to the court the references in the catalogue which is marked "Bulletin D-3" of the defendant, the references therein to oscillions, and repeat as your testimony in this case so much of the affidavits filed by you on the motion to extend the decree in this case as you desire.

Mr. Bull: First I will offer in evidence the DeForest Bulletin D-16.

Marked Plaintiff's Exhibit 1.

A. The explanation, I think, will be sufficient if I simply read the portions of the affidavits which I gave on the motion which relate to the oscillion.

Referring now to the so-called "oscillion", I produce as [fol. 2537] Exhibit D, DeForest circular marked Bulletin D-16, entitled "DeForest Radio Telephone Apparatus". This bulletin states as follows:

"DESCRIPTION OF APPARATUS

"As shown in the accompanying cuts the new type of DeForest Radio Telephone is distinctly different from all earlier types. In every particular, from principle to detail, it marks a great advance.

"The arc used in previous types has been completely eliminated. The generator of the high frequency currents is a modification of the now famous DeForest Audion which has been in use for years in the best commercial wireless stations.

"It is entirely fitting, therefore, that a form of this famous device should have been developed into a generator of high frequency currents for telephoning without wires, for its constancy and thorough reliability are its distinguishing features and these are absolutely essential in a practical commercial wireless telephone.

"When this transmitter is adjusted to the desired wave length no further change is required, it being merely necessary to throw the transfer switch from talking to listening or vice versa."

According to my understanding, the sole "modification" of the bulb employed in the oscillion consists in making it larger with accompanying alterations of detail structural features. All the Fleming valve bulbs, including the so-called three element audion exhibited before the Court, have the property of "oscillating" when properly constructed—that is, if they are provided with a sufficiently high vacuum. This means, of course, that they will oscillate provided they are connected in a proper circuit and supplied with a suitable source of local current. This is not an exclusive property of the Fleming Valve, but is a property of other detectors having the same sort of characteristic curves. For Example, Dr. Eccles in his book entitled "Wireless Telegraphy and Telephony", page 220, states as follows:

"Solid conductors may exhibit instability. The possibility of the phenomenon was deduced by the author from the thermodynamic theory of contacts between substances whose resistivity coefficients are negative, and in May, 1910, he showed before the Physical Society of London a galena detector generating oscillations in an oscillatory circuit. The circuits were precisely those of the arc, Fig. 113. In fact the processes in many detectors are reversible; so that if the application of oscillatory voltage to a detector results in the production of a direct current, the passage of a direct current through the detector results in the production of oscillations in a suitable associated circuit. Conversely,

a device for generating oscillations from steady current can be adapted for rectifying A. C.

"Vacuum Tubes as Generators

"Like the contact detector, and for a similar reason, some [fol. 2538] samples of the Fleming valve can be arranged to give oscillatory current in a shunt circuit. On account of the high resistance of the gas path the capacity of the shunt circuit must be small, and the inductance large."

The feature of the circuits usually found essential in causing such oscillations to persist is that the circuit connected to the grid element in the three-element type should be sufficiently closely coupled with the circuit connected to the plate element, so that a disturbance in the one is communicated to the other. When this is the case, then any small disturbance, such as the switching on of the battery in the plate circuit, will cause a disturbance in the tuned circuit connected to the grid element, which will set the latter oscillating. These oscillations are at once detected in the plate circuit and evidenced by an alteration of current therein. This alteration of current again disturbs the grid circuit, which continues, therefore, to oscillate and with an increased energy. This oscillation again creates a current variation in the plate circuit, which is again transferred to the grid circuit, and there is thus built up an oscillating current whose frequency is that of the high frequency circuit connected to the grid element, and which increases in intensity until the energy is lost or abstracted at as great a rate as it can be transferred between the circuits. The device, therefore, becomes a generator and it is this generating action which is used in the heterodyne method of reception, and for creating a high frequency continuous oscillation for measuring purposes of various kinds, and as a transmitter in wireless telephony. As I understand it, therefore, the use of one of these vacuum tubes as a generator is simply one of the well-known uses to which wireless detectors having such a characteristic curve as that possessed by the Fleming valves may be put. Its use in this manner is a mere reversal of its normal functions as stated in the passage of Dr. Eccles' work, just quoted, where he says:

"In fact the processes in many detectors are reversible, so that if the application of oscillatory voltage to a detector

results in the production of a direct current, the passage of a direct current through the detector results in the production of oscillations in a suitable associated circuit. Conversely, a device for generating oscillations from steady current can be adapted for rectifying A. C."

Furthermore, oscillion bulbs are capable of effective use as detectors, particularly as detectors of continuous oscillations. These bulbs when properly connected generate oscillations of radio-frequency, and if used at a receiving station are capable of detecting signals sent out by generators or by transmitting stations using continuous oscillations, and also capable of acting as so-called "amplifiers." Due to the combined effect of the amplifying property of the oscillion and the heterodyne effect due to its own generation of oscillations, its effectiveness for receiving wireless signals of both the damped and undamped or continuous type is apparent.

I will now read from the rebuttal affidavit.

[fol. 2539] With reference to the oscillating audion or oscillion, I observe that it is not denied that, structurally, these bulbs are substantially the same as those already before the Court, save that some of them are larger. It should be pointed out that, as a matter of fact, the bulbs supplied with the DeForest amplifiers, as, for example, the bulbs in Defendant's Exhibit A-4, are oscillating bulbs and in the tests upon Defendant's Exhibit A-4, we so used one or more of them.

The instrument in fact has a switch marked "Ultra-audion", and this so-called "Ultra-audion" is nothing but the ordinary audion provided with means of coupling together the two circuits of the bulb so as to permit of generation of oscillations.

This oscillating action not only supplies a means of giving heterodyne reception, the bulb acting both as the detector and the source of local oscillations, but it greatly increases the sensitiveness of the bulb as a detector for the reception of spark signals. For example, it is a common experience to find that when a given signal from a spark or damped oscillation transmitter cannot be heard at all with a valve (either two or three element) operating as a detector without oscillations, a good signal is obtained when oscillations are set up in the bulb, owing to the increased sensitiveness of the detector which results. These oscillating audions

are, therefore, particularly sensitive as detectors, either for damped or undamped oscillations.

In some recent tests made by Mr. Weagant and myself, for example, the signals being sought were those sent from Carnarvon. The so-called "fancy" circuits were being used. So long as the bulb was not oscillating the signals were inaudible, but upon slightly readjusting (but without change of circuit) so that the bulb oscillated, the sensitiveness was so greatly increased that the signals were not only audible but readable.

Further, it is a fact that, whether the oscillating bulb is used as a detector in the receipt of signals or for some other purpose, its operation in so oscillating is essentially a detecting action. The operations going on within the bulb are assumed to be as follows:

The bulb is provided with two circuits, one an oscillatory, tunable circuit, and the other a battery circuit, and some means is provided for "coupling" the two circuits together electrostatically or electromagnetically (such as a condenser or coil common to the two circuits) so that disturbances in one circuit will be experienced to some extent in the other. When the battery circuit is closed, the filament being heated there is, of course, a flow of current, and the establishment of voltages in the circuit. A charge is, therefore, imparted to the oscillatory circuit, which, of course, gives rise to oscillations therein. These oscillations, acting upon the valve in the ordinary way, produce fluctuations of current in the plate or battery circuit. Since, however, this circuit is coupled to the oscillatory or first-mentioned circuit, energy is again transferred thereto from the battery circuit. If the circuits are properly adjusted this brings about a sustained oscillatory condition, which will continue until something occurs to disturb the equilibrium of adjustment thus established. The operation is quite analogous to the [fol. 2540] well-known whistling phenomena which occurs when a telephone receiver is suddenly brought close to a telephone transmitter. A sustained whistling or squealing sound will frequently be produced.

Dr. DeForest states in his affidavit that he does not know of any way of making a two-element bulb oscillate, and Mr. Stone makes a similar statement. This may easily be accounted for by assuming that they did not have in their hands when they tried to do so bulbs capable of oscillating. It should be borne in mind that, whether such bulbs have

two or three elements does not determine whether they are oscillatory or non-oscillatory. There are two-element bulbs which will oscillate, and three-element bulbs which will not oscillate, no matter what may be the circuit in which they are used. The fact that a two-element valve will oscillate has been known to me for several years, and one circuit in which it will oscillate is the ordinary oscillating circuit used with the oscillating arc, which has been known for many years—as early, in fact, as the year 1900, which is prior to the date of the Fleming patent in suit.

It is unquestionably true that three-element bulbs oscillate more readily than two-element bulbs, so far as my experience enables me to judge, and that the adjustment necessary to produce sustained oscillations is less critical in the three-element bulb.

Mr. John L. Hogan, Jr., in the course of a discussion before the Institute of Radio Engineers, March 3, 1915, said that it was a well known fact that the two-electrode evacuated bulb can be used to produce radio-frequency oscillations. As reported at page 254 of the September 1915 Proceedings of the Institute of Radio Engineers, the statement reads:

"As has been known for some time, radio frequency oscillations can be produced by a simple two-electrode evacuated bulb, but my experience has been that steadier currents may be made by the application of the singing telephone relay principle to the audion repeater."

Q. 3. I will ask you now to demonstrate to the court the oscillating capacity of the two-element bulb.

A. I might explain the apparatus to your Honor while the adjustment is being made. The valve which is being used is the small cylindrical tube having the ordinary filament, and the cold element is a plate simply suspended above it. The circuit which is being used is clearly traceable upon the board. I produce a diagram showing it in which the hieroglyphic which I mark I is the Fleming valve represented in the diagram simply by this filament and plate. The circuit is the P X circuit which was often referred to in the prior case. The regular wireless receiving coil is indicated at the extreme left, the tuning condenser at 3, shunted across it. A stopping condenser is marked C^1.

The local battery circuit is indicated at the right of the bulb and comprises a battery B2. The circuit includes a

telephone in order that the device may be used both to receive and to transmit, and an inductance coil Z which I identify on the board. Shunted across this circuit is a con-
[fol. 2541] denser C2 which I also identify. Identifying the other elements, the coil 2 is at the left, the condenser 3 is just adjacent to it, the transmitting key which will be used to send the signals is shunted across a part of the inductance. That is a common way of transmitting the signals, and it has the effect of changing the period of the oscillations. The adjustment for temperature is by a rheostat here. The stopping condenser is here. This coil is the coil Z, and this is a coil with a single layer wound upon an iron core, the telephones connecting to the circuit as shown in the diagram.

The receiving apparatus is an ordinary receiving set containing the usual coils and condensers, and so forth, of such a set, and is arranged with all the necessary means for causing a three-element bulb, seen at the right, to oscillate and act as a detector. Similarly shunted across the coil of this is a key so that this may be used as a transmitter, and telephones are provided in the circuit so that it may be used as a receiver. Several batteries for the local circuits are seen on the back of the board. I produce a diagram which shows the circuits diagrammatically of the receiving apparatus, located on the right of the table.

Mr. Bull: The diagram is offered in evidence, the diagram of the transmitting.

Marked Plaintiff's Exhibit 2.

I also offer in evidence the diagram of the receiving outfit.

Marked Plaintiff's Exhibit 3.

A. (continued) The Fleming bulb is now being used as a transmitter, and Mr. Weagant is working the key which in practice would determine the sending of signals.

The Court: The court notes a high musical note with a kind of whistling sound.

Mr. Darby, Sr.: May I ask the court to note that in the operation of the apparatus a distinct blue glow appears in the Fleming valve between the filament and the plate?

The Court: Yes, I see that.

By Mr. Bull:

Q. 4. Will you explain what it is that indicates that the two-element valve is acting as a generator of wireless waves?

A. The Fleming valve at the left is being used as a generator of continuous oscillations, the frequency of which was changed by the operation of the key. The instrument at the right is being used as an ordinary heterodyne receiving apparatus, and the operation of the key acts to so change the frequency of oscillations due to the valve, as to bring it within the heterodyne range of the receiving bulb. The heterodyne principle is briefly this: if a set of oscillations are receiving as wireless waves, they cannot be heard in a telephone. If, however, a local source of oscillations is set up and its frequency is so adjusted that there shall be a difference between the two rates, which is an audible rate, then what are called beats will be produced and the audion which is being used as a receiver is oscillating at a frequency [fol. 2542] differing from that at which the Fleming valve is oscillating, which is about, I judged at the time when I heard it, from 600 to 1,000 per second. Therefore, the note which is heard is of that frequency, and when the key transmitter is not operated, no note is heard, which shows that the signal is not being sent at that time at a frequency which is capable of producing an audible tone when combined with that of the receiving valve.

Mr. Bull: I offer to make a demonstration, using the same apparatus inverted so that the three-element valve will act as the generator of continuous oscillations, and the two-element valve will act as the receiver of said oscillations.

The Court: As I view the matter at this time, there is no necessity for the test suggested by Mr. Bull. If, before the trial shall have concluded, either that or some other test seems desirable, we can revert to it.

Mr. Darby, Jr.: Before starting the cross-examination of this witness, if your Honor please, I would like permission—in the first place, may I have the privilege of cross-examining Mr. Weagant who actually operated this machine for your Honor? In connection with the operation of the machine, and when I reach that part of the cross-examination I will have another request, that is, I would like to request permission to operate the device myself if Mr. Waterman and Mr. Weagant have no objection.

Mr. Bull: As to cross-examining Mr. Weagant, I was only going to put one witness on the stand, Mr. Waterman. Mr. Weagant also filed an affidavit simply confirming what Mr. Waterman said. We were before your Honor then on affidavits and it was necessary or desirable to have as the statement of fact more than one witness, so I examined Mr. Weagant. Now, we have demonstrated the thing. It is not a question of what Mr. Waterman says any longer; it is a question of what we have done.

The Court: I will let Mr. Darby ask, if I understand the purport of the request, Mr. Weagant what he did just now in the way of practical demonstration in the courtroom, but as long as the plaintiff has offered only one expert, I do not want to enlarge the number of experts.

Mr. Darby, Jr.: If your Honor please, this is of vital importance to the defendant in this case. Mr. Weagant has given expert testimony in this case ex parte, and it is of vital importance that we be given the opportunity of cross-examining him as to the statements he made under oath in those affidavits. I am perfectly willing to have Mr. Bull offer the pertinent part of Mr. Weagant's testimony so far as the oscillion is concerned in the affidavits he has already made in the case, and allow me to cross examine him on those affidavits. It will not be necessary for him to read it for the purposes of this record.

The Court: You have got your point, I do not know what it is, but we are in this situation. The plaintiff offers an expert. Mr. Weagant has not been offered. At this stage of the [fol. 2543] proceeding I cannot read the affidavit of Mr. Weagant on the motion for the injunction.

Mr. Darby, Jr.: Mr. Waterman has read into the record his affidavits, not only in connection with what he said, but with tests that he and Mr. Weagant conducted. Now, Mr. Weagant was as much a party to that as Mr. Waterman was, and all I ask is the privilege of accepting Mr. Weagant's testimony under affidavit, and allow me the opportunity of cross examining him in so far as Mr. Waterman's and Mr. Weagant's testimony are linked with each other.

Mr. Bull: My friend overlooks the fact that I am captain of the plaintiff's case.

Mr. Darby, Jr.: I do not overlook it. Mr. Waterman has brought in Mr. Weagant in his affidavit, referring to the tests that Mr. Waterman and Mr. Weagant made.

Mr. Bull: Perfectly true; if you want to put Mr. Weagant on the stand as your witness you can do it, but I do not think you can put him on the stand as my witness if I do not choose to call him.

The Court: I will tell you what I think will be the orderly thing. Mr. Weagant can be placed on the stand and submitted for cross examination in regard to the physical facts as to the tests made this morning; that is to say, you may ask him how he used this instrumentality or whatever occurred this morning. Now, in so far as anything beyond that goes, if the plaintiff does not call him, you have the right to call him, but then you call him as your own witness. Of course, you are entitled in the circumstances to latitude on cross examination, as he is not your witness, but beyond the point where the cross examination ceases as to the physical procedure this morning in making the tests for the information of the court,—

Mr. Darby, Jr.: Then I will assume that the affidavit of Mr. Weagant is completely abandoned so far as this case is concerned.

The Court: It is not before me. As my opinion indicated, and as counsel followed out, this is the trial of an equity suit on bill and answer, and what has gone heretofore so far as the affidavits are concerned in respect of the motion, all of that has passed away.

Mr. Darby, Jr.: Is there any objection to Mr. Stone and myself, before we start in the cross examination of this witness, operating the apparatus ourselves?

Mr. Bull: No.

Cross-examination.

By Mr. Darby, Jr.:

X Q. 5. You are financially interested in the Marconi Company, if I am not mistaken?

A. Not in the slightest degree. I do not and never did own a share of stock.

X Q. 6. Or any of the Marconi interests?

A. No.

X Q. 7. Were you not one of the incorporators of the Pan-American Company, I think it is called?

[fol. 2544] A. I believe I am a director in the Pan-American Company at the request of Mr. Nally, but if I own a share of stock, I have never seen it.

X Q. 8. That company, however, is owned and controlled by the Marconi Company?

A. I do not even know that.

X Q. 9. You spoke in your testimony, Mr. Waterman, of the oscillion being a mere reversal of function from a detector; is that correct?

A. Yes.

X Q. 10. By that you mean that it can operate either way; that is what you would consider a fair example of the phenomenon of reversal?

A. I do not know what you imply by the word fair; it is a reversal.

X Q. 11. I will put it a different way. Take an electric motor, you put current on one side and you get mechanical energy on the other side?

A. Yes.

X Q. 12. If you put mechanical energy on that one side you get current on the other side; that is a true example of the reversal function?

A. Under proper conditions that is true, yes.

X Q. 13. You do not have to change anything as far as the motor is concerned, do you?

A. It depends on the circumstances; it depends what the motor is; it depends on all the circumstances of the case. You can arrange it so that you do not have to change anything.

X Q. 14. You can arrange it?

A. Yes.

X Q. 15. That is not so in the case of the oscillion, is it?

A. Yes.

X Q. 16. It is, for transmitting purposes?

A. I did not understand the question was limited to transmitting purposes.

X Q. 17. In other words, you can take the audion as connected in the P N circuit, and either have it receive oscillations, or to generate oscillations?

A. Yes.

X Q. 18. Without any changes whatever?

A. I have done it.

X Q. 19. Without any changes whatever?

A. Yes.

X Q. 20. Used exactly the same batteries, the same strength of currents, you have done that?

A. I do not mean to say without the adjustment of circuit, without any change of circuit.

X Q. 21. You did not have to put in any additional apparatus?

A. No; it is not usual to find a bulb that will do that, but I have done it.

X Q. 22. In fact, it is very unusual?

A. Yes, because ordinarily the valve itself does not furnish coupling enough. When you work under those circumstances the only coupling which you have between the circuits is that furnished by the valve itself. Now, in most valves that is not enough; they do not oscillate readily enough, but I have done it. I would not say that you would find one per cent. of the valves that would do it; you would have to put something in to increase that coupling. The reason for that is this, that in the three-element bulb, one circuit is connected to the filament, and to the grid, and the other to the plate and to the filament. Therefore, the only coupling, the only common part of the circuit, is the space between the grid and the filament.

[fol. 2545] Now, with the two-element valve that is not so because using the same P N circuit, both circuits are connected between the plate and the filament. Therefore you have coupling enough from the bulb itself usually. But with the three-element valve you usually do not have coupling enough, but in certain valves they oscillate perfectly well in the regular P N circuit. Now, ordinarily, you want a coupling, and that coupling may be done either by including the telephones in the common circuit, or by a small coil in the circuit, into the B battery circuit which is put where it is influenced by the grid circuit coil. Any means, in other words, that will carry energy enough over from one circuit to the other is all that is needed.

By the Court:

X Q. 23. Of course, the valves, as has been demonstrated by the cases, vary greatly?

A. Yes, sir; the individual characteristics.

X Q. 24. And the reason for that has never really been ascertained?

A. Not to rationalize it.

By Mr. Darby, Jr.:

X Q. 25. I believe the figures you used were about one per cent, if that high, of the valves could be used in a reversible manner.

The Court: Without coupling, you mean?

A. Yes; without special coupling.

By Mr. Darby, Jr.:

X Q. 26. Without changing the circuit?

A. It is not a change of circuit, Mr. Darby; it is merely changing the relation of the circuits, increasing the tightness of coupling.

X Q. 27. You are adding something which you did not have before.

A. Yes, sir, you are adding the element of coupling.

X Q. 28. That in fact is what you have done in this sketch for transmission, is it not; you have added a coupling there?

A. The three-electrode valve, yes.

X Q. 29. You have added a coupling there?

A. In the receiving arrangement there is a coupling between the two circuits which is indicated by the coils in the two which are related.

X Q. 30. And it is by means of that coupling that you can use that same arrangement for transmission in the test that was offered to be made?

A. Yes. I assume that is the case with that valve; I do not know whether it is or not; I never tried it.

X Q. 31. You have referred, Mr. Waterman, to a statement by Mr. John L. Hogan, supporting your views in connection with the testimony you have given. This statement by Mr. Hogan, as I recall, was after this original suit was filed, was it not; I think the exact date is March 3, 1915.

A. I do not know; if you say it is I will accept it.

Mr. Darby, Jr.: I believe it is the fact; the bill was filed the latter part of 1914.

The Court: Whatever the fact is.

Mr. Betts: We will concede whatever the facts are.

[fol. 2546] X Q. 32. Mr. Hogan was one of the witnesses for the plaintiff in the original hearing; I believe that is a fact too.

Mr. Bull: I note the bill was filed October, 1914.

A. My recollection is he was called, yes; he was called to testify about the hot wire bareter of Professor Fessenden which it had been said was an incandescent lamp and Mr. Hogan was called to say whether or not it was.

X Q. 33. Referring to this circuit in the transmitting circuit, where the inductance is shunted by a condenser, in the P N circuit, for example; I believe both you and Mr. Weagant hotly contested the statement of Mr. Pickard that that was an oscillatory circuit, and in the tests which you made March 6, 1916, you gave some very heated testimony about that point with the result that upon mutual consent some of the testimony was stricken from the record.

Mr. Bull: I object to that.

A. You seem to be designating one diagram and talking about another.

Mr. Bull: I ask for a ruling on that question

Mr. Darby, Jr.: I will come back to that again.

X Q. 34. You noticed this blue glow that occurred in this circuit, Mr. Waterman, when it was acting as an oscillator, as a so-called oscillator.

A. There was a trace of blue glow.

X Q. 35. What is the explanation of that?

A. It is the incipient state of the ionization which is occurring around the edge of the plate. If that blue glow is sufficient, then it would not oscillate. That is true of both two-element and three-element bulbs. If the blue glow really comes between the elements effectively, neither one of them will oscillate.

X Q. 36. Do you know the approximate degree of oscillation of this bulb?

A. No, I do not, except that I know those bulbs were not made for this occasion. Those bulbs are simply samples out of several hundred bulbs which were made many years ago by Mr. Weagant in some work in which I was associated with him, in the investigation of the characteristics of the Fleming valve, and they were all made, in that series, of that shape, and with that shape plate, and they have various spacings, and they are all made with vacuæ of the order of incandescent lamps, or better. That bulb from its behavior

I would say had a vacuum of the order of the better incandescent lamps of Fleming's time.

X Q. 37. To get back to the blue glow, it extended from the filament to the plate?

A. No; I did not say that.

Mr. Darby, Jr.: Would you mind showing that, Mr. Weagant, for the benefit of this witness. I would like to show that blue glow does extend between the plate and the filament.

(Mr. Weagant makes demonstration.)

X Q. 38. It practically fills the space between the plate and the filament?

A. I would be very glad to admit it if I could see it, but I cannot see it. That is the usual edge blue which indicates [fol. 2547] that if you could push it harder it would blow over and go out of action, and that is where most of the bulbs, both the two-element and the three-element, have to be worked, where the spacing is as great as it is in this bulb. You recognize that is a very wide spacing, but in the ordinary commercial bulbs the spacing is only a trivial fraction of that spacing.

Now, it is my fault that we have not special bulbs here. I told Mr. Weagant not to make special bulbs. I wanted to have him just take bulbs which he had made with no thought of oscillations in mind, and I went down there and helped him select it, and we went through several hundred bulbs, and I guess we found fifty that would oscillate. Some of them oscillated better than others, and there are a few of them here in court. But I told him I did not want him to make valves for this very case, and in these long space bulbs you will always find that the local battery required is high on account of the spacing, and you will always find they work best when they are approaching the blue glow such as this, always indicated by the edge glow.

X Q. 39. Have you ever made one of these bulbs oscillate when you did not have the blue glow?

A. I do not know as I looked for it as critically as you did, but I have known them to oscillate when I did not see a blue glow.

X Q. 40. Is not in fact the blue glow striking an arc between the two electrodes: when this bulb is generating os-

cillations, as you say it does, have you not established an arc between the two electrodes?

A. Well, Mr. Darby, I began working with arcs in 1888, and I have not yet heard anyone define one. If you can define an arc to me I can answer your question.

X Q. 41. Will you please answer the question?

A. I do not call that an arc, nor do I call that anything which in any way resembles an arc.

X Q. 42. You say that it does not in any way resemble an arc?

A. Yes; that is my understanding of it.

X Q. 43. What would you consider to be a fair description of an arc, as a scientific man?

A. An arc is the most difficult thing that in all my experience I have run across to define. Now, I am not willing to say that I can define an arc, but I can define certain things which unquestionably are arcs, without saying that I can limit the definition. When you connect a circuit between carbon pencils in the air and separate the pencils you draw that which everyone agrees is an arc if you have a sustained current flow. Now, that arc is a passage of current through the space separating two electrodes, using as the conveyor for current the vaporized material of the terminals. That is an arc and that definition will I think pass muster anywhere as being an arc. Now, you may have an arc under another condition.

X Q. 44. I do not believe it is necessary to go any further into that; that definition that you have given I am perfectly willing to accept. An arc, according to your definition, is where due to vapor a conducting path is established between two separate terminals.

A. Due to the vapor of the electrode.

X Q. 45. Accepting that definition, have you not established an arc between the filament and the electrodes in this [fol. 2548] valve?

A. You certainly have not.

X Q. 47. You are quite positive of that?

A. I am absolutely certain about it.

X Q. 47. As a matter of fact, Mr. Waterman, are you generating the current that comes from the bulb itself between the two terminals; is that oscillating current or alternating current, or is it pulsating current?

A. I never saw its picture, but I take it to be an oscillating current, but I do not see that it makes any difference.

X Q. 48. In other words, there is very little difference between pulsating and oscillating; there is a distinction, of course.

A. No; I do not know what the distinction is unless it is one of wave form, and I do not see that wave form interests us.

X Q. 49. Then it is immaterial whether it is pulsating or oscillating so far as its operation as a generator is concerned?

A. I did not say that. I do not know what restriction you put on the words. As I interpret them I should say it was immaterial if you merely mean to raise the question whether or not there is a true sine wave form there.

X Q. 50. First you say there is practically no distinction between them and then you will not admit that there is no distinction?

A. I did not say there was no distinction; I said I did not know what the distinction was.

X Q. 51. Do you know the difference between them?

A. I do not know how you use the term.

X Q. 52. I am trying to use the term in perfectly plain English; what is the difference between a pulsating current and an oscillating current?

A. I would say that all of these bulbs necessarily give what I now understand you mean by pulsating current. None of them oscillate because none of them go through zero; in other words, we have always a battery; we have always therefore a direct current through the space. Now, when we say it oscillates we do not mean there is an alternating current.

Mr. Darby, Jr.: If your Honor please, I asked the question as to what is the difference between oscillating currents and pulsating currents if he finds any difference.

The Court: His answer is along proper lines; I will let him continue.

A. (continued) That direct current during the oscillating process never fails to zero, so that what really is happening is that the direct current is pulsating; it is going up and down. If that is what you mean by pulsating, that the current never goes through zero, I agree most decidedly with that; that I think is universally accepted, that in none of these bulbs does the current in the plate circuit ever go through zero; the current in the high frequency circuit, however, is a real oscillating current.

X Q. 53. I understand you then that the current which is generated, to use that expression, by that valve structure, is oscillating current.

A. Of which circuit are you speaking?

X Q. 54. Of the circuit connected between the two terminals of the Fleming valve when it is used as a generator; is that pulsating according to your definition, and I think [fol. 2549] we are agreed on the definition, or is it oscillating current?

A. The current which is passing through the plate circuit is an alternating current, superposed upon the direct current. Therefore, it never goes through zero and is what I now understand you to mean by pulsating. The current in the circuit at the left in diagram Plaintiff's Exhibit 2, and which was received as a signal at the other end of the table, representing the receiving station, that is an oscillating current in that it is not superposed on a battery current.

By the Court:

X Q. 55. When you referred to the other end of the table you were referring to the device here in court on which the experiments were made?

A. Yes; I was referring to that part of it which was used as a receiving station.

By Mr. Darby, Jr.:

X Q. 56. You are in fact referring to the three-electrode arrangement for reception?

A. I am referring to the current which was received by the three-electrode arrangement; that was an oscillating current.

X Q. 57. And the current at the transmitting station between the two electrodes of the Fleming valve is a pulsating current?

A. In the same sense that it always is in those bulbs, whether two or three element, yes.

X Q. 58. In the three electrode audion is it a pulsating current or an alternating current?

A. In the battery circuit it is a pulsating current; that is, one which never goes through zero.

X Q. 59. You mean in the circuit connecting the plate electrode and the filament electrode?

A. Yes.

X Q. 60. That is what you call the battery circuit?

A. Yes.

X Q. 61. Of course, it is perfectly apparent that while this Fleming valve structure is operating as a generator, it is not operating as a detector; you agree to that?

A. That is so much a matter of definition that I hardly know what you mean. I could hardly agree to that without taking back what I said in my prima facie case. To me the action is essentially a detecting action.

X Q. 62. When it is generating oscillations?

A. Yes; in other words, it is the detecting action that maintains the oscillation.

X Q. 63. You could substitute for this bulb a high frequency dynamo, could you not, or an alternating current dynamo; would that still be a detector?

A. If I had it I could, and it would of course not be a detector. If I may add to that, I do not want to be misunderstood here, your present question is different from your preceding one. The preceding one involved the question whether it was acting as a detector; as after the manner or in a similar way to a detector. Your second question asked me whether it would be a detector. Now, it would not be a detector, and the bulb is not a detector, but the bulb is acting after the manner of a detector in the act of generating.

X Q. 64. That is what I was very anxious to get at; if you inserted an alternating current dynamo, it would work just as well as with this valve, would it not; that is, it would [fol. 2550] work successfully?

A. I do not know of any alternating current that would give that frequency, but if you had one it would.

X Q. 65. It would perform the same function, of course?

A. As a transmitter, yes.

X Q. 66. And a dynamo, of course, could not function as a detector?

A. But that operates for an entirely different reason.

X Q. 67. That is true; when this bulb is operating as a generator it is not operating at the same time as a rectifier, is it?

A. In the sense that it can only conduct one way, yes.

X Q. 68. In the sense that it is detecting and rectifying alternating currents, it is not acting in that manner, is it, when it is generating electrical oscillations—I do not intend to put indefinite questions to you; that is a very simple question. I think you have said already that when it is generat-

ing oscillations it is not detecting; you have said, of course, it depends upon the same function.

A. I said it is not acting as a detector.

X Q. 69. It is not acting as a combined detector and rectifier?

A. I do not know.

X Q. 70. You said it is not acting as a detector; do you not know whether it is acting as a combined detector or rectifier?

A. I do not follow your use of terms. Obviously it is not acting as a detector because it is not being used as a detector. Now, according to my understanding, similar operations are going on within it, identically similar operations are going on within it, to those that would be going on within it if it was being used as a detector. Possibly that will answer your question.

X Q. 71. Suppose I put it to you this way. Assume for the moment that my definition of the Fleming invention is a combined detector and rectifier, is this bulb when it is generating electrical oscillations acting as a combined detector and rectifier?

A. I do not know what you mean by those words. Similar sorts of actions are going on. You are utilizing the characteristic curve in both cases. I cannot pretend to know precisely what you mean by your use of the word rectifier.

X Q. 72. You have great difficulty in understanding that question; might I put it this way?

The Court: You see, there is probably a surviving controversy as to what rectifying means; that is his point, among others.

Mr. Darby, Jr.: If your Honor please, I think the question is perfectly clear. I am asking this witness to admit what is an obvious fact, and the difficulty is in having him admit it. The cause for the difficulty I cannot understand.

X Q. 73. When that bulb is acting as a generator of electrical oscillations, is it functioning as a detector and rectifier?

A. Certainly it is not functioning as a detector. When I say that I do not take back what I said on my direct examination.

X Q. 74. Of course, it is unnecessary to ask whether you are familiar with the Fleming patent.

A. I am familiar with it.

X Q. 75. May I ask if there is any part of the Fleming patent which states, or which to you as an expert in the art [fol. 2551] would instruct you that that device could be used for the generation of electrical oscillations, and if so point out any such passage.

A. Not specifically, of course.

X Q. 76. My question was if there is anything in the patent.

A. My answer is there is nothing that has any specific reference to it.

X Q. 77. Is there anything in that patent which to you as an expert in the art would instruct you or tell you that that device could be used as a generator of electrical oscillations and if so, point out the particular passage.

A. I do not think there is. I do not think that at the date of the Fleming patent I would have derived from it the understanding that that would oscillate, but after learning that detectors which are able to amplify oscillate, knowing the telephone oscillation phenomenon, knowing that this device does amplify as a matter of fact, I would have no difficulty in understanding that it must be capable of oscillating and generating.

X Q. 78. Did you not know that any two-electrode device would generate electrical oscillations as of 1905, and by device I mean a vacuum tube.

A. No; I did not know that.

X Q. 79. I will read a passage of your affidavit made in this case—I do not recall whether this particular passage is in the record.

"There are two element bulbs which will oscillate and three-element bulbs which will not oscillate, no matter what may be the circuit in which they are used. The fact that a two-element valve will oscillate has been known to me for several years, and one circuit in which it will oscillate is the ordinary oscillating circuit used with the oscillating arc, which has been known for many years—as early, in fact, as the year 1900."

You are familiar with that?

A. I was.

X Q. 80. What is the distinction between what you referred to there and your answer to my last question?

A. I understood your last question to ask me whether I would have known in 1905 that any two-electrode vacuum

bulb would oscillate. I do not see any relation between the two myself.

The Court: You see in the testimony just referred to he said he had this knowledge for several years; in the other question he was asked as to 1905.

By the Court:

X Q. 81. This knowledge, I assume from your answer, was only acquired later than 1905?

A. That is quite right; there was the Poulsen arc.

By Mr. Darby:

X Q. 82. You did not refer to a vacuum tube there?

A. No.

X Q. 83. Have you ever heard of the Geissler tube?

A. I have.

X Q. 84. Had you heard of it in 1905?

A. Yes.

[fol. 2552] X Q. 85. Had you ever heard that Geissler tubes would generate oscillations?

A. No, sir, never.

X Q. 86. That is a two-electrode valve, is it not?

A. It has not got any electrodes.

X Q. 87. What is known as the Geissler tube has no electrode?

A. The Geissler tube does not need to have any electrodes.

X Q. 88. Have you ever seen prior to 1905 a Geissler tube?

A. Yes.

X Q. 89. With two electrodes in it?

A. I think so.

X Q. 90. But you did not know in 1905 that the Geissler tube would generate oscillations?

A. I do not know it now.

XQ. 91. You do not know it now?

A. No.

XQ. 92. You are not in a position to deny it, though?

A. No.

XQ. 93. The Geissler tube, the two-electrode tube that I referred to consists of a tube with two electrodes separated from each other, separated in substantially the same manner as the plate and filament electrodes are separated from each other, so far as the tube structure itself is concerned: is that correct?

A. I do not think your question is complete; make your question clear. If you will make it clear you are talking about a bulb there.

XQ. 94. I am referring to the Fleming bulb.

A. I never saw a Geissler tube which would at all compare with the description of your question. The Geissler tubes which I have seen are long, slender tubes having a wire sealed in at each end, and separated six, eight, ten inches, as the case may be, and they do not in any way resemble the construction of this valve, either as to the separation of the elements or as to the character of the elements.

XQ. 95. You mean they are separated a little greater distance than the filament and plate of the Fleming valve?

A. If ten, twenty, or thirty times is a little greater, yes.

XQ. 96. That would make it a great deal difficult to create electrical oscillations, would it not?

A. I do not know.

XQ. 97. If I show you a patent of 1892, a British patent to Hutin & Leblanc, No. 23,892, of 1892, stating an alternating current of high frequency produced at a central station by an interrupter of continuous current, or by a passage of the current through vacuum tubes is sent, and so forth, would you agree that it was known in 1905 that a two-electrode tube or a vacuum tube was known for the generation of the electrical oscillations?

A. I do not know.

XQ. 98. Do you agree with that statement?

A. I have not seen it.

Mr. Bull: I object to that, your Honor.

The Court: I cannot see how this is material to the controversy.

Mr. Darby, Jr.: Your Honor, it is material, in this respect. One of our positions, which is not inconsistent with other positions which we have to take in this case, is the minute the Marconi Company, or Mr. Waterman, makes this device act as a generator, they are compelled to ignore the Fleming invention, and they are coming to the point where [fol. 2553] they are doing what was done years before, known in 1892, using two electrodes separated from each other in a vessel, in a tube, and having it set up oscillations. In other words,—I can see that your Honor does not quite get the point that I have to make. I did not want to make it

at this time—the only distinction between Fleming and the prior art devices is that it uses a hot electrode, and I am prepared to show your Honor that the hot electrode has absolutely nothing to do with its operating as a generator, and as a fact it is detrimental to its operation as a generator. Secondly, I believe it is very pertinent on the question as to whether or not the oscillion is an infringement of the Fleming valve merely because it uses a hot electrode which is absolutely essential to its operation, and the Fleming valve uses a hot electrode which is absolutely a detriment to its operation.

Mr. Bull: Now that my learned friend has stated what his purpose is, it is very evident that this is absolutely not germane to anything which we are considering here. The relating of the prior art to the Fleming invention has been gone into fully and it has been finally determined, as to the prior art and its relation to the Fleming device. I understand now he is going to attack the Fleming patent.

Mr. Darby, Jr.: Absolutely, so far as the oscillion is concerned.

Mr. Bull. We are to determine the question as to whether this same Fleming device used as a generator of wireless waves is an infringement of the Fleming patent and what we are here today to do is, as I understand it, and the only thing we are expected to do, or that it is desired we should do, was to show your Honor, convince your Honor that this thing would oscillate. When we were before you before Mr. Waterman and Mr. Weagant said it would oscillate. Now, Mr. Stone and Dr. DeForest said it would not oscillate. These proceedings were started for the purpose of ascertaining which were right.

The Court: I think there are only two issues in the case in view of the previous litigation. One is whether in point of fact the Fleming valve does the generation of the oscillations which the plaintiff claims. That is the question of fact in the case. Secondly, there may be a question of law involved as to whether, taking the Fleming patent as it was written, the Fleming patent can be availed of to cover an instrumentality such as this, whose operation was not in 1905 perhaps understood or fully understood. That is the secondary question which is a question of law. That is all there is to the case. I am not going to let any opening up of the prior art at all because that is nothing but in effect—

I do not mean to say you have not the right to press the point—but it is nothi ·· in effect other than reopening the Fleming case, Marconi v. DeForest, which has gone through this court and the Circuit Court of Appeals. I would have been in a position to decide the motion on the preliminary [fol. 2554] injunction if it were not for the contest of the fact in the affidavits which made it necessary for me to determine this fact, as I explained in my opinion, in orderly fashion, where demonstration could be had, and a witness or witnesses could be examined and cross examined to see whether in point of fact this thing oscillated or it did not. We did have the Hutin & Leblanc patent in some litigation, but I am going to make the issue very narrow and if I am in error you go up on a thin record, one side or the other, and if I am not in error, that is the end of it.

Mr. Darby, Sr.: But it is not the purpose to go into the prior art; the purpose is in the present case, it is only necessary, as we conceive it, to consider the prior art with reference to the bearing on the second point that your Honor makes, and that is the question of law; whether or not the Fleming patent can be construed as a grant in the light of what it contains within itself, with sufficient breadth and scope to include something which is not referred to in that patent, not described, a characteristic which is not mentioned in the remotest way.

The Court: That seems to turn solely on the question of law,—how much of a dragnet is the patent. That involves a consideration of perhaps two or three principles of the patent law, one of which is that, of course, normally a man is entitled to all of the approximate results, even though he did not foresee them. The other is how liberal shall you be with the patent which involves an understanding of what that patent represented in the way of inventive thought and advance in the art. Those are the two cardinal principles that govern here and those are the only questions of law. Now, if Hutin and Leblanc used some words in 1892 which now in 1919 somebody or other can construe in the light of after events as meaning something that nobody ever thought about, we are going to get into a wilderness.

Mr. Darby, Sr.: That is not the purpose.

The Court: I sustain the objection.

Mr. Darby, Jr.: The whole point I had in mind was this, on the second point, which we will accept and confine ourselves strictly to in this case, and I will ask your Honor is

it not pertinent to show that the use of a generator which they are seeking to carry in this dragnet, is it not pertinent to show that that is old over their particular device; is not that pertinent; it is old at the time of their patent.

Mr. Bull: We have already determined this case; that that particular device is new.

Mr. Darby, Jr.: Not as an oscillator.

The Court: I will adhere to my ruling. I am perfectly clear as to what I have in my mind; I may be wrong, but I am clear about it.

Mr. Darby, Jr.: Exception.

X Q. 99. You have noted that in 1892 the use of a two-[fol. 2555] electrode vacuum tube for the production of the generation of electrical oscillations was old?

Mr. Bull: I object to that. Objection sustained; exception.

X Q. 100. I believe you stated, Mr. Waterman, that the use of the valve as an oscillator or generator of oscillations depends upon its function as an amplifier; is that correct?

A. Yes; that is, I do not understand that a bulb which will not amplify will oscillate.

X Q. 101. You do not understand that a valve which will not amplify will oscillate?

A. Right.

X Q. 102. And I believe it is your contention that the Fleming invention further includes both amplification and oscillation?

A. I make no contention as to the invention at all; I know that Fleming bulbs will amplify and will oscillate.

X Q. 103. I believe you have given testimony that the Fleming invention is present.

Mr. Bull: I do not think he is allowed to do that.

The Court: That is not allowed.

By the Court:

Q. 104. So far as you are familiar with the art can you tell me when this oscillation feature was realized?

A. I think I first knew it in 1913, your Honor.

Q. 105. Was that the result of experiments, or what; I mean, the ascertainment of that knowledge?

A. That was the result so far as my personal knowledge is concerned, of the work of Mr. Weagant and Mr. Arm-

strong. I was personally familiar with Mr. Weagant's work, and Mr. Armstrong's work I learned of through statements made to me by Mr. Weagant.

Q. 106. Then so far as that oscillation feature is concerned what it comes down to is this, does it not, and see if I have it right; that from the time of the Fleming patent in 1905 up to 1913, the time that this knowledge came to you, there had been a constant development in the general direction of greater knowledge of the phenomenon affecting radio?

A. Yes; that is right.

Q. 107. That is to say, that while many of the reasons for certain actions were still either unknown or debatable among scientists, the fact that certain things happened had become known?

A. Yes.

Q. 108. And this oscillation feature, or the knowledge of the oscillation, came in the course of the development of facts, to the attention of yourself and presumably other men who were concerned with a study of the art?

A. That is correct. My first knowledge of the oscillation of these tubes was as to the three-element tube. Naturally, that raised the question whether the two-element tubes would also oscillate, and on trying it we found that they would.

Q. 109. So that, putting it in another way, when this fact of oscillation became known then you endeavored to find out whether the Fleming valve would oscillate?

A. That is exactly what happened.

[fol. 2556] By Mr. Darby, Jr.:

X Q. 110. You say in 1913 you became familiar with the fact that the three-electrode valve would oscillate. You are quite sure of your date as to that?

A. No; I have not looked it up. I do not know that I could fix it. I only fix it by my recollection as probably 1913.

By the Court:

Q. 111. I suppose you are not able to definitely state 1913; it may be 1914?

A. It may be 1914, but from other events my impression is it is in 1913.

Q. 112. It is not important except as indicating that a period of years had passed from the time of the Fleming patent until this realization came about.

A. Yes.

By Mr. Darby, Jr.:

X Q. 113. Did you assist Mr. Weagant in these tests in finding that the three electrode devices would oscillate?

A. No. Mr. Weagant was engaged in the work—it is his custom to work both night and day—and he worked daytimes, and I living only a few miles away from him very frequently ran down by automobile and worked with him at night and he showed me the phenomenon, as I remember it, after having discovered it himself. I remember he showed it to me as to both the three and the two-element bulbs, but my recollection is that he showed it to me as to the three-element bulb first, and later we received signals, transatlantic signals, with the two-element bulb, acting as an oscillating heterodyne machine.

By the Court:

Q. 114. Will you state on the record in a sort of summary way what difference if any there is between the physical installation in the court room now and the physical installation under the Fleming patent?

A. In the first place, the circuit which is used in the physical installation as affecting the Fleming valve in this court is the P N circuit, and not the other circuit, although I have more usually used and seen used the other circuit, that is the literal circuit of the Fleming patent.

The difference in precise detail between a P N circuit as here used and the P N circuit as was before your Honor in the exhibit DeForest box which was in evidence, is the addition of the coil Z which was not involved in that. That coil Z has the effect of adding to the apparent inductance of the telephone, and that is what it is there for, and the reason that it is desirable to add to the inductance of the telephone is that it gives a greater energy storage, and in order to supply energy rapidly as demanded by the bulbs, some storage is desirable, although it is not absolutely essential. Then, of course, the transmitting key is an additional feature.

Mr. Darby, Jr.: I was trying as far as possible to keep the testimony concerning this particular apparatus separate from the rest. I intended to cross examine on that particu- [fol. 2557] lar point, and there are several questions I want to ask Mr. Waterman in connection with this circuit which I will defer for just a minute.

By Mr. Darby, Jr.:

XQ. 115. You said a few minutes ago that you became familiar with the Fleming valve as an oscillator quite recently: that is, fairly recently, subsequent to 1913 or 1914.

A. About that time.

XQ. 116. After Mr. Weagant had demonstrated to you that the three-electrode valve would oscillate?

A. I think it occurred in that order.

XQ. 117. When did you first have knowledge of the Fleming valve as a detector for wireless?

A. I could not say.

XQ. 118. You do not recall, you mean?

A. I think probably not very far from the time when Fleming first announced it.

XQ. 119. You were familiar with the Fleming patent about the time it was issued, or shortly afterwards?

A. No; I had no interest of an especial nature in wireless telegraphy until about 1911, as I remember, or 1910. My interests prior to that time was merely that of keeping ordinarily well informed in scientific matters.

XQ. 120. When did you first know of the Fleming patent as a patent?

A. I should say it was not so very long before the institution of this suit of which this is a continuation.

XQ. 121. You did not know that the Fleming patent was in existence until just a short time before this suit?

A. I should not say more than a year or so before that; possibly two years.

XQ. 122. Of course, you were not familiar with the use of the Fleming valve as a detector in 1905 then, if you did not know of the patent?

A. Not from any personal knowledge of it; I knew of its existence and use by others as a detector, but I had no experience with it.

XQ. 123. In 1905?

A. I would not say that.

XQ. 124. Around that time?

A. I first read about it in a paper I think published by Fleming in the ordinary course of scientific reading.

XQ. 125. You did not use one of them yourself as a detector until subsequent to 1911?

A. That is correct.

XQ. 126. I would like to read a statement, bearing in mind your answer to a question a little while ago, to the effect that an oscillator must necessarily be an amplifier. I am reading from a statement made by counsel for Dr. Fleming himself, the patentee, in the British case in which the corresponding British patent was involved.

Mr. Bull: I object to that as immaterial.

Mr. Darby Jr.: Dr. Fleming himself was a party to this proceeding and appeared personally in court, and the statement that I will read from is the statement made by his leading counsel.

The Court: How is that material? Suppose that leading counsel got up and said that Fleming did not invent anything at all. Such a statement cannot bind the people [fol. 2358] who own the patent. They take the patent for what it is worth, and the development of patent cases has indicated that time and again there is a misapprehension; either sometimes too much is attributed to the patent, sometimes too little. Statements of that kind are not in any sense germane.

Mr. Darby, Jr.: It goes further than that; it goes into the invention.

The Court: It cannot; Mr. Fessenden in Kintner *v.* The Atlantic, endeavored to disown his own child but without success; I mean, with success but not on that ground.

Mr. Darby, Jr.: The Marconi Company of England which is a stockholder of the Marconi Company of America were vitally interested. But the point is this; they have a suit in the United States on one ground and in England on another ground. To substantiate both suits they have got to take absolutely opposite positions.

The Court: That does not make any difference, either.

Mr. Darby, Jr.: They produce the man who originally drew the Fleming patent.

The Court: I will sustain the objection on the ground that it is utterly immaterial.

Mr. Darby, Jr.: Exception.

Mr. Darby, Sr.: In order to make the record clear, the offer is to read extracts from the record in the high court of justice, Chancery Division, London, England, trial before Justice Sargent in the matter of Fleming Patent No. 24,850 of 1904, and in the matter of the Patents and Designs Act of 1907, petition for prolongation; excerpts from the transcript of record of Mr. J. Hunter Gray, K. C. as counsel for the petitioners, the Marconi Company, and Professor Fleming.

The Court: That is the defendant Marconi Company?

Mr. Darby, Sr.: Yes, and Professor Fleming, the patentee of the patent in suit, and also extracts from the testimony given by witnesses called in behalf of the petitioners in that case, and also from the judgment of the court entered in the case.

The Court: What date is that?

Mr. Darby, Jr.: It started the 4th day of December, 1918, and lasted nine days.

The Court: As I understand it, there are some statements of counsel and witnesses exhibiting their views as to the scope of the patent.

Mr. Darby, Jr.: And the invention itself.

The Court: And the invention itself, in a litigation between entirely different parties from those that are here present.

Mr. Darby, Sr.: But involving the same subject matter.

The Court: Yes; involving the same subject matter. I will sustain the objection as far as the testimony is concerned. Of course, it is always permissible by way of argument in briefs to present the judgment of any court on the same subject matter.

[fol. 2559] By Mr. Darby, Jr.:

X Q. 127. Mr. Waterman, will you please explain why you have used an oscillating audion in this demonstration?

A. I do not know of any other way of receiving the undamped oscillations that I could conveniently bring to court.

(After recess.)

X Q. 128. The blue glow effect which was noticed in this bulb is due to the amount of voltage which was used to cause the device to generate electrical oscillations; that is correct, is it not?

A. Yes; the voltage in the plate circuit.

X Q. 129. Would the two-electrode Fleming valve device using a battery current of sufficient potential to cause the blue glow to appear, operate effectively as a detector for radio purposes?

A. Yes; in the condition in which the bulb was seen this morning, it will neither oscillate nor detect if the blue glow is too pronounced. The blue glow is a pure incident to certain valves; that particular one happens to work at that point on the characteristic curve; that is all.

X Q. 130. If you were to use this valve for detecting purposes you would not use the same amount of voltage in the circuit as you would use when it is connected for generation purposes, would you?

A. I think so, yes.

X Q. 131. You would use the same amount of voltage?

A. Yes.

X Q. 132. What is the amount *for* voltage that is employed in the oscillating circuit of the Fleming two-electrode device as demonstrated by this apparatus?

A. I did not notice that; I can ascertain it.

Mr. Bull: You can ascertain by having Mr. Weagant tell it.

X Q. 133. In using this device, and I refer to the Fleming two-electrode device for detection purposes, what is the amount of voltage that you employed in the circuit?

A. It depends upon the individual valve and upon what particular part of the characteristic curve you are working on.

X Q. 134. What is the maximum voltage which you have ever used for that purpose?

A. In valves of that construction, I should say around 100 volts; maybe 200; I cannot say to a certainty.

X Q. 135. I am asking you what is the maximum voltage which you have ever employed in connection with a two-electrode valve for detection purposes?

A. That is what I was answering to. In my own station, I customarily have only about 100 volts and I have used about all of that, I am sure, but when I have been working with Mr. Weagant he had higher voltages, and I do not know whether he used them or not on these particular tubes. I should think these tubes the voltage ran between 25 and 100.

X Q. 136. What is the normal voltage that is used in the actual commercial use of this detector?

A. Are you speaking of valves of this particular type?

[fol. 2560] X Q. 137. Any two-electrode type.

A. Well, they have often been used with no voltage at all.

X Q. 138. For detection purposes?

A. I think in the customary commercial use that I have been familiar with it is between zero and twelve volts. These bulbs, however, have a greater separation between filament and plate, and therefore take a higher voltage.

By Mr. Bull:

Q. 139. You mean the bulb?

A. I mean the bulb of which the individual here in court is a sample.

By Mr. Darby, Jr.:

X Q. 140. You have witnessed, of course, the two-electrode bulb used for detection purposes commercially, have you?

A. Yes.

X Q. 141. In that particular instance, do you recall what the voltage was?

A. No; I do not.

X Q. 142. You could not limit it; you could not come within limits of which you feel certain it was used?

A. The limit of the total storage battery I believe was 12 volts.

X Q. 143. You have stated in your testimony that the Fleming two-electrode device if properly constructed—I think those are the exact words you used—will oscillate: that is correct?

A. Yes.

X Q. 144. Do you find any information in the Fleming Patent as to instructions as to how to properly construct the Fleming valve device to cause it to generate oscillations?

A. Yes.

X Q. 145. Will you refer to the particular passage please that tells you what the proper construction is?

A. Well, at page 1, line 71.

X Q. 146. Will you please read it?

A. It says, "I generally heat the carbon filament to a high state of incandescence by a continuous electric current." That is one of the essentials.

X Q. 147. Before we go to the next essential, will you please tell me what is contained in that statement which tells you how to properly construct the Fleming valve structure to cause it to generate electrical oscillations.

A. It is only a matter of so proportioning the filament that with the battery to be used the filament will heat to a bright incandescence.

X Q. 148. Then, as I understand you, before we get to the next point, that the only proper construction of the bulb is the amount of current that you have got to supply to the filament?

A. I said that is one feature.

X Q. 149. Am I correct that what you had in mind was not the proper construction of the bulb but the amount of current that is used for the filament; is that correct?

A. That is a matter of construction of the bulb in the ordinary sense. If you are constructing to meet a certain set of conditions you must so construct your filament that it can be brought to a very high state of incandescence. That is one of the necessary conditions. I was going to refer to another.

X Q. 150. But pardon me, I just want to clear these different points up as you raise them. In your testimony where you said that a bulb properly constructed, you mean [fol. 2561] that all you have got to do is to supply more current to the filament of the structure?

A. I did not say that.

X Q. 151. That is what I am trying to get at; just exactly what do you mean by your expression?

A. That is not what I said: I was going on to tell you the rest.

By the Court:

Q. 152. Suppose you then give all of the elements.

A. Then he says at various places, as for example, page 1, line 96,

"As a very high vacuum could be obtained in the bulb and as a considerable quantity of air, and so forth——"

The two conditions are that you should be able to heat the filament to a high temperature and that you should have a high vacuum in the bulb. Now, it is true that not all bulbs, so far as I know, which have a high vacuum, and which can have the filament heated to a high temperature within the

limits of the apparatus, will oscillate, and what the critical condition that makes them oscillate is I do not know. It is a matter of the characteristic curve as to which we have comparatively little control, but by "properly constructed" I think I said in my examination exactly what I meant, namely, provided it had high enough vacuum. What I said was that all the Fleming valve bulbs, including the so-called three-element audion, exhibited before the court, have the property of "oscillating" when properly constructed—that is, if they are provided with a sufficiently high vacuum.

Q. 153. Then the only proper construction which you would require would be a sufficiently high vacuum in the bulb, to which you have added now the condition of supplying more current to the filament?

A. Yes. In other words, what I meant to say was that no special or different conditions are imposed than that imposed in constructing the bulb as a detector.

Q. 154. Let me ask you this; the higher the vacuum you have in this tube the poorer the tube will act as a generator of oscillations; is that correct?

A. I do not know.

By Mr. Darby, Jr.:

XQ. 155. I will now ask you a few questions in connection with the circuits employed along the lines of the questions asked by his Honor. It is so obvious that I do not believe it is necessary to emphasize it. The circuit employed in connection with the Fleming valve as a generator is nowhere disclosed in the Fleming patent.

A. I will be glad to operate it in that circuit if you would like.

XQ. 156. The fact that it will operate in connection with this circuit for the generation of electrical oscillations is something that has developed in the art subsequent to the Fleming invention.

The Court: That is in the circuit shown on Plaintiff's Exhibit 2.

A. The fact that it will oscillate at all, so far as I am personally concerned, is something that has been developed in [fol. 2562] comparatively recent years. That circuit is the P N circuit, and it is the circuit which is Fig. 1 of the Marconi Patent No. 627,650, I believe, which I showed in the

main case. I showed in that case that there were in that patent two circuits shown, one of which is the circuit shown in the Fleming patent and the other of which is the circuit that happened to be used with the DeForest audion box which was the subject of that litigation, and this circuit here is that circuit of the audion box but which is known as the P X circuit.

Re direct examination.

By Mr. Bull:

RDQ. 157. Will you please explain how the oscillating function of the incandescent lamp detector was discovered, so far as you know?

Mr. Darby, Jr.: If your Honor please, on that point I believe that Mr. Waterman has already testified that Mr. Weagant was the one who discovered it. Mr. Weagant is available to Mr. Bull if he cares to examine him on that point. This is secondary evidence.

The Court: He may answer.

A. The matter first came to my attention in my own use of the three-element bulbs. I was using them as detectors for the receipt of ordinary damped oscillation signals, including for example the station at Sayville, and that was the longest wave length station which my apparatus was able to receive, and I had one valve which I noticed, a three-element valve which I noticed would on a certain adjustment of the secondary condenser give a thump and immediately upon giving that thump the bulb became more sensitive and the signal came with a broken or raspy note, whereas it was characteristically a clear and musical note.

RDQ. 158. You mean the Sayville note was a clear note?

A. Yes, and I endeavored for many weeks, or over a period of time covering many weeks, to try and get the same sensitiveness without getting that peculiar note, but without success. Some time later when I was working with Mr. Weagant he explained to me that the three-element bulb was capable of acting as an oscillator and he tuned his circuits to a longer wave length than I was able to reach and immediately there came in a clear and musical signal which was the signal from an undamped oscillation station and I then recognized that what had happened was that the audion which I was using had begun to oscillate, and it was

in the use of the bulb as a detector in that way that the matter first came to my knowledge, and so far as I know also to Mr. Weagant and Mr. Armstrong.

RDQ. 159. You mean, you recognized the fact that when you got this loud and disagreeable note it was due to the fact the bulb was oscillating?

A. Yes. It is characteristic, I ought to explain, that when a damped oscillation is received with the bulb in the oscillating state, the musical note which is transmitted and which that signal would have if received by a crystal, or by a bulb in the non-oscillating setting, is changed from the [fol. 2563] pure musical note to a tone which has an aspirated sound, a whispering sound; it is broken up and ceases to be clear and musical.

When, on the other hand, a continuous wave or undamped oscillation is received by the beat method, then it is a characteristic of the oscillating valve that it gives a clear musical note. The musical note, for example, that your Honor listened to this morning is the note which is characteristic of a beat note due to the superposition of the oscillations of a different frequency, and the reason it is purely musical is because both giving continuous oscillations which differ by a definite amount, the beats are in effect sinusoidal; that is, simple harmonic, as it is called, and therefore makes a pure tone. Probably the nearest to a pure musical note of a signal that it is possible to produce in any way.

Now, when a damped oscillation is received there is no such adjustment. The valves may be oscillating, for example, at a frequency five or ten times that of the signal. Therefore, we do not have any beat effect produced, but we are merely using the valve in its ordinary way of detector plus the extra sensitiveness that comes from the oscillating condition, and so when you receive a damped oscillation one gets usually this ragged sound when the bulb is oscillating and recognizes the oscillation in that way, whereas, to receive the undamped or continuous oscillation, the beat effect has to be produced and that results in the pure musical note. And when I had my audion valve, it was a DeForest bulb, oscillate, before I knew its capacity for oscillating, it was giving this raspy note, although I did not at that time recognize it as the oscillating state and was using it as a detector, and noticed this happening, but I had not the capacity to adjust to the long wave length stations of the continuous oscillations and therefore I never myself proved

it was oscillating; Mr. Weagant did that by his ability to tune to the wave length of the continuous oscillation stations which was very long.

Of course, when it is once recognized that the bulb is oscillating, it is perfectly evident that it may be used either for heterodyne reception or as a source of oscillations for some other purpose.

RDQ. 160. Speaking from your general knowledge of the art, your expert knowledge of this art, is it or is it not true that the oscillating capacity of these incandescent lamp detectors was discovered in connection with, and directly in connection with a use as detectors of wireless waves?

A. That is the fact so far as I know, and as has always been stated and understood.

RDQ. 161. And when it was ascertained that one of these valves had the capacity for oscillating, was it or was it not obvious to one skilled in the art that that valve could be used as a generator of wireless waves?

Mr. Darby, Jr: I object to that. Objection sustained.

RDQ. 162. Have Geissler tubes ever been used in the radio art for any purpose so far as you know, either a detector or generator or anything else?

A. They have not, with the single exception that when without electrodes they have been used in experimental work to indicate nodes of wires and the like.

[fol. 2564] RDQ. 163. But not for the purpose of receiving radio signals or generating radio waves?

A. They have not so far as I know.

Re-cross-examination.

By Mr. Darby, Jr.:

RXQ. 164. In this work in which you discovered the oscillating characteristic of these vacuum tubes you were working with a three-electrode audion?

A. Yes.

RXQ. 165. And as you have previously testified, that was around 1913 or 1914?

A. That was earlier, it was before I learned from Mr. Weagant about the capacity of the valve to oscillate. I noticed this peculiar behavior and I did not know what it was, but I identified it afterwards.

RXQ. 166. In your work with the Fleming two-electrode valve prior to this discovery of oscillations with the three-electrode device you did not discover any oscillating characteristic of the two-electrode device, did you?

A. No.

RXQ. 167. In fact, the discovery of the oscillation characteristic of the two-electrode device was subsequent to your discovery and explanation by Mr. Weagant of the three-electrode device.

A. Mr. Weagant made it and my understanding is that that was the succession; it was the order in which it was revealed to me, at any rate.

RXQ. 168. It was your understanding, referring to the question asked you by Mr. Bull, that Mr. Weagant made this discovery while using the audion as a detector; is that correct?

A. Yes; all his work at that time I was familiar with was detector work; in fact, if he did not know it would oscillate he could hardly have been using it as a generator.

RXQ. 169. And as you say that was somewhere around 1914 that Mr. Weagant, or the latter part of 1913, that Mr. Weagant when using it as a detector discovered that the three-electrode valve would oscillate?

A. I said to the best of my recollection it was 1913.

RXQ. 170. Could you construct a two-electrode valve that you know would generate electrical oscillations, and by two-electrode valve I mean a two-electrode valve of the structure shown by Professor Fleming?

A. If you mean if I could construct a single valve and guarantee that it would oscillate, I do not think I could. But, of course, I personally am not skilled in the construction of those things. I never built one in my life.

RXQ. 171. In other words, you never know whether a Fleming valve structure, two electrodes, will generate oscillations until you try?

A. Well, that is not peculiar to the matter of generating oscillations. The valves are very hard to control. It is not possible in advance to tell precisely what they are going to do, whether it be acting as a detector or as a generator.

RXQ. 172. At any rate, you agree to this, that not every Fleming two-electrode structure which will act as a detector will act as an oscillator?

A. That is true as to the few that will not act to amplify; if they will amplify they will oscillate.

By Mr. Bull:

Q. 173. Let me ask you this; when one of these incandes- [fol. 2565] cent lamp detectors is being used as a detector of wireless waves, and it is in the oscillating condition, is it true that that valve at that time is acting as a generator of wireless waves?

A. It is, absolutely.

Q. 174. And as to some two-element bulbs acting as generators and others not, is the same thing true of the three-element valves?

A. So far as I know, it is; that has always been my observation.

By Mr. Darby, Jr.:

R. X Q. 175. You do not know definitely, though, do you?

A. I would not say that I do, No.

By Mr. Bull:

Q. 176. Did you ever have a three-element valve that would not oscillate?

A. Yes; I have got some now.

Q. 177. Then you do know definitely?

A. I understood Mr. Darby to ask whether one could be constructed with a certainty that it would oscillate.

By the Court:

Q. 178. Mr. Bull's question was whether you would find instances of failure to oscillate in three electrode valves just as well as in two-electrode valves.

A. There is no question about that. I have at least two made by the DeForest Company that cannot be forced into oscillations and I know that in some of those that were in evidence in this case I tried very hard to make them oscillate and did not succeed.

Q. 179. You mean in the same case?

A. I mean in the same case. There were several in the case and they were all alike; some of them oscillated and some of them did not under my manipulation; I do not know what anybody else might be able to do.

By Mr. Darby, Jr.:

R. X Q. 180. In those valves which would not oscillate, did you try them to see whether they would detect?

A. Oh, yes; they detected but they would not amplify.

Mr. Darby, Jr.: I would like to ask Mr. Weagant a question in connection with this apparatus which Mr. Waterman was not in position to answer.

ROY A. WEAGANT, a witness called on behalf of the defendant, being duly sworn, testifies as follows:

Direct examination by Mr. Darby, Jr.:

Q. 1. Mr. Weagant, do you know the amount of voltage that is employed in the oscillating circuit of the Fleming valve structure in this apparatus?

A. I think it is approximately 100 volts; I can have it measured right off, if you would like it.

Q. 2. I would like it. (Witness measures apparatus.)

A. The voltmeter shows 96 volts.

[fol. 2566] Q. 3. Are you familiar with the use of the Fleming valve structure, of the two-electrode structure, used for detection?

Mr. Bull: I object to that. I am going to try and confine this witness's examination to the condition of this apparatus and the manipulation of it and anything of that sort.

The Court: Objection sustained unless you call him as your own witness.

Mr. Darby, Jr.: I will make Mr. Weagant my own witness for the purposes of this question.

The Court: You better call him in your case.

Plaintiff's prima facie case closed.

Defendant's Proofs

ROY A. WEAGANT, recalled in behalf of the defendant, testifies as follows:

Direct examination by Mr. Darby, Jr.:

Q. 4. Are you familiar with the use of a two-electrode Fleming valve for detection purposes commercially?

A. Somewhat, yes.

Q. 5. When did you first become familiar with it for detection purposes in commercial use?

A. I do not know that I remember exactly.

Q. 6. Can you give me the approximate time?

A. It was at least earlier than 1912.

Q. 7. You cannot be more definite than that?

A. No; I do not know that I can; I do not remember particularly.

Q. 8. You do not know whether it was one or two or five years earlier than that?

A. No; I really do not.

Q. 9. Was it as much as two years?

A. I cannot say definitely because I am not sure; it may have been.

Q. 10. That is your best recollection then?

A. That is my best recollection, yes.

Q. 11. What voltage was normally used and was used in connection with the circuit of the two-electrode valve as used as a detector when you first became familiar with it?

A. I cannot be sure as to that, when I first became familiar with it. I recollect voltages of six, twelve, and I think occasionally eighteen and twenty-four, but I am not very certain about the latter.

Q. 12. Is it not a fact that the general and usual voltage used commercially is around twelve volts for detection purposes?

A. Are you referring now to the two-electrode valve and to any specific type?

Q. 13. Any type of two-electrode valve used commercially for detection purposes; I am, of course, referring to the Fleming valve.

A. I have seen the two-electrode valve used with so many voltages and over such a wide range that I am not sure I can answer your question definitely; voltages of six and twelve were very commonly employed.

Q. 14. They were the more common?

A. Yes; and I would say they were the more common, as far as I can recollect.

[fol. 2567] Q. 15. And I believe the record shows that the voltage that is employed here is about 96 volts?

A. That is correct.

Q. 16. When did you first discover that a two-electrode valve, Fleming structure, would generate oscillations?

A. I do not know that I can say; it is since 1913, but I do not definitely remember the exact time.

Q. 17. Your discovery of that characteristic of the two-electrode valve was subsequent to your discovery that the three-electrode audion would generate oscillations; is that correct?

A. It may have been, but I am not certain at this time.

Q. 18. You considered yourself to be the inventor or discoverer of the phenomenon that the three-electrode valve would generate oscillations, did you not?

A. I probably did.

Q. 19. In fact you filed an application for patent for it, did you not, claiming that particular feature?

A. Very likely; yes, I think I did.

Q. 20. And in that application you did not show a two-electrode valve, did you?

A. That I cannot say; I am quite hazy in my recollection of the application at that time.

Q. 21. I will ask you if this is a correct copy of the drawings of your application for patent disclosing and claiming the use of a three-electrode audion as a generator of electrical oscillations.

A. It evidently is one of my applications, yes, as near as I can judge from the figures.

Q. 22. You have never filed an application for the discovery that a two-electrode valve would generate oscillations, have you?

A. Yes.

Q. 23. A two-electrode valve alone?

A. Yes; I think so.

Q. 24. Are you referring to a structure where you use a three-electrode surrounding the tube?

A. No.

Q. 25. And the application which you refer to is completely independent of this application that I hold in my hand?

A. So far as I recollect. I am not certain on that because my recollection is not very definite.

Q. 26. In this application which was filed for you and in which you took the oath that you had invented the subject matter the following illustrates what you claim to be your invention, does it not?

"Means for generating electrical oscillations comprising a plurality of elements separated by a conducting gaseous medium."

A. I do not know that that was the language.

Mr. Bull: I object to that, your Honor. If he wants to ask him any questions of fact, well enough. He is reading evidently a claim which is the product of a patent solicitor. I do not see that that has anything to do with the case.

Mr. Darby, Jr.: We will offer in evidence a copy of the application as a physical exhibit. The claim that I have read is a claim as filed; it is not, as has been suggested by Mr. Bull, the wording of a patent attorney; it is what Mr. Weagant took the oath on as constituting part of his invention.

[fol. 2568] The Court: Counsel for the other side do not object to the receipt in evidence of this application; it may be marked.

Mr. Darby, Jr.: I offer in evidence the file wrapper of the application of Mr. Weagant, Serial No. 830,584, filed April 9, 1914, for "Means for generating electrical oscillations."

Marked Defendant's Exhibit A.

Q. 27. Now, for the purpose of fixing the time when you made this invention, may I ask you if you did not file an affidavit in that case in which you set forth the time you made the invention?

Mr. Bull: The application is in evidence.

Q. 28. Do you recall when you filed your application for the two-electrode valve as a generator?

A. No; I do not.

Q. 29. You do not know whether it was before or after this application?

A. I do not recall to a certainty, no.

Q. 30. That is your recollection?

A. I think it was after.

Cross-examination by Mr. Bull:

X Q. 31. You have been asked about the voltage commonly used with two-element valves. Does the voltage used have anything to do with the space between the incandescent element and the plate filament?

A. Yes.

X Q. 32. That is, the separation of those two elements?

A. Yes. The voltage used depends to a very great extent on the separation between the hot and the cold electrodes. In general, the greater you make that separation the greater is the voltage that will be used in the use of the valve as a detector.

X Q. 33. Is the separation of this particular valve which was demonstrated this morning greater or less than the separation which is ordinarily present in the commercial two-electrode valve?

A. It is quite a bit greater than is usual.

X Q. 34. If this particular valve were used as a straight detector would it not therefore require a higher voltage than one of the ordinary commercial two-electrode detectors?

A. In all probability it would, yes.

Re-direct Examination by Mr. Darby, Jr.:

R. D Q. 35. In using the Fleming two-electrode valve for detection purposes, you refer to the voltage as the battery A, or the voltage used for lighting the filament, do you not?

A. Not in any answers I have made so far, no.

R. D Q. 36. You have been using what has been called the B battery voltage?

A. I am referring to the voltage between the cold electrode and the hot electrode.

R. D Q. 37. In what respect does the spacing of the electrodes of the device employed for this demonstration differ from that employed using the two-electrode device for detection purposes?

A. Of necessity it does not differ at all; that same spacing is a perfectly good spacing for detecting purposes.

By Mr. Bull:

Q. 38. Were not these made for detectors, as a matter of fact?

A. Yes; they were.

[fol. 2569] By the Court:

Q. 39. As I understand from Mr. Waterman's testimony, this bulb with some other bulbs were on hand from some time ago?

A. Yes; that is correct.

Q. 40. That is to say, he selected some old bulbs for the purpose of the demonstration to the court?

A. Yes.

Mr. Darby, Jr.: I believe Mr. Waterman also said that he tried them and picked out those which would oscillate.

Mr. Bull: Yes.

JOHN STONE STONE, a witness called in behalf of the defendant, being duly sworn, testifies as follows:

Mr. Darby, Jr.: May I ask if you will concede Mr. Stone's qualifications?

Mr. Bull: I certainly will.

Direct examination:

By Mr. Darby, Jr.:

Q. 1. How long have you been familiar with vacuum tubes?

A. Since about 1892.

Q. 2. How long have you been familiar with the use of vacuum tubes with respect to high frequency work?

A. My first experience with vacuum tubes in high frequency work was some time in 1893.

Q. 3. Have you had occasion to make a thorough investigation and study of vacuum tubes in the various uses to which they may be put?

A. I have had considerable experience with vacuum tubes, the matter of detecting electrical oscillations and generating electrical oscillations.

Q. 4. And amplification?

A. Some.

Q. 5. You witnessed and took part in the demonstration of this apparatus that had been set up by the plaintiff I believe?

A. Yes.

Q. 6. You noticed the blue glow effect that took place in the Fleming two-electrode structure when it was as the plaintiff states generating electrical oscillations?

A. Yes.

Q. 7. Will you please describe in your own language what produced that blue glow, its effect on the circuit, and what

you can tell us in connection with the phenomenon of the appearance of that blue glow.

A. The blue glow is a phenomenon which takes place in a vacuum tube when the potential difference, or the electromotive force acting between the two electrodes, reaches such a high value as to produce a sudden decrease in the electrical resistance between those electrodes. I will not go into the scientific explanation of the mechanism that produces that sudden diminution of resistance, and will say that it is a very well recognized phenomenon, however, and amongst operators and the like, the character of users of audions and valves, it is generally spoken of as striking an arc. Personally I do not consider that the phenomenon is identical with the electric arc, but it is in the same nature an arc in so far as its effect upon the resistance of the space between the electrodes is concerned.

[fol. 2570] Q. 8. Might I ask when you say striking an arc in the colloquial, if you please, the interpretation of that, do you mean striking an arc between the electrodes?

A. Yes.

Q. 9. Might I ask is the function of that blue glow the same as the arc?

A. Functionally it seems to operate in much the same way as if a true arc were struck between the electrodes. It differs from a true arc between the electrodes only in that the diminution of the resistance which it establishes between those electrodes is not so great as would be the case if a true arc were struck between them.

Q. 10. What is the effect of that blue glow or arc on the two-electrode device for detection purposes?

A. As soon as the blue glow commences to appear in a rectifying valve, vacuum tube valve, its qualities as a rectifier, and therefore as a detector, begin to wane very rapidly, and as the blue glow increases until it finally reaches from one electrode to the other, the deleterious effect upon the detecting function of the valve becomes greater and greater until finally the valve becomes extremely inefficient or inoperative for detection purposes. And when I speak of this diminution of efficiency in the valve as a detector I do not refer to matters of small percentage, but the change is so great that a detector which may be receiving easily readable signals may cease to develop audible signals even, and a valve which is receiving quite loud signals may under the

influence of the blue glow become so inefficient that the signals become unreadable.

Q. 11. Is it possible to make a two-electrode device generate oscillations without striking that arc which you refer to?

A. So far as my experience goes, and theoretical investigation that I have made of the simple valve, or rectifier, I am convinced that it cannot oscillate unless the blue glow or so-called arc exists between the electrodes.

Q. 12. In other words, striking the arc which I believe is admitted causes the blue glow to appear, is absolutely essential and necessary for the two-electrode device to act as a generator of oscillations?

A. That is my opinion.

The Court: Then what follows from that?

Mr. Darby, Jr.: This follows, if your Honor please; it shows conclusively that you have to completely eliminate Fleming's invention to use it as a generator; in other words, the contention that it will detect is absolutely opposed to the contention that it will act for generation purposes. The minute that it strikes an arc, the minute that it generates oscillations, it absolutely ceases to rely upon its detection properties for operation.

Q. 13. May I ask if you are familiar with a similar blue glow effect in the three-electrode audion?

A. Yes.

Q. 14. Is the striking of the arc, or causing this blue glow effect to appear, necessary for the operation of the audion?

A. No; the presence of the blue glow or so-called arc militates greatly against the efficient operation of the three-electrode audion as a detector, and it also militates against its operation as an oscillion or oscillator.

[fol. 2571] Q. 15. Would the audion operate if the blue glow effect appears?

A. It begins to cease to operate effectively as soon as the blue glow appears.

Q. 16. That is what has been commonly known as paralyzing the audion, is it not?

A. Yes; the operators use that word.

Q. 17. And means have got to be taken to prevent the paralyzing of the audion or to immediately dissipate that condition as soon as it appears; is that correct?

A. Yes.

Q. 18. I believe I understood you to say that you personally knew that a two-electrode device would generate high frequency oscillations about 1893.

Mr. Bull: I object to that, if they are going into the prior art. I do not know whether that will anticipate our patent or not.

Mr. Darby, Jr.: I want to lead up to the point of when the discovery was made of the osciliation and generation by a three-electrode device as distinguished from a two-electrode device.

Mr. Bull: Ask him that question.

Mr. Darby, Jr.: I have asked that question; I wanted to be correct as to my starting point before proceeding.

The Court: Reframe the question.

Q. 19. Will you please explain how you discovered in 1893 that a two-electrode device would generate electrical oscillations?

The Court: I do not get this at all.

Q. 20. I will ask you this: when did you first obtain knowledge that the three-electrode device would generate electrical oscillation?

A. In 1912 I received that knowledge indirectly in this way; I received a letter from Dr. DeForest who was out on the Pacific Coast informing me that he had discovered that his audion would amplify alternating currents, whereupon as an old telephone engineer I wrote him a letter stating that if it would amplify telephone currents or any other currents, it would certainly oscillate, and pointed out to him what particular kind of circuits he would have to use in connection with his audion in order to prevent it from oscillating in case he wanted to do so in its use as a telephone amplifier, and I needed no further information than the fact that the audion would amplify to know that it would oscillate, nor would any other competent telephone engineer need to know anything more.

Q. 21. In what connection were the two electrode vacuum tubes that you were familiar with in 1893 used; that is, for what purpose were they used?

Mr. Bull: I object to that.

Mr. Darby, Jr.: If your Honor please, this is of the two-electrode device for generating high frequency electrical

oscillation. I want to prove by this witness that in 1893, two-electrode devices for the production of high frequency oscillation were known, and further than that, that the only difference between this device and what was known [fol. 2572] and used at that time for that purpose was that in Fleming they used a hot electrode, one electrode is heated, whereas in the old device one electrode was not heated. I want to further prove that so far as the operation of a generator of electrical oscillations is concerned, it makes no difference whether that electrode is heated or not, and further that the actual heating of the electrode is detrimental to its generation of electrical oscillations. I think that is wholly pertinent.

Mr. Bull: In the first place, I object to their going into the prior art. That is simply an effort to anticipate our patent, as I understand it. In the second place, I do not think I could have correctly heard what Mr. Stone said because my understanding is that we are here simply because Mr. Stone on the motion filed an affidavit in which he said you could not make a two-electrode device work and I think he is asking him if he did not make a two-electrode device generate way back in 1893.

The Court: Your argument as to certain proofs covered several points. I alone directed myself to one. I think any testimony which in effect is in the nature of anticipation of the state of the art prior to Fleming is not admissible in this case. Now, that is the theoretical side. Now, the practical side is this, that the books have now grown full of cases which show that certainly not in 1893 did any person have any conception of the power of generation and oscillation in its present relation; that is as certain as anything can be. A man might look back for all I know on some theoretical business about oscillations and all that sort of thing, but from the radio standpoint to go into the dark ages and the past ages to find out what happened in 1893 to my mind is utterly immaterial.

Now, on the question as to what the two-electrode will do and what a three-electrode will do, that is a different proposition. There Professor Stone's experience as a scientific man and an expert is entirely relevant along the questions which are intended to show how these things work and what in fact they do, and so on. I am perfectly clear from the testimony, I do not believe anybody disputes the fact,

that the oscillating properties or the characteristics were unknown in this relation to the scientific world until a considerable number of years after Fleming invention. As I said this morning, if the thing does oscillate, if the Fleming valve does generate, the next question is purely a question of law.

Mr. Darby, Jr.: If your Honor please, I ask you not to forget one point and that is that the plaintiff in this case is seeking to include the oscillating audion as an infringement of their patent, and to do so they have got to broaden the scope of their claims to enable them to do so.

The Court: That is a question of argument; that has got nothing to do with this 1893 proposition; I will sustain the objection.

Mr. Darby, Jr.: Exception.

Q. 22. Mr. Stone, is the heated electrode or hot electrode of the Fleming two-electrode device absolutely essential [fol. 2573] to its use as a rectifier?

A. Yes. I will say that the heating of the filament electrode in the Fleming valve is essential to its operation.

Q. 23. If the hot electrode of the Fleming valve is not heated; in other words, if the heating battery is omitted, and a sufficient voltage is employed, would the device generate electrical oscillations?

Mr. Buil: I object to that; I think it is utterly immaterial.

The Court: What is your theory on that?

Mr. Darby, Jr.: My theory is this; my next question which I intended to ask to bring it out, was if the filament was not heated, it would generate electrical oscillations more efficiently than if it were heated.

The Court: Suppose it did; then go and use one that is not heated.

Mr. Darby, Jr.: Then, of course, they would not have the Fleming invention there.

The Court: You have got one electrode that is heated; they have one that is heated. Now, you can use the finest kind of cold electrodes in the world and they do not care anything about it.

Mr. Darby, Jr.: Suppose in the three-electrode device, the hot electrode is absolutely essential for its work, whereas in the two-electrode device it is detrimental; does not that alter the situation, as a generator?

The Court: I will sustain the objection on the ground that the question is immaterial and irrelevant.

Mr. Darby, Jr.: Exception.

Q. 24. Will you examine those two circuits, Plaintiff's Exhibits 2 and 3; referring to the apparatus which those circuits, for the sake of convenience represent, you will note that an oscillating audion at the receiving end is employed, and you will further note that the receiving end is inductively coupled to the transmitting end; that is correct, is it not?

A. It is correct as to the apparatus of the demonstration but it is not shown in these exhibits as far as I can see.

Q. 25. You mean that the inductive coupling between the receiving and the transmitting is not shown?

A. Yes; that is what I mean.

Q. 26. In the receiving system the electrical oscillations are being generated, are they not?

A. Yes.

Q. 27. What effect would the electrical oscillations generated in the receiving system have upon whether or not the two-electrode device is actually generating electrical oscillations?

A. It is very difficult to say. The oscillations which are generated in the receiving circuit or the oscillating three-electrode audion, are in part due to the oscillation circuit of the two-electrode valve, and what effect that would have upon the oscillation of that circuit, or the maintenance of the oscillations of that circuit, is very difficult to say; it is impossible to say—*a priori*. The only way that I can imagine the effect of these oscillations to be determined would be to substitute a non-oscillation producing detector in a receiving circuit, and coupled with the interrupter, breaking [fol. 2574] up the train of continuous waves, and then see whether the two-electrode valve would oscillate in the transmitter without the coupling between the transmitter and the receiver.

Q. 28. What is the nature of the coupling between the oscillating audion system and the receiving system?

A. It is difficult to say what it is because the wires run back of the board, but I fancy it is a simple inductive coupling.

Mr. Bull: If you want any wires straightened out for you we will be glad to help you.

The Witness: I have examined it and find it is a simple inductive coupling between the transmitter and receiver as I had previously supposed.

Q. 29. What ordinarily is the effect of an inductive coupling between an oscillating circuit and another circuit?

A. Well, in the well known case of the grid plate circuit of the three-electrode audion, and the filament grid circuit, it is essential in causing the device to operate. A similar action might or might not take place here by the coupling between the plate filament circuit of the oscillating audion and the filament plate circuit of the two-electrode valve.

Q. 30. By the use of this three-electrode oscillating audion in this demonstration apparatus, coupled as shown by the apparatus itself, does it raise a doubt in your mind as to whether or not the two-electrode device is generating electrical oscillations of a degree sufficient to be detected?

A. No; it is undoubtedly generating those oscillations, but the coupling makes me doubt whether the two-electrode tube would oscillate in that circuit, except for the coupling with the oscillating three-electrode audion in the other circuit.

Q. 31. In other words, it raises a doubt in your mind whether this two-electrode device would generate electric oscillations without this inductive coupling with the oscillating audion at the receiving end?

A. It seems to me that that is an obvious doubt in such a structure.

Q. 32. In your opinion, Mr. Stone, do you consider this a fair test of whether or not the two-electrode device with its circuits alone would generate electrical oscillations when using a three-electrode device?

A. It is by no means so conclusive as would be a test in which there was no coupling between those circuits, and there would be no difficulty in substituting another detector for the oscillating audion and using a tone wheel.

By the Court:

Q. 33. Have you made any experiments along that line?

A. I have made a number of experiments in an effort to cause a two-electrode valve to oscillate with one of the electrodes heated to incandescence, and I have never succeeded in making it oscillate, whereas, with the tubes with both

electrodes cold and a very much higher voltage, there was no difficulty whatever in making them oscillate.

[fol. 2575] Q. 34. What effect in your opinion does the oscillating characteristic of the audion at the receiving end have on the two-element valve in its oscillation in this present connection?

A. The possible effect is due to the fact that the electromotive force impressed upon that valve is no longer, owing to the coupling, a purely direct voltage or constant unidirectional voltage; it is a uni directional voltage where the superimposed vibratory voltage comes from the oscillating audion in the receiving circuit. Moreover, the coupling is so arranged, the voltage developed by the coupling, that the oscillatory voltage produced at the terminals of the two-electrode bulb by that coupling is very much amplified by resonance in the circuit of Plaintiff's Exhibit 2.

Adjourned to March 12, 1919, at 12 m.

Trial Resumed

March 12, 1919, 12:00 m.

John Stone Stone: Resumes.

Direct Examination by Mr. Darby, Jr. (Continued):

Q. 35. Mr. Stone, have you read and do you understand the Fleming patent in suit?

A. I have and do.

Q. 36. Did you examine and did you understand the operation of the test apparatus that was demonstrated yesterday?

A. I examined the apparatus and understood its operation.

Q. 37. Will you please compare the arrangement, operation and functioning of the two-electrode valve device as shown and described in the Fleming patent with the arrangement, operation and function of the valve device used in the demonstration which was made yesterday?

A. The Fleming valve of the patent in suit as described and illustrated is included in a simple circuit, in an inductive relation with the antenna, which circuit comprises a coupling coil with the antenna and a galvanometer or other device capable of indicating the presence of a direct current in that circuit.

In the apparatus of the demonstration given in Court yesterday the two-electrode valve is connected to two branch circuits, one branch circuit comprising an iron cord impedance coil marked Z in Exhibit 2, the condenser marked C2 and a battery of approximately 95 volts potential, in addition to the telephone receiver not marked on the drawing.

The other branch circuit comprises an inductance coil marked 2 in Plaintiff's Exhibit 2, a blocking condenser marked C1 and a variable condenser marked C in that exhibit.

In the patent in suit there is no electromotive force impressed upon the two-electrode valve between the filament and grid save the minute alternating electromotive force induced in the oscillations in the antenna, and in the description contained in this patent the operation of the valve is described to be that of a simple rectifier, whereby this [fol. 2576] minute alternating impressed electromotive force is rectified and produces a small direct current in the simple circuit.

In contrast to this in the test yesterday a very large electromotive force is impressed upon the valve between its filament and plate, in addition to a very large oscillating electromotive force developed by the resonant circuit marked 2-3 by virtue of its coupling with the oscillating circuit of the three-electrode audion in the receiving circuit.

I will add here by interjection that the mode of couple employed resulted in a great magnification of the potential difference across the two-electrode valve represented in Plaintiff's Exhibit 2 by virtue of the resonant circuit 2-3 of Plaintiff's Exhibit 2. This magnification of voltage is not a small magnification, but in circuits of this type they amount to a multiplication of the impressed voltage a thousand fold.

Coming down to the disclosure of the mode of operation in the patent as compared with the mode of operation I apprehended in the apparatus of the demonstration yesterday, I find that in the patent in suit the valve is under such electrical conditions as to make it operate effectively as a simple rectifier. By contrast I find that in the test in Court yesterday owing to the presence of the large direct or unidirectional voltage due to the batery B-2 of Plaintiff's Exhibit 2 a blue glow extended from the filament to the plate, and I apprehend that under those circumstances the

action of the valve would cease to be an effective simple rectifier, but would possess different electrical properties characterized by a relatively extremely low resistance being established between the filament and the plate.

Q. 38. What elements if any do you find necessary to add to the circuits of the patent, or Fig. 1 of the patent in suit, in order to make the two-electrode valve generate oscillations, if it can be done?

A. Judging from the apparatus of the test, performed in Court yesterday, and for the sake of argument assuming that those conditions were sufficient to cause the two-electrode valve to execute sustained oscillations, I find that the elements necessarily added for this purpose are the addition of an iron cord impedance coil Z in Plaintiff's Exhibit 2, three condensers marked respectively C, C^1 and C-2, C being adjustable, a tap upon an inductance coil marked 2 in that exhibit and a battery of approximately 95 volts.

Q. 39. What is the relation of the condensers that are employed relative to the inductance that is employed in the transmitting end as illustrated in Plaintiff's Exhibit 2?

A. Calling the circuit to which you refer of the transmitting circuit the branch to the left hand of the valve in Exhibit 2, the elements are the condenser C^1, the variable condenser C and the tap on the inductance coil; also the coupling coil associated with that inductance coil in case that coupling coil was effective in producing and maintaining the oscillations in the valve in that test.

Q. 40. And in fact the variable condenser C is not shown around the inductance coil; that is correct, is it not

A. Yes; thus constituting the resonant circuit which I have referred to as 2-3.

[fol. 2577] Q. 41. Do you find any directions in the Fleming patent to add any of these elements?

A. No.

Q. 42. Do you find any directions in the Fleming patent which would make it possible to use a resonant circuit therewith, or which would direct you to use a resonant circuit in connection therewith?

A. I find no specific instructions to that effect.

Mr. Bull: I object to that; that is a matter that is for argument. We all agree as to what is in and what is not in the Fleming patent.

Q. 43. You have referred to the use of a high voltage employed in connection with tests yesterday of approximately 95 volts, as I recall the testimony of Mr. Weagant. Do you find anything in the Fleming patent which would as one familiar with the art at the date of the Fleming patent instruct you not to use a voltage sufficiently large to strike the so-called arc between the filament and the plate electrodes?

A. I do, because I find throughout the patent a description of its mode of operation as that of a rectifier or a device of uni-lateral conductivity, and as one skilled in the art I should feel that the patent directed me not to do anything that would militate against the operation of the apparatus as a rectifier.

Mr. Bull: I move to strike out the last part of that answer.

Motion granted; exception.

Mr. Bull: As a matter of fact, we are right back on the old case now.

The Court: Not only that, but this part of the testimony is quite contrary to the rule. It is perfectly all right to say that nowhere is such and such a thing, and I do not think that there is any disagreement really as to the facts between both sides, but when he starts in to say that he as one skilled in the art finds that there is in effect or by virtue of his reasons or his inferences a direction not to do something or another, that is merely argument.

Mr. Darby, Jr.: We will simply let it rest there.

Q. 44. As one skilled in the art would you say that the generation of the oscillations by the Fleming two-electrode device, if it may be made to generate electrical oscillations, would be an expected result from the directions, description and illustration contained in the Fleming patent in suit?

Mr. Bull: I object to that. Objection sustained; exception.

Q. 45. Now confining myself strictly to the functioning of the two-electrode device as shown and described in the Fleming patent in suit, the electromotive force in the plate filament circuit is an alternating electromotive force with

minute high frequency alternating voltage, I believe you stated in your answer to one of your previous questions?

A. It is.

Q. 46. And that minute high frequency alternating voltage is induced by the received radio oscillations in the antenna circuit; that is correct, is it not?

A. It is.

Q. 47. So that the result is that rectification takes place [fol. 2578] and a uni-directional current is thereby developed in that circuit?

A. Yes.

Q. 48. Is any change in that functioning of the device effected by reducing the minute alternating high frequency electromotive force by replacing the minute alternating high frequency electromotive force by a direct or uni-directional electromotive force of high voltage?

A. Yes. The functioning is completely different. In one case the alternating electromotive force acting upon the two electrodes of the device causes a rectification action to take place, resulting in a uni-directional current in the circuit. In the second case, the large electromotive force impressed upon the valve may either produce no current at all if poled in one direction, or may produce a large uni-directional current in the opposite direction, but in either case there would be no rectification.

Q. 49. You heard Mr. Waterman's testimony when the apparatus was demonstrated yesterday to the effect that he did not believe the blue glow extended between the plate and filament, did you not?

A. Yes.

Q. 50. Do you agree with Mr. Waterman's statement?

A. I do not.

Q. 51. What would be the effect on the functioning of the device if the blue glow did not extend between the filament and plate?

A. Assuming that it developed sustained oscillations when the blue glow extended between the filament and the plate in my opinion those sustained oscillations would not have been developed if the blue glow did not extend between the filament and the plate.

Q. 52. What would be the effect on the functioning of the apparatus demonstrated yesterday if the blue glow were suppressed or eliminated?

A. In my opinion the valve would become a simple rectifier and would under no circumstances develop sustained oscillations.

Q. 53. Referring again to the coupling back of the oscillating circuit, of the oscillating audion that was employed in the receiving end of the apparatus, what advantage for the test that was given in that test apparatus was secured from the arrangement employing that coupling back for the purpose of that test?

A. Owing to the fact that that coupling was made with the resonant circuit 2-3 illustrated in Plaintiff's Exhibit 2, it developed a high potential oscillating electromotive force at the terminals of the valve, and this would tend to disturb its equilibrium which might in my opinion possibly result in causing it to sustain oscillations which in its absence would not be developed.

Q. 54. Do you know of any practical use to which the arrangement employed for the demonstration yesterday with the receiver coupled back on the transmitter could be put in radio communications using the apparatus of the test apparatus on the table?

A. No. I can see no useful purpose to which it could be applied in view of the fact that the three-electrode bulb was itself developing a sustained train of oscillation which could have been used for any purpose that this apparatus was used.

Q. 55. You have heard Mr. Waterman's testimony with regard to the theory of reversibility of function; you heard Mr. Waterman's testimony?

[fol. 2579] A. I did.

Q. 56. Mr. Waterman's testimony was to the effect that the valve as a detector and rectifier is merely the reversal of the valve as a generator, or, in other words, that this is merely the phenomenon of the reversibility of function; do you agree with Mr. Waterman?

A. I do not.

Q. 57. Will you please explain that?

A. The reversible phenomena are the class of phenomena which may be best described by specific examples, as, for instance, the motor transformer which is an apparatus which when you supply it with direct current at one set of terminals will develop an alternating current in the other set of terminals, and conversely when you apply an alternating

current to the second set of terminals a direct current will be developed at the first set of terminals.

Similarly, in the case of the thermopile, if you heat one end of the thermopile, cooling the other, it will develop an electric current, and conversely if you pass an electric current through the thermopile it will heat one of these terminals and cool the other. Those are strictly reversible phenomena. But an apparatus which has been put under entirely new conditions as is the case with the two-electrode valve, assuming that it does produce sustained oscillations, in order to have it reverse its function, is not the case of the simple reversal of function; it is not a reversible phenomena that is taking place.

Cross-examination.

By Mr. Bull:

X Q. 58. I understand you to say that in this apparatus as it was operating yesterday there was present such a blue glow as would put the two-electrode valve out of action as a detector; am I right about that?

A. It would be sufficient to very greatly diminish its function as a detector.

X Q. 59. And practically put it out of commission actually as a detector?

A. Under some circumstances it would render it completely ineffective in that respect.

X Q. 60. Did you not hear this same valve with the same conditions used as a detector yesterday?

A. I do not remember.

X Q. 61. You do not remember asking Mr. Weagant to do something and Mr. Weagant misunderstood what you wanted him to do and he turned the apparatus around as we had offered to do so that the three-electrode end acted as the generator and the two-electrode end acted as the receiver?

A. I was not aware that he was doing any such thing; he may have been doing it.

X Q. 62. I was standing there and I heard him say, "Oh, excuse me, I thought that is what you wanted me to do."

A. He told me I was listening on the wrong set of telephones.

X Q. 63. You did hear something at that time?

A. I did not know what he was doing.

X Q. 64. But you did hear signals?

A. I heard a noise, it sounded to me like an arc.

X Q. 65. One of those high musical arcs?

A. Not musical; on the contrary it was just a roar.

[fol. 2580] X Q. 66. You have referred several times to the presence of an inductive coupling; you did not testify in the main case, did you?

A. No, I had nothing to do with it.

X Q. 67. Would you be surprised that precisely that same inductive coupling was used in every experiment that was made in the Court by both sides in this case?

A. I do not know what the experiments were in that case; I have not read the record.

X Q. 68. Experiments for sending and receiving; would you be surprised?

A. I could not be surprised unless I knew what the tests were and I never read the record in that case.

X Q. 69. You said that by reason of that inductive coupling you were not sure that the oscillations of the three-element valve were what were causing the two-element valve to oscillate?

A. Substantially that.

X Q. 70. And you say that notwithstanding the fact that the two valves were oscillating at different rates?

A. There appeared to be beats.

X Q. 71. There were beats?

A. Yes.

X Q. 72. Then they were oscillating at different rates?

A. I think that they were oscillating at different rates from the presence of beats.

X Q. 73. Do you think it at all probable that oscillations at one rate would set up in the other valves oscillations of a different rate?

A. I think they might very well where the oscillations produced were of the very high frequencies, and the two circuits were slightly out of tune.

X Q. 74. Is it not true that this inductive coupling which we are talking about causes the receiving circuit to abstract energy from the transmitting circuit?

A. I think it undoubtedly causes a swapping of energy between the two circuits.

X Q. 75. But you would not admit that it would cause them to abstract energy?

A. Both abstract and return.

Re-direct examination.

By Mr. Darby, Jr.:

R. D. Q. 76. You did not state in your testimony, did you, that when the blue glow occurred in a two-electrode device that that spoiled the electrode device for future use, did you?

A. No; I did not intend to imply anything of that kind.

Mr. Bull: I did not intend to imply any thing of the kind either.

Mr. Darby, Jr.: I gathered from Mr. Bull's question that on using this two-electrode device as a receiver that the inference was raised that Mr. Stone was testifying that the blue glow made it impossible for it to be used as a receiver.

Mr. Bull: I probably must apologize to my friend Mr. Darby. My scientific language was weak; my exact words were "put out of action"; I meant temporarily; I did not mean permanently.

Mr. Darby, Jr.: The file wrapper of the Fleming patent is in evidence as an exhibit, Exhibit W, in the main case. I would like also to use it in this case; do you desire it as a separate exhibit?

[fol. 2581] Mr. Bull: I think all the evidence in the main case, this is merely under a supplemental bill, all the other evidence is in this case.

The Court: There is no question about that. Let it be noted for convenience at this point that Exhibit W is the file wrapper.

Defendant's Proofs closed.

Plaintiff's Rebuttal Proofs

Frank L. Waterman, recalled in rebuttal, testifies as follows:

Direct examination.

By Mr. Bull:

Q. 181. Mr. Waterman, you heard Professor Stone say that he believed the two-element valve could not operate as a generator of wireless waves unless the blue glow was present. Does that statement accord with your experience with these lamps?

A. It does not.

Q. 182. Are you prepared to demonstrate the operation of this two-element valve to the court as a generator in the absence of the blue glow?

A. We have a bulb there which last night generated without a blue glow and again this morning. I will be glad to try and see if we can do the same thing again.

Q. 183. You have heard Professor Stone state that the presence of the three-element valve in the receiving station might have been the cause of the oscillations of the two-element valve in the generating part of the apparatus. You also heard, I suppose, Professor Stone indicate a desire to see the two-element valve operate as a generator in circuits which did not include any three-element valve; is that true?

A. I did.

Q. 184. Are you prepared to demonstrate to the court the operation of the two-element valve as a generator in circuits which do not include any three-element valve?

A. I am, with some make-shift apparatus. I tried last night to get a commercial ticker, as it is called, without success, but by the use of a file and a wire scraped over it we break up the oscillations so that they may be received with the ordinary crystal detector, that simply being a rough way of imitating the action of the ticker.

Q. 185. Did you hear me in an informal way last evening after adjournment ask Professor Stone if he happened to have a ticker apparatus in his pocket and he said he did not?

A. I did.

Q. 186. Did you also hear Mr. Weagant ask him if he would be satisfied if the demonstration were made with an ordinary file?

A. I did.

Mr. Darby, Jr.: If your Honor please, as I recall it, that is not the way the question was put to Mr. Stone. There was a qualification that Mr. Bull has not expressed.

Mr. Bull: If you will correct me.

Mr. Darby, Jr.: Mr. Stone, as I recall, stated that the file could be used in the receiving circuit in place of the inter-[fol. 2582] rupter which he expressly mentioned could be used in the receiving circuit.

Mr. Bull: I did not know anything about that. We asked him if we could use a file.

Mr. Darby, Sr.: If new tests are going to be made we ought to have an opportunity to explain them.

Mr. Bull: I suppose you will have an opportunity to explain them, but you will understand these tests are not in any sense new tests, they are tests which your Honor almost indicated yesterday his desire to see.

The Court: Yes; I did want to see it.

Mr. Bull: And we have with such other apparatus as we could get together overnight, we are prepared to show the operation.

By Mr. Bull:

Q. 187. Will you proceed to make those demonstrations, and if you can do so make them both at one time.

A. If I can get Mr. Weagant to operate the apparatus; he is familiar with it.

The Court: Mr. Weagant, will you just state for the record what you are doing?

Mr. Weagant: In this test I am going to operate the two-element Fleming valve as a generator and I am going to use the same receiving set as was used yesterday with the exception that I employ a crystal detector to detect the oscillations.

Mr. Bull: In place of the three-element valve?

Mr. Weagant: In place of the three-element valve. These oscillations, being continuous oscillations, will not make any sound in the detector unless they are broken up in some way, or unless we have the beat as we had yesterday. So I am going to break these up at the transmitter here with a file and a light piece of wire connected across the points where the key is connected in the transmitter so that that merely disturbs the oscillations that are being generated in this coil, and there will be heard in the telephone receivers a scratching corresponding to my drawing the file across, and I shall show that that scratching stops if I stop the valve, or if I throw the tuner out of tune, showing that it is due to the oscillations.

The Witness: May I make a statement? Mr. Weagant used the expression "disturbing the oscillations". That I think is not quite an apt expression of what happens. We are merely replacing the sending key by the file which makes

the interruptions at such rapidity as will correspond to a rate that the ear can obtain.

Mr. Weagant: Yes.

The Witness: There is no blue glow in the valve, if your Honor will notice.

By Mr. Bull:

Q. 188. Will you explain, Mr. Waterman, the demonstration which has just been made?

A. The demonstration is identical with that which was made yesterday, with three exceptions. The valve which is [fol. 2583] being used is a different valve and one which on account of a higher vacuum, or some characteristic that we do not know, does not require the blue glow in order to oscillate. The detector employed is an ordinary crystal detector, and the three-element valve which was employed yesterday certainly not in operation, but it has been removed from the table entirely. I may say if I may interject that the sole reason why the valve was employed as the receiver was that I apprehended that the court would desire to receive oscillations with the two-element valve as well as transmit, and that was the convenient way of doing it, and furthermore, the set is a perfectly standard regular set without modification or alteration of any kind, and, further, was immediately and readily available to bring here.

The third difference is that the oscillations, or rather the signals sent, are broken up in this instance by what is in the parlance of the art called a chopper, the file and the wire imitating the chopper. That breaking up may be done at either the transmitting or the receiving station. I have had it put where it is for two reasons. In the first place, the circuit to which it is now connected is not one which is in any way associated with the battery. Hence, it cannot by any line of argument be reasoned that the operation of the wire over the file was affecting a battery current, and that it was not the valve that was operating. The second reason was that the coil is already tapped for the purpose while the commercial apparatus which we had is not tapped for that purpose, and to connect it across a whole coil would be apt to interfere with the tuning of the coil.

The operation was as follows: Upon the lighting of the filament by merely connecting the battery to it, the two-element valve started to oscillate. Those oscillations were re-

A. Yes; that is correct.

Q. 40 That is to say, he selected some old bulbs for the purpose of the demonstration to the court?

A. Yes.

Mr. Darby, Jr.: I believe Mr. Waterman also said that he tried them and picked out those which would oscillate.

Mr. Bull: Yes.

JOHN STONE STONE, a witness called in behalf of the defendant, being duly sworn, testifies as follows:

Mr. Darby, Jr.: May I ask if you will concede Mr. Stone's qualifications?

Mr. Bull: I certainly will.

Direct examination:

By Mr. Darby, Jr.:

Q. 1. How long have you been familiar with vacuum tubes?

A. Since about 1892.

Q. 2. How long have you been familiar with the use of vacuum tubes with respect to high frequency work?

A. My first experience with vacuum tubes in high frequency work was some time in 1893.

Q. 3. Have you had occasion to make a thorough investigation and study of vacuum tubes in the various uses to which they may be put?

A. I have had considerable experience with vacuum tubes, the matter of detecting electrical oscillations and generating electrical oscillations.

Q. 4. And amplification?

A. Some.

Q. 5. You witnessed and took part in the demonstration of this apparatus that had been set up by the plaintiff I believe?

A. Yes.

Q. 6. You noticed the blue glow effect that took place in the Fleming two electrode structure when it was as the plaintiff states generating electrical oscillations?

A. Yes.

Q. 7. Will you please describe in your own language what produced that blue glow, its effect on the circuit, and what

you can tell us in connection with the phenomenon of the appearance of that blue glow.

A. The blue glow is a phenomenon which takes place in a vacuum tube when the potential difference, or the electromotive force acting between the two electrodes, reaches such a high value as to produce a sudden decrease in the electrical resistance between those electrodes. I will not go into the scientific explanation of the mechanism that produces that sudden diminution of resistance, and will say that it is a very well recognized phenomenon, however, and amongst operators and the like, the character of users of audions and valves, it is generally spoken of as striking an arc. Personally I do not consider that the phenomenon is identical with the electric arc, but it is in the same nature an arc in so far as its effect upon the resistance of the space between the electrodes is concerned.

[fol. 2570] Q. 8. Might I ask when you say striking an arc in the colloquial, if you please, the interpretation of that, do you mean striking an arc between the electrodes?

A. Yes.

Q. 9. Might I ask is the function of that blue glow the same as the arc?

A. Functionally it seems to operate in much the same way as if a true arc were struck between the electrodes. It differs from a true arc between the electrodes only in that the diminution of the resistance which it establishes between those electrodes is not so great as would be the case if a true arc were struck between them.

Q. 10. What is the effect of that blue glow or arc on the two-electrode device for detection purposes?

A. As soon as the blue glow commences to appear in a rectifying valve, vacuum tube valve, its qualities as a rectifier, and therefore as a detector, begin to wane very rapidly, and as the blue glow increases until it finally reaches from one electrode to the other, the deleterious effect upon the detecting function of the valve becomes greater and greater until finally the valve becomes extremely inefficient or inoperative for detection purposes. And when I speak of this diminution of efficiency in the valve as a detector I do not refer to matters of small percentage, but the change is so great that a detector which may be receiving easily readable signals may cease to develop audible signals even, and a valve which is receiving quite loud signals may under the

influence of the blue glow become so inefficient that the signals become unreadable.

Q. 11. Is it possible to make a two-electrode device generate oscillations without striking that arc which you refer to?

A. So far as my experience goes, and theoretical investigation that I have made of the simple valve, or rectifier, I am convinced that it cannot oscillate unless the blue glow or so-called arc exists between the electrodes.

Q. 12. In other words, striking the arc which I believe is admitted causes the blue glow to appear, is absolutely essential and necessary for the two-electrode device to act as a generator of oscillations?

A. That is my opinion.

The Court: Then what follows from that?

Mr. Darby, Jr.: This follows, if your Honor please; it shows conclusively that you have to completely eliminate Fleming's invention to use it as a generator; in other words, the contention that it will detect is absolutely opposed to the contention that it will act for generation purposes. The minute that it strikes an arc, the minute that it generates oscillations, it absolutely ceases to rely upon its detection properties for operation.

Q. 13. May I ask if you are familiar with a similar blue glow effect in the three-electrode audion?

A. Yes.

Q. 14. Is the striking of the arc, or causing this blue glow effect to appear, necessary for the operation of the audion?

A. No; the presence of the blue glow or so-called arc militates greatly against the efficient operation of the three-electrode audion as a detector, and it also militates against its operation as an oscillion or oscillator.

[fol. 2571] Q. 15. Would the audion operate if the blue glow effect appears?

A. It begins to cease to operate effectively as soon as the blue glow appears.

Q. 16. That is what has been commonly known as paralyzing the audion, is it not?

A. Yes; the operators use that word.

Q. 17. And means have got to be taken to prevent the paralyzing of the audion or to immediately dissipate that condition as soon as it appears; is that correct?

A. Yes.

Q. 18. I believe I understood you to say that you personally knew that a two-electrode device would generate high frequency oscillations about 1893.

Mr. Bull: I object to that, if they are going into the prior art. I do not know whether that will anticipate our patent or not.

Mr. Darby, Jr.: I want to lead up to the point of when the discovery was made of the oscillation and generation by a three-electrode device as distinguished from a two-electrode device.

Mr. Bull: Ask him that question.

Mr. Darby, Jr.: I have asked that question; I wanted to be correct as to my starting point before proceeding.

The Court: Reframe the question.

Q. 19. Will you please explain how you discovered in 1893 that a two-electrode device would generate electrical oscillations?

The Court: I do not get this at all.

Q. 20. I will ask you this; when did you first obtain knowledge that the three-electrode device would generate electrical oscillation?

A. In 1912 I received that knowledge indirectly in this way; I received a letter from Dr. DeForest who was out on the Pacific Coast informing me that he had discovered that his audion would amplify alternating currents, whereupon as an old telephone engineer I wrote him a letter stating that if it would amplify telephone currents or any other currents, it would certainly oscillate, and pointed out to him what particular kind of circuits he would have to use in connection with his audion in order to prevent it from oscillating in case he wanted to do so in its use as a telephone amplifier, and I needed no further information than the fact that the audion would amplify to know that it would oscillate, nor would any other competent telephone engineer need to know anything more.

Q. 21. In what connection were the two-electrode vacuum tubes that you were familiar with in 1893 used; that is, for what purpose were they used?

Mr. Bull: I object to that.

Mr. Darby, Jr.: If your Honor please, this is of the two-electrode device for generating high frequency electrical

oscillation. I want to prove by this witness that in 1893, two-electrode devices for the production of high frequency oscillation were known, and further than that, that the only difference between this device and what was known [fol. 2572] and used at that time for that purpose was that in Fleming they used a hot electrode, one electrode is heated, whereas in the old device one electrode was not heated. I want to further prove that so far as the operation of a generator of electrical oscillations is concerned, it makes no difference whether that electrode is heated or not, and further that the actual heating of the electrode is detrimental to its generation of electrical oscillations. I think that is wholly pertinent.

Mr. Bull: In the first place, I object to their going into the prior art. That is simply an effort to anticipate our patent, as I understand it. In the second place, I do not think I could have correctly heard what Mr. Stone said because my understanding is that we are here simply because Mr. Stone on the motion filed an affidavit in which he said you could not make a two-electrode device work and I think he is asking him if he did not make a two-electrode device generate way back in 1893.

The Court: Your argument as to certain proofs covered several points. I alone directed myself to one. I think any testimony which in effect is in the nature of anticipation of the state of the art prior to Fleming is not admissible in this case. Now, that is the theoretical side. Now, the practical side is this, that the books have now grown full of cases which show that certainly not in 1893 did any person have any conception of the power of generation and oscillation in its present relation; that is as certain as anything can be. A man might look back for all I know on some theoretical business about oscillations and all that sort of thing, but from the radio standpoint to go into the dark ages and the past ages to find out what happened in 1893 to my mind is utterly immaterial.

Now, on the question as to what the two-electrode will do and what a three-electrode will do, that is a different proposition. There Professor Stone's experience as a scientific man and an expert is entirely relevant along the questions which are intended to show how these things work and what in fact they do, and so on. I am perfectly clear from the testimony, I do not believe anybody disputes the fact,

that the oscillating properties or the characteristics were unknown in this relation to the scientific world until a considerable number of years after Fleming invention. As I said this morning, if the thing does oscillate, if the Fleming valve does generate, the next question is purely a question of law.

Mr. Darby, Jr.: If your Honor please, I ask you not to forget one point and that is that the plaintiff in this case is seeking to include the oscillating audion as an infringement of their patent, and to do so they have got to broaden the scope of their claims to enable them to do so.

The Court: That is a question of argument; that has got nothing to do with this 1893 proposition; I will sustain the objection.

Mr. Darby, Jr.: Exception.

Q. 22. Mr. Stone, is the heated electrode or hot electrode of the Fleming two-electrode device absolutely essential [fol. 2573] to its use as a rectifier?

A. Yes. I will say that the heating of the filament electrode in the Fleming valve is essential to its operation.

Q. 23. If the hot electrode of the Fleming valve is not heated; in other words, if the heating battery is omitted, and a sufficient voltage is employed, would the device generate electrical oscillations?

Mr. Bull: I object to that; I think it is utterly immaterial.

The Court: What is your theory on that?

Mr. Darby, Jr.: My theory is this: my next question which I intended to ask to bring it out, was if the filament was not heated, it would generate electrical oscillations more efficiently than if it were heated.

The Court: Suppose it did; then go and use one that is not heated.

Mr. Darby, Jr.: Then, of course, they would not have the Fleming invention there.

The Court: You have got one electrode that is heated; they have one that is heated. Now, you can use the finest kind of cold electrodes in the world and they do not care anything about it.

Mr. Darby, Jr.: Suppose in the three-electrode device, the hot electrode is absolutely essential for its work, whereas in the two-electrode device it is detrimental; does not that alter the situation, as a generator?

The Court: I will sustain the objection on the ground that the question is immaterial and irrelevant.

Mr. Darby, Jr.: Exception.

Q. 24. Will you examine those two circuits, Plaintiff's Exhibits 2 and 3; referring to the apparatus which those circuits, for the sake of convenience represent, you will note that an oscillating audion at the receiving end is employed, and you will further note that the receiving end is inductively coupled to the transmitting end; that is correct, is it not?

A. It is correct as to the apparatus of the demonstration but it is not shown in these exhibits as far as I can see.

Q. 25. You mean that the inductive coupling between the receiving and the transmitting is not shown?

A. Yes; that is what I mean.

Q. 26. In the receiving system the electrical oscillations are being generated, are they not?

A. Yes.

Q. 27. What effect would the electrical oscillations generated in the receiving system have upon whether or not the two-electrode device is actually generating electrical oscillations?

A. It is very difficult to say. The oscillations which are generated in the receiving circuit or the oscillating three-electrode audion, are in part due to the oscillation circuit of the two-electrode valve, and what effect that would have upon the oscillation of that circuit, or the maintenance of the oscillations of that circuit, is very difficult to say; it is impossible to say—*a priori*. The only way that I can imagine the effect of these oscillations to be determined would be to substitute a non-oscillation producing detector in a receiving circuit, and coupled with the interrupter, breaking [fol. 2574] up the train of continuous waves, and then see whether the two-electrode valve would oscillate in the transmitter without the coupling between the transmitter and the receiver.

Q. 28. What is the nature of the coupling between the oscillating audion system and the receiving system?

A. It is difficult to say what it is because the wires run back of the board, but I fancy it is a simple inductive coupling.

Mr. Bull: If you want any wires straightened out for you we will be glad to help you.

The Witness: I have examined it and find it is a simple inductive coupling between the transmitter and receiver as I had previously supposed.

Q. 29. What ordinarily is the effect of an inductive coupling between an oscillating circuit and another circuit?

A. Well, in the well known case of the grid plate circuit of the three-electrode audion, and the filament grid circuit, it is essential in causing the device to operate. A similar action might or might not take place here by the coupling between the plate filament circuit of the oscillating audion and the filament plate circuit of the two-electrode valve.

Q. 30. By the use of this three-electrode oscillating audion in this demonstration apparatus, coupled as shown by the apparatus itself, does it raise a doubt in your mind as to whether or not the two-electrode device is generating electrical oscillations of a degree sufficient to be detected?

A. No; it is undoubtedly generating those oscillations, but the coupling makes me doubt whether the two-electrode tube would oscillate in that circuit, except for the coupling with the oscillating three-electrode audion in the other circuit.

Q. 31. In other words, it raises a doubt in your mind whether this two-electrode device would generate electric oscillations without this inductive coupling with the oscillating audion at the receiving end?

A. It seems to me that that is an obvious doubt in such a structure.

Q. 32. In your opinion, Mr. Stone, do you consider this a fair test of whether or not the two-electrode device with its circuits alone would generate electrical oscillations when using a three-electrode device?

A. It is by no means so conclusive as would be a test in which there was no coupling between those circuits, and there would be no difficulty in substituting another detector for the oscillating audion and using a tone wheel.

By the Court:

Q. 33. Have you made any experiments along that line?

A. I have made a number of experiments in an effort to cause a two-electrode valve to oscillate with one of the electrodes heated to incandescence, and I have never succeeded in making it oscillate, whereas, with the tubes with both

electrodes cold and a very much higher voltage, there was no difficulty whatever in making them oscillate.

[fol. 2575] Q. 34. What effect in your opinion does the oscillating characteristic of the audion at the receiving end have on the two-element valve in its oscillation in this present connection?

A. The possible effect is due to the fact that the electromotive force impressed upon that valve is no longer, owing to the coupling, a purely direct voltage or constant unidirectional voltage; it is a uni-directional voltage where the superimposed vibratory voltage comes from the oscillating audion in the receeiving circuit. Moreover, the coupling is so arranged, the voltage developed by the coupling, that the oscillatory voltage produced at the terminals of the two-electrode bulb by that coupling is very much amplified by resonance in the circuit of Plaintiff's Exhibit 2.

Adjourned to March 12, 1919, at 12 m.

Trial Resumed

March 12, 1919, 12:00 m.

John Stone Stone: Resumes.

Direct Examination by Mr. Darby, Jr. (Continued):

Q. 35. Mr. Stone, have you read and do you understand the Fleming patent in suit?

A. I have and do.

Q. 36. Did you examine and did you understand the operation of the test apparatus that was demonstrated yesterday?

A. I examined the apparatus and understood its operation.

Q. 37. Will you please compare the arrangement, operation and functioning of the two-electrode valve device as shown and described in the Fleming patent with the arrangement, operation and function of the valve device used in the demonstration which was made yesterday?

A. The Fleming valve of the patent in suit as described and illustrated is included in a simple circuit, in an inductive relation with the antenna, which circuit comprises a coupling coil with the antenna and a galvanometer or other device capable of indicating the presence of a direct current in that circuit.

In the apparatus of the demonstration given in Court yesterday the two-electrode valve is connected to two branch circuits, one branch circuit comprising an iron cord impedance coil marked Z in Exhibit 2, the condenser marked C2 and a battery of approximately 95 volts potential, in addition to the telephone receiver not marked on the drawing.

The other branch circuit comprises an inductance coil marked 2 in Plaintiff's Exhibit 2, a blocking condenser marked C^3 and a variable condenser marked C in that exhibit.

In the patent in suit there is no electromotive force impressed upon the two-electrode valve between the filament and grid save the minute alternating electromotive force induced in the oscillations in the antenna, and in the description contained in this patent the operation of the valve is described to be that of a simple rectifier, whereby this [fol. 2576] minute alternating impressed electromotive force is rectified and produces a small direct current in the simple circuit.

In contrast to this in the test yesterday a very large electromotive force is impressed upon the valve between its filament and plate, in addition to a very large oscillating electromotive force developed by the resonant circuit marked 2-3 by virtue of its coupling with the oscillating circuit of the three-electrode audion in the receiving circuit.

I will add here by interjection that the mode of couple employed resulted in a great magnification of the potential difference across the two-electrode valve represented in Plaintiff's Exhibit 2 by virtue of the resonant circuit 2-3 of Plaintiff's Exhibit 2. This magnification of voltage is not a small magnification, but in circuits of this type they amount to a multiplication of the impressed voltage a thousand fold.

Coming down to the disclosure of the mode of operation in the patent as compared with the mode of operation I apprehended in the apparatus of the demonstration yesterday, I find that in the patent in suit the valve is under such electrical conditions as to make it operate effectively as a simple rectifier. By contrast I find that in the test in Court yesterday owing to the presence of the large direct or unidirectional voltage due to the batery B-2 of Plaintiff's Exhibit 2 a blue glow extended from the filament to the plate, and I apprehend that under those circumstances the

action of the valve would cease to be an effective simple rectifier, but would possess different electrical properties characterized by a relatively extremely low resistance being established between the filament and the plate.

Q. 38. What elements if any do you find necessary to add to the circuits of the patent, or Fig. 1 of the patent in suit, in order to make the two-electrode valve generate oscillations, if it can be done?

A. Judging from the apparatus of the test, performed in Court yesterday, and for the sake of argument assuming that those conditions were sufficient to cause the two-electrode valve to execute sustained oscillations, I find that the elements necessarily added for this purpose are the addition of an iron cord impedence coil Z in Plaintiff's Exhibit 2, three condensers marked respectively C, C^1 and C-2, C being adjustable, a tap upon an inductance coil marked 2 in that exhibit and a battery of approximately 95 volts.

Q. 39. What is the relation of the condensers that are employed relative to the inductance that is employed in the transmitting end as illustrated in Plaintiff's Exhibit 2?

A. Calling the circuit to which you refer of the transmitting circuit the branch to the left hand of the valve in Exhibit 2, the elements are the condenser C^1, the variable condenser C and the tap on the inductance coil; also the coupling coil associated with that inductance coil in case that coupling coil was effective in producing and maintaining the oscillations in the valve in that test.

Q. 40. And in fact the variable condenser C is not shown around the inductance coil; that is correct, is it not

A. Yes; thus constituting the resonant circuit which I have referred to as 2-3.

[fol. 2577] Q. 41. Do you find any directions in the Fleming patent to add any of these elements?

A. No.

Q. 42. Do you find any directions in the Fleming patent which would make it possible to use a resonant circuit therewith, or which would direct you to use a resonant circuit in connection therewith?

A. I find no specific instructions to that effect.

Mr. Bull: I object to that; that is a matter that is for argument. We all agree as to what is in and what is not in the Fleming patent.

Q. 43. You have referred to the use of a high voltage employed in connection with tests yesterday of approximately 95 volts, as I recall the testimony of Mr. Weagant. Do you find anything in the Fleming patent which would as one familiar with the art at the date of the Fleming patent instruct you not to use a voltage sufficiently large to strike the so-called arc between the filament and the plate electrodes?

A. I do, because I find throughout the patent a description of its mode of operation as that of a rectifier or a device of uni-lateral conductivity, and as one skilled in the art I should feel that the patent directed me not to do anything that would militate against the operation of the apparatus as a rectifier.

Mr. Bull: I move to strike out the last part of that answer.

Motion granted; exception.

Mr. Bull: As a matter of fact, we are right back on the old case now.

The Court: Not only that, but this part of the testimony is quite contrary to the rule. It is perfectly all right to say that nowhere is such and such a thing, and I do not think that there is any disagreement really as to the facts between both sides, but when he starts in to say that he as one skilled in the art finds that there is in effect or by virtue of his reasons or his inferences a direction not to do something or another, that is merely argument.

Mr. Darby, Jr.: We will simply let it rest there.

Q. 44. As one skilled in the art would you say that the generation of the oscillations by the Fleming two-electrode device, if it may be made to generate electrical oscillations, would be an expected result from the directions, description and illustration contained in the Fleming patent in suit?

Mr. Bull: I object to that. Objection sustained; exception.

Q. 45. Now confining myself strictly to the functioning of the two-electrode device as shown and described in the Fleming patent in suit, the electromotive force in the plate filament circuit is an alternating electromotive force with

minute high frequency alternating voltage, I believe you stated in your answer to one of your previous questions?

A. It is.

Q. 46. And that minute high frequency alternating voltage is induced by the received radio oscillations in the antenna circuit; that is correct, is it not?

A. It is.

Q. 47. So that the result is that rectification takes place [fol. 2578] and a uni-directional current is thereby developed in that circuit?

A. Yes.

Q. 48. Is any change in that functioning of the device effected by reducing the minute alternating high frequency electromotive force by replacing the minute alternating high frequency electromotive force by a direct or uni-directional electromotive force of high voltage?

A. Yes. The functioning is completely different. In one case the alternating electromotive force acting upon the two electrodes of the device causes a rectification action to take place, resulting in a uni-directional current in the circuit. In the second case, the large electromotive force impressed upon the valve may either produce no current at all if poled in one direction, or may produce a large uni-directional current in the opposite direction, but in either case there would be no rectification.

Q. 49. You heard Mr. Waterman's testimony when the apparatus was demonstrated yesterday to the effect that he did not believe the blue glow extended between the plate and filament, did you not?

A. Yes.

Q. 50. Do you agree with Mr. Waterman's statement?

A. I do not.

Q. 51. What would be the effect on the functioning of the device if the blue glow did not extend between the filament and plate?

A. Assuming that it developed sustained oscillations when the blue glow extended between the filament and the plate in my opinion those sustained oscillations would not have been developed if the blue glow did not extend between the filament and the plate.

Q. 52. What would be the effect on the functioning of the apparatus demonstrated yesterday if the blue glow were suppressed or eliminated?

A. In my opinion the valve would become a simple rectifier and would under no circumstances develop sustained oscillations.

Q. 53. Referring again to the coupling back of the oscillating circuit, of the oscillating audion that was employed in the receiving end of the apparatus, what advantage for the test that was given in that test apparatus was secured from the arrangement employing that coupling back for the purpose of that test?

A. Owing to the fact that that coupling was made with the resonant circuit 2-3 illustrated in Plaintiff's Exhibit 2, it developed a high potential oscillating electromotive force at the terminals of the valve, and this would tend to disturb its equilibrium which might in my opinion possibly result in causing it to sustain oscillations which in its absence would not be developed.

Q. 54. Do you know of any practical use to which the arrangement employed for the demonstration yesterday with the receiver coupled back on the transmitter could be put in radio communications using the apparatus of the test apparatus on the table?

A. No. I can see no useful purpose to which it could be applied in view of the fact that the three-electrode bulb was itself developing a sustained train of oscillation which could have been used for any purpose that this apparatus was used.

Q. 55. You have heard Mr. Waterman's testimony with regard to the theory of reversibility of function; you heard Mr. Waterman's testimony?

[fol. 2579] A. I did.

Q. 56. Mr. Waterman's testimony was to the effect that the valve as a detector and rectifier is merely the reversal of the valve as a generator, or, in other words, that this is merely the phenomenon of the reversibility of function; do you agree with Mr. Waterman?

A. I do not.

Q. 57. Will you please explain that?

A. The reversible phenomena are the class of phenomena which may be best described by specific examples, as, for instance, the motor transformer which is an apparatus which when you supply it with direct current at one set of terminals will develop an alternating current in the other set of terminals, and conversely when you apply an alternating

current to the second set of terminals a direct current will be developed at the first set of terminals.

Similarly, in the case of the thermopile, if you heat one end of the thermopile, cooling the other, it will develop an electric current, and conversely if you pass an electric current through the thermopile it will heat one of these terminals and cool the other. Those are strictly reversible phenomena. But an apparatus which has been put under entirely new conditions as is the case with the two-electrode valve, assuming that it does produce sustained oscillations, in order to have it reverse its function, is not the case of the simple reversal of function; it is not a reversible phenomena that is taking place.

Cross-examination.

By Mr. Bull:

X Q. 58. I understand you to say that in this apparatus as it was operating yesterday there was present such a blue glow as would put the two-electrode valve out of action as a detector; am I right about that?

A. It would be sufficient to very greatly diminish its function as a detector.

X Q. 59. And practically put it out of commission actually as a detector?

A. Under some circumstances it would render it completely ineffective in that respect.

X Q. 60. Did you not hear this same valve with the same conditions used as a detector yesterday?

A. I do not remember.

X Q. 61. You do not remember asking Mr. Weagant to do something and Mr. Weagant misunderstood what you wanted him to do and he turned the apparatus around as we had offered to do so that the three-electrode end acted as the generator and the two-electrode end acted as the receiver?

A. I was not aware that he was doing any such thing; he may have been doing it.

X Q. 62. I was standing there and I heard him say, "Oh, excuse me, I thought that is what you wanted me to do."

A. He told me I was listening on the wrong set of telephones.

X Q. 63. You did hear something at that time?

A. I did not know what he was doing.

X Q. 64. But you did hear signals?

A. I heard a noise, it sounded to me like an arc.

X Q. 65. One of those high musical arcs?

A. Not musical; on the contrary it was just a roar.

[fol. 2580] X Q. 66. You have referred several times to the presence of an inductive coupling; you did not testify in the main case, did you?

A. No, I had nothing to do with it.

X Q. 67. Would you be surprised that precisely that same inductive coupling was used in every experiment that was made in the Court by both sides in this case?

A. I do not know what the experiments were in that case; I have not read the record.

X Q. 68. Experiments for sending and receiving; would you be surprised?

A. I could not be surprised unless I knew what the tests were and I never read the record in that case.

X Q. 69. You said that by reason of that inductive coupling you were not sure that the oscillations of the three-element valve were what were causing the two-element valve to oscillate?

A. Substantially that.

X Q. 70. And you say that notwithstanding the fact that the two valves were oscillati , at different rates?

A. There appeared to be beats.

X Q. 71. There were beats?

A. Yes.

X Q. 72. Then they were oscillating at different rates?

A. I think that they were oscillating at different rates from the presence of beats.

X Q. 73. Do you think it at all probable that oscillations at one rate would set up in the other valves oscillations of a different rate?

A. I think they might very well where the oscillations produced were of the very high frequencies, and the two circuits were slightly out of tune.

X Q. 74. Is it not true that this inductive coupling which we are talking about causes the receiving circuit to abstract energy from the transmitting circuit?

A. I think it undoubtedly causes a swapping of energy between the two circuits.

X Q. 75. But you would not admit that it would cause them to abstract energy?

A. Both abstract and return.

Re-direct examination.

By Mr. Darby, Jr.:

R. D. Q. 76. You did not state in your testimony, did you, that when the blue glow occurred in a two-electrode device that that spoiled the electrode device for future use, did you?

A. No; I did not intend to imply anything of that kind.

Mr. Bull: I did not intend to imply any thing of the kind either.

Mr. Darby, Jr.: I gathered from Mr. Bull's question that on using this two electrode device as a receiver that the inference was raised that Mr. Stone was testifying that the blue glow made it impossible for it to be used as a receiver.

Mr Bull: I probably must apologize to my friend Mr. Darby. My scientific language was weak; my exact words were "put out of action"; I meant temporarily; I did not mean permanently.

Mr. Darby, Jr.: The file wrapper of the Fleming patent is in evidence as an exhibit, Exhibit W, in the main case. I would like also to use it in this case; do you desire it as a separate exhibit?

[fol. 2581] Mr. Bull: I think all the evidence in the main case, this is merely under a supplemental bill, all the other evidence is in this case.

The Court: There is no question about that. Let it be noted for convenience at this point that Exhibit W is the file wrapper.

Defendant's Proofs closed.

Plaintiff's Rebuttal Proofs

Frank L. Waterman, recalled in rebuttal, testifies as follows:

Direct examination.

By Mr. Bull:

Q. 181. Mr. Waterman, you heard Professor Stone say that he believed the two-element valve could not operate as a generator of wireless waves unless the blue glow was present. Does that statement accord with your experience with these lamps?

A. It does not.

Q. 182. Are you prepared to demonstrate the operation of this two-element valve to the court as a generator in the absence of the blue glow?

A. We have a bulb there which last night generated without a blue glow and again this morning. I will be glad to try and see if we can do the same thing again.

Q. 183. You have heard Professor Stone state that the presence of the three-element valve in the receiving station might have been the cause of the oscillations of the two-element valve in the generating part of the apparatus. You also heard, I suppose, Professor Stone indicate a desire to see the two-element valve operate as a generator in circuits which did not include any three-element valve; is that true?

A. I did.

Q. 184. Are you prepared to demonstrate to the court the operation of the two-element valve as a generator in circuits which do not include any three-element valve?

A. I am, with some make-shift apparatus. I tried last night to get a commercial ticker, as it is called, without success, but by the use of a file and a wire scraped over it we break up the oscillations so that they may be received with the ordinary crystal detector, that simply being a rough way of imitating the action of the ticker.

Q. 185. Did you hear me in an informal way last evening after adjournment ask Professor Stone if he happened to have a ticker apparatus in his pocket and he said he did not?

A. I did.

Q. 186. Did you also hear Mr. Weagant ask him if he would be satisfied if the demonstration were made with an ordinary file?

A. I did.

Mr. Darby, Jr.: If your Honor please, as I recall it, that is not the way the question was put to Mr. Stone. There was a qualification that Mr. Bull has not expressed.

Mr. Bull: If you will correct me.

Mr. Darby, Jr.: Mr. Stone, as I recall, stated that the file could be used in the receiving circuit in place of the inter-[fol. 2582] rupter which he expressly mentioned could be used in the receiving circuit.

Mr. Bull: I did not know anything about that. We asked him if we could use a file.

Mr. Darby, Sr.: If new tests are going to be made we ought to have an opportunity to explain them.

Mr. Bull: I suppose you will have an opportunity to explain them, but you will understand these tests are not in any sense new tests, they are tests which your Honor almost indicated yesterday his desire to see.

The Court: Yes; I did want to see it.

Mr. Bull: And we have with such other apparatus as we could get together overnight, we are prepared to show the operation.

By Mr. Bull:

Q. 187. Will you proceed to make those demonstrations, and if you can do so make them both at one time.

A. If I can get Mr. Weagant to operate the apparatus; he is familiar with it.

The Court: Mr. Weagant, will you just state for the record what you are doing?

Mr. Weagant: In this test I am going to operate the two-element Fleming valve as a generator and I am going to use the same receiving set as was used yesterday with the exception that I employ a crystal detector to detect the oscillations.

Mr. Bull: In place of the three-element valve?

Mr. Weagant: In place of the three-element valve. These oscillations, being continuous oscillations, will not make any sound in the detector unless they are broken up in some way, or unless we have the beat as we had yesterday. So I am going to break these up at the transmitter here with a file and a light piece of wire connected across the points where the key is connected in the transmitter so that that merely disturbs the oscillations that are being generated in this coil, and there will be heard in the telephone receivers a scratching corresponding to my drawing the file across, and I shall show that that scratching stops if I stop the valve, or if I throw the tuner out of tune, showing that it is due to the oscillations.

The Witness: May I make a statement? Mr. Weagant used the expression "disturbing the oscillations". That I think is not quite an apt expression of what happens. We are merely replacing the sending key by the file which makes

the interruptions at such rapidity as will correspond to a rate that the ear can obtain.

Mr. Weagant: Yes.

The Witness: There is no blue glow in the valve, if your Honor will notice.

By Mr. Bull:

Q. 188. Will you explain, Mr. Waterman, the demonstration which has just been made?

A. The demonstration is identical with that which was made yesterday, with three exceptions. The valve which is [fol. 2583] being used is a different valve and one which on account of a higher vacuum, or some characteristic that we do not know, does not require the blue glow in order to oscillate. The detector employed is an ordinary crystal detector, and the three-element valve which was employed yesterday certainly not in operation, but it has been removed from the table entirely. I may say if I may interject that the sole reason why the valve was employed as the receiver was that I apprehended that the court would desire to receive oscillations with the two-element valve as well as trannmit, and that was the convenient way of doing it, and furthermore, the set is a perfectly standard regular set without modification or alteration of any kind, and, further, was immediately and readily available to bring here.

The third difference is that the oscillations, or rather the signals sent, are broken up in this instance by what is in the parlance of the art called a chopper, the file and the wire imitating the chopper. That breaking up may be done at either the transmitting or the receiving station. I have had it put where it is for two reasons. In the first place, the circuit to which it is now connected is not one which is in any way associated with the battery. Hence, it cannot by any line of argument be reasoned that the operation of the wire over the file was affecting a battery current, and that it was not the valve that was operating. The second reason was that the coil is already tapped for the purpose while the commercial apparatus which we had is not tapped for that purpose, and to connect it across a whole coil would be apt to interfere with the tuning of the coil.

The operation was as follows: Upon the lighting of the filament by merely connecting the battery to it, the two-element valve started to oscillate. Those oscillations were re-

ceived by the receiving set and when Mr. Weagant rubbed the fine wire over the file, the court, as I assume, heard the peculiar, raspy noise which is characteristic of the ticker type of detector, and that noise ceased when Mr. Weagant disconnected the filament, and therefore stopped the valve from oscillating. The existence of that sound was evidence that the valve was producing radio oscillations.

The fact that the valve while producing those radio oscillations was not also producing the blue glow shows what I said yesterday, that the blue glow is not a necessary accompaniment of this oscillating condition and is merely an incident to the particular valve used. The valves of this wide spacing will commonly, not always, but often show this edge glow, as I have called it, and they do not go out of action, nor do they lose their sensitiveness until suddenly a change occurs which is visible to the eye when the blue glow becomes self-perpetuating, and suddenly fills the space, and then the bulb ceases to act entirely. This is equally true of three-element bulbs and is in no way peculiarly characteristic of two-element bulbs.

Q 189. Professor Stone intimated that the condition of the blue glow which is present in the two-element valve used yesterday was the condition which rendered it either inoperative as a detector or which decreased its efficiency as a detector. Is that statement in accordance with the facts [fol. 2584] as you observed them?

A. It is not. On the contrary, the valve as used yesterday with what little evidence of blue glow there was there, was undoubtedly in or approximately in its most efficient detector condition. As a matter of fact, that apparatus could be taken and used in the oscillating state as a receiver to receive distant signals and apparatus like that was used in the demonstration to me by Mr. Weagant when he received European signals. The signals of Nauen in Germany, and as I think Professor Stone himself said yesterday, when we make beats we do not thereby detect, we merely produce something that can be detected. The beats, as Mr. Weagant said a few moments ago, themselves cannot be heard. We have to have a detecting function and that detecting function is performed by the bulb at the same time. Hence, in order that the bulb may be used, as Professor Stone used it, for example, yesterday when he listened to signals sent from the nominal receiving end, the detecting function has to be there in order that one may

receive at the time when the bulb is oscillating, and hence this oscillating condition, whether it is accompanied by this blue glow or not, not only does not destroy the detector function, nor, so far as my observation goes, impairs it in any way. On the contrary, it increases the sensitiveness of the bulb always as a detector.

When, of course, the blue glow passes the point where it is tolerable then suddenly both the detecting and the oscillating function ceases.

Q. 190. Then you distinguish between such a blue appearance which was exhibited in the two-element bulb yesterday and the true blue glow which puts a detector out of action temporarily?

A. There is a very marked distinction between them.

Q. 191. From what you have said I gather that you do not agree with Professor Stone's statement that this apparatus with the two-element valve as it stands has no commercial utility whatsoever.

A. I do disagree, and on the contrary that apparatus just as it stands when put on the big antenna could be used to receive signals from across the water.

Q. 192. Professor Stone has stated that the presence of the inductive coupling between the generating and the receiving ends of this apparatus is perhaps responsible for the fact that the two-element valve acted as a generator when the three-element valve was being used as a receiver. Will you state your views on that point?

A. I disagree with Professor Stone for three reasons. First, this coupling coil merely replaces the antenna that would ordinarily be employed in a full practical apparatus, and it is the thing which is universally used for laboratory or indoor tests. It is the same means of coupling that was used in all analogous tests in the main case and its substantial propriety was recognized by both sides throughout the case and is recognized generally in the art because it is universally employed.

The second reason why I disagree with Professor Stone is that that coil is not in any way connected with the valve that was oscillating. On the contrary, that coil connects with the primary coil in the receiving set and that is only loosely [fol. 2585] coupled to the circuit to which ultimately the three-element valve is connected. Hence it is only a feeble energy in any case which can flow in that circuit from the

valve, and it is not of a large and controlling order as might be inferred from what Professor Stone said.

In the second place, such oscillating energy as flows in that circuit, due to the oscillations of the valve, is of a different frequency from that being generated by the two-element valve acting as generator, and necessarily so, because it is the heterodyning frequency which must differ from the frequency being generated in order that beats may be produced.

Now, it is only by concurrence of impulsing that an effect such as Professor Stone referred to can be produced. The resonant effect to which he refers implies that each time an oscillation occurs an impulse is delivered strictly in time. In contradistinction to this the essence of the beat method is that that thing shall not occur, but that that shall occur successively in time and out of time so that every beat which occurs out of time tends to stop the oscillation, while every beat which occurs in time may tend to an equal amount to undue that stopping force. The net result, therefore, is zero, so far as any effect of this different frequency current on the circuit is concerned.

One aspect of the coupling that I neglected to refer to a moment ago is that the function of that coupling is to withdraw energy; that is what it is there for. Professor Stone preferred to say that they swapped energies. The energy, however, which was withdrawn was the energy produced by the two-element oscillating bulb, withdrawn at its own frequency, and therefore tended to stop the bulb from oscillating. The energy which, if we adopt Professor Stone's testimony, was swapped, was energy of a different frequency which did not tend either to stop or to make it go, the total effect was necessarily zero because of the beat phenomenon which it is its purpose to produce.

Q. 193. The circuit which is used in this demonstration apparatus has been criticised, and I am referring now to the circuit used both yesterday and today; what circuit is that; where does that come from?

A. That circuit was suggested for ti purpose by myself because it is the circuit of the DeForest apparatus that was at issue in the main case.

Q. 194. The P N circuit?

A. The P N circuit, and I supposed that that had been settled, and I just had it on that account. Also a further reason was that it was a circuit that had been dealt with

at such great length that its characteristics were made very clear. No one told me to use it, or said anything about it. I selected it myself and I am solely responsible for it.

Q. 195. As I understand it, that is the P N circuit with an impedence coil and a key added to it?

A. Yes. That is true, but the original circuit from which the P N circuit is derived had a choking coil in it. That designation P N is merely a DeForest Company's trade name. The circuit is an old well known circuit which was devised by Marconi and has been known since many years before the bulbs came into the art at all.

[fol. 2586] Q. 196. I think you referred to the Marconi patent to which you are now referring in your direct examination. To make the matter clear, I will ask if you refer to the circuit of the Marconi patent No. 627,650 which is printed at page 2669 of the printed transcript of record in this case?

A. Yes; that is what I referred to, and the iron coil, as I said, was present, as is indicated as C1, C2 in this circuit, so that in its original form the circuit included that coil.

Q. 197. Professor Stone has said that we have not here a case of true reversibility because in using this two-element valve as a generator we must change the circuits from those in which we use it as a detector; is that correct?

A. It is not. If it is going to be called reversibility at all it is certainly true reversibility because the same circuit in the same condition without alteration and adjustment, or touching it in any way, could be used to send and receive, and it was so used in this room yesterday afternoon.

Q. 198. In other words, our offer to the court was to use that same circuit in the same identical condition as a receiving circuit after we demonstrated to the court the use of it as generator circuit?

A. Yes.

Q. 199. And there was to be no alteration in the circuit whatsoever?

A. There was to be no alteration whatsoever. Furthermore, it is not necessary to call it reversibility because that action is something that occurs while you are using it as a detector, and it only requires that sort of signal known as undamped oscillation to immediately give you the beat reception whether you are looking for it or not, just as in the case where my using the three-element valve got the peculiar

characteristic of the oscillated signal, so the same thing occurs here in the use of this two-element valve.

Q. 200. In other words, as I understand you, when you are using it as a detector with the beat note the thing is generating just as truly and exactly the same way as when you are using it as a generator?

A. Yes. It takes no different manipulation of the apparatus, and if the valve is one that tends to do that, it just does it automatically.

Q. 201. It is just as truly a generator when you are using it as a beat detector as it is when you are using it as a generator?

A. Absolutely.

Cross-examination.

By Mr. Darby, Jr.:

XQ. 202. You recall Mr. Stone's suggestion of yesterday, do you not, of using a ticker or an interrupter in the receiving circuit?

A. Yes.

XQ. 203. Do you recall Mr. Weagant suggesting, or you suggesting, that you might use a file in place of it?

A. Yes.

XQ. 204. In this demonstration which you are giving now you have not done that, have you?

A. No, but we will if you want us to. The only reason it is not done is what I explained in my last answer.

XQ. 205. The principal one being you were afraid we would raise the point that the voltage was causing, or rather the current supply was causing, the click to be heard in the telephone receivers?

A. That was one reason, yes.

[fol. 2587] XQ. 206. You say you would be willing to connect it in the receiving circuit?

A. Yes.

XQ. 207. May I ask you to do it?

A. We have not the taps to do it to the same advantage, therefore it would not tune. This coil, I may say, has the special tap put in to put the sending key across. It is tapped in such a way as not to interfere with the tuning, whereas we have not this provision on this ticker.

By the Court:

Q. 208. Will this take long?
A. It might take anywhere from one minute to five or ten.

Mr. Bull: Do you want to go on with the cross-examination while they are getting that ready?
Mr. Darby, Jr.: I will be glad to do it, except I may have some cross-examination on that.
The Court: Yes.

By Mr. Darby, Jr.:

X Q. 209 Has there been any change in the amount of voltage that was employed for this demonstration today from the amount of voltage that was employed in the demonstration of yesterday?
A. I assume so; that always follows when you change valves. You always do that because you take the voltage that brings the particular valve you are using to the right point on its characteristic curve.
X Q. 210. Did you find out the approximate amount of change?
A. Yes.

Mr. Darby, Jr.: I would also like you to get that information for me; I presume that can be gotten, Mr. Weagant?
Mr. Bull: That is right; Mr. Weagant will get that.

The Witness: As I said yesterday, these valves may take anywhere from 25 to 200 volts. The amount to use is the amount that the particular valve requires.

By Mr. Bull:

Q. 211. We had some experiments relating to that, it seems to me, in the main case.
The Witness: I think we had a number.

By Mr. Darby, Jr.:

X Q. 212. Are you familiar with the use of grid oscillion?
A. I am familiar with the ordinary three-element bulbs. I have not used the large bulbs which I believe DeForest calls the oscillion.

X Q. 213. You are familiar with its use as an oscillation generator?

A. Yes.

X Q. 214. Are you familiar with its use as an oscillation generator for transmission purposes?

A. Yes, but not the bulb actually made by the DeForest Company.

X Q. 215. One of that general form including those elements in the same arrangement?

A. Yes.

X Q. 216. What voltage did you use in connection with that device, that bulb?

A. I have seen them work all the way from five or six volts up to 500 or 600, I judge; I cannot tell.

[fol. 2588] X Q. 217. In generation?

A. Yes.

X Q. 218. Of electrical oscillations for transmission purposes?

A. When you are using them for transmission purposes you choose a bulb on which you can put a high voltage.

X Q. 219. What is the voltage you generally employ?

A. I cannot say as to that, but my recollection is that on the one big bulb which I have used, which is a General Electric bulb, we used 500 or 600; it may have been 1,000, I am not certain.

X Q. 220. You have no cause to disagree with my statement, then, that the voltage generally employed with those bulbs runs from 200 to 1,500 volts?

A. That agrees with my understanding. You make a bulb with a spacing so that it will take that voltage.

Mr. Bull: Mr. Weagant is ready with his tests.

Mr. Weagant: Do you hear the scratching, your Honor?

The Court: Yes. I heard it. When the Fleming valve is put out of action the scratching noise stops. Now I hear a very faint scratching. Now the scratching is very distinct.

Mr. Bull: In the meantime Mr. Weagant was adjusting the apparatus.

The Court: Now it is thoroughly distinct.

The Witness: Will your Honor note there is no blue glow in the valve? You can get that more critically if you stand where the coil cuts the light of the filament out of your eye.

The Court: Yes, there is no blue glow as far as I can see.

The Witness: Will you please measure the voltage which you are using?

Mr. Weagant: Yes.

By Mr. Bull:

Q. 221. Will you explain the demonstration which has been made?

A. The demonstration requested by Mr. Darby has just been made. The same two-element valve was caused to send oscillations as before, but in this instance the file which was used to interrupt the oscillations was connected as requested to the receiver and the file alone was used as a ticker, as is customary in ordinary receiving practice where the ticker is employer. The bulb oscillated in this test as in the former without the production of any blue glow.

I find that the voltage employed, the measurement of which was requested by Mr. Darby, is 110 volts.

By Mr. Darby, Jr.:

X Q. 222. Referring to the Fleming disclosure in the Fleming patent, and confining yourself particularly to the disclosure in Fig. 1: Under your definition of the reversibility of function, or the phenomenon of reversibility, in your opinion would that be capable of reversible action?

Mr. Bull: I object to that; I have not asked this witness anything about the Fleming patent.

The Court: I will allow it.

[fol. 2589] A. Yes, provided that the galvanometer used is either shunted by a condenser to give a path for the oscillatory currents, or that it has sufficient capacity of itself in its own winding, as it probably would have. I assume, of course, that the question contemplates the use of the battery to provide the local source of energy.

X Q. 223. In this last demonstration that was made, Mr. Waterman, were parts of the same battery used to excite the crystal detector at the receiver and for exciting the valve at the transmitting; I do not refer to the last test, I mean the test before the last?

A. No. The crystal receiver was not connected to the battery at all.

X Q. 224. May I ask why you did not use the simple Fleming circuits as disclosed by the Fleming patent for the purposes of these tests?

A. I have already said that without giving the matter any particular thought I told Mr. Weagant to arrange his apparatus to correspond exactly to the P N circuit which was already demonstrated on various occasions before the court. I had no other reason.

X Q. 225. You had absolutely no other reason?

A. I had no other reason, no. As a matter of fact, my experience is the valve oscillates either in that circuit, or in the P N circuit, but I certainly had no reason for trying to dodge that circuit.

Testimony Closed

To be argued March 24, 1919, at 2:30 P. M.
Briefs to be submitted also.

New York, May 16, 1919.

Trial Resumed

Present: J. Edgar Bull, Esq., *Attorney for Plaintiff;* Samuel J. Darby, Esq., and Samuel J. Darby, Jr., Esq., *Attorneys for Defendant.*

Before: Hon. Julius M. Mayer, Judge.

FRANK L. WATERMAN, a witness on behalf of the plaintiff, recalled, further testifies as follows:

Redirect examination.

By Mr. Bull:

R. D. Q. 226. Mr. Waterman, at the last session you were asked the following questions and made the following answers (I read from page 58 of the record): X Q. 155: "I will now ask you a few questions in connection with the circuits employed along the lines of the questions asked by his Honor. It is so obvious that I do not believe it is necessary to emphasize it. The circuit employed in connection with the Fleming valve as a generator is nowheres disclosed in the Fleming patent?

A. I will be glad to operate it in that circuit if you would like."

[fol. 2590] Then, at page 119, on cross-examination you were asked, X Q. 222: "Referring to the Fleming disclosure in the Fleming patent and confining yourself particularly to the disclosure in Fig. 1, under your definition of the reversibility of function, or the phenomenon of reversibility, in your opinion would that be capable of reversible action?

A. Yes, provided that the galvanometer used is either shunted by a condenser to give a path for the oscillatory currents, or that it has sufficient capacity of itself in its own winding as it probably would have. I assume, of course, that the question contemplates the use of the battery to provide the local source of energy."

Now, are you prepared to make the demonstration which you expressed your willingness to make at that time?

Mr. Darby: If you Honor please, I submit this is not what we are here today for; that circuit they are going to show is substantially the identical circuit they showed at the other test, and is not the Fleming patent. I understand we are here today for a demonstration of this valve as an oscillator on the circuit of the Fleming patent. If it is merely a repetition of what was done before it is useless, and I think it appears on its face that is what it is, a repetition of what was done before.

Mr. Bull: We are getting to that, your Honor. I will show it is not a repetition of what was done before. The other was PX circuit. This is Fleming circuit. The other was a divided circuit we were talking about all through that case; this is a single circuit and not a divided circuit. It is the Fleming as distinguished from the PX circuit.

Will you please make the demonstration? (Demonstration is made.)

The Court: I hear a scratching noise as Mr. Weagant draws a fine wire across the file.

Mr. Weagant: You will notice you cannot hear that scratching device when the valve is stopped.

The Court: That is true.

Mr. Weagant: The valve is no longer lighted.

The Court: With the valve lighted I hear it again.

R. D. Q. 227. Will you please explain the experimental apparatus which has thus been demonstrated before the Court?

A. May I have the diagram, please? The experimental apparatus which is demonstrated to the Court is the same as that which was employed before with the following exceptions: The inductance coil having the iron coil and the condenser corresponding to what was removed from the circuit, and the rest of the apparatus has been rearranged so that instead of being a divided or PN circuit it is a simple series circuit such as is shown in the Fleming patent with the addition, as I stated in my former testimony, of a condenser, that is to say, the condenser C which was in the former apparatus has been preserved. The apparatus therefore is identically that of the Fleming patent as shown at the left hand side of the diagram which I produce, with the added condenser which I said would be necessary. The telephone apparatus and the coils not furnishing sufficient capacity within themselves, and that condenser being the usual accompaniment of a circuit. The actual circuit connections are shown at the right hand of the diagram where the receiving apparatus is shown. The file is used on a receiver instead of the heterodyne, because in the former tests the use of the heterodyne was objected to [fol. 2591] and the file substituted for limited tests thereon, and therefore the file has been preserved.

The Court: That is, without the condenser, as I understand it, it won't work?

A. Can you make it work without the condenser, Mr. Weagant?

Mr. Weagant: I am not sure of that. I do not think I can with this particular apparatus.

The Witness: The condenser is necessary to provide a path for the high frequency oscillations.

R. D. Q. 228. Will you point out in detail to his Honor the difference between the circuit arrangement the other day and the circuit arrangement today, because counsel has contended they are the same.

A. May I have the exhibit volume of the record? There is a diagram in there which just exactly does that. I refer to Plaintiff's Exhibit 64, found in the transcript of record, page 2455, in Marconi against DeForest.

Mr. Bull: That is this case?

The Court: Yes, this case.

A. (continuing): The circuit which was demonstrated before is that marked "DeForest Fig. 1" and which is found at the bottom of this Exhibit 64 sheet. The characteristic of this circuit is that what waves are received are impressed upon the valve used as a detector by means of one circuit through a condenser. The effect produced in the detector is recorded or made evident in a circular circuit.

Now, in the Fleming circuit, which is that shown at the top of the Exhibit 64, both of those functions are combined in one circuit. The high frequency oscillations received are impressed upon the valve in that circuit and the effect produced is registered in that same circuit, whereas in the lower figure the oscillations are registered through the upper one of the two circuits which the lower figure shows, while the effect produced is indicated in the lower one of the two circuits. That is the difference between the P N circuit and the circuit of the Fleming patent. Both of these are circuits which were shown simultaneously in Marconi Patent 627,650, and they are interchangeable circuits, that being so ever since. Their difference is in all cases we have in one instance the impression of the oscillations through a separate circuit, whereas in the simpler form of circuit which Fleming happens to show, both functions are performed in one circuit.

R. D. Q. 229. Now then, as I understand it, the apparatus which you demonstrated today is exactly like that marked "Fleming" in Plaintiff's Exhibit 64, at page 2455 of the transcript of record?

A. Yes.

R. D. Q. 230. And what you demonstrated before was like that marked "DeForest Fig. 1" in the same exhibit?

A. That is correct.

The Court: Let me ask you this, to refresh my memory: At the time of the Fleming patent was the use of the condenser as you used it today familiar to the art?

The Witness: Oh, yes, it had been familiar to the art at least three years; I think four.

[fol. 2592] R. D. Q. 231. Are you prepared to now confirm those statements by reference to literature?

A. Yes. If I may I will refer also to Plaintiff's Exhibit 12, which is the original diagram which I used in comparing the DeForest alleged infringing device with the Fleming patent. The Court will see that the same difference exists

as that pointed out by reference to Exhibit 64. In this instance the antenna happens to be shown in that issue and the wireless wave received through its effect on the coil M impresses the energy on the coil K, which is impressed by that circuit upon the valve, and what happens as a result thereof is indicated by the instrument I in that same circuit, whereas in the PN circuit the circuit which I used for demonstrating also if the valve is an oscillator, at the last hearing, we have the energy which is transported to the coil K impressed on one circuit and its effect indicated in the instrument I in another circuit. And that is the difference between those two circuits.

Now, in the circuit which I am using today the energy of the oscillation takes place in this circuit; that oscillation is tuned in the same circuit upon the valve. What happens here in this oscillating state apparently is that a disturbance produced an effect which is recorded in a change of energy here in the circuit. That change of itself is impressed again on the valve and another oscillation occurs. Each wave thus repeats. That is the way in which the oscillation apparently takes place and is preserved.

The Court: Was the tuning condenser shown in what we have often spoken of as the old Marconi circuit, referring now to Letters Patent 627,650, to Marconi?

The Witness: No, that tuning condenser in this instance is not shown.

The Court: Now, Mr. Bull suggested that we show by authority or literature this use of the condenser was known in the art at the time of the Fleming patent.

The Witness: Mr. Pickard, in this record, pointed it out at pages 336-337 of the record, and I have here quotation from his testimony which refers to Stone Patent 714,756 which I believe was in that record.

Mr. Bull: Does your Honor want that to be read in?

The Court: I think I would read it in.

The Witness: I read from page 337, folio 1010 of the record:

"In the Stone system of 1900 (Chart 35) a tune import circuit is used in which there is two condensers. One is shown as the upper condenser, which I will mark C^1 in red pencil on the chart, and the other condenser is the lower condenser, which I will mark C^2 also in red pencil on the chart. These two condensers perform different functions. One is a

tuning condenser, that is to say it has to do with the tuning of the circuit. The other is what is often in this art called a blocking condenser; that is to prevent the flow of current from Battery B over into this secondary circuit."

Referring to the Stone patent mentioned, which as appears from page 336, folio 1008, is Stone Patent 714,756, I refer to Fig. 6 thereof. In this Fig. 6 this tuning condenser is shown at C and the stopping condenser at C^1. The con- [fol. 2593] denser which I have employed is the condenser C, that is the tuning condenser, and it is connected in the same relation in the circuit as is shown in this Fig. 6 of the Stone patent, namely, effectively across this valve or detector element.

The use of this condenser was disclosed by Marconi at a very early date in his Journal of the Society of Arts paper, of May 17, 1901, and it is also disclosed in his patent which I think is in evidence in this record, 763,772, Marconi Tuning Patent as it is generally called. I refer here to Fig. 2, where the tuning condenser H^1 is shown in the same relation across the detector.

R. D. Q. 232. When was that application filed?

A. November 10, 1900. Referring to the Marconi Journal of the Society of Arts paper, I refer to page 511, near the top of the first column.

R. D. Q. 233. What is the date of that paper?

A. May 17, 1901, where Marconi says: "In order to make the tuning more moderate I place an adjustable condenser across the coherer in Fig. 9." Another instance is in Fessenden Patent 706,735, where Fessenden places a condenser in shunt to a galvanometer detector, the condenser being indicated at 19 in Fig. 1 for the purpose of permitting the free passage of oscillations and controlling the tuning. In DeForest Patent 730,246, dated June 9, 1903, the same arrangement is shown in a great many different forms. I will refer to Fig. 26, where the condenser K is shown as a tuning element in the secondary circuit. The shoemaker patent, 711,131, dated October 14, 1902, shows such arrangement in Figs. 3, 4 and 5.

I made note that Fleming in his testimony in this case, at page 141 of the record, referred to the use of a condenser. Fleming says, referring to page 141, folio 422, of the record:

"It is of course an advantage that the receiving circuit should be tuned to the wave frequency and to the transmitter frequency. The receiver circuit therefore usually contains inductance and capacity. In the simple diagram of receiving circuit figured in Fig. 1 of the specification of my U. S. Patent No. 803,684, the circuit in which the oscillation valve is placed is shown as a simple aperiodic circuit. The subject matter of that patent is, however, the nature of the wave detector itself and not of the circuits to which it is attached. It makes no manner of difference to the mode of operation of this thermionic detector in itself, whether it is connected to an aperiodic or to a tuned receiving circuit."

Professor Fleming here calls the circuit aperiodic, that is, a circuit which is incapable of sustaining oscillations. That is on the assumption that the apparatus itself does not furnish sufficient capacity, but sometimes it will. In this instance the condenser has been found apparently necessary although it oscillated with the condenser at zero, which means that the condenser has had little or no effect.

Mr. Bull: I offer in evidence the Shoemaker Patent 711,131, the DeForest Patent 730,246, the Fessenden Patent 706,735, and the Marconi Patent 763,772.

I also offer in evidence the Sketch produced by the witness, illustrating the arrangement of the circuits in the apparatus demonstrated today. The patents are marked with appropriate titles, and the Sketch is marked Plaintiff's Exhibit Waterman's Sketch, May 16, 1919.

[fol. 2594] Mr. Darby: I want to enter objection to the offer in evidence of the patents, for the reason that it is not timely, and irrelevant, immaterial, and further, it is contrary to what we understand the purpose of this demonstration, and we are therefore taken by surprise and we certainly would be entitled to rebut any evidence given in respect to these.

The Court: I will receive them and if you want to study them over, you may.

Mr. Darby: I would like to say this, your Honor, that so far we have not been favored by Mr. Bull with the data we asked for and which he promised at the hearing the other day.

The Court: I receive these in evidence in view of my own inquiry as to the state of the art at the time in regard to this

matter of the tuning condenser. Of course, if you desire an opportunity to have some time to go into that, you may have it.

Mr. Darby: It may be that the cross-examination of Mr. Waterman will supply what we want. I do not know about that. I want to reserve the point.

The Court. All right; proceed.

R. D. Q. 234. Have you any other patents illustrating the same point?

A. I have a considerable number of other patents to Stone. These are 714,831, dated December 2, 1902, where I refer for example to Fig. 5.

R. D. Q. 235. Which shows tuning condenser where?

A. It shows tuning condenser at C.

R. D. Q. 236. Now, if you will, just go through each one of those, saying that.

A. Stone Patent 716,136, dated December 16, 1902, where the condenser is shown at C in the figure.

Stone Patent 717,514, dated December 30, 1902, where the condenser is shown at C in Fig. 3.

Stone Patent 725,634, dated April 14, 1903, where the tuning condenser is shown at C in Fig. 9.

Stone Patent 725,635, April 14, 1903, where the condenser is shown at C in Fig. 2.

Stone Patent 725,636, where the condenser is shown at C, in Fig. 3.

In citing these figures I do not cite them as the only instances where such tuning condenser is shown in these patents but merely take a figure as illustrative.

R. D. Q. 237. Mr. Waterman, can you now demonstrate the oscillation of this apparatus with the condenser disconnected?

(Witness demonstrates.)

The Court: I hear a scratch on the file distinctly.

The Witness: The condenser is now disconnected.

Mr. Bull: That is all.

Recross-examination.

By Mr. Darby, Jr.:

R. X Q. 238. I understood you to say, Mr. Waterman, that Fleming, the inventor, states that the circuit of his path is

aperiodic and consequently it is not oscillatory, is that correct?

A. I quoted what he said.

R. X Q. 239. That is correct substantially?

A. I may say whether such a circuit is or is not aperiodic [fol. 2595] depends upon the apparatus that is used. If the apparatus itself has sufficient capacity and sufficient lower resistance then it is oscillatory, and that proves to be the case here.

R. X Q. 240. That is merely incidental though, is it not?

A. That is usual. As a matter of fact such circuits used to be called aperiodic, but it is the usual thing to find them oscillatory, but it is not necessarily true that even if oscillatory they will have energy storage capacity enough to sustain oscillations in the valve because such oscillations imply that the circuit shall have some energy storage capacity that is appreciable as compared to the sensitiveness of the valve.

R. X Q. 241. The oscillations produced by this valve without the condenser are not of sufficient strength for any commercial purpose of transmission, are they?

A. In that particular apparatus probably not, no. It was not made for that purpose. That valve is a very small valve, made for detector purposes.

R. X Q. 242. Then you have taken what Fleming has called an aperiodic circuit and have made it an oscillatory circuit by merely controlling the capacity and inductance of the circuit, is that true, or have you added something in addition?

A. I have neither added anything nor have I controlled the constants of the circuit. The coil is just an ordinary wireless coil, such as has always been used; and an ordinary telephone is substituted for the galvanometer which Fleming shows.

R. X Q. 243. Can you make this valve oscillatory without the B Battery?

A. Certainly not.

R. X Q. 244. Is the B Battery shown in the Fleming Patent?

A. No, the B Battery is not shown in the Fleming patent, but that I assume has been sufficiently thrashed out in this case.

R. X Q. 245. Not for the purpose of transmission. Then you have in fact added an element to the Fleming circuit which is not shown in the patent?

A. Absolutely, I have added the battery. That I said in my former testimony.

Re-redirect examination.

By Mr. Bull:

R. R. D. Q. 246. Did you ever suggest, Mr. Waterman that you could with one of these valves generate current if you did not have any current to oscillate?

A. I certainly did not.

R. R. D. Q. 247. Or cause oscillations, rather, if you did not have any current to oscillate?

A. I certainly did not. There must be a source of energy. There must be a cold wire energy when you generate energy in your electric wires.

R. R. D. Q. 248. And that is what you specifically pointed out in answer to Mr. Darby's question at the last hearing, when he asked you if this circuit could be made to generate oscillations?

A. I did.

Re recross examination.

By Mr. Darby, Jr.:

R. R. X Q. 249. Is not the A Battery a source of energy for reception purposes?

A. For heating the filament prone only.

Mr. Darby, Jr.: For the sake of the record, I would like to have it noted that the B Battery employed is 150 volts.

R. R. X Q. 250. Are these the same valves, do you know, that were used at the last demonstration, or have they been constructed since that time?

A. Well, I know the valves that were used in the last demonstration are here.

[fol. 2596] R. R. X Q. 251. Are here?

A. Are here also; all; which one is used I do not know, but I do know, that is, I understand, that they have not been constructed since the last demonstration.

Mr. Darby, Jr.: Mr. Weagant, is this particular valve that was employed in the demonstration constructed since the last demonstration, or has it been altered in any way?

Mr. Weagant: No. They are all of the same lot. They were made two or three years ago.

The Court: Mr. Waterman seems to think even more than that.

The Witness: It is so long ago that I really forget just when.

The Court: They were just that lot of valves which you spoke of before; they were taken from what you have?

Mr. Weagant: Yes.

Mr. Darby, Jr.: I would like to ask Mr. Weagant; Mr. Weagant can probably tell us, if this particular valve is one that was refitted for detector purposes?

Mr. Weagant: I can say that it is not.

Mr. Darby, Jr.: It is not one that was refitted for detector purposes?

Mr. Weagant: It is not.

The Witness: There is one thing I think might appear on the record in connection with the fact that the voltage is 150, and that is this valve is one of very long spacing, fully $^3/_4$ of an inch between the nearest point of the filament and the plate, and as I explained at the last hearing, the voltage which is employed could not fag; and the lot of valves which Mr. Weagant and I were experimenting on when this was made was with that spacing.

Mr. Darby, Jr.: If your Honor please, I do not like to burden you with continued demonstrations or anything of that nature, but what I did want to show was this, and I do not know whether you would be interested in it or not, and if you are not interested in it we will drop it, but the Fleming patent calls for a valve containing a very high degree of vacuum. I am prepared to demonstrate if they keep this valve in the condition it is now that that valve is a low vacuum valve, and that if it is made of a high vacuum valve they cannot make it oscillate. It is true that it is a question of degree between the high and the low vacuum, but Fleming has put himself on record what he meant by high vacuum. He has done so again recently, in 1916, what he meant by high vacuum as used in his patent at that time.

Mr. Bull: We do not care what he meant by it.

The Court: Under well settled principles of the patent law, he is not the one to whom we have to refer.

Mr. Darby, Jr.: What was meant by him at the time the patent was drawn up?

The Court: It is a simple and well settled proposition that we do not get the man's own construction of his patent. If you did, why, every man who patented something would be sure to have a valid patent.

Mr. Darby, Jr.: Well, you will recall there were some letters offered by the plaintiff as exhibits on this question. [f. 2597] Mr. Darby: It is not a question of construction of the patent, it is a question of the physical structure.

The Court: I do not see that we gain anything by that at all.

Mr. Darby, Jr.: Except this, in the one instance they have got a high vacuum which is of high resistance across that path and in the other instance to have it control it at all they have to have a low resistance across that path.

A lot has been said about the condenser. We did not bring that up.

Mr. Bull: Excuse me, your father did if you did not.

Mr. Darby, Jr.: On the condenser?

Mr. Bull: Yes, the very first thing you said was about the condenser to me.

Mr. Darby, Jr.: In the trial?

Mr. Bull: Off the record.

Mr. Darby, Jr.: I mean on the record. I have not brought up the question of condenser at all because that is not the point on which we are relying. We accepted at the start Mr. Waterman's statement when the distribution capacity is sufficient you could make it oscillate provided you put in a B Battery and provided you have a gasless medium in there or other low degree vacuum absolutely contrary to what is called for by the Fleming patent, and I think the B Battery situation has taken care of itself.

We are prepared to make any test to show that with the degree of vacuum called for by the Fleming patent they could not make it oscillate even with the B Battery.

Mr. Bull: As to the degree of vacuation, I do not see what it has got to do with it, but I am prepared by Mr. Waterman to have him state what kind of vacuum that has got in it, if he knows.

The Court: Do you know, Mr. Waterman?

The Witness: I know, from the way it behaved.

The Court: What is your judgment?

The Witness: The filament was run during these adjustments at temperatures that are exceedingly high for even a tungsten filament, which temperatures are enormously higher than the carbon filament which Fleming's could have been run at. It had 150 volts on the space, and under none of these conditions was there a blue glow. That indicates a vacuum which is of very high order, probably of an order very much superior to anything that could have been obtained as a matter of physical fact in Fleming's day, so that it probably has not only Fleming's vacuum, but one very much higher than Fleming could have gotten.

Mr. Darby, Jr.: We are prepared to make an accurate measurement of that bulb, and with regard to its being of higher vacuum, it is a physical and scientific impossibility. I am informed by engineers that valve would not oscillate with 150 volts; it is a scientific impossibility, if it has a high vacuum.

The Court: I think your proposition is very simple. You have here the hot and cold electro device of Edison?

Mr. Darby, Jr.: Yes, sir. Now, in the course of description Fleming refers to a high vacuum, which is a relative [fol. 2598] term. Now they take one of these Edison electric bulbs and in connection originally with the detector Fleming made this invention by demonstrating that he could use this Edison device in certain relations and make the thing detect radio signals. Now then, they take for all practical purposes the same thing and insist that it can generate oscillations as well as detect. I do not think they insisted all of them could do it; about one per cent.

Mr. Bull: No; I pointed out at the last argument it was absolutely not so at all.

Mr. Darby, Jr.: He further testified he can not take any one of these bulbs, build one, and be sure it is going to oscillate.

The Court: You mean in the relation shown strictly in the Fleming patent?

Mr. Darby, Jr.: Yes, sir. That is, it is an idiosyncrasy.

The Court: If this experiment is true they have demonstrated that it can be done.

Mr. Darby, Jr.: In certain circuits, yes.

Mr. Darby: 150 volts is comparable with the voltage employed for different purposes.

The Court: My point is, that whatever the controversy is and the points of difference between the litigants, that the controversy is well exposed. I do not see that I will gain anything by an experiment which takes different bulbs and maybe gets a lesser result. Now, probably they would try 20 bulbs and maybe two of them would do the thing without the condenser and the 18 might not, for all I know.

Mr. Darby, Jr.: For the sake of the record, the experiment I wanted to make is this: Take any bulk and show where it will oscillate and show where it stops to operate. As I stated at the outset, you may not be interested.

The Court: Revolving on the question of high vacuum?

Mr. Darby, Jr.: Yes. What is high vacuum? Using Fleming's own statement, even of 1916, and even today when a man skilled in the art saw and read the words "high vacuum", what would he understand? The high vacuum obtainable, and then see what was the highest vacuum obtainable at that time, which is pretty nearly the same degree they can get now. I think that shows pretty nearly in the art.

Mr. Bull: You were not in the main case or you would have heard your brother counsel argue there——

The Court: Brother-father counsel.

Mr. Bull: Yes. That the vacuum of the Fleming patent was not any vacuum at all; it was all gas; they said it was full of gas.

The Court: In the main case the vacuum referred to was the vacuum of the order of an incandescent electric lamp. Now that being so and the case having been there fully considered both by this court and the Circuit Court of Appeals, upon that together with other matters, I do not see that on this question we gain anything at all by further experiment on the line indicated by you.

Mr. Darby: Could we, if your Honor please, along that line ascertain just what the vacuum is in the lamp that was tested?

The Court: I do not see any objection to that. Can you measure that now, or do you have instrumentalities?

[fol. 2599] Mr. Darby, Jr.: We have to have instrumentalities to measure it. I think if Mr. Bull and I can agree on some mutual third party to take charge of the valve and have it tested, we can have it done that way.

The Court: What kind of test do you have to make?

Mr. Bull: Mr. Weagant says they can never agree as to what the result was after it was measured: in other words there is no accurate method of determining from the outside what vacuum there is on the inside.

The Court: Let me ask you this, Mr. Waterman: this, as I understand, is a normal type of an incandescent lamp? Is that so?

The Witness: Absolutely.

The Court: And is fundamentally known and at all times has been known in the art as such?

The Witness: Yes.

The Court: With a vacuum?

The Witness: Yes, and the vacuum we are using is high for incandescent lamps; that is, they were of the best, and we tested the highest point voltage they would stand without beginning to produce a blue bulb and with the high temperature filament.

The Court: I do not see that we can gain anything, Mr. Darby.

Mr. Darby, Jr.: All right, sir. Are we to file briefs or memoranda?

The Court: Yes, I wish you would give me a memorandum practically on two points. I mean I do not confine you to that: if there is anything occurs to either of you you may add.

Point No. 1: Whether the use of the Battery B current in any manner affects the proposition of law which the plaintiff advances, that is to say, whether the use of that Battery B device, which was not shown in the Fleming patent, has any legal effect upon the comprehensiveness of the patent. Do you understand the point?

Mr. Darby, Jr.: Yes, sir.

The Court: Now then, the second point is: Assume for the purpose of the argument that the oscillating qualities of the Fleming valve when shown in the Fleming circuit without the condenser and even with the Battery B current is only occasionally perceptive, and assume further that the Fleming valve when used in the old Marconi circuit or in any other relation of circuits then known to the art does in point of fact clearly and plainly oscillate, then as applied to the oscillating qualities as distinguished from the detecting ones, may the plaintiff in seeking to have its present construction of the patent obtain, have the advantage of the situation of the Fleming valve with existing circuits

known to the art other than the circuit shown in the Fleming patent? Do you understand?

Mr. Bull: I think we do.

The Court: In other words, to explain that a little, when Fleming made this invention, which I held and the Circuit Court of Appeals sustained me, was a very marked advantage and a very meritorious invention for detecting wireless signals at a time when neither he nor any other scientist understood or appreciated that the same instru- [fol. 2600] mentality could generate wireless waves, must the patent be held within the strict limits of its physical disclosures, the diagrams and the words, or may it go to the point of taking in any result which was obtainable by using precisely that same device with other well known circuits? Now, there is the whole case.

Mr. Darby, Jr.: How about the time?

The Court: Anything that is within reason.

(Briefs to be submitted June 3, 1919.)

UNITED STATES DISTRICT COURT, SOUTHERN DISTRICT OF NEW YORK

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA,
Plaintiff,

against

DEFOREST RADIO TELEPHONE & TELEGRAPH COMPANY,
Defendant

MEMORANDUM OF MAYER, D. J., HOLDING "AMPLIFIERS" WITHIN ORIGINAL DECREE—Filed July 11, 1917

This is the return of an order to show cause why the decree and injunction heretofore made and issued do not cover and include certain devices which defendant makes and sells and why the reports already filed should not be extended to include such devices.

The devices in question are called "amplifiers" and "oscillions."

In the first place, this procedure is correct. It has frequently been followed in this Court and, as I understand, approved by the Circuit Court of Appeals.

The opinions of the Circuit Court of Appeals and of this Court on the main controversy so fully discussed the essential features of the patent and the infringing devices that it must be assumed that the litigants are, by this time, fully informed of the views of the two courts. As in the original case, there is again the use of "audion" language which is more or less meaningless from the standpoint of the patent law and certainly does not add to a clear understanding of what has now become reasonably simple, even in an abtruse art.

1. An amplifier consists really of two or more detectors in tandem with a telephone transformer interposed between each element of the series. The primary element of such an amplifier may be either an audion or any other form of detector. In some of the amplifier sets sold by defendant [fol. 2001] ant, the primary element is a part of the outfit. In other instances, the primary element is not part of the outfit. (See Exhibit E, J. 2.)

I fully agree with Waterman on his facts and explanation as to the "amplifiers." In other words, an "amplifier" is part of a detector. In any event, the case falls under the familiar rule of *Bobbet v. Enos*, 91 U. S. 150, 457, many times since reiterated and followed. I have no doubt whatever that the motion in this regard must be granted.

2. I am not clearly convinced that the Fleming valve can perform the functions of an "oscillion" so as to oscillate and generate radio waves. On this branch it will be necessary to give demonstrations or oral testimony, or both, and witnesses should be subject to cross-examination. This is really equivalent to a trial. My view is that where the court on an application of this kind is not clearly convinced that the motion should not be granted, then the proceeding should be by bill and answer because the inquiry necessarily develops into a trial and, therefore, the issue should be clearly joined. There is usually little saving of time or labor in short cuts.

The motion, therefore, as to "oscillions" is denied.
Submit order on two days' notice.
July 11, 1917.

Julius M. Mayer, District Judge

United States District Court, Southern District of New York

Marconi Wireless Telegraph Company of America, Plaintiff,

against

DeForest Radio Telephone & Telegraph Company, Defendant

Opinion of Mayer, D. J., Holding "Oscillations" Interpolements. Filed July 7, 1919

J. Edgar Bull and L. F. H. Betts, of New York City, for Plaintiff.

Samuel E. Darby and Samuel E. Darby, Jr., both of New York City, for Defendant.

Final hearing on supplemental bill.

Mayer, District Judge:

The Fleming patent No. 803684, so far as concerned a [Fol. 2602] detector for radio waves, was fully discussed in *Marconi v. DeForest*, 236 Fed. Rep. 942; affirmed 243 Fed. Rep. 560.

The effect of the decision *supra* of this court, as affirmed by the Circuit Court of Appeals, *supra*, was to accord to Fleming's invention a high place in the art.

Eight or nine years after the date of the Fleming patent — the exact dates are unimportant — Armstrong, Hogan, Waterman, Weagant and probably other experts in the radio art, while using these devices as radio wave detectors, independently observed that the detectors possessed the function of oscillating or, in other words, of generating radio waves. This was an extraordinary additional property or function of the so-called incandescent lamp detector of which Fleming had no knowledge.

Claim 1 of the patent in suit read:

"1. The combination of a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for heating one of the conductors, and a circuit outside the vessel connecting the two conductors."

While the claim covers broadly the device when used in the radio art, yet when read with the context of the specification, it is plain that Fleming's disclosure was addressed to use of the instrumentality as a detector only.

It is, however, a principle of the patent law—so well settled as not to call for citations of authority—that a patentee is entitled to all of the benefits of his invention whether or not known to or foreseen by him.

Thus, the first inquiry is whether the Fleming valve, as disclosed by the patent, will oscillate when used in circuits and with instrumentalities available as of the Fleming date and of the kind and character which, upon the evidence, it would be assumed would or could have been used as of that date.

The testimony of the experts and numerous demonstrations in the court room (some required by the court by way of extra caution and assurance), proved beyond peradventure that the two element valve possesses inherently the same capacity for generating radio waves as is possessed by defendant's three element device.

The only question in this connection is whether plaintiff, in order to hold this feature of the Fleming invention, may use a battery.

Obviously, the Fleming valve cannot oscillate unless a battery is used; but, to use a battery would, of course, not involve invention, once it is determined that the Fleming valve possesses inherently the ability to generate radio waves.

As counsel for plaintiff aptly say, "one might as well ask whether a boiler could be made to generate steam without a fire under it or whether a dynamo could be made to generate electricity without an engine to drive it."

Indeed, on this branch of the case, the question is whether, in order to make the Fleming valve oscillate, anything need be done or added which would amount to invention. As the answer to this inquiry is plainly in the negative, one necessarily returns to the proposition that as Fleming gave the art a new instrumentality, and as that instrumentality [fol. 2003] without inventive changes or additions will oscillate as well as detect, he is entitled to this feature although unknown to him.

The next question is: If the two element valve will certainly and reliably oscillate in common and well-known detector circuits of Fleming's day (Marconi or PN circuit), but will not certainly and reliably oscillate in the precise circuit shown in the Fleming patent without a condenser, is Fleming entitled to the benefits of the device as a generator of oscillations?

The valve was made to oscillate without a condenser although the action in this regard is not certain and reliable; but, this latter fact is immaterial.

The main case has really disposed of this point because this court and the Circuit Court of Appeals have held, inter alia, that Fleming's contribution was the device per se, which could be used in any circuits and with any instrumentalities then known to the art.

Bell Telephone Case, 126 U. S. 1.

Indeed, the case on analysis is much simpler than when first presented.

On preliminary impression there is reluctance to extend the patent to an unexpected characteristic only observed after a considerable lapse of time by the highly skilled men who are students in the art.

Yet, after all, it was Fleming who made this remarkable contribution of a wholly new device which, of itself, and its development has done so much toward the practical advance of this great art.

The case is fully as meritorious as Western Electric Company vs. La Rue, 139 U. S. 601, 605, which, as nearly as may be, presented an analogous question.

Under the authority of that case it is clear that where there is a capacity of reversibility with the same instrumentality, the courts will not restrict the claim to one attribute to the exclusion of the reversible attribute; and, for that matter, this case is stronger than the La Rue case because Claim 1 supra is broadly for the instrumentality.

It is concluded, therefore, that the so called oscillation of defendant intringes and that the decree heretofore filed should be extended thereto with costs.

Submit decree accordingly not later than July 11, 1919.

Julius M. Mayer, District Judge.

July 7, 1919.

[fol. 2604] At a stated term of the United States District Court for the Southern District of New York, held in the United States Court Rooms, in the Borough of Manhattan, City and State of New York, on the 9th day of July, 1919.

Present: Hon. Julius M. Mayer, U. S. D. J.

In Equity No. 12-31. On Fleming Patent No. 803,684

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA,
Plaintiff,

vs.

DEFOREST RADIO TELEPHONE & TELEGRAPH COMPANY,
Defendant

This cause having come on to be further heard on the supplemental bill of complaint and answer and proofs taken and filed on behalf of both parties herein and counsel for the respective parties having been heard and due consideration having been had, it is, upon motion of Sheffield & Betts, Solicitors for the Plaintiff,

Ordered, adjudged and decreed that in addition to the devices or apparatus heretofore manufactured and sold by the defendant and decreed to be an infringement of claim 1 of the Fleming patent No. 803,684, in suit, the devices or apparatus called by the defendant "oscillions" which have been manufactured and sold by the defendant separately, as well as the devices or apparatus which the defendant has manufactured and sold comprising "oscillions" alone or in combination with other apparatus or instruments are infringements of said claim 1 of the said Fleming patent in suit; and that any bulbs embodying said claim 1 manufactured and sold by the defendant for use in such "oscillions" or combination of "oscillions" and other instruments or apparatus, are also an infringement of said claim 1, of the said Fleming patent in suit; and that the injunction ordered to issue out of and under the seal of this Court by the Interlocutory Decree of October 9, 1916, and said Interlocutory Decree shall cover and include each and all of such devices or pieces of apparatus and that the defendant shall account to the plaintiff for all damages and profits to which the plaintiff may be entitled by reason of such infringing manufacture and sale as provided for in said Decree of October 9, 1916.

And it is further ordered, adjudged and decreed that the plaintiff, Marconi Wireless Telegraph Company of America, do recover of the defendant, DeForest Radio Telephone

[fols. 2605-2606] and Telegraph Company, the costs and taxable disbursements in connection with said supplemental bill of complaint herein and the trial thereunder.

(Sgd.) J. M. Mayer, U. S. District Judge

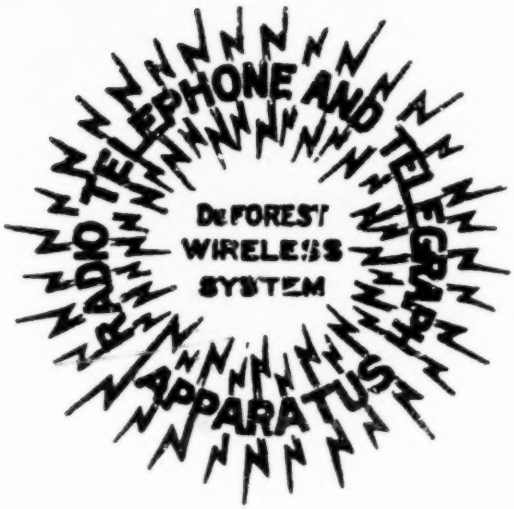
It is hereby consented that the above order may be entered without further notice.

(Sgd.) Sheffield & Betts, Plaintiff's Solicitors: (Sgd.) Darby & Darby, Defendant's Solicitors.

PLAINTIFF'S EXHIBIT NO. 1

Bulletin D 16

De Forest Radio Telephone Apparatus



Manufactured by

De Forest Radio Telephone & Telegraph Co.

NEW YORK CITY

Domestic Sales Office
101 Park Avenue

Factory and Foreign
Sales Office
1391 Sedgwick Avenue

Cable Address: Radiotel, N. Y.

2607

SOME FACTS ABOUT THE DE FOREST RADIO TELEPHONE AND TELEGRAPH

Compared with the ordinary wireless telegraph, the Radio Telephone can transmit from five or ten times as many words per minute.

As regards its ability to work through adverse interference, static disturbances, etc., the Radio Telephone is actually superior to the Wireless Telegraph. The British Admiralty Tests demonstrated this particularly. Such a percentage of accuracy, for example, as that of only two errors out of a list of 154 numbers (some of five and six figures) as a distance of 50 miles, through severe interference, would have been impossible by means of the spark telegraph.

To replace flag-signalling at sea the Radio Telephone, calling off merely the numbers of the code signals used, has clearly demonstrated its great merit, and this for distances ten times those possible by visual signalling, through fog, smoke, or foul weather, by night as well as day, and with a hundred fold greater speed.

The apparatus is thoroughly reliable. When once properly installed and adjusted, it is simply necessary to turn on the power and throw the transfer switch to one position for talking and to the other for listening.

The transmission of speech is perfect. It is at least as clear and distinct as that over a wire telephone line if not more so.

The experiments conducted at the naval station at Arlington (Washington, D. C.), whereby speech was transmitted to Paris, San Francisco and Honolulu, were carried out on this same system, under license of our patents. This speaks volumes for the range and clearness of speech.

The apparatus is compact and comparatively inexpensive, both from the standpoint of initial and operating costs.

Where electric power is available, the Radio Telephone Set is operated from it by means of a motor generator furnished. The consumption of power is low and entirely within the capacity of any standard electric lighting plant.

Where no electric power can be obtained, a small gasoline engine is furnished, connected to a generator either directly or by belt.

APPLICATIONS

For yachts and house boats. The Radio Telephone enables the captain or owner to talk to the home, club house or to other craft, saving time and obtaining an instant reply.

For all classes of commercial ships, barges, tugs and lighters. The captain can be in touch with the office and passing ships. No special operator is needed.

For intercommunication between islands and with the mainland, e.g., along the Carolina and Florida Coasts, in Delaware and Chesapeake Bay, the Thousand Islands, etc., the apparatus is now available.

For Revenue Service, coast and inland Surveys, Forestry, etc., the Radio Telephone has a large field.

For connecting offices and factories where wire telephone tolls are excessive or service unreliable.

For emergency or regular service by electric transmission companies to insure communication between generating and sub-stations and switching points at all times.

For communicating on railroads between towers and moving trains. This will be of immense service where unnecessary stopping of trains is an item of importance.

AND A THOUSAND OTHER VALUABLE USES

We particularly desire to introduce the Radio Telephone for river work—on the waters of the Mississippi and tributaries, not only for steam boats where it is convenient or a genuine economy for the captain to talk direct to a landing station or another boat long before his arrival or passing, but between small towns and stations on opposite banks between which there is no telephone cable.

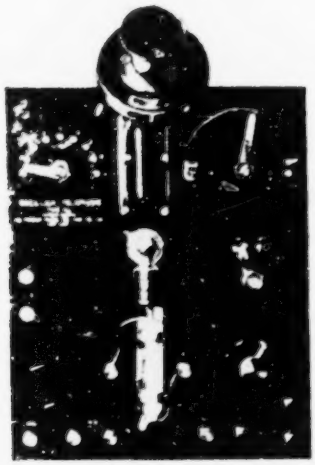
As shown in the accompanying cuts the new type of De Forest Radio Telephone is distinctly different from all other types in every particular, from principle to detail, it marks a great advance.

Simplicity of operation and greatest possible freedom from adjustment have been carefully sought, and the present model can be easily manipulated by any intelligent person who follows the very few instructions which are needed.

The arc used in previous types has been completely eliminated. The generator of the high frequency currents is a modification of the now famous De Forest Audion which has been in use for years in the best commercial wireless stations. The Bulletin of the United States Bureau of Standards shows that the Audion is fully 50 per cent more sensitive than any other known form of detector. Its use has doubled the receiving range of wireless equipment during the past few years. It is employed almost to the exclusion of other detectors by the U. S. Navy. The Audion is the one device, above all other factors, which made possible telephony from Coast to Coast on the Bell Telephone System.

It is entirely fitting, therefore, that a form of this famous device should have been developed into a generator of high frequency currents for telephoning without wires, for its constancy and thorough reliability are its distinguishing features and these are absolutely essential in a practical commercial wireless telephone.

RADIO TELEPHONE
Type OJ



The cut illustrates the smallest size of transmitter. All the instruments are mounted on a panel of Formica measuring 11 by 18 inches, including the oscillion Bulb or Tube, potentiometer for close regulation, filament rheostat, impedance coils, loading inductance, telephone transformer coil, microphone transmitter, fixed condenser and minor accessories. With the set a battery delivering 150 to 300 volts is required. This may be composed of flashlight cells, or a motor generator is supplied where the set is to be used a great deal. The filament operates from a small storage battery. A variable condenser in oil is needed also and is connected to binding posts V C

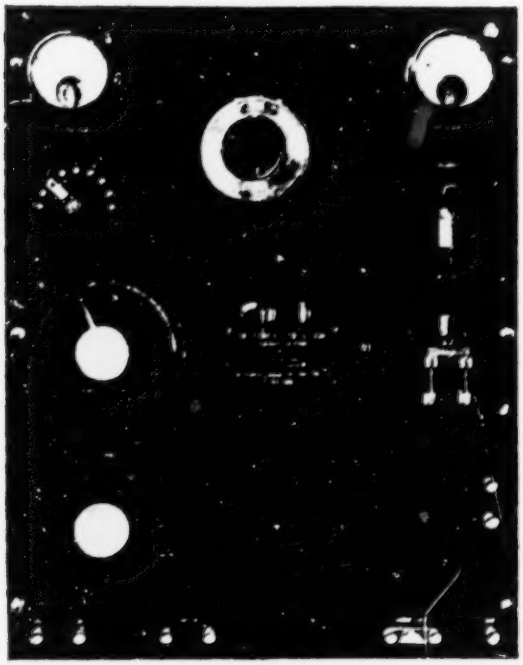
This type of set is particularly adapted for yacht use to communicate to club houses, other ships and residences; also for any purpose where a radius of from one to five miles is sufficient. It may be used as a wireless telegraph transmitter of continuous waves as well, having two or three times the telephone range.

The life of the Oscillion Bulb or Tube when properly used is from 300 to 500 operating hours, equivalent to about a year's service. The set is extremely simple. Once adjusted, no attention is required other than to keep the batteries charged.

This type of radio telephone is furnished as a transmitter only or complete with receiving cabinet and all accessories, as desired. It occupies small space, is simple to install, can be operated by almost any one and is thoroughly reliable and efficient.

RADIO TELEPHONE

Type OB1



The cut illustrates the standard radio telephone transmitting panel, measuring 18 by 24 inches. Upon it are mounted all the various parts, all of which, except the transmitter arm, the loading inductance switch, the variable condenser knob, and meters are mounted on the rear. This protects the parts and simplifies the operation.

On the rear are placed the large Oscillion Bulb or Tube, the cooling fan for same, loading coil, telephone transformer and variable condenser, impedance coils and minor accessories.

The two ammeters on the front of the panel operate at highest efficiency, the one showing the filament current and the other the radiation. By this the operator actually sees himself talk, for the speech causes corresponding deflections of the pointer, showing at all times the condition of the set at a glance.

With the set a motor generator is furnished, designed to operate on any available electric circuit. This furnishes 1,200 volts direct current to the Oscillion.

This small type of set has successfully transmitted speech over a distance of 100 miles, in connection with an antenna 300 ft. high. With a lower antenna, the range would, of course, be less. The set is recommended that it may be employed also as a wireless telegraph transmitter of continuous waves. Its range when so used is from two to three times the telephone range, where the Ultraudion Detector is employed at the distant station.

With this transmitter it is only necessary to connect the antenna and ground to the proper binding posts, connect to the 110 volt direct current source and to the generator and the set is ready to operate. When 110 volts direct current is not available a second generator is provided, directly connected to the motor of the motor generator, to supply same.

For telegraphing where a crystal detector or a plain audion detector is used at the distant station, we supply a chopper or whistling circuit, at additional cost, so that the signals may be received. But it is always recommended, on account of the greatly increased range, to transmit undamped or continuous waves and equip the distant station with the Ultraudion Detector or Receiving Cabinet.

When this transmitter is adjusted to the desired wave length no further change is required, it being merely necessary to throw the transfer switch from talking to listening or vice versa.

The set is furnished as a complete transmitter, ready to install, or as a complete sending and receiving station, as desired.

RADIO TELEPHONE

Type OB2.

This is a larger panel than the Type OB1 Radio Telephone transmitter and is equipped with two Oscillion Bulbs or Tubes having a cooling fin common to both. The output is approximately 250 watts into an antenna of 10 ampères. The motor generator is also of larger capacity, delivering 1,500 volts to the Oscillion Tubes.

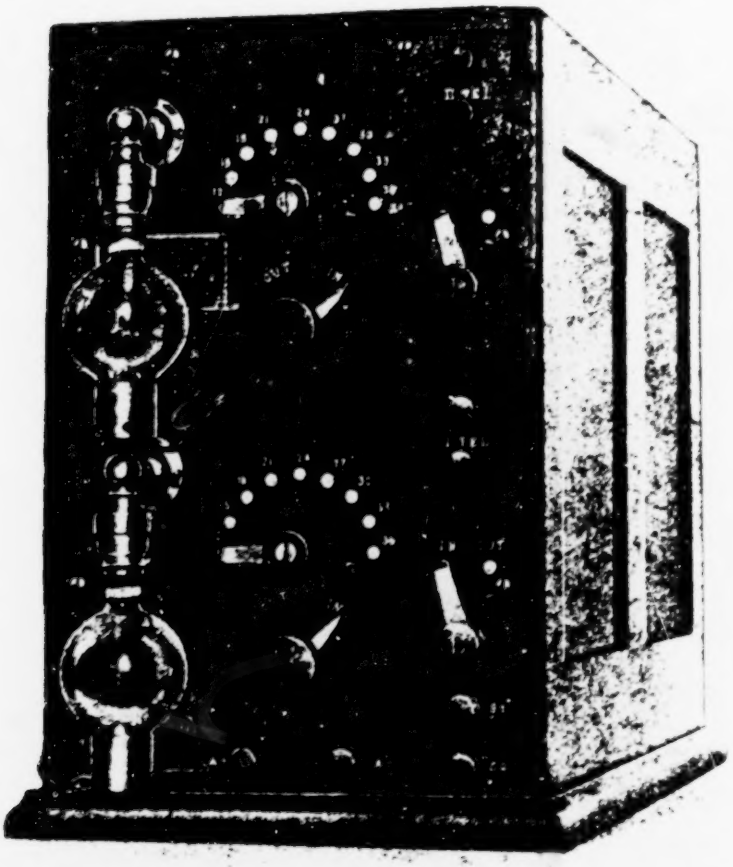
With a suitable antenna the telephone range is from 150 to 200 miles over water and the telegraph range about twice to three times this where the Ultraudion Detector is employed at the distant station.

It may be used either as a telephone or a telegraph, and where a crystal detector is employed at the distant station the transmitter is equipped with a chopper or whistling circuit as in the Type OB1 Transmitter.

With each set of every type complete instructions are furnished.

Prices are quoted on receipt of specifications as to range desired, character of service whether public or private, character of land between stations and kind of power available. If possible a rough sketch should be sent, showing altitudes and general contours to enable us to quote intelligently.

AUDION AMPLIFIER



Type P 2, Two-Step Amplifier.

The De Forest Audion Amplifier in connection with the fies the sound of the received voice, or signals, from 5 to 1, the type supplied.

This device increases signals of small intensity with absolute fidelity, and without lag or distortion and is thoroughly reliable. It is the one device, which above all other makes possible telephone communication between the Atlantic and Pacific coasts on the lines of the Bell system. (The A. T. & T. Co. is licensed under the DeForest Audion Patents for wire telephone work.)

Where a greater volume is desired than the Radio Telephone Sets provide, or where the distance between stations is greater than the range of the Set alone, the Amplifier will enable the desired results to be obtained.

This instrument is made in several styles with various degrees of amplification and is more fully described in our special bulletin covering same.

N. B.—This Company owns all the wireless telephone patents of Dr. Lee de Forest and John Stone Stone, covering every method of loose coupling, tuning, microphone-in-earth-connection, audion and audion amplifier, etc., etc. We own or are licensed under 185 U. S. Letters patent. Infringers of our telephone system patents will be prosecuted.

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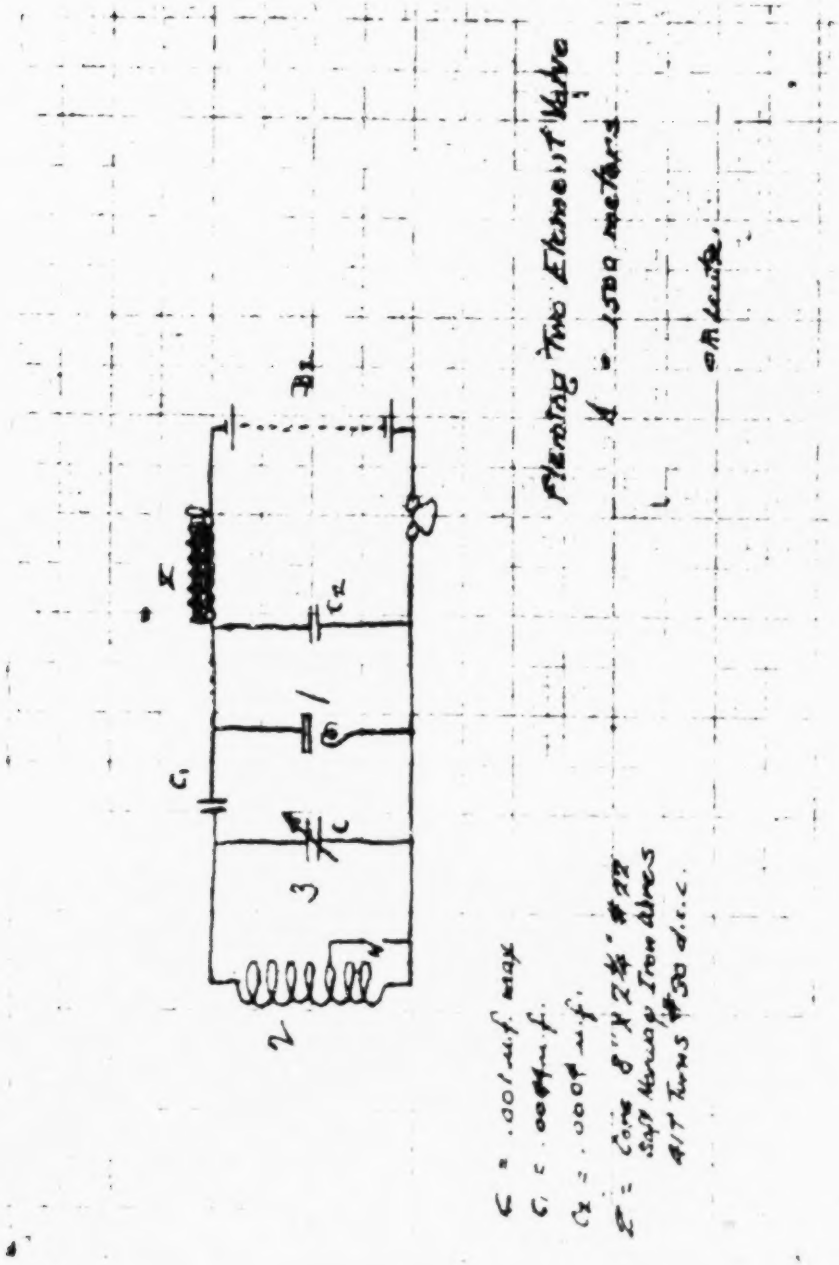
PLAINTIFF'S EXHIBIT NO. 2



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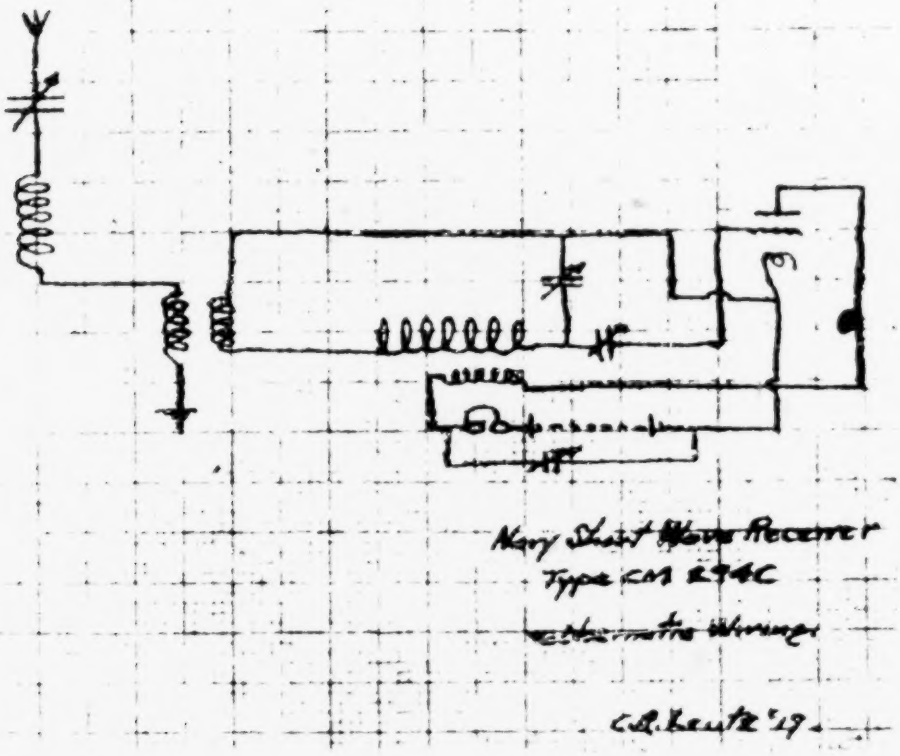
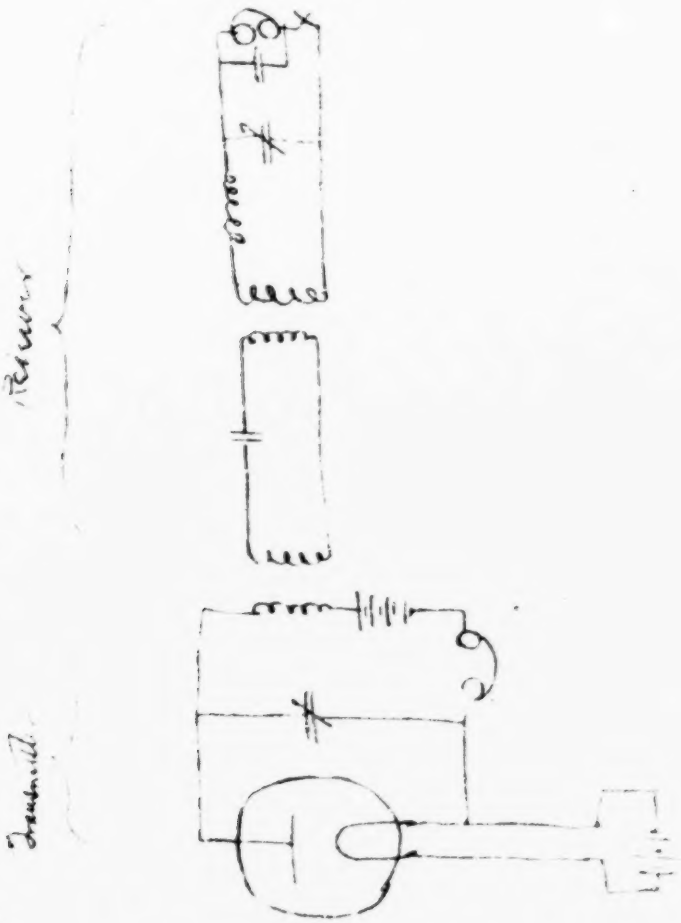
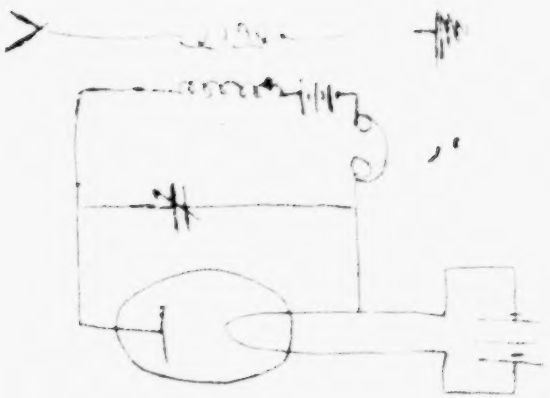
PLAINTIFF'S EXHIBIT No. 3



Plaintiff's Exhibit Waterman's Sketch
(May 16 1919)





90

PLAINTIFF'S EXHIBIT

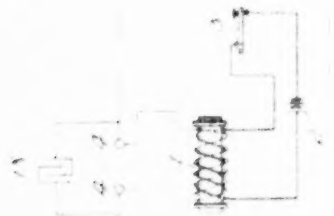
No. 706,735 Patented Aug. 12, 1902

R. A. FESSENDEN

WIRELESS TELEGRAPHY

Application filed Dec. 15, 1900.

(No Model.) 3 Sheets—Sheet 1



WITNESSES:

INVENTOR

Reginald A. Fessenden

by Dannie & Wilcox

Atty.

91

No. 706,735 Patented Aug. 12, 1902

R. A. FESSENDEN

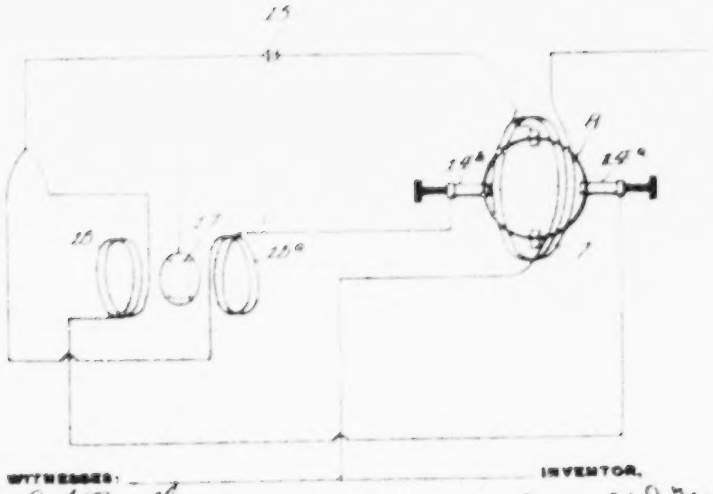
WIRELESS TELEGRAPHY

Application filed Dec. 15, 1900

No Model. 3 Sheets—Sheet 2

FIG 2

FIG 5



WITNESSES:

Herbert Bradley

F. M. Dunipace

INVENTOR.

Reginald A. Fessenden

by Fessenden & Dole

2619

92

No. 706,735

Patented Aug. 12, 1902.

R. A. FESSENDEN.

WIRELESS TELEGRAPHY

Application filed Dec. 10, 1900.

(No Model.)

3 Sheets—Sheet 3

FIG 3

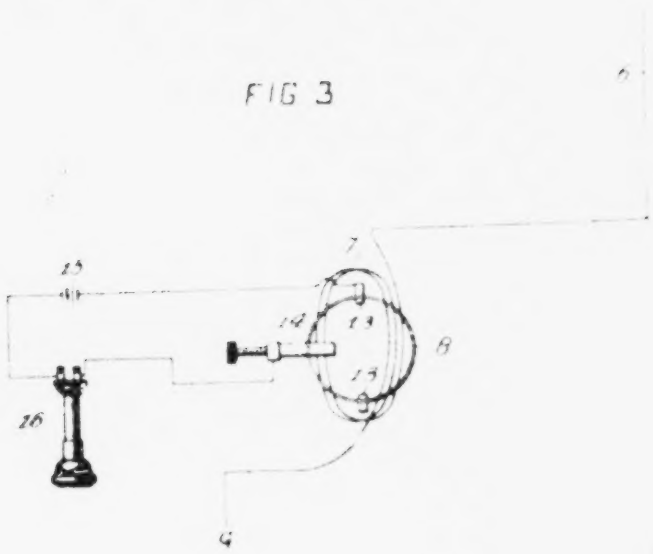
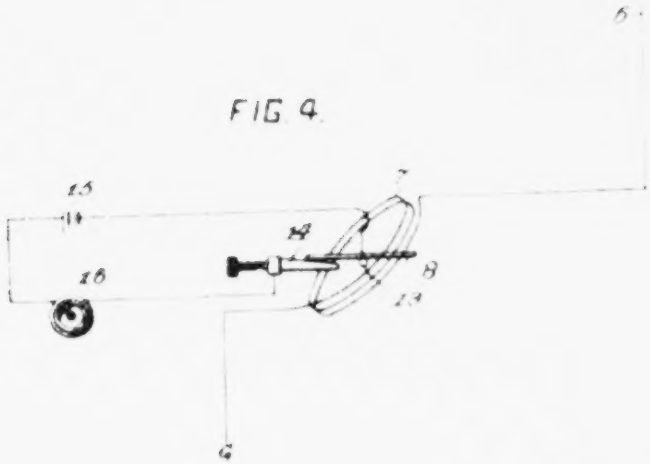


FIG 4.



WITNESSES:

Robert Bradley

F. W. Dappen

INVENTOR,

Reginald A. Fessenden

by Dennis & Wolcott

Att'ys

:30112

UNITED STATES PATENT OFFICE.

REGINALD A. FESSENDEN, OF ALLEGHENY, PENNSYLVANIA.

WIRELESS TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 706,735, dated August 12, 1902.

Application filed December 15, 1898. Serial No. 740,419. (No model.)

To all whom it may concern:

Be it known that I, REGINALD A. FESSENDEN, a citizen of the United States, residing at Allegheny, in the county of Allegheny and State of Pennsylvania, have invented or discovered certain new and useful Improvements in Wireless Telegraphy, of which improvements the following is a specification.

The invention described herein relates to certain improvements in the electrical transmission of signals from one station to another without the use of conductors connecting such stations.

In the methods heretofore employed the electromagnetic waves generated at the receiving-station produce voltages in the receiving-circuit. These voltages passing through a suitable material normally non-conductive render the same conductive, and thereby permit the passage of a current through a circuit in which said material, usually termed a "coherer," is included. After the cessation of the voltages produced by each series of electromagnetic waves generated at the sending-station the coherer must be operated on in some way to restore it to normal or non-conductive condition.

The object of the present invention is to provide for the generation by currents produced by electromagnetic waves of currents in a second element or circuit and by the reaction of the current in this second element or circuit on the field formed or produced by the currents in the receiving-wire to produce motion which is directly or indirectly observable.

In general terms the invention consists in the generation by electromagnetic waves of a current directly or indirectly in coils at the receiving-station, the current in said coils inducing a current in another element or circuit which is arranged in such relation to the coils that the current induced therein reacts with the field produced by the coils, thereby producing motion.

The invention is hereinafter more fully described and claimed.

In the accompanying drawings, forming a part of this specification, Figure 1 is a diagrammatic view showing the arrangements employed at the sending and receiving stations. Figs. 2 and 3 are diagrammatic views illustrating modifications of the receiving apparatus. Fig. 4 is a side elevation of the apparatus shown in Fig. 3, and Fig. 5 is a further modification of the receiving apparatus.

The apparatus employed at the sending-station may be similar to that now in use for the generation of electromagnetic waves and consists of an induction-coil 1, having its primary coil in circuit with a generator 2, said circuit having a make-and-break mechanism 3 included therein. One of the discharging knobs or terminals 4 is connected with the vertical sending-conductor 5, while the other knob or terminal is grounded. I have found that by placing a capacity formed by a body 5ª of conducting material having a comparatively large radiating-surface the waves generated at the sending-station have a very much higher energy, thereby correspondingly increasing the effect or energy of the current produced in the receiving-conductor.

The terms "sending-conductor" and "receiving-conductor" are employed herein as indicating all of the circuits at the sending and receiving stations from top to ground, if grounded, or if not grounded from one extreme end to the other extreme end, including all apparatus in series with the circuits, while the term "radiating portion" indicates all of the sending-conductor from top or extreme end of same to point of junction with the apparatus for effecting the oscillatory charging and discharging thereof, such as sparking terminals, transformer-coils, armature-windings, &c. By the term "electromagnetic waves" as used herein is meant waves of a wave length long in comparison with the wave length of what are commonly called "heat waves" or "radiant heat." By "grounded conductor" is meant a conductor grounded either directly through a capacity, an inductance, or a resistance, so that the currents in the conductor flow from the conductor to ground, and vice versa, when electromagnetic waves are being generated. The terms "tuned" and "resonant" are used herein as one including the other. By the term "current-operated wave-responsive device" as used herein and by me generally is meant wave-responsive devices having their contacts good contacts and operated by currents produced by electromag-

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netic waves. They are hence to be distinguished from wave-responsive devices depending for operation upon varying contact resistance.

At the receiving station the receiving conductor is formed by a wire or wires 6, projecting up vertically or at an inclination to a suitable height, which are also grounded. A coil or coils 7 are arranged in the circuit of the receiving conductor 6, and an element or coil of wire 8, forming a closed circuit, is supported with a freedom of movement in such relation to the coil or coils 7 that the current produced by the electromagnetic waves will induce a current in the element 8. The element 8 is supported, preferably, in such manner that a plane at right angles to its axis will form an angle of approximately forty-five degrees (45°) with a plane at right angles to the axis of the coils 7, so that the reaction of the current induced in said element with the field produced by the coils 7 will cause the element 8 to move with reference to the coils 7. This motion of the element may be observable by means of a mirror 9, attached thereto, reflecting a beam of light on a scale, or said element may form a part of the circuit of a recording-siphon, &c.

As shown in Fig. 2, the coils 7 may be connected to the secondary coil 11 of a transformer whose primary coil 12 is connected in series with the receiving-wire.

A desirable means for transforming the electromagnetic waves into recordable motion is shown in Figs. 3 and 4. The element 8 is balanced on supporting-rods or knife-edges 13, one of which is formed of a good electrical conductor, as silver, the element 8 being preferably formed by a silver ring. A carbon block 14 is so arranged that a portion of the ring between the supporting-rods will normally rest lightly thereon. This microphonic contact, the conducting pivotal support, and the portion of the ring between them form parts of an electric circuit, which also includes a generator 15 and a recording instrument 16 as a telegraphic sounder or the receiver of a telephone. When a current is generated, as above described, in the coil 7, the element or ring 8 will be caused to press on the carbon block, thereby increasing its conductivity. When using a telephone-receiver as a recording instrument, the generator 15 is preferably of a character capable of producing an alternating current, as such current causes a constant vibration of the diaphragm, the vibrations increasing in intensity with an increased flow of current in the circuit. This increase in intensity of action with increased flow of current is characteristic of this form of receiver and also of the form shown in Fig. 1. In this it is sharply differentiated from such devices as the coherer, which either give a strong indication or do not give any. This characteristic is advantageous in that if the signal sent—any dot—be too weak to give an action of the full intensity it may still in most cases be read and not missed entirely, which is of value in sending code-messages.

In the construction shown in Fig. 5 the circuit of the generator is divided, one branch including a coil 16 and connected to a microphonic contact 14, while the other branch of the circuit includes a reversely-wound coil 16' and is connected to a microphonic contact 14'. These contacts are arranged on opposite sides of the ring 8 and are so adjusted that the ring will normally rest equal on both blocks, so that an equal current will flow through both of the coils 16 16', thereby maintaining a magnetic bar 17, suspended between the coils in equilibrium with relation to the coils. Adjustable resistances may be placed in the circuits of the coils, thereby avoiding the necessity of delicate adjustments of the carbon blocks. When the coils and the ring or element 8 are energized, the pressure of the latter on one contact is increased and that on the other decreased, thereby correspondingly changing the resistances in the two branches. The increased flow of current through one coil and decreased flow through the other coil, due to the change in resistances, will produce a greater movement of the magnetic bar 17 than if only a single coil were used. The movement of the bar 17 can be rendered observable in many ways known in the electric signaling art—as, for example, by securing a mirror thereon.

As shown in Fig. 1, a condenser 19 may be connected in shunt with the field coil or coils 7 for the purpose of obtaining as large a current as possible in the field-coil 7, as this increase in current will give a greater torque to the ring 8. When no condenser is employed, this large current must flow in the vertical wire, and there would be great loss of energy on account of the resistance of wire 6, and, further, without the condenser a large amount of energy will be required to give the statical charge to the receiving-conductor. Hence on account of the small energy furnished by the wave a large current cannot be obtained in field coil or coils 7 without the condenser. By employing a condenser of the proper size current in wire 6 may be made to have a value equal to the difference between the current in the field coil or coils and the current in the condenser. Either of these currents may therefore be large and either or both may be used to produce motion, while the current in wire 6 may be kept so small that there is practically no loss of energy on account of its resistance or of the statical charging of the receiver, and all the energy may be used in producing motion. Without the condenser the current in the field coil or coils 7 will be practically a quarter phase behind the voltage on account of the self-inductive lag in the field-coil. If the condenser were substituted for the field coil, there would be a current in it nearly a quarter-phase in advance of the voltage due to the capacity lead. When both the

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field coil and the condenser are introduced one in shunt with the other, there will be a current in the field coil or coils lagging ninety degrees (90°) and in the condenser a current leading ninety degrees (90°). The sum of two currents one hundred and eighty degrees apart in phase is equal to the difference between their values. Hence if there is a current in the field coil or coils of one ampere and in the condenser a current of nine-tenths (9/10) of an ampere the current in the receiving-wire will be one-tenth (1/10) of an ampere.

By the employment of a condenser in shunt with the coil or coils 7 the current in the receiving wire is reduced without reducing the current in the coil or coils 7, so that the resistance-drop, which is at times sufficiently great to affect the operation of the system, is eliminated or so reduced as not to have any material effect.

It is preferred to place a shunt circuit containing a condenser across the terminals of the induction-coil at the sending-station for the purpose of maintaining sustained radiation. This shunt-circuit must be tuned to the receiving-conductor; otherwise the oscillations produced by it will have no action upon the wave-responsive device at the receiving-station. This shunt-circuit by virtue of its capacity stores up an additional amount of energy, and when a spark passes across the gap, since the sending-conductor can radiate energy at a given rate, it must continue to radiate for a longer time in order to dissipate this additional stored-up energy.

I am aware that apparatus consisting of a fixed primary and a movable secondary circuit has been used for detecting oscillatory currents. This apparatus was a modified form of an earlier alternating voltmeter, a silver disk or thick-rimmed annulus being substituted for the wire coil used in the voltmeter and delicately suspended so as to have a long period of swing. This apparatus was used not for the purpose of detecting electromagnetic waves emitted and received by unclosed circuits, but for detecting the magnetic inductive effects which one closed circuit (having rapidly-oscillating currents produced in it by a transformer, Hertz oscillator, or other suitable means) produced on another closed circuit. The effects to be obtained by such an apparatus were therefore different in kind from those sought in wireless telegraphy and the method of producing them were different from that described herein. This Northrup apparatus was used to detect magnetic-induction effects to a distance of approximately one hundred yards. Although distances somewhat longer could doubtless have been attained with such apparatus, the method employed by Northrup is not available for commercial wireless signaling, as magnetic-induction effects fall off as the cube of the distance, and approximately ten thousands of millions times the energy would be required to obtain effects with the Northrup apparatus at a distance of one hundred miles.

The construction of Northrup's receiving instrument is not suitable for the purposes of wireless telegraphy, as the movable member consists of a disk or thick-rimmed annulus, whereas the movable member of the receiving-mechanism for wireless telegraphy should be a ring formed of thin wire (indicated at 8 in the drawings) having a ratio of internal and external diameters equal or approximately equal to unity. If a disk or thick-rimmed annulus should be used as the movable member of the receiving-mechanism for wireless telegraphy, the efficiency of such mechanism would be so greatly reduced as to render it inoperative, for the reason that the currents induced in the disk or thick-rimmed annulus tend to get as near as possible to the center of such parts, and thereby weaken the reactive effect between the fixed and movable parts and to exert small torque, and, further, as the disk and thick-rimmed annulus have low self-induction the currents induced in them tend to get out of phase with the currents in the fixed coil or coils, and hence the torque is weakened. Moreover, the period of oscillation of a disk or thick-rimmed annulus for a given restoring force is so long that extremely-powerful restoring forces must be used to enable a mechanism having such a movable member to record signals at commercially-practical speeds, and since the force varies as the square of the speed deflecting forces many thousands of times greater must be employed than is required in the receiving-mechanism described herein. In other words, the thin light ring 8 will work with but a fraction of the energy required to operate a disk or thick-rimmed annulus. By the employment of a thin ring of good conducting material and a fixed coil of few turns, as shown in the drawings, the electrical forces between fixed and movable members of the receiving-mechanism are rendered more efficient, and hence the force necessary for commercially-practical signaling is greatly lessened.

The inapplicability of the Northrup apparatus is further shown by the fact that the coils of the fixed member of his apparatus consist of a large number of turns of wire, so that the resistance in such coils is high, whereas a commercially-practicable instrument for wireless telegraphy should have its fixed coil or coils formed by a few turns of wire, and consequently of low resistance. By the employment in the receiving-instrument of a fixed coil or coils of few turns and a movable member formed by a thin light ring of highly-conducting wire high resonance effects combined with a rapid natural period of the moving part and a maximum efficiency are attained and the advantageous use of transformers, as in Fig. [illegible] is rendered possible.

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It is characteristic of the method shown that the receiving mechanisms are actuated by currents produced by electromagnetic waves and not by voltages, as in the case of the coherer. Hence when the receiving mechanisms described herein are used in connection with a secondary circuit said circuit is controlled by the currents generated by electromagnetic waves and not by voltages. It is also characteristic that when a secondary circuit is used in connection with the type of wave-responsive device shown in Figs. 3, 4, and 5 a portion of the secondary circuit is traversed and controlled by currents produced by electromagnetic waves. It is further characteristic of my improved system that the indications produced by the receiving mechanism herein described are dependent upon the total amount of energy emitted to form the signal and are not, as in the case of the coherer, dependent upon the maximum of the voltage.

I claim herein as my invention—

1. As an improvement in the art of transmitting signals electrically by electromagnetic waves, the method herein described, which consists in the generation of electromagnetic waves at one station and transforming the energy of the currents generated by such waves at the receiving-station into the energy of motion, that is without the necessary interposition of a secondary or auxiliary generator for the production of such motion, substantially as set forth.

2. As an improvement in the art of transmitting signals between stations by electromagnetic waves, the method herein described which consists in causing the radiation of electromagnetic waves from a grounded conductor, generating voltages by such waves in a conductor at the receiving-station and transforming the energy of each of said voltages into the energy of motion, substantially as set forth.

3. As an improvement in the art of transmitting signals electrically between stations by electromagnetic waves, the method herein described which consists in producing an electromagnetic field in a receiving mechanism consisting of relatively fixed and movable members arranged in operative relation to each other by the generation of electromagnetic waves at the sending-station, thereby causing a movement of one of the parts of the receiving mechanism, substantially as set forth.

4. As an improvement in the art of transmitting signals electrically between stations by electromagnetic waves, the method herein described which consists in the generation of a current or currents in a portion of a receiving mechanism consisting of relatively fixed and movable members by the generation of electromagnetic waves at the sending-station and then producing a current or currents in the other portion of the receiving mechanism by the current or currents generated by the electromagnetic waves, whereby one part of the receiving mechanism is caused to move relative to the other part, substantially as set forth.

5. As an improvement in the art of transmitting electrical energy by electromagnetic waves the method herein described, which consists in maintaining a secondary circuit in an energized condition and controlling the energy of said circuit by current effects produced by electromagnetic waves flowing through a current-operated wave responsive device forming a portion of the secondary circuit.

6. As an improvement in the art of transmitting electrical energy by electromagnetic waves the method herein described, which consists in prolonging the oscillations of an energy-radiating conductor by energy from a source external to the radiating conductor and tuned to the period of the radiating-conductor, substantially as set forth.

7. As an improvement in the art of transmitting electrical energy by electromagnetic waves the method herein described, which consists in the generation of electromagnetic waves at one station and transforming the energy of the currents generated by such waves at the receiving-station into the energy of motion, varying the motion thus produced by varying the amount of energy delivered at the receiving-station without the necessary interposition of a secondary or auxiliary generator for the purpose of such motion, substantially as set forth.

8. As an improvement in the art of signaling by electromagnetic waves the method herein described, which consists in generating electromagnetic waves in a grounded conductor at the sending-station, receiving such waves at the receiving-station and transforming the energy of electromagnetic waves so received into the energy of motion by means of a receiving instrument having a low resistance, substantially as set forth.

9. As an improvement in the art of transmitting electrical energy, the method herein described, which consists in varying the conductivity of a secondary circuit at the receiving-station by motion produced by currents generated by electromagnetic waves, substantially as set forth.

10. As an improvement in the art of transmitting electrical energy, the method herein described, which consists in the generation of electromagnetic waves at one station, transforming the energy of the currents generated by such waves at the receiving-station into energy of motion, varying the currents in two or more local circuits by such energy of motion and transforming the energy of such currents into the energy of motion, substantially as set forth.

11. As an improvement in the art of transmitting electrical energy, the method hereby described, which consists in generating electromagnetic waves at one station, transforming the energy of currents generated by such

waves into the energy of motion, varying the currents in two or more local or secondary circuits by such energy of motion, transforming the energy of the varied currents into the energy of motion and causing the energies of motion so produced to operate in the same direction, substantially as set forth.

In testimony whereof I have hereunto set my hand.

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PLAINTIFF'S EXHIBIT

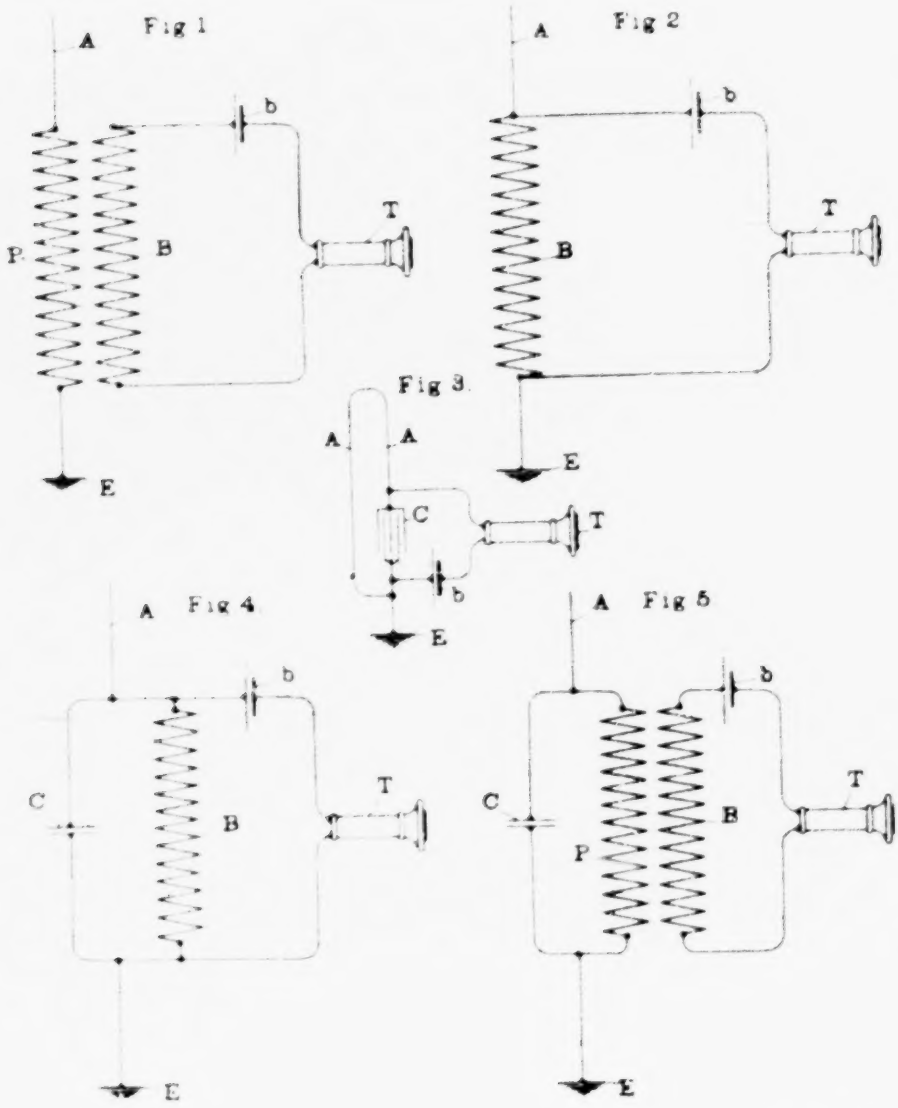
No. 711,131 Patented Oct. 14, 1902.

H. SHOEMAKER.

ART OF TRANSMITTING INTELLIGENCE

Application filed Aug. 9, 1900.

(No Model.)



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UNITED STATES PATENT OFFICE.

HARRY SHOEMAKER, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR TO CONSOLIDATED WIRELESS TELEGRAPH AND TELEPHONE COMPANY AND MARIE V. GEHRING, OF PHILADELPHIA, PENNSYLVANIA.

ART OF TRANSMITTING INTELLIGENCE.

SPECIFICATION forming part of Letters Patent No. 711,131, dated October 14, 1902.

Application filed August 9, 1902. Serial No. 119,030. (No model.)

To all whom it may concern.

Be it known that I, HARRY SHOEMAKER, a citizen of the United States, residing at Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented a new and useful Art of Transmitting Intelligence, of which the following is a specification.

My invention relates to an improvement in the art of signaling electrically, more particularly by means of electroradiant energy which is impressed upon the natural media and which causes manifestations at the receiving-stations.

My invention comprises a method of receiving signals represented by electroradiant energy by causing such energy to change the resistance of a material in virtue of a magnetic field caused by such energy. Of such materials many are well known in the electrical arts, though bismuth is a good example of the same.

My invention consists of a method of rendering intelligible transmitted electroradiant energy by causing such energy at the receiving-station to cause a varying magnetic field in which is placed a material having the property of changing its resistance under the influence of magnetism and producing a signal or recording a message by the changes of resistance of such material.

My invention consists, further, of a method of rendering intelligible transmitted electroradiant energy by causing such energy in the receiving-circuits to vary, either directly or indirectly, the resistance of a material which is not in the nature of an imperfect electrical contact, but rather in the nature of a continuous conductor of relatively low resistance or great conductivity as compared with the imperfect electrical contacts known in the art of wireless signaling.

By the use of bismuth or other materials which change their resistance when in a magnetic field I am enabled to construct a receiving device for wireless signaling systems in which the received electroradiant energy causes, directly or indirectly, a change in the resistance of such material, and the change of such resistance is caused to control a local circuit to produce a signal or record a message. The use of such material is distinctly different from the use of imperfect contacts now well known in the art as coherers and the like, which in general manifest great and sudden changes in resistance and are more or less uncertain in their action.

By employing bismuth or other similar material and subjecting it to the varying magnetic field due to received electroradiant energy there is attained a smooth variation in the resistance of a circuit, which renders the receiver certain in its operation, in marked contrast with the operation of the imperfect electrical contacts heretofore employed in wireless signaling systems.

Besides bismuth it is to be understood other materials may be used which have the same property—namely, that of changing resistances when in a magnetic field. I have found that iron, and even copper, behaves similarly to the bismuth when placed in a magnetic field.

Reference is to be had to the accompanying drawings, in which—

Figure 1 is a diagrammatic view of the receiving-circuits of a wireless signaling system in which a bismuth conductor is placed in the field generated by received energy within a winding in series with the aerial conductor. Fig. 2 is a diagrammatic view in which the bismuth or like material is connected in series with the aerial conductor. Fig. 3 is a diagrammatic view in which a loop of bismuth or like material is used for the aerial conductor and comprises in these two aerial conductors bismuth or other material which are connected at their tops. Fig. 4 is a modified arrangement of the circuits of a receiving device in which by proper proportions of the electrical constants of the circuit the magnetic field produced by the arriving energy is very great compared with the amount of such energy. Fig. 5 is similar to Fig. 4, except that the bismuth or other material is placed in the field generated by a winding through which an abnormal amount of current flows under the influence of a certain amount of received energy.

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In Fig. 1, A represents the usual aerial conductor, in series with which is connected the winding B', which connects at its lower terminal with earth plate E. The received radiant energy causes oscillations in the aerial conductor and through the winding B' to manifest a magnetic field. Within this field is placed a length of bismuth, preferably in the form of wire B, forming a part of the circuit including the telephone-receiver T and the source of energy *b*. The bismuth is normally has a certain resistance, and there is accordingly a certain current flowing through the telephone-receiver T, producing no sound. Upon the reception of electrical energy, however, the resistance of B varies, due to the magnetic field generated by the winding B', and there results a fluctuation of current through the receiver T, causing a sound to be produced in accordance with the received energy. In this manner the code characters or other signal characters may be read by the ear.

In Fig. 2, A is the usual aerial conductor, in series with which there is connected a bismuth winding B, which connects at its lower terminal with the earth plate E. The received radiant energy causes oscillations through said conductor B, producing a magnetic field. This magnetic field generated by the winding B' causes in the conductor B a change of resistance, which is noted by means of the telephone-receiver T and the source of energy *b*, as in the case of Fig. 1.

In Fig. 3, A A represent two aerial conductors, of bismuth or similar material, which conductors are joined at their upper ends. The left-hand conductor A connects directly to earth plate E, while the right-hand conductor connects to earth plate E through condenser C. The condenser C is so large as to be perfectly transparent to the oscillations received in the right-hand conductor A, and in effect, therefore, the right-hand conductor A is connected directly to earth. In shunt to the condenser C, or, what is the same thing, in series with the two conductors A A are connected the telephone-receiver T and the source of energy *b*. In this case the conductors upon the reception of radiant energy are surrounded by a magnetic field, and such field in turn causes a variation of resistance of such conductors A A. There results, therefore, a variation in the resistance of the circuit embracing source of energy *b*, telephone-receiver T, right-hand conductor A, and left-hand conductor A. From such change of resistance there results a variation in the flow of current through the telephone-receiver T, producing a signal, as previously described.

In Fig. 4, A is the usual aerial conductor, between which and the earth plate E are connected the condenser C and inductance-winding B in parallel relation to each other. The condenser C and this inductance-winding B are so related to each other as to their magnitudes that they form what is known as an "antiresonant" or "closed-resonant" circuit for the frequency of oscillations which are received upon the aerial conductor A. When the radiant energy received upon the said conductor A is of a particular frequency, there is set up in the local circuit, embracing the condenser C and the inductance B in series with each other, a current many times greater than that appearing in the aerial conductor itself. This inductance B is composed of bismuth wire. The excessive current flowing through it, due to the relations above stated, causes an abnormally powerful magnetic field to be produced in the vicinity of said winding, resulting in a correspondingly great variation in resistance of the bismuth wire forming the winding of such inductance. The variation in resistance of such bismuth inductance B is recorded then by the telephone-receiver T, with the aid of the source of energy *b*, as described in the previous cases.

In Fig. 5, A is the aerial conductor, between which and the earth plate E are connected in parallel with each other the condenser C and the primary winding B'. The relations of this condenser C and the winding B' are the same as described in connection with Fig. 4 for the condenser C and the inductance B. As described in connection with Fig. 4, the winding P will produce an abnormally strong magnetic field due to the antiresonant effect, and within this field is located a bismuth conductor B, as in the case shown in Fig. 1, and the variation of resistance of such conductor is recorded by the telephone-receiver T with the aid of the source of energy *b*.

I do not wish to be limited to the precise arrangement of circuits as herein described by me, for it is apparent that this system may be applied in many other relations by those skilled in the art. It is broadly new to me to generate a magnetic field by the received electroradiant energy and to cause such field to vary the resistance of certain materials and cause such variation of resistance to control a local circuit to produce a signal or record a message.

It is of course to be understood that in place of telephone-receivers sensitive relays may be employed to control local circuits. Furthermore, the telephone-receivers may be omitted and the primary of a transformer substituted therefor, and in the secondary circuit of such transformer may be placed telephone-receivers or other devices, such as relays and the like. By this arrangement upon a change of resistance in the bismuth or like material there is a large change in the strength of the current in the primary of the transformer, because a large source of energy is used, resulting in a great change in the ampere-turns of the primary of the transformer, and consequently a great change in the potential of the secondary circuit.

In the arrangement shown in the drawings the telephone-receivers are to be of low resistance, so that normally there may be a relatively large current flowing through the

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telephone-receiver. In virtue of this slight change in resistance of the material there will be considerable change in the current strength, and therefore considerable change in the ampere-turns in the telephone-receiver.

The bismuth or other material as used in my system may be in the form of a wire. The cross-section of the conductor or wire is such as to permit the use of a considerable current in the circuit of the wave-responsive device, which is, in fact, the wire. Heretofore in wireless signaling systems but very slight amounts of current had been used in the wave-responsive device. In the case of coherers and the like the current has been extremely small, and in the case of other systems employing a metallic conductor as a wave-responsive device the current employed has been extremely small. In my system, however, I am enabled for the first time in the art to employ currents of relatively great magnitude through the wave-responsive device. This is an advantage which is appreciated in view of the considerations named above. In other words, if the telephone-receiver T were of high resistance as compared with the bismuth or like material the slight fluctuation in the resistance of such material would cause but slight effect in the receiver. The bismuth or other material being of relatively low resistance, the telephone-receiver should also be of relatively low resistance.

What I claim is—

1. The method of rendering intelligible transmitted electroradiant energy representing a signal, which consists in varying the resistance of a material by a magnetic field which varies with the transmitted energy, and recording the variations of resistance of said material.

2. The method of rendering intelligible transmitted electroradiant energy representing a signal, which consists in changing the resistance of a material by a magnetic field due to the transmitted energy, and recording the changes of resistance of said material.

3. The method of rendering intelligible transmitted electroradiant energy representing a signal, which consists in changing the resistance of a material by a magnetic force due to the transmitted energy, and producing a signal by the change of resistance of said material.

4. The method of rendering intelligible transmitted electroradiant energy representing messages, which consists in transforming the received electroradiant energy into the energy of electric currents, generating a magnetic field by said currents, subjecting a material to said field to vary its resistance, and recording the resistance changes of said material.

5. The method of rendering intelligible transmitted electroradiant energy representing messages, which consists in transforming the received electroradiant energy into the energy of electric currents, producing a magnetic force by said currents, changing the resistance of a material by said magnetic force, and recording the resistance changes of said material.

6. The method of rendering intelligible transmitted electroradiant energy representing a message, which consists in generating a magnetic field by the received energy, changing the resistance of a material by said magnetic field, and recording the resistance changes of said material by varying the current strength in a circuit of a translating device.

7. The method of transmitting intelligence, which consists in impressing upon the natural media electroradiant energy representing a message, converting the received energy into the energy of electric currents at the receiver, increasing the current component of said energy of electric currents in a closed resonant circuit, generating a magnetic force by the increased current component, varying the resistance of a material by and in accordance with said magnetic force, and recording the resistance changes of said material.

8. The method of rendering intelligible electroradiant energy transmitted through the natural media and representing a signal, which consists in producing a magnetic field by the received energy, changing the resistance of a material by the influence of said magnetic field, and producing a signal by the change of resistance of said material.

9. The method of rendering intelligible electroradiant energy transmitted through the natural media and representing a signal, which consists in producing a magnetic field by the received energy, changing the resistance of a mass of bismuth by the influence of said magnetic field, and producing a signal by the change of resistance of said mass of bismuth.

10. The method of rendering intelligible transmitted electroradiant energy representing a signal, which consists in varying the resistance of a mass of bismuth by a magnetic field which varies with the transmitted energy, and recording the variations of resistance of said mass of bismuth.

11. The method of rendering intelligible transmitted electroradiant energy representing a signal, which consists in generating a magnetic field by the received energy, varying the resistance of a material by said varying magnetic field, and recording the resistance changes of said material.

12. The method of rendering intelligible transmitted electroradiant energy representing a signal, which consists in generating a magnetic force by the received energy, varying the resistance of a mass of bismuth by said magnetic force, and recording the resistance changes of said mass of bismuth.

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Witnesses:
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PLAINTIFF'S EXHIBIT

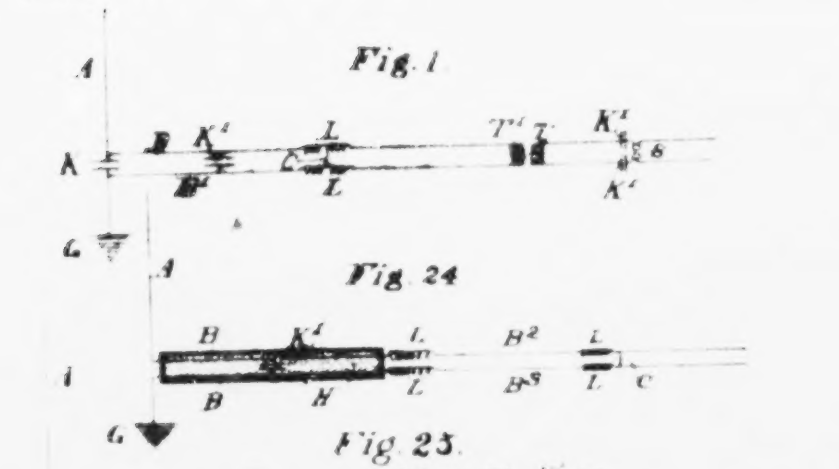
No. 790,246. PATENTED JUNE 6, 1905.

L. DE FOREST.

SPACE TELEGRAPHY.

APPLICATION FILED MAR. 8, 1902.

3 SHEETS—SHEET 1.



WITNESSES

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Lee de Forest,

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ATTORNEY

No. 730,246.

PATENTED JUNE 9, 1903.

L. DE FOREST.

SPACE TELEGRAPHY.

APPLICATION FILED MAR. 8, 1902.

NO MODEL.

2 SHEETS—SHEET 2.

Fig. 2.

Fig. 3.

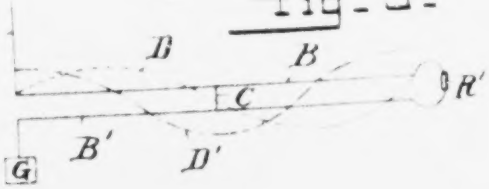


Fig. 4.

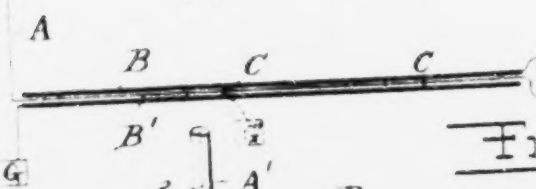


Fig. 5.

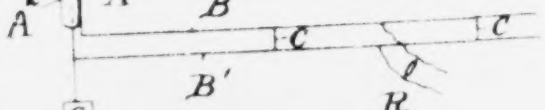
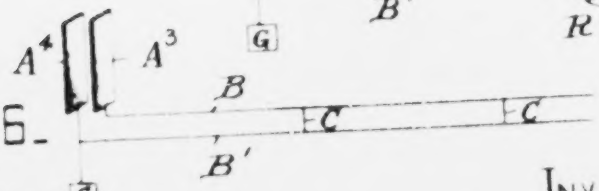


Fig. 6.



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No. 730,246. PATENTED JUNE 9, 1903.

L. DE FOREST.

SPACE TELEGRAPHY.

APPLICATION FILED MAR. 6, 1902.

NO MODEL. 6 SHEETS—SHEET 1.

Fig. 7.

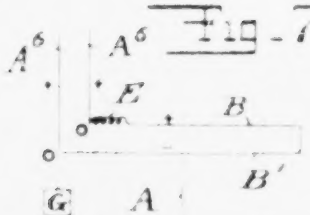


Fig. 8.

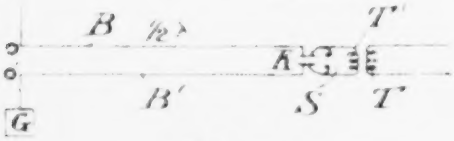


Fig. 9.

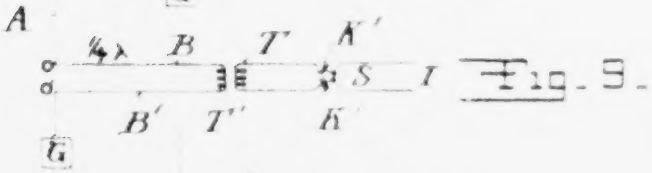


Fig. 10.

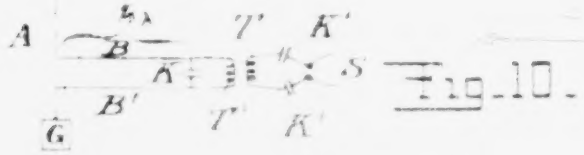


Fig. 11.

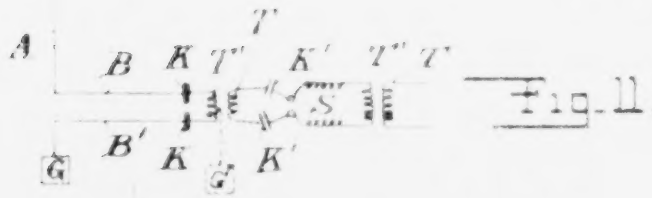
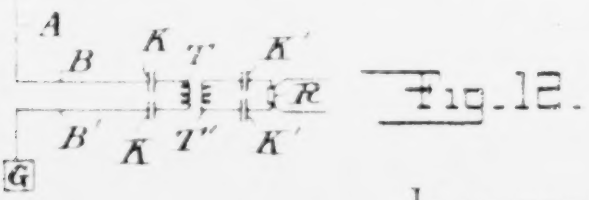


Fig. 12.



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No. 730,246. PATENTED JUNE 9, 1903.

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SPACE TELEGRAPHY.

APPLICATION FILED MAR. 8, 1902. 6 SHEETS—SHEET 4.

NO MODEL.

Fig. 13.

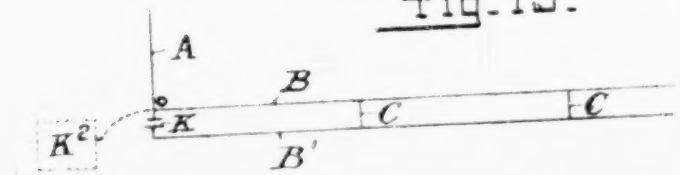


Fig. 14.

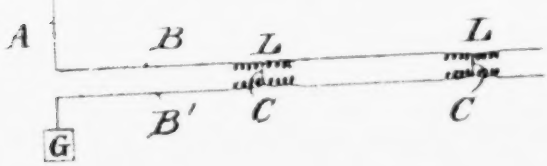


Fig. 15.

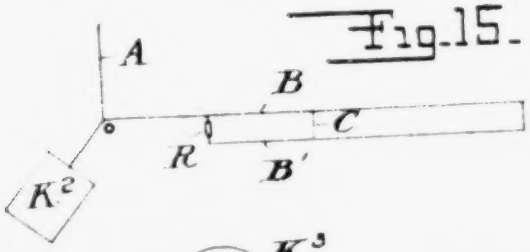


Fig. 16.

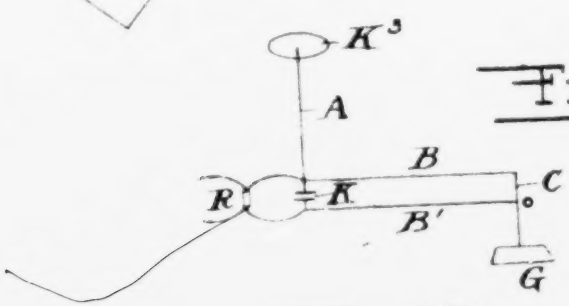
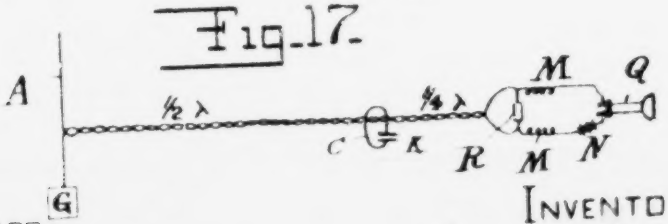


Fig. 17.



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No. 730,246. PATENTED JUNE 9, 1903.

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SPACE TELEGRAPHY.

APPLICATION FILED MAR. 9, 1903.

NO MODEL. 5 SHEETS—SHEET 1.

Fig. 18.

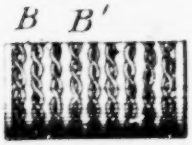


Fig. 19.

Fig. 20.

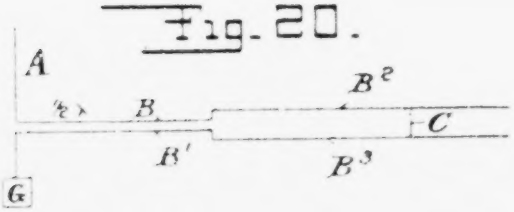


Fig. 21.

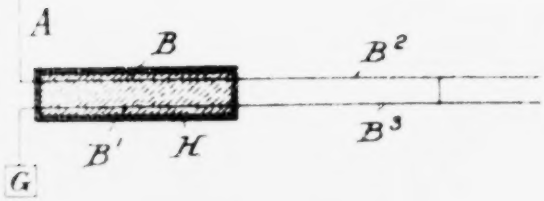


Fig. 22.

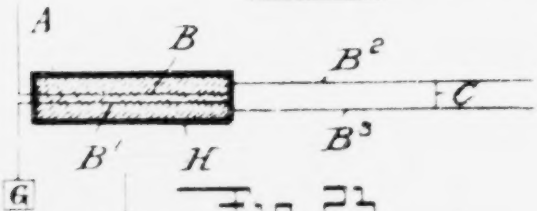
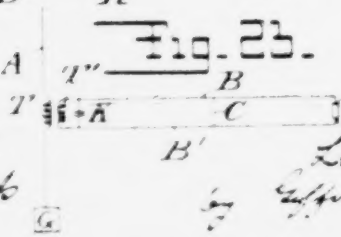


Fig. 23.



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No. 730,246. Patented June 9, 1903.

UNITED STATES PATENT OFFICE.

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SPACE TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 730,246, dated June 9, 1903.

Application filed March 8, 1902. Serial No. 97,239. (No model.)

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, and a resident of New Haven, in the county of New Haven, State of Connecticut, have invented a new and useful Improvement in Space Telegraphy, of which the following is a full, clear, and exact description.

My invention relates to improvements in those systems of electric signaling between two points which use natural media for the transmission of the electrical impulses and which are ordinarily referred to as "space" or "wireless" telegraphy.

My invention comprises certain novel features, which will be herein described, and particularly pointed out in the claims.

In the drawings accompanying herewith I have shown and in the specification have described numerous forms of apparatus in illustration of the manner of applying my invention to use and of adapting it to different circumstances and requirements. I am aware, however, that it may be embodied in other forms, and do not, therefore, wish to be understood as limiting myself to the forms herein shown, but seek to claim my invention in any form in which it may be embodied. The scope of my invention is to be determined by a reference to the accompanying description and particularly to the claims attached thereto.

The accompanying specification is a description of my invention as embodied in the figures of drawings given.

Figure 1 shows an apparatus employing my invention used as a sender. Fig. 2 shows diagrammatically a simple form of apparatus containing my invention employed as a receiver. Figs. 3 to 7, inclusive, show modified forms, which by the use of either a responder or an energizing device may be used either as a sender or as a receiver. Figs. 8 to 11, inclusive, show my invention in various modifications employed as senders. Figs. 12 to 23, inclusive, show forms of my invention employed as receivers. Figs. 24, 25, and 26 show other arrangements of parts employed in my invention.

While I have shown and described some arrangements employed as receivers and others as senders, and while some of the arrangements shown are better adapted for the one use than for the other, there is in general nothing to forbid the employment of any of the arrangements shown in either capacity by substituting either a responder or an energizing apparatus for whichever of these is shown.

In systems of space or wireless telegraphy now being employed a failure to attain the efficiency or power desired is largely due to the fact that the electrical waves emanating from the sending device are rapidly damped or decreased in intensity or amplitude. In other words, while the maximum intensity or amplitude of the waves may be satisfactory their persistence is unsatisfactory, as they rapidly fall in amplitude to nothing. In consequence of this their energizing action upon the receiving-antenna being repeated but a few times does not have the cumulative energizing effect that a much weaker impulse would have if repeated a greater number of times. The effect is comparable to the effect produced upon a vibrant body, as a piano wire, by its note being sounded loudly for a very short time or less loudly for a much longer time.

I have discovered a means whereby I am able to produce with each signal a longer and better sustained series of waves, the same means also lending themselves readily to use in the receiver, in which use they have special and marked advantages.

It is a well-known fact that if two adjacent and parallel wires of equal length are connected each with a terminal of any form of apparatus producing electrical oscillations of high frequency the charges in said wires at any point of their length are of exactly equal intensity and of opposite phase. The currents flowing in these two wires are also at corresponding points equal in amount and flow in opposite directions. If these wires are the equivalent of one-quarter or any multiple thereof of the wave length of the electrical oscillations transmitted thereto, very efficient reflection occurs at the ends of these wires, with the result that stationary or standing waves are set up, caused by the incident and reflected oscillations. The system then divides up into quarter or half wave lengths

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with nodes and loops symmetrically situated on each wire. At the nodes of these electrostatic stationary waves a conducting-body, as a wire bridge, may be placed across both wires without seriously interfering with the action beyond. At a distance of one-quarter wave length from said nodes loops are formed, at which points the maximum possible difference of potential between the two parallel wires exist. Such a system of parallel conductors is known in the art as the "Lecher" system of wires. The phenomena involved in this system have been worked out theoretically, notably by Lord Rayleigh, Drude, Heaviside, and others, and have been set forth by these and other people, as in the following instances: By E. Lecher, in *Wiedemann's Annalen*, No. 41, page 850; Barton and Bryan, *Phil. Mag.*, August, 1897; E. Marx, in *Wiedemann's Annalen*, No. 11, 1898; Lord Rayleigh, *Phil. Mag.*, No. 43, 1897; E. Lecher, *Wiedemann's Annalen*, No. 42; Heaviside, *London Electrician*, April 9, 1897; Bjerknes, *Wiedemann's Annalen*, No. 55, page 121. As has been pointed out by investigators, what is known as the "wire and sheath" return, consisting of a wire surrounded by a coaxial tubular conductor insulated therefrom, is only a special form of the Lecher system and is subject to the same laws as the simple system. The general theory has shown that in this [illegible] system of conductors, or for a wire with return, the self induction and capacity are evenly distributed and are reciprocals per unit length of the system—that is to say, the capacity and self induction cancel each other as far as the dimensions of the wire are concerned, that the period of vibration is independent of the distance between the two wires and of their diameters. Such a system of conductors is known in the art as a "distortionless" circuit. The velocity of propagation thereon for high-frequency oscillations is approximately that of light. For example, this is the velocity when the resistance per unit length is negligible compared to the self induction and when this self-induction is the reciprocal of the capacity per unit length. These conditions are satisfied when the wires are less than one-half millimeter in diameter and less than two meters long.

The formula for the self induction per unit length of the Lecher system is $L = \text{Log nat } \frac{d}{r}$, where d is the distance between the centers of the two parallel wires and r their common radius. The expression for the capacity per unit length is the reciprocal of the above, or $= \frac{1}{\text{Log nat } \frac{d}{r}}$, hence the remarkable property of the Lecher system that the velocity of the propagation of an electric wave along its length is not dependent in the least on the size of the wires or of the distance between their centers, and this velocity comes out as equal to the velocity of light. This being the case it will be at once understood how the period of any section of a Lecher system embraced between two consecutive bridges is a function of the length between said bridges alone. Hence in arrangements shown in Figs. 20, 21, 22, and 24 the velocity of propagation along section B B is identical with that along section B^2 B^2, and if the length of these two sections is the same the period of oscillation of each section will be the same, but although the product (L S) be the same for both, L is small in B B and large in B^2 B^2, while S is large in B B and small in B^2 B^2. Now the relative quantities of electromagnetic and electrostatic energies depend wholly on the ratio of L to S. Where self-induction is large and capacity small, we will have a greater proportion of the total energy as energy of inertia or momentum. Where capacity is large and self induction small, we will have a greater proportion of the total energy as energy of elasticity. Hence in passing from B B to the section B^2 B^2 we will have a transference of energy from the electrostatic to electromagnetic—for example, two opposite charges are traversing B and B. When these pass upon B^2 and B^2, respectively, where the capacity is less their potential difference must be increased, and vice versa.

On account of losses from resistance, leakage, and imperfect reflection at bridges or open ends in such a system of parallel wires as is here described the stationary waves set up therein are never perfect, and therefore absolute nodes are never found in practice, although with suitable reflecting devices the approximation thereto when a slowly-damped wave train is transmitted is very good. We get instead points of maximum and minimum potential difference and of current, whose magnitudes are dependent on the coefficient of resistance, leakage, and reflection.

Ordinarily the order of magnitude of the energy involved in the two sets of waves (the electrostatic and electromagnetic) is the same, and if the parallel wires were infinitely small in diameter the magnetic force must equal the electric, and the greater the surface the less becomes the magnetic force relative to the electric, the one increasing as the other decreases.

The characteristics and advantages of the Lecher system are:

(a) It is to a high degree a resonant vibrator—that is, it has a very marked period of its own and is very little responsive to oscillations of any other frequency than its own.

(b) It is a poor radiator and consequently a persistent vibrator, persisting for some time in its vibrations since they are set up, therefore producing a long wave-train and damping slowly. This is because most of the lines of force lie in the space between the two conductors and the radiation losses are therefore small, except when a radiator is attached.

One authority states that the observable magnetic effect from a Lecher system, even strongly excited, does not extend beyond three centimeters from the parallel wires.

(c) By reason of the stationary waves set up higher potentials are obtained than are otherwise possible.

(d) The nodes and loops of these stationary waves are fixedly located, thus enabling connections to be made with the wires at any phase of the wave desired.

(e) The system may be easily and accurately tuned to any frequency desired.

(f) It is simple in its mathematical and theoretical aspects. Its constants are easily calculated and regulated, so that the dimensions of a system for securing definite results may be readily predetermined. This has not yet been satisfactorily done for other forms of apparatus employed in connection with currents of very high frequency, such as are employed for space signaling. The velocity of transmission in a simple Lecher system is approximately equal to that of light. Therefore the wave lengths or frequency may be readily determined and exactly defined. A brief description of the phenomena and laws obtaining in such a system of parallel conductors has been given by me in the *American Journal of Science* for July, 1899.

I have discovered that these characteristic features of the Lecher system of wires render them especially adaptable for use in wireless telegraphy. In their application they are flexible, being adaptable to various modifications as may be required by the various circumstances, as the type of transmitter or receiver employed and the practicable dimensions of the apparatus, as the height and character of the upright wire.

In the figures of the drawings accompanying herewith I have shown various modifications in which the Lecher wires are employed, some representing the sending apparatus and others the receiving apparatus, although in general either a sending or a receiving apparatus may be employed with either.

In Fig. 2 I have shown Lecher wires B B in use with a receiver, one wire, B, connected with an upright wire or antenna A and the other, B', connected with the ground G or other capacity. The equivalent length of the upright wire or collector A is one-quarter of the wave length of the natural oscillation to which the system is attuned. At a distance of one-half wave length from the foot of the upright, as at 1, occurs the first node, and if the wires are long enough other nodes are formed separated by the same distance as the node 2 shown in the figure. At these nodes the wires may be connected by no-resistance bridges, as C C, without destroying or seriously affecting the oscillations or the propagation of the waves. These bridges may also be grounded, as shown by dotted lines at G' in Fig. 4 without affecting the period of vibration.

If the wires be continued one-quarter wave length beyond the last node, as shown in Fig. 2, a loop of electrostatic force will be formed by the open-end reflection. At such open ends all the energy of the system is electrostatic. Therefore, as the sensitive device operated by a difference of potential across its terminals, such as a coherer or other responder, may be inserted most advantageously at a static loop, these ends form a desirable location for such a device. The dotted lines D, Figs. 2 and 3, indicate the position and intensity of such waves in the system. In Fig. 2 a responder is shown at R as inserted between the open ends of the Lecher wires. Such a device may, however, be inserted wherever an electrostatic loop occurs. A sensitive device operated by current or electromagnetic stationary wave, such as a bolometer or thermo element, should be placed at the loop of an electromagnetic wave. The electromagnetic waves do not coincide in location with the electrostatic waves, but, as is well known in the art, are separated along the wire by ninety degrees or by a quarter-wave length. The relative positions of these different waves are shown in Fig. 3, in which the dotted line D represents the electrostatic wave, and D' the electromagnetic wave. A bolometer or other device operated by current or electromagnetic waves may be located at any loop of an electromagnetic wave. Such a device is shown at R in Fig. 3.

Since the simple antenna A is a strongly-damped vibrator and the system of parallel wires attached at its base a weakly-damped or strongly-resonant vibrator, it sometimes results that a violent oscillation received by the antenna, if strongly damped, may excite in the parallel conductors vibrations having the distinctive period of said conductors, regardless of the period of the exciting impulse. Were this exciting impulse, however, a long wave-train, interferences in the parallel wires would arise and the effect above described could not obtain. Conversely, if this long wave-train have the frequency to which the wire system is attuned this latter would be violently excited. Thus by regulating the sensitiveness of the receiving device R response to oscillations other than those to which the system is attuned may be prevented.

In Fig. 4 the wire and sheath return is shown, wherein, as in the Lecher wires, the self-induction and capacity are also evenly distributed. This, as shown, consists of a central conductor, as a wire B, and an outer tubular conductor B surrounding it. These two conductors may be connected at the location of electrostatic nodes by bridges, as C. As shown in Fig. 4, the waves travel upon the outer surface of the inner conductor and back on the inner surface of the tubular or outer conductor. The connections, however, of the antenna and the ground may be reversed, or we may regard the annular space between the two conductors as the region within which the

other oscillations are suffined. A responder, reflector, or other equivalent device is shown as located at R, the same being at an electrostatic loop.

In Fig. 3 the wires B and B are simple Lecher wires, such as described in connection with Fig. 2. The antenna A of Fig. 2 is however replaced by the conductive cylinder A connected with wire B and the central wire A' which latter is connected with the wire B. These form a wire and sheath return system employed as a radiating or a receiving antenna. This is only an exemplification of the wire and sheath return employed as an antenna. When used as a radiating antenna [illegible] the inner conductor A' and the field of force is limited part [illegible] between the exterior of conductor A and the ground and the greater portion concentrated in the annular space between the cylinders A and A'. This arrangement results in a conservation of force only a small portion of the energy being radiated out into space at each oscillation, but the oscillations are continued for a considerable time. When used as a receiver the wire system of the type of the responder should be located at a static loop as shown at R.

In Fig. 4 the conductors B B are the simple Lecher conductors, one of them being connected with the ground G. The simple antenna is replaced by two plates A' and A' which may be considered as the extension of the Lecher conductors. If the plates of the plates at parallel and adjacent, the greater part of the energy is concentrated in the field between them. The receiving in front of A will at one instant be occupied by lines of force representing a positive wave, and that in front of A' will at the same instant be occupied by lines of force representing a negative wave. The respective lines of force radiating from these plates are constantly changing their direction, extending from one to another in a series of opposite sign in the same amount of wave length distant from the respective plates. In the region of the plates parallel with the plates the [illegible] equal radiations from both plates will neutralize each other, while in the region [illegible] affected by the ground plate as A' [illegible] the plate A' tends to [illegible] preventing [illegible] the intensity [illegible] lines of force [illegible] plate and the earth [illegible] between this plate and the earth [illegible] the reflection set [illegible] For these reasons radiation [illegible] comparatively slight. The [illegible] direct propagation is therefore [illegible] A' and the plate A' tends to [illegible] which proceed in the approximate direction the direction [illegible] set propagation is perpendicular to its plane. This feature enables the direction of propagation of the effective energizing or signaling waves to be in a measure controlled or directed or. In other words, provides for the maintenance of a neutral zone or zones. If these plates be mounted so as to be rotatable upon a common axis the position of these neutral zones may be controlled, and the same apparatus may thus be utilized for signaling in any direction desired, while approximately non-effective in other directions. This fact may also be utilized in preventing interference between different apparatus located in a common field of energy which would otherwise interfere with each other. When used as a receiving antenna, the rotative plates may be utilized for receiving messages coming from a given direction, while in considerable measure neutralizing or cutting out the waves coming from other directions. It follows that if the device has a direction of maximum propagation and directions of minimum or no propagation it will conversely have directions of maximum and minimum sensitiveness to the reception of waves, from which it follows that if more than one series of waves are coming in it will be most responsive to those which come from its direction of maximum efficiency, and also by turning the plates to the position where the message is most clearly received the plate A' will be found to be facing the direction from which the impulses are received. In this way the direction from which a signal comes may be approximately told.

If it is desired that both antenna be charged alike instead of oppositely, as may at times be desirable to secure increased radiating or collecting power, this result may be obtained by inserting between the base of one and the leg of the Lecher system connected thereto a retarding device, such as a coil or length of wire equivalent in length to one-half wave length of the oscillation for which the system is attuned. Such a coil is shown at E in Fig. .

If used as a receiver, a wave traveling down the antenna A' will be delayed by its passage through the coil E by a time equal to one half its period, and so will enter upon the arm of the Lecher wires at a time when a wave of opposite sign enters upon the other arm of the Lecher system. Thus the necessary condition of waves of opposite sign in the Lecher system is fulfilled.

In Figs. 8, 10 and 11 means are shown for exciting my apparatus or for transmitting thereto the electrical oscillations necessary when employed as a sender. These figures do not show all the means which may be employed for this purpose, but are given as illustrative of well-known means which adapt themselves to this use.

In Fig. 8 a "static" method of charging is shown. The parallel or Lecher wires are shown as of only one half wave length. In series in the bridge across their ends is a

denser K. In shunt around this condenser are a spark-gap S and the secondary coil T of a transformer T T. When this condenser is charged to the breaking-down point of the spark-gap S, a discharge occurs at this point, and this serves as a connecting-bridge between the parallel wires, and these wires are set in vibration as a Lecher system. Part of the energy is reflected back at O and O', forming stationary waves with nodes at O and O'. A part goes into the upright conductor or antenna A and is radiated outward.

In Figs. 9, 10, and 11 the Lecher system is charged inductively—that is, the secondary T of the transformer is in the circuit of the Lecher system and oscillates therewith, while in Fig. 8 it is not in such circuit and does not enter directly into its oscillations. In fact, in Fig. 8 the transformer may be replaced by any source of electrical energy giving the requisite potential.

In Fig. 9 the parallel wires are shown as equal to one-quarter wave-length and the coil T, forming the secondary of the transformer, is equivalent to one-half wave-length. The primary coil T' of this transformer is connected in series with the condenser K and spark-gap S. This primary circuit is charged from any suitable source of energy I. It is obvious that for self-connection of the primary coil T and the capacities K be so chosen that the natural period of oscillation of this primary system shall be that of the adjoining Lecher system.

Fig. 10 shows a system essentially the same as in Fig. 8, except that a condenser K is connected to the Lecher wires at the static loop. A condenser so located is the equivalent of a certain length of [illegible] wire, so that a system containing a condenser adjusted with a period of oscillation longer than one corresponding to the length of wire necessary for a system of a given period. The effective capacity of such a condenser depends somewhat upon its location in the Lecher system, being most effective when placed at a point where the potential difference across its terminals is a maximum.

It has been observed that a capacity-bridge [illegible] located across the two Lecher conductors exerts a greater or less disturbing or retarding effect upon the wave-system according as it is located near an electrostatic loop or near a node. If near a loop, the potential difference across its terminals is greater. Hence the quantity of electricity capable of being stored thereby is correspondingly greater, and the effect of the retarding up at such a point is proportional, therefore, to the location of the condenser in the Lecher system. In other words, while the absolute capacity is independent of this location, its effective or equivalent capacity is dependent thereon.

The use of a condenser as a means for adjusting the period or equivalent length of a system, for which purpose it is most effectively placed adjacent a static loop, should be distinguished from its use in a bridge to prevent direct connection between the wires, as is shown at K in Figs. 1, 17, and 25, where it is located at a static node. In this position it acts as a bridge, while at the same time insuring the transfer to the system beyond the bridge of a larger percentage of the energy than would a plain wire bridge or direct connection. It is, however, not altogether devoid of an effect in lengthening the period of the system. Condensers may be employed for both of these purposes in the same system, as is shown in Figs. 1 and 25.

Fig. 11 shows the Lecher wires cut at static loop and a condenser inserted in such run between the Lecher wires and the secondary terminals of the transformer. Here also the armatures of the condenser behave as the equivalent of a certain length of wire, this relation depending upon the amount of surface in the condensers and the distance between the armatures. This affords a ready means of attuning the system by changing the distance between the armatures of the condensers, since the maximum potential of opposite sign occurs at the terminals of the secondary T of the transformer, the middle point of the coil must be one of zero potential and may therefore be grounded as shown at G without interrupting the action of the system.

In the devices shown in Figs. 10 or 11 are used as receivers the transformer coils T and T' should be reversed in arrangement, as shown in Fig. 12, the low-potential coil T being connected with the Lecher wires and the secondary T' in circuit or responder R may be substituted for the spark-gap S. The same necessity arises in this case as in the sender for tuning alike the two circuits shown.

In the receiver it is not always necessary to ground any point of the Lecher system of wires. In Fig. 13 if a node be formed, as at O, at the base of the upright A stationary waves will be set up in the parallel wires as before, and in the absence of any earth-connection the energy of the oscillations has no opportunity to leak away and must be consumed only in heat and reflection-losses in the receiver-instruments. To insure the formation of a node at O, a key, capacity, or the like, may be connected at this point. If a condenser as K be connected at O between the two wires, its capacity should be small. A condenser at this point in the system shown acts as a bridge.

In Fig. 14 is shown a method of reducing the actual length of wires required to form the equivalent of the proper wave-length, which consists in inserting coils L L in the wires of the Lecher system. The several coils should be inserted at loops of current where the inductive effect will be maximum. If the Lecher wires are to be bridged, these bridges should connect the middle points of two corresponding coils, as shown at C.

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In Fig. 1 I have shown a system which employs both inductance-coils L and a condenser K as lag producing or period adjusting devices. I also show a condenser K employed as a bridge at the base of the antenna. The bridge C, which connects the two inductance-coils, might be of the same form. The wave-producing device is of the same construction and is connected with the system in the same manner as that shown in Figs. 9 and 10.

The use of bridges at the nodes of wires of more than one half wave length and placing the receiving instrument beyond said bridge or bridges has one advantage. The bridge, if grounded, will have the effect of leading off or grounding waves of such length that their nodes are formed elsewhere and will thus screen or protect the responder or equivalent receiver from the effect of all waves except those which are of the length for which the apparatus is adjusted. Upon waves of the proper length the bridges produce but little effect of this character.

It is not always necessary that the two parallel or Lecher wires be of the same length. Fig. 15 shows an arrangement in which the responder R is located at a static loop of the wires and one quarter wave length removed from the base of the upright wire. At this point in the lower wire we have a static loop formed by open end reflection. The node at O may be connected to earth or to a capacity K'.

In all the foregoing figures the upper end of the upright wire has been considered as the location of the static loop, of which the node was at the base one-quarter wave length below it. If a body having a large capacity, as K' in Fig. 16, be located at the top of the upright wire or antenna, its capacity may be such as to produce reflection in the waves oscillating in the upright conductor equivalent in sign to the reflection obtained at a bridge in the Lecher wire system. This means that a static node will be formed at this point with a loop at the lower end. The earth connection then should be at a point along the parallel wires one quarter wave length distant from the base of the upright wire or antenna where the second node will be located. As the capacity K' makes a static node at the top of the antenna where ordinarily is a static loop, the location of the condenser K corresponds with a static loop. The condenser K of Fig. 10 is also at a static loop. In both cases the condenser represents or absorbs a certain amount of the wave length and is so located as to shorten the apparent wave length of the Lecher system. The condenser K in Fig. 1 shortens the length necessary in B B, and consequently also shortens the length necessary in A to still keep A in resonance with the attach of Lecher system. The responder may be located, as shown, in shunt around the condenser.

In Fig. 17 is shown a convenient form of using the Lecher wires. Here the two wires which are insulated, are twisted together, forming a twisted pair, the distance between them being regulated by the thickness of the insulation. It is desirable that the pitch of the twist be not too steep. The twisted pair is well adapted to use upon a spool or coiled in any other manner which may be desirable to economize space or to secure portability. If the two simple parallel wires untwisted were coiled upon a spool, with convolutions parallel and near together, interference by induction between adjacent convolutions would arise; but when closely twisted such adjacent convolutions of the coil if not too close together will not interfere with one another. In any considerable length of the convolution one wire will first be adjacent to another carrying current of like sign and then to one carrying current of opposite sign, so that for any considerable length of wire the inductive effects from the two wires in the convolutions adjoining will be neutralized. In practice I have successfully used such wires twisted with a pitch equal to three turns to the inch wound upon a spool about three inches in diameter with successive turns separated about an eighth of an inch. Their use is not, however, limited even a near approximation to the above proportions, which are given only to show what has been found successful without any intention of limiting myself thereto.

So far as I am aware such a method of embodying the Lecher wires and of utilizing their advantages has never before been used. It retains practically all the theoretical advantages of the straight parallel wires embodied in a compact form, which makes the apparatus portable and practical. Wherever in the accompanying drawings or description straight Lecher wires are shown or described, it is to be understood that the twisted pair, as above described, may be substituted, either coiled, as shown in Fig. 18, or disposed in any suitable way—for instance, as in Fig. 19. Bridges, a condenser, or any other device such as described in connection with the previous features may be inserted as desired and are controlled in location and action by the same principles as apply to the simple straight wires. In Fig. 17 a responder R, choke coils M M, a battery N, and a telephone Q, or other indicating instrument are inserted in a local circuit after the manner common in wireless telegraph apparatus.

As shown in Fig. 17, the responder is placed across the open end of a loop and one-quarter wave length distant from the responder, and one-half wave length distant from the upright A is or may be placed a bridge C. To avoid shunting the local circuit about the responder, which would occur if a no-resistance bridge or a metallic connection were used, a condenser K is placed in the bridge, which condenser is of sufficient capacity to act as a no-resistance bridge for the Hertzian oscillation, while for

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ing an effective interruption for the local current.

When employed in the sending device, it may be desirable for purposes of insulation to immerse the entire system in oil.

In Figs. 20, 21, and 22 are shown constructions by which the potential may be simply and effectively transformed either to raise or lower it, as desired. The principle therein illustrated may be employed either in the sender or the receiver, but is more especially recommended for use in the receiver.

The general theory shows that the mutual induction of the Lecher wires decreases as the two parallel wires are brought closer together, becoming zero for the wires in actual contact, and that conversely the capacity of the system is thus increased. Consequently if one system of such parallel wires, as B B, Fig. 20, of length equivalent to one-half wave length of the vibration transmitted be added to another system, as B^2 B^2, of the same period of electrical vibration, but having its two parallel wires farther apart, then this second system B^2 B^2 may take up the impulse transmitted from the first system unaffected as to its period of vibration, yet transformed to a wave of higher potential, but of correspondingly diminished magnetic energy or current. On the same principle if the first-mentioned system—say of one-half wave length—have for the dielectric between its two parallel wires a substance of higher specific inductive capacity than that between the two parallel wires of the second system then the capacity of the first system per unit length is greater than that of the second system. The electrical energy will therefore be transferred from the first to the second system altered in its relative proportions of electrostatic and electromagnetic energies. So in the arrangement last described the transformation will be, as before, to step up the potential and to diminish the currents flowing in the second system. Such a system is illustrated in Fig. 21, in which the wires B B are parallel throughout their length, but the first half wave length from the upright is inclosed in a casing H, containing oil. Thus I employ one pair of parallel wires—for example, of length equivalent to a half wave length of the vibration transmitted—immersed in and separated by an oil, and connected to one end of this system another system of parallel wires of a length also equivalent to one-half wave length, but normally separated by air or other dielectric of small specific inductive capacity, and thus obtain between the two wires of this second system a higher difference of potential than existed between the wires of the first system. Such immersion in a fluid may result in a change in the wave length required for a given period. In Fig. 22 a combination of both plans is shown, the first half wave length B B being immersed in oil and also having its wires closer together than the second half wave length B^2 B^2, which are separated only by air.

When desirable to still further increase the self-induction of one of such systems of parallel wires as I have described, I may insert at corresponding points in each of the two wires inductive or momentum coils of suitable impedance and construction, as shown at I. I, Fig. 24. Similarly, to increase the capacity of the other system I may attach to each of the parallel wires thereof an armature of a condenser of suitable area, as shown at i i, Fig. 24.

Such combination of systems as I have here described thus affords a step-up or step-down device entirely differing from "transformer coils," ordinarily so called, a device novel and useful in its application to the art of space telegraphy.

In all the figures so far mentioned the antenna is shown as directly connected with what may be called the "resonant" conductors—that is, with the parallel conductors which produce the stationary waves. This is, however, not a necessity, as the resonant conductors and the antenna may contain device in circuit therewith whereby the wave effect is transmitted inductively. Such a construction is shown in Figs. 25 and 26, in which I I represent the two coils of a transformer or induction-coil, one being in the circuit of the resonant conductors B B and the other in the circuit of the antenna. When applied to a receiving device, the coil I is the primary coil and I' the secondary. When applied to a sending device they would be reversed in position or function. This method of connecting the parallel conductors and the antenna may be employed in the forms illustrated in the other figures. As shown in these figures, the conductors extending each way from the center of the coil T to the first bridge C or the point where the first node is formed are each the equivalent of a half wave length, the condensers K, if employed being taken into consideration. The condenser may, however, be dispensed with and its effect produced by employing some other form of lag-producing device, such as the impedance-coils, after the manner illustrated in Fig. 14 or the conductors B B lengthened to the proper amount. The indirect or inductive method of connecting the antenna with the parallel Lecher conductors B B is employed generally with the arrangements in the other figures of [illegible] shown therein. Where one or the description or claims one form of connection is specified, I am to be understood as stating or claiming the other form to be an equivalent [illegible].

In Fig. 25 the last system with which the receiver circuit is connected is inductively connected with the other systems after the manner shown in Fig. 12.

In Figs. 25 and 26 condensers h h are

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shown as placed in and forming part of the conductive systems after the manner shown in Figs. 11 and 12.

In Fig. 26 the antenna is directly connected with the ground G and inductively with the resonant system by the coils T T', and described in connection with Fig. 23.

In the foregoing description I have endeavored to describe such modifications and variations in the apparatus which may be employed as will make clear the principles of my invention without intending to show all the modifications which are available or feasible. Other combinations will suggest themselves to one familiar to the art.

I am not to be understood as limiting myself to the forms or exact combinations of various elements shown, as I am aware of other modifications and combinations which might be employed. The further multiplication of the drawings seems, however, to be unnecessary, as those given serve to clearly set forth the principles of my invention.

The scope of my invention is to be determined by reference to the claims terminating this specification, in which the omission in any claim of any element or the failure to include therein any qualification of an element is to be understood as a distinct statement that such element or qualification is not essential to that particular combination.

Having thus fully described my invention, I claim as new and desire to secure by Letters Patent—

1. In an apparatus for space telegraphy, in combination, an antenna and two parallel conductors adapted to act inductively upon each other, one of which is electrically connected with the antenna, said conductors being each equivalent to a multiple of a quarter-wave length.

2. In an apparatus for space telegraphy, in combination, an antenna and a plurality of parallel conductors cooperating therewith and adapted to develop stationary electrical waves.

3. In an apparatus for space telegraphy, the combination with an antenna of two conductors each equivalent in length to a multiple of a quarter-wave length and adapted to the production in each other of stationary electrical waves.

4. In space telegraphy, in combination, parallel conductors adapted to the production of stationary electrical waves, and an antenna connected to one of the conductors whose natural period of vibration corresponds to that of the parallel conductors.

5. In space telegraphy, in combination, parallel conductors adapted to the production in each other of stationary electrical waves, and an antenna connected at a node of said waves to one of the conductors and having a natural period of vibration corresponding to that of the parallel conductors.

6. In space telegraphy, in combination, plural conductors adapted for the production of stationary electrical waves, bridges connecting said conductors at points corresponding with the nodes of said waves and an antenna connected with one of the conductors.

7. In space telegraphy, in combination, plural conductors adapted for the production of stationary electrical waves, bridges connecting said conductors at points corresponding with the nodes of said waves, ground connections for said bridges and an antenna connected with one of the conductors.

8. In space telegraphy, in combination, a plurality of mutually-inductive conductors adapted for the production of stationary electrical waves, an antenna connected to one of said conductors and a receiver located at a loop of said stationary waves.

9. In space telegraphy, in combination, a plurality of mutually-inductive conductors adapted for the production of stationary electrical waves, an antenna connected to one of said conductors at a node of said waves, and a receiver located at a loop of said waves.

10. In wireless telegraphy, the combination with an antenna, of two conductors of substantially uniform separation, one of said conductors being connected with the antenna.

11. In wireless telegraphy, the combination with an antenna of two conductors of substantially uniform separation, one of said conductors being connected with the antenna, and tuning or period adjusting devices connected with said conductors.

12. In space telegraphy, in combination, an antenna, two conductors adapted to the production of stationary waves, one of said conductors being connected with the base of the antenna and a condenser between the base of the antenna and the other of said conductors.

13. In space telegraphy, in combination, an antenna, two parallel conductors connected at one end and having a condenser between their other or open ends, and an antenna connected with the open end of one conductor.

14. In space telegraphy, in combination an antenna, two parallel conductors connected at one end and open at the other, and an antenna connected to the open end of one conductor, the joint lengths of said conductors being equivalent to a multiple of one-quarter of the wave length for which the antenna is adapted.

15. In space telegraphy, in combination, an antenna, a conductor consisting of a wire and sheath return having one end of the sheath connected with the antenna, and the corresponding end of the wire connected with a capacity.

16. In space telegraphy, in combination, an antenna, a conductor consisting of a wire and sheath return having an end of one of said members connected with the antenna.

17. In space telegraphy, in combination, an antenna, a conductor consisting of a wire and sheath return having one end of one of said

members connected with the antenna, said wire and sheath return being equivalent in length to a multiple of a quarter wave length.

18. In space telegraphy, in combination, an antenna, a conductor consisting of a wire and sheath return connected with a capacity, said wire and sheath return being equivalent in length to a multiple of a quarter-wave length.

19. In space telegraphy, the combination with parallel conductors forming a resonant system, an antenna connected with one end of said system, and means connected with the said conductors for the production therein of stationary electrical waves, of a capacity connection between said conductors adapted to lengthen their period of vibration.

20. In space telegraphy, the combination with parallel conductors forming a resonant system, an antenna connected with one end of said system, and means connected with the said conductors for the production therein of stationary electrical waves, of a capacity connection thereto adapted to lengthen their period of vibration.

21. In space telegraphy, the combination with parallel conductors forming a resonant system, an antenna connected with one end of said system, and means connected with the said conductors for the production therein of stationary electrical waves, of a capacity connection between said conductors adjacent to a static loop of said waves.

22. In space telegraphy, the combination with an antenna and two parallel conductors adapted to form a resonant system, one of which conductors is connected with the antenna, of condensers inserted between said parallel conductors.

23. In space telegraphy, the combination with an antenna and two parallel conductors adapted to form a resonant system, one of which conductors is connected with the antenna, of condensers inserted between said parallel conductors at points corresponding substantially with the loops of the electrostatic waves therein.

24. In space telegraphy, the combination with an antenna and two parallel conductors adapted to form a resonant system, one of which conductors is connected with the antenna, of lag-producing devices connected with said parallel conductors.

25. In space telegraphy, the combination with an antenna and two parallel conductors adapted to form a resonant system, one of which conductors is connected with the antenna, of lag-producing devices connected with said parallel conductors, and means for adjusting said devices to control the amount of lag produced thereby.

26. In space telegraphy, the combination with an antenna and two parallel conductors adapted to form a resonant system, one of which conductors is connected with the antenna, of condensers connected with said conductors and having their poles adjustable toward and from each other.

27. In space telegraphy, in combination an antenna, parallel conductors connected therewith and adapted to the production of stationary waves, and a condenser between the ends of said conductors.

28. In space telegraphy, in combination, an antenna, a conductor connected therewith and adapted to the production of stationary waves, a condenser between the ends of said conductor and a wave-indicating device connected in shunt about said condenser.

29. In an apparatus for space telegraphy, in combination, an antenna and two parallel and mutually-inductive conductors, one of which is electrically connected with the antenna and a wave-indicating device between said conductors.

30. In an apparatus for space telegraphy, in combination, an antenna, two parallel and mutually-inductive conductors one of which is electrically connected with the antenna, said conductors being each equivalent to a multiple of a quarter-wave length, and a wave-indicating device connecting said conductors at a point equivalent to a multiple of a quarter-wave length distant from said antenna.

31. In an apparatus for space telegraphy, in combination, an antenna, a plurality of parallel conductors coöperating therewith to develop stationary electrical waves, and a wave-indicating device placed in the field of said waves substantially at a loop thereof.

32. In an apparatus for space telegraphy, the combination with an antenna, and two parallel conductors each equivalent in length to a multiple of a quarter-wave length and adapted to the production of stationary electrical waves, and a wave-indicating device connecting said conductors at a point corresponding substantially with loops of said waves.

33. In space telegraphy, in combination, a plurality of conductors adapted for the production of stationary electrical waves, bridges connecting said conductors and located substantially at nodes of said waves, an antenna connected with one of the conductors and a wave-indicating device connected with said conductors substantially at a loop of said waves.

34. In space telegraphy, in combination, a plurality of conductors adapted for the production of stationary electrical waves, an antenna connected with one of the conductors, bridges connecting said conductors and located substantially at nodes of said waves, and a wave-indicating device connected with said conductors substantially at a loop of said waves and beyond a bridge from the antenna.

35. In space telegraphy, in combination, an antenna, a conductor consisting of a wire and sheath return having the wire and sheath connected one with the antenna and the other with a capacity and a wave-indicating device connected between the wire and sheath.

36. In space telegraphy, in combination, an antenna, a conductor consisting of a wire and

sheath return, one of which is connected with the antenna and a wave-indicating device connected between the wire and its sheath.

37. In space telegraphy, in combination, an antenna, a conductor consisting of a wire and sheath return, one of which is connected with the antenna and a wave-indicating device connected between the wire and its sheath, at a point corresponding substantially with the loop of the waves in said conductor.

38. In space telegraphy, in combination, an antenna, a conductor consisting of a wire and sheath return, one of which is connected with the antenna, said wire and sheath return being equivalent in length to a multiple of a quarter-wave length, and a wave-indicating device connected between the wire and its sheath.

39. In space telegraphy, the combination with parallel conductors, means connected therewith for the production in said conductors of stationary electric waves, of a capacity connection between said wires adapted to lengthen their period of vibration, and a wave-indicating device connected between said wires.

40. In space telegraphy, the combination with parallel conductors, means connected therewith for the production in said conductors of stationary electrical waves, a capacity connection between said wires adjacent the static loop of the waves in said conductors, and a wave-indicating device connecting said conductors adjacent a static loop of the waves therein.

41. In space telegraphy, the combination with an antenna and two parallel conductors which are connected at one end one with the antenna and the other with the earth or other capacity, and a wave-indicating device connected between said conductors.

42. In space telegraphy, the combination with an antenna and two parallel conductors, one of which is connected with the antenna, of condensers inserted between said parallel wires, and a wave-indicating device in shunt about said condensers.

43. In space telegraphy, the combination with an antenna and two parallel conductors which are connected at one end, one with the antenna and the other with the earth or large capacity, and a wave-indicating device connected between said conductors at a point along the wires substantially corresponding to a loop of the wave with which it is designed to operate.

44. In space telegraphy, the combination with an antenna and two parallel conductors, one of which is connected with the antenna, a lag-producing device operative upon said conductors, and a wave-indicating device connected with such conductors.

45. In space telegraphy, the combination with an antenna and two parallel conductors, one of which is connected with the antenna, of lag-producing devices operative upon said conductors, means for adjusting said devices to control the amount of lag produced thereby, and a wave-indicating device connected with said conductors.

46. In space telegraphy, the combination with an antenna and two parallel conductors, one of which is connected with the antenna, of condensers connected with said conductors and having their poles adjustable toward and from each other, and a wave-indicating device connected with said conductors.

47. In space telegraphy, the combination with an antenna, two parallel conductors, one of which is connected with the antenna, of a condenser connected between said conductors substantially at an electrostatic loop of the waves therein, and a wave-indicating device connected between said conductors substantially at a loop of the electrostatic wave therein.

48. In space telegraphy, an antenna, a conductor connected therewith and adapted to the production of stationary waves harmonizing in period with those of the antenna, a wave-indicating device connected with the conductor, and connections with said conductor between the wave-indicating device and the antenna adapted to remove from the conductor such waves as are not in harmony with its designed period.

49. In a sending apparatus for space telegraphy, the combination with a wave-producing device and an antenna, of a conductor connecting the wave-producing device and the antenna and equivalent in length to a multiple of a quarter-wave length, and a second conductor parallel thereto and acting inductively to produce stationary electrical waves.

50. In a sending apparatus for space telegraphy, the combination with a wave-producing device and an antenna, of parallel conductors connecting the wave-producing device and the antenna and equivalent in length to a multiple of a quarter-wave length, and bridges connecting said parallel conductors substantially at nodes of the waves produced therein.

51. In a sending apparatus for space telegraphy, the combination with a wave-producing device and an antenna, of parallel conductors connecting the wave-producing device and the antenna and equivalent in length to a multiple of a quarter-wave length, bridges connecting said parallel conductors substantially at nodes of the waves produced, and ground connections for said bridges.

52. In space telegraphy, the combination with a wave-producing device and a radiating antenna, of a plurality of conductors connecting the wave-producing device and the antenna and the other acting inductively therewith to produce stationary electrical waves.

53. In space telegraphy, the combination with a wave-producing device and a radiat-

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ing antenna, of a plu ality or parallel conductors each equivalent in length to a multiple of a quarter-wave length, said conductors being adapted to the production of stationary vibrations, one of said conductors connecting the wave-producing device and the antenna.

In testimony whereof I have hereunto affixed my signature in the presence of two witnesses.

LEE DE FOREST.

Witnesses:
H. L. REYNOLDS,
ADOLPH FUCHS.

2645-2646

PLAINTIFF'S EXHIBIT 203

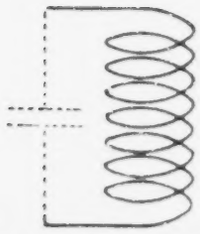


FIG. 45.—*Circuit which is equivalent to a coil having distributed capacity*

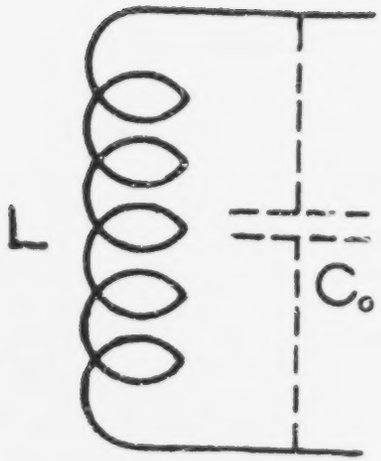


Fig. 218.—Distributed Capacity of Inductance.

Claimant's Exhibit No. 211

MANUAL OF WIRELESS TELEGRAPHY

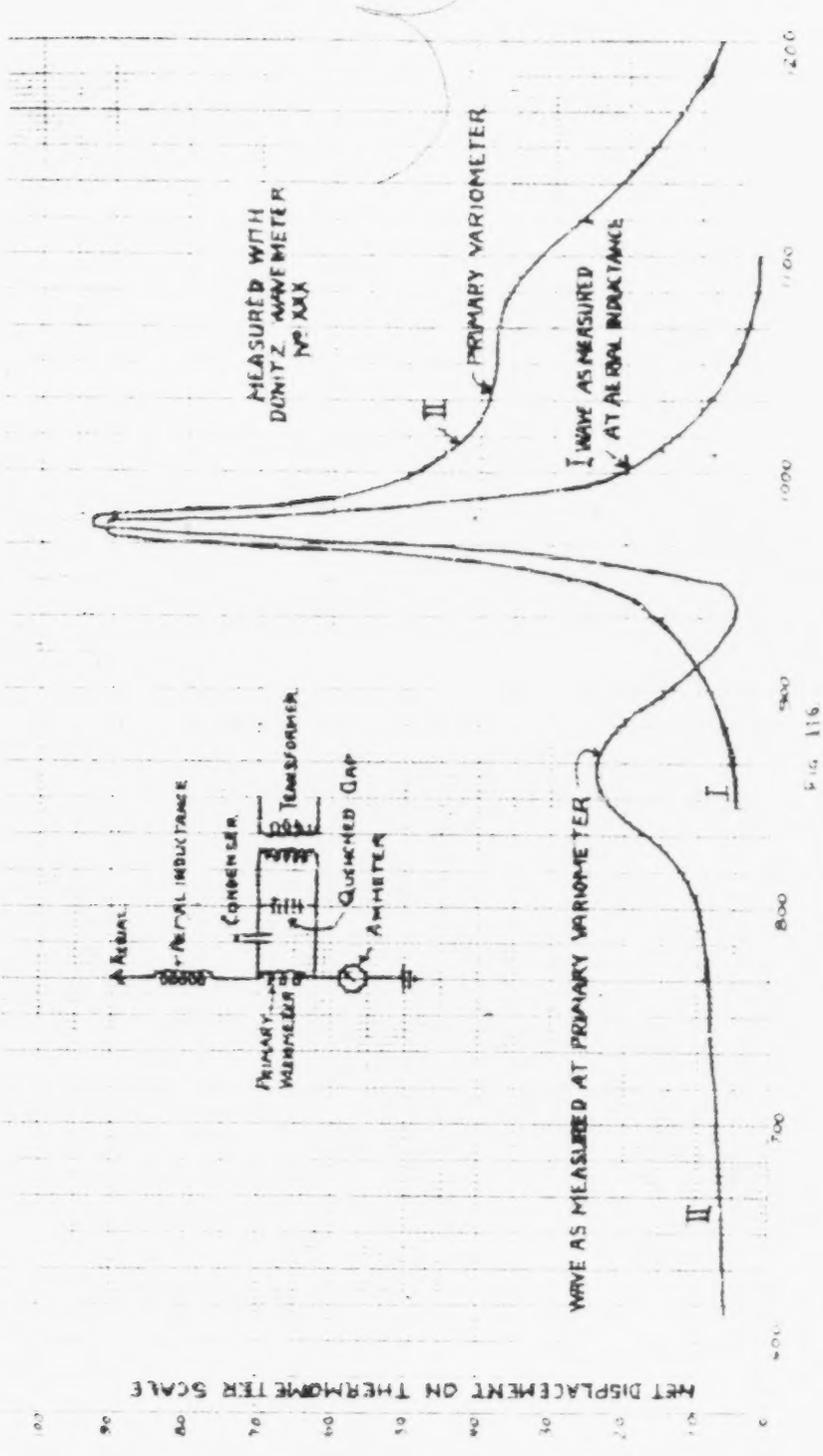
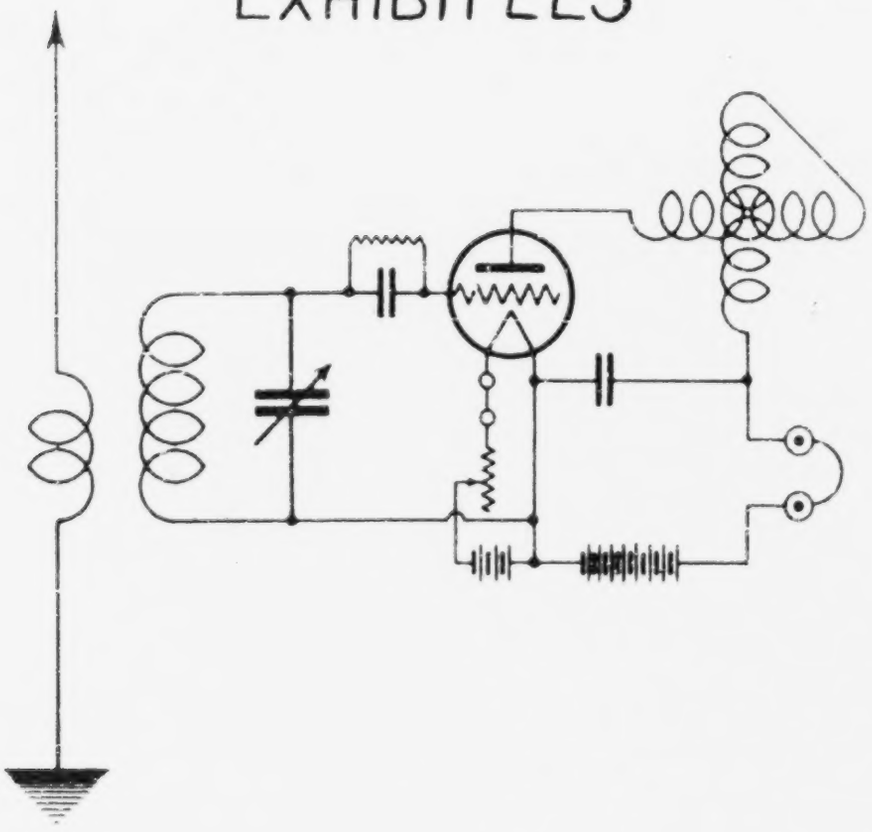


Fig. 116

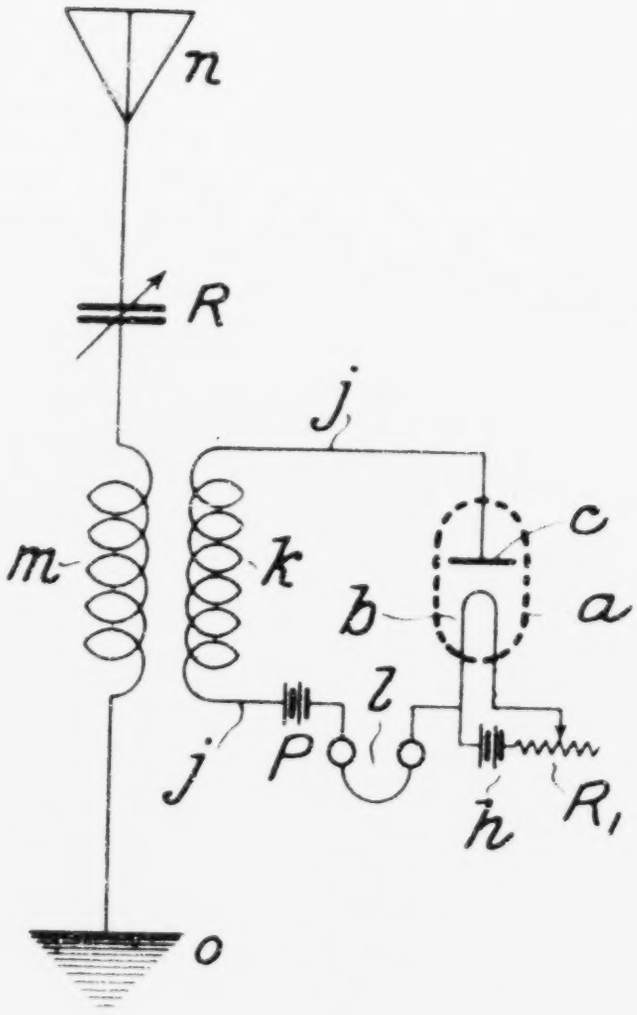
Claimant's Exhibit No. 223

EXHIBIT 223



Claimant's Exhibit No. 225

EXHIBIT 225



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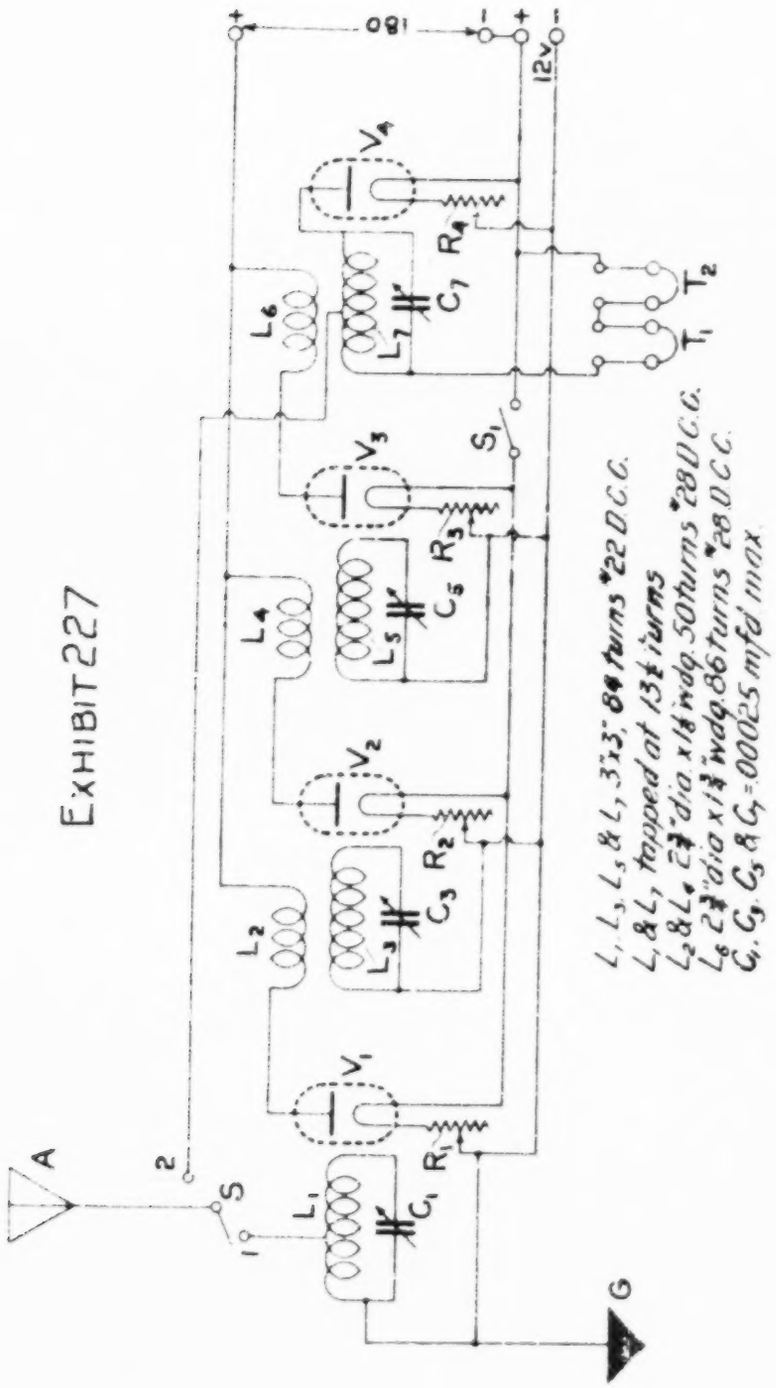
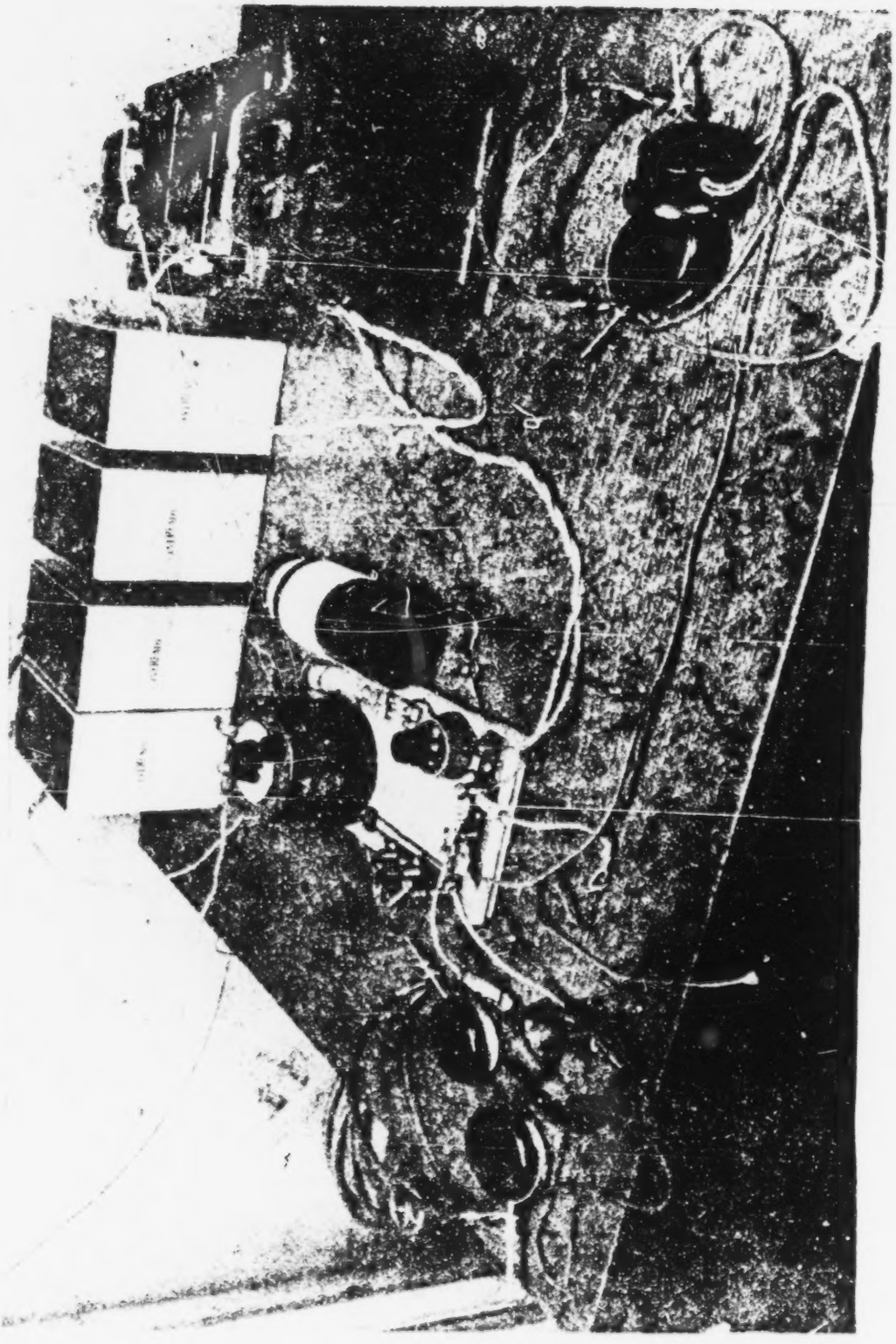
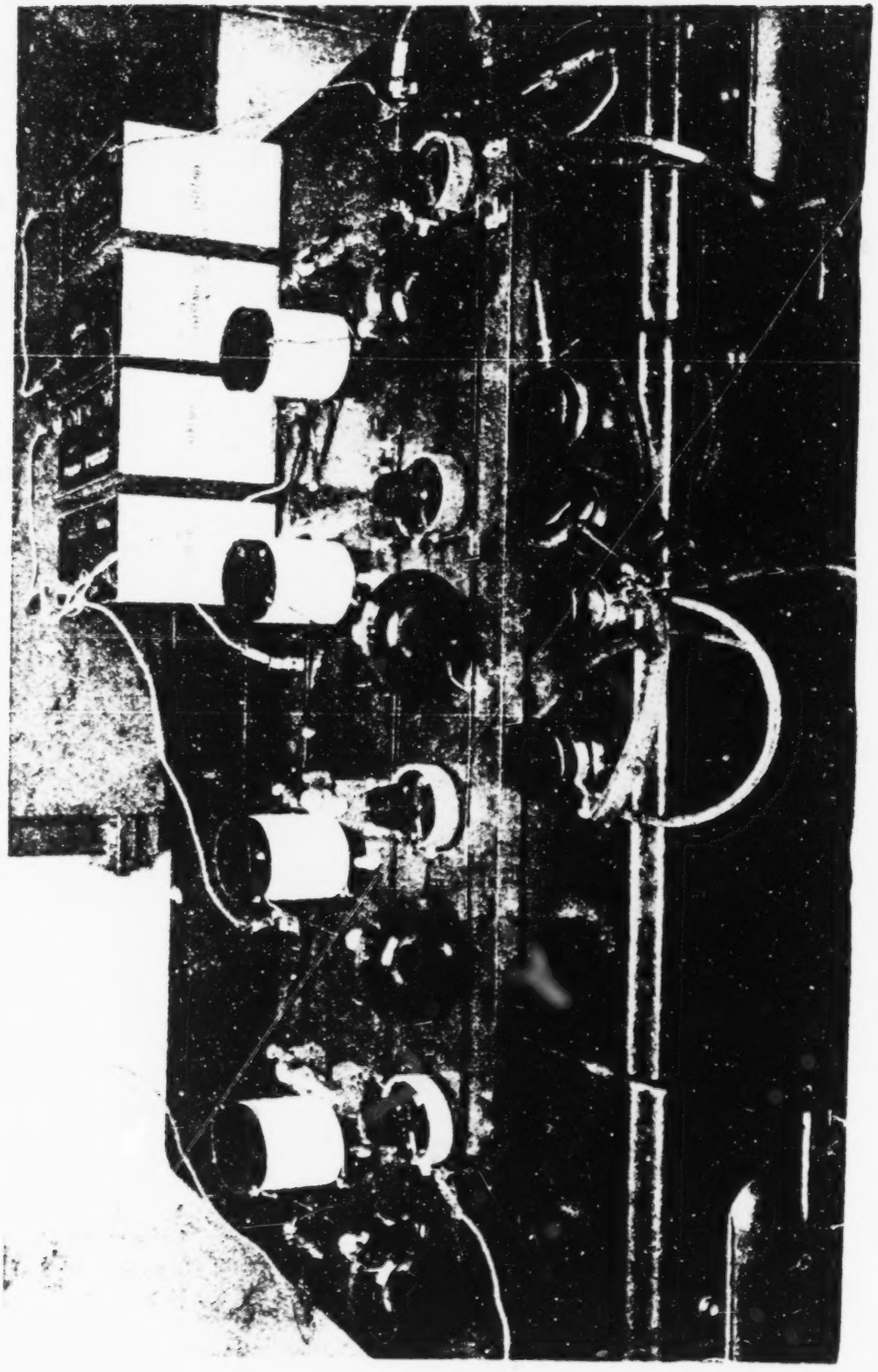


Claimant's Exhibit No. 228



Claimant's Exhibit No. 229



PLAINTIFF'S EXHIBIT 230

~~Armstrong Article Adopted in Judge Mayer's Opinion in Marconi vs. DeForest - 236 Fed. 942, And Opinion of Circuit Court of Appeals in Armstrong vs. DeForest - 270 Fed. 445.~~

~~24~~

Operating Features of the Audion

Explanation of its action as an amplifier, as a detector of high-frequency oscillations and as a "valve." By E. H. Armstrong

ALTHOUGH the audion has been in use for several years as an amplifier and a detector of high-frequency oscillations, the explanations advanced to account for its action do not appear to be satisfactory. With the idea of pointing out some features of operation which heretofore do not seem to have been

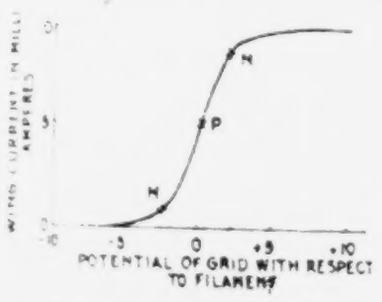


FIG. 1—VARIATION OF WING CURRENT WITH GRID POTENTIAL

with respect to the filament, but only one grid was employed. It was found that, under similar conditions of filament temperature and voltage of the battery B_p, a considerably smaller current was obtained between the filament and plate on the side in which the grid was inserted. In both measurements the grid was left entirely free of any connection with the rest of the apparatus. Obviously the grid obstructed the flow of the thermionic current. Investigation showed that this was due to the charge accumulating on the grid when exposed to bombardment by the electrons passing from

FIG. 4—TIME VARIATION OF GRID POTENTIAL AND WING CURRENT

elucidated the following explanation and oscillograms are given.

The audion is essentially an electron relay, that is, the exhaustion is carried to such a point that the amount of gas present is exceedingly small, and the current between the hot and cold electrodes is entirely thermionic, the absence of gas making impossible the presence of positive ions. The operating characteristic of such a relay is as shown in Fig. 1. This characteristic was obtained in the manner indicated in Fig. 2.

The potential of the grid with respect to the filament was varied in steps between — 10 and + 10 volts, by means of the potentiometer P, corresponding readings of grid voltage and wing current being taken in order to plot the curve of Fig. 1. The characteristic shows that, starting with the grid and filament at zero potential difference, a negative charge imparted to the grid produces a decrease in the wing current and a positive

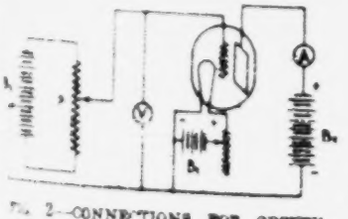


FIG. 2—CONNECTIONS FOR OBSERVING WING CURRENT AND GRID POTENTIAL

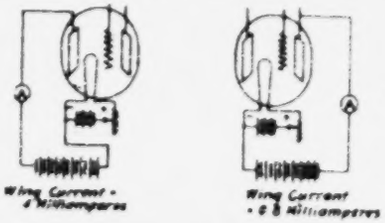


FIG. 3—CONNECTIONS GIVING TWO VALUES OF WING CURRENT

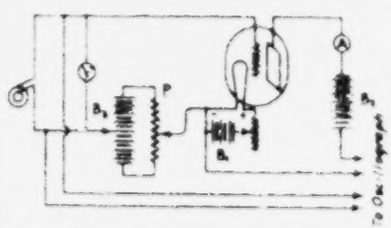


FIG. 5—CONNECTIONS TO OSCILLOGRAPH

charge imparted to the grid produces an increase in the wing current. This is the fundamental action of the audion when used either as an amplifier or a detector. The reason for this action will appear upon examination of the behavior of an audion of the type shown in Fig. 3.

The wings of the audion were placed symmetrically the filament to the wing. The electrons pass readily enough into the grid but cannot easily escape from it and as a consequence of this negative electricity piles up on the grid. The potential assumed by the grid when exposed to this bombardment may be several volts negative with respect to the negative terminal of the filament, it may be the same as the negative terminal or it may be positive with respect to the negative terminal, but it will always be negative with respect to the potential of the field in the plane of the grid which would exist if the grid were removed from the bulb. The negative charge on the grid, therefore, impedes the flow of electrons from filament to plate, causing the decrease in the wing current. The placing of a positive charge on the grid from an external source tends to neutralize the negative charge on the grid, thereby permitting an increase in the wing current. The addition of a negative charge to the grid increases the deflection of the electrons and produces a further decrease in the wing current.

An alternating emf impressed between the grid and the filament causes variations in the wing current in the manner indicated in Fig. 4, the positive alternation producing an increase and the negative alternation a decrease in the wing current. This is the action in-

volved in the audion when it is used as an amplifier.

To substantiate the above and other actions, the writer, working in conjunction with Prof. J. H. Morecroft, of Columbia University, has secured oscillograms which substantiate the idea just presented. Fig. 5

FIG. 6—ACTION OF AUDION AS AN AMPLIFIER

shows the arrangements with which the test was carried out.

The potentiometer P was used to adjust the grid to a potential corresponding to point P at the center of the operating part of the curve shown in Fig. 1. The audion is capable of handling the greatest amount of energy as an amplifier when the grid potential is adjusted to this point.

Fig. 6 shows the oscillogram of the action as an amplifier. The result bears out the explanation already given.

The action of the audion as a detector of high-frequency oscillations is quite different from its action as an amplifier. Since the incoming oscillations are of too high a frequency to affect directly the telephone receiver, the audion must be so connected and adjusted that the cumulative effect of a group of oscillations in the grid circuit is translated into a single low-frequency pulse or variation in the telephone current. This may be done in two ways, one depending on the non-linear form of the operating characteristic of the audion and the other depending on the so-called "valve" action between hot and cold electrodes at low pressures.

Fig. 7 shows the connection used for operating in the first-named manner. The potentiometer P is employed for the purpose of adjusting the potential of the grid to point M on the characteristic curve of Fig. 1. The action is much the same as in one of Professor Fleming's methods of using his valve. A group of high-frequency oscillations impressed on the grid causes corresponding high-frequency variations in the continuous current in the wing circuit, but owing to the fixing of the grid potential at the lower bend in the curve by adjustment of the potentiometer in the grid circuit, the amplitude of the positive part of the high-frequency current in the wing circuit exceeds the amplitude of the negative part. As the positive half-waves are greater than the negative half-waves, more electricity flows in one direction than the other, and the condenser C, through which the high-frequency current in the wing circuit flows, becomes charged, the side connected to the battery B_1 having the positive charge. This charge accumulates in C in a relatively short time, approximately that of the duration of a wave train. C then discharges through the telephones T, the rate of this discharge being determined by the constants of the telephones and the condenser. It is probable that this discharge is aperiodic or nearly so. In any case the main part of the discharge through the telephones is in the same direction as the current due to the battery B_1 and constitutes an increase in the current in the telephones. As this action is repeated for each group of oscillations, a series of wave trains causes what might be regarded (in its action on the telephones) as an alternating current in the telephones superposed on the continuous current and having a fundamental frequency equal to the number of wave trains per second. The action is shown diagrammatically in Fig. 8.

If the potential of the grid is adjusted to the upper bend in the curve of Fig. 1, as at point N, the func-

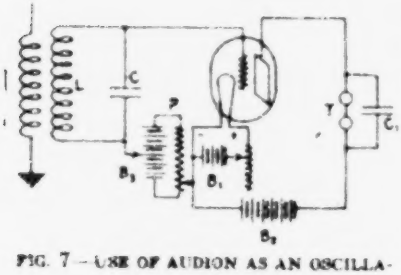
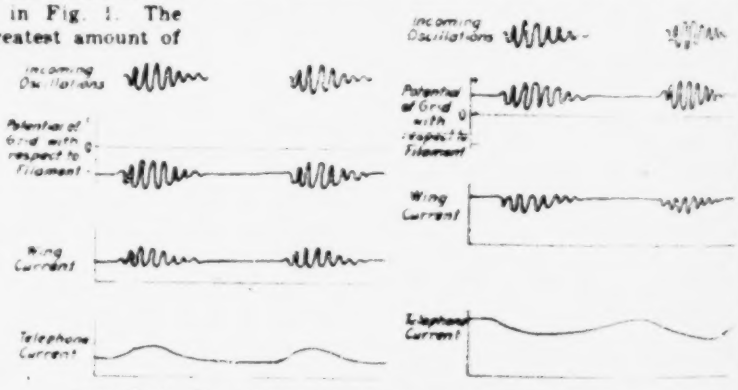


FIG. 7—USE OF AUDION AS AN OSCILLATION DETECTOR



FIGS. 8 AND 9—ACTION OF AUDION AS AN OSCILLATION DETECTOR

mental action will be the same, but the effect of high-frequency oscillations in the grid circuit on the wing current will be reversed. The amplitude of the negative part of the high-frequency oscillations in the wing circuit will exceed the amplitude of the positive part and

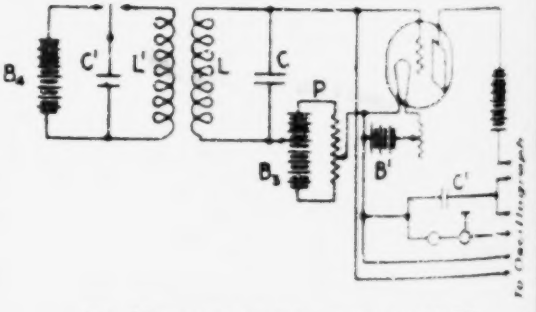


FIG. 10—CONNECTIONS TO OSCILLOGRAPH

the condenser C will become charged, but in the opposite sense, the side connected to the battery B becoming negative. The discharge of the condenser through the telephones will therefore be in the opposite direction to the flow of the continuous current of the wing circuit

and will constitute a decrease in the telephone current. Diagrammatically the action is as indicated in Fig. 9.

Oscillograms bearing on these actions were obtained in the manner indicated in Fig. 10. Oscillations were set up by the discharge of the condenser C through the

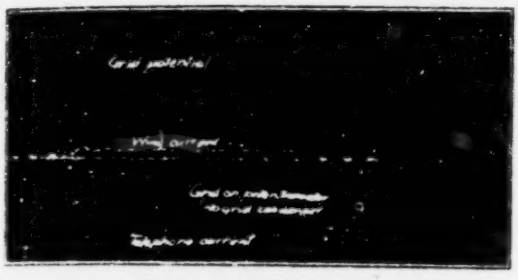


FIG. 11—OSCILLOGRAM OF ACTION AS A DETECTOR

inductance L_1 which was coupled with the inductance L of the tuned grid circuit. To permit the use of an ordinary General Electric oscillograph, an oscillation frequency of about fifty cycles per second and a group frequency of two or three cycles were employed. The action of the audion is the same regardless of frequency, provided that the circuit constants are suitably modified to fit the frequency employed. In this case the oscillation frequency of the circuit CL was fifty cycles and the circuit L_1 was accordingly tuned to the same frequency. The capacity of C was selected to correspond to the low frequency employed. Figs. 11 and 12 show oscillograms taken as indicated in Fig. 10, with the grid potential adjusted respectively to the lower and upper bends of the operating characteristic.

It will be observed that the telephone current reaches in Fig. 11 its maximum value, and in Fig. 12 its minimum value, when the oscillating current has almost died away. This effect would be shown more plainly with a higher oscillation frequency, but even at the frequency used it is quite evident.

To make use of the "valve" action between hot and cold electrodes for the detection of high-frequency oscillations a connection as shown in Fig. 13 is used.

In this case a condenser C_1 is inserted somewhere in the circuit between the grid and filament to prevent the flow of a continuous current between them, and the grid is therefore left free to assume a potential determined by its position with respect to the filament and wing. Usually this will be somewhere near the center

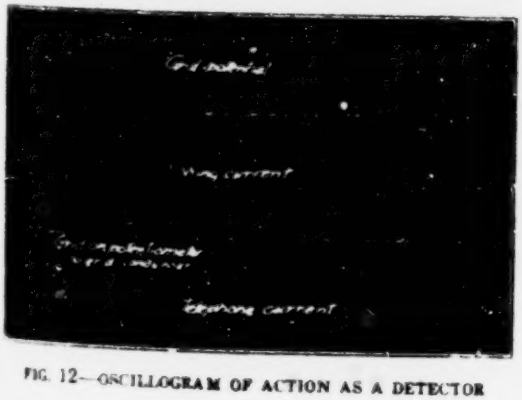


FIG. 12—OSCILLOGRAM OF ACTION AS A DETECTOR

of the operating part of the curve of Fig. 1; that is, near point P. Now the action for incoming oscillations, as far as the closed oscillating circuit, filament, grid and condenser C_1 are concerned, is identical with the rectifying action of the Fleming valve. An incoming wave train sets up oscillations in the closed circuit LC which are rectified by the "valve" action of the filament and grid, and the rectified current is used to charge the condenser C_1. Electrons pass readily enough

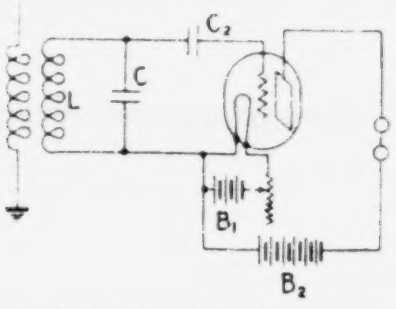


FIG. 13—USE OF AUDION AS A "VALVE"

into the grid but cannot easily escape therefrom, and a negative charge is built up on the side of the condenser connected to the grid. The negative charge thus imparted to the grid cuts down the flow of electrons from the filament to the wing, producing a decrease in the wing and telephone currents. At the end of a wave

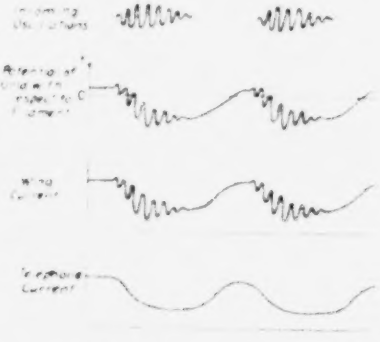


FIG. 14—ACTION OF AUDION AS A "VALVE"

train the charge in C_1 gradually leaks off and the wing current returns to its normal value. The charge and discharge of this condenser take place in the manner indicated in Fig. 14.

One group of oscillations produces a single low-frequency variation (decrease) in the telephone current

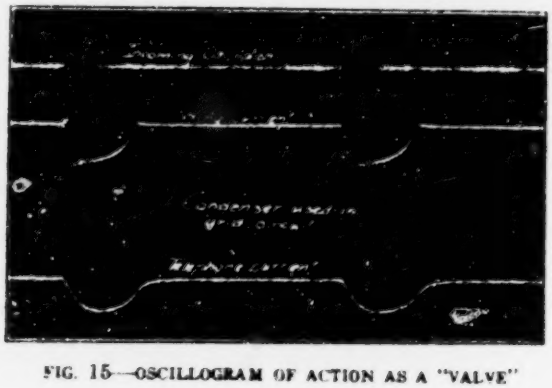


FIG. 15—OSCILLOGRAM OF ACTION AS A "VALVE"

and a series of wave trains produces a corresponding series of low-frequency variations in the telephone current. In Fig. 15 is shown an oscillogram of the behavior of the audion when the "valve" action is employed for the detection of oscillations.

With the means at hand it was impossible to ascertain the variations of the grid potential, as the leak introduced by connecting the oscillograph to the grid would destroy the cumulative action in the grid condenser. The grid potential, however, varies in exactly the same manner as the wing current. It will be seen that the fundamental detecting action is that of a valve, the high-frequency oscillations being rectified between the filament and grid, thereby causing a charge to accumulate on the grid and in the grid condenser. The charged grid then exerts a relay or trigger action on the wing current so that the audion is at once a rectifier and an amplifier. A somewhat similar combination of rectifying and amplifying actions occurs in the arrangement shown in Fig. 7. The action of the audion is being further studied by Prof. Morecroft and the writer in the research laboratory in electro-mechanics, Columbia University, and the results of these investigations will soon be published.

High-Potential Voltmeter Based on Corona Pressures

Striving by experiment to determine the relation between the corona current and the increase in air pressure which occurs if direct-current corona takes place in an inclosed space, members of the physics department of the University of Illinois, Urbana, have hopes of being able to construct a high-potential voltmeter based on this pressure phenomenon. Professor Jacob Kunz, in describing some of the experiments before the American Physical Society, stated that the tests covered potentials ranging from 3000 volts to 15,000 volts and that manometer deflections as great as 25 cm had been observed. Professor Kunz emphasized the fact that the pressure noted was not due to heating of the air, for the liquid used in the manometer responded instantly upon the application of potential. Curves plotted between potential and pressure from data obtained thus far approximate very nearly to straight lines.

The Electron Theory and Metallic Selenium Crystals

Since the usual free-electron hypothesis does not offer an explanation of (1) the increase of light sensitiveness with pressure, proportional to the conductivity of metallic selenium crystals in the dark, (2) why the change of conductivity by pressure or electrical fields is limited to the region of the crystal under stress, and (3) why the increase of light sensitiveness is limited to the region under pressure and is practically unlimited as to what region of the crystal is illuminated, Prof. F. C. Brown, Iowa State University, Iowa City, has proposed a modified form of the electron theory to satisfy all the fundamental experiments thus far recorded. This new view supposes that a large portion of the conducting electrons in the crystal are ordinarily fixed in the crystal structure in varying degrees of stability. When an electric field is established across the crystal a certain average number of these fixed electrons is rendered unstable or free. The divergence from the usually accepted notion is the conception that these electrons remain free only for a relatively short interval of time. Thus in these crystals the current increases with voltage more rapidly than is required by Ohm's law.

The effect of the increase of pressure is to lessen the degree of the stability, so that the mean interval before the recombination of the electrons is increased. "Obviously," says Professor Brown, "this seems to explain satisfactorily the increased light sensitiveness with increased pressure, and also the exact proportionality observed. It also explains the limitation of the increase to the region of the crystal under pressure. The transmitted light action observed by Prof. L. E. Sieg and myself is probably a mechanical disturbance propagated in the crystal, and enters into this theory only as the disturbance keeps electrons out of their fixed positions. If it were not for this rapid recombination of the electrons, the change of conductivity by pressure or electrical forces should be noticeable throughout a given crystal structure."

In closing his remarks, which were made before the American Physical Society at Chicago, Professor Brown suggested that a study of the conductivity changes very near the region of applied pressure might give some information as to the rate of recombination of the electrons.

Valuation in Houston, Tex.

Messrs. James E. Allison & Company, of St. Louis, Mo., have submitted a report on the rate case of the Houston (Tex.) Lighting & Power Company. They represented the company and reported on the capital now invested in the property and entitled to a return. In the letter of transmittal they say that they were aware that the report was to be submitted to the consideration of the Mayor and commission of the city of Houston in connection with a contemplated regulation of rates. A report on the property has been made by Messrs. Lyndon & Elrod, representing the Mayor of Houston.

In stating that valuation for rate making is comparatively new, the report says that the Wisconsin commission "is the one which is in great part responsible for the adoption of theoretical depreciation, and it is a very curious commentary on the theory of its members put forth in the early part of their work that while in nearly all of their cases they figure out the depreciated value, yet when they come actually to assign the amount of capital entitled to returns, the effect of depreciation cannot always be traced clearly in their announced result. The commission, while it has not yet admitted the error of applying this theory, has generally greatly raised the figures of its valuations as not to bring the results very seriously in question. There seems to have been what may be called an instinctive recognition of a just amount which has often been assigned in the commission's reports without making it very clear just how it was arrived at.

"Notwithstanding that by such methods of arriving at practical justice the Wisconsin commission has preserved itself from bringing about an impossible state of affairs in that State, yet its doctrine, which it does not always follow, has gone forth and has been adopted in many other places without that careful analysis which should have been given it. The consequence is that while Wisconsin has in some quarters gained a reputation for fair treatment of its utilities and may have so far escaped complete stagnation in utility enterprises, other localities which have followed the doctrines of Wisconsin without following its practice are already beginning to feel the effect of a theory of regulation under which private capital will not enter the public service."

An appendix to the report includes papers on the subject of depreciation by Mr. James E. Allison, Prof. Allyn A. Young, Cornell University; Prof. J. Laurence Laughlin, University of Chicago; Prof. W. F. Gephart, Washington University, and Prof. Lewis H. Haney, University of Texas.

Plaintiff's Exhibit 241.

in which λ is the frequency, e is the base of the natural logarithms and I_0 is the "initial amplitude" when $t = 0$.*

Fig. 16 shows the decrease in amplitude per cycle for different decrements, while in Table IV the oscillation curves have been drawn out for various decrements.

d. It follows from *a* that the Bjerknes decrement can be determined from the ratio of the energy lost in one cycle to that transferred in the same cycle. Hence substituting I for $I_{av.}$ we have

$$d = \frac{\frac{1}{2}RI^2T}{LI^2} = \frac{R}{2L}T = \frac{R}{2N_\lambda L} \qquad (4)$$

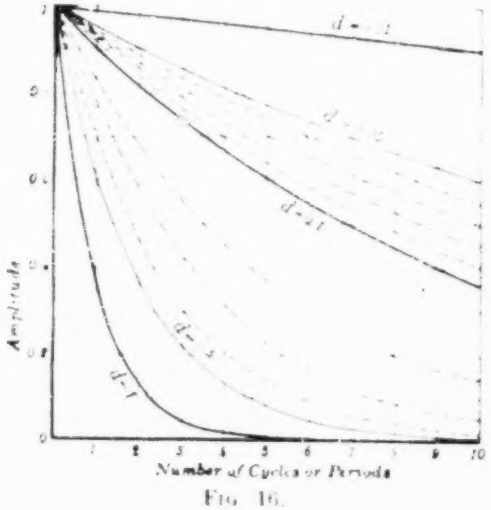


Fig. 16.

or replacing T by $2\pi\sqrt{LC}$ (Art. 8*a*) we have

$$d = \pi R\sqrt{\frac{C}{L}}$$

or from the foot-note in Art. 8*a*

$$d_1 = 2\pi^2 N_L \frac{RC}{\lambda}.$$

9. Condenser Circuit with Spark Gap. Damping due to Spark. *a.* The curves A_1 and A_2 of Fig. 17 are the amplitude curves of condenser circuits containing a spark gap (J. Zenneck) obtained with the Braun Tube. A_1 being for a circuit of very low, A_2 for one with higher ohmic resistance. Comparison with Fig. 16 shows a marked difference from the cases in which the damping is due to heat loss only. The amplitude

* In Fig. 14 I_1 is the upper, I_2 is the lower curve.

† $L_1 = 0.000_{\lambda_1} \frac{R_{\lambda=\infty} C_{\lambda_1}}{\lambda_{1=\infty}}$ $50.0 \frac{R_{\lambda=\infty} C_{\lambda_2}}{\lambda_{2=\infty}}$ or $= \frac{R_{\lambda=\infty} C_{\lambda_2}}{150\ \lambda_{2=\infty}}$ approximately.

Claimant's Exhibit No. 241

Claimant's Exhibit No. 242

The conditions may be such, however, that the spark gap, during the [illegible] which the amplitude in the primary circuit is very small, becomes

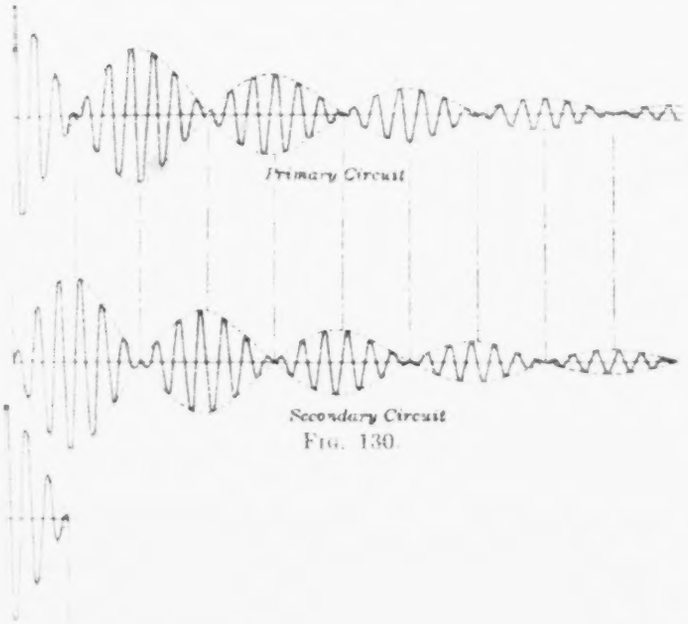


FIG. 130.

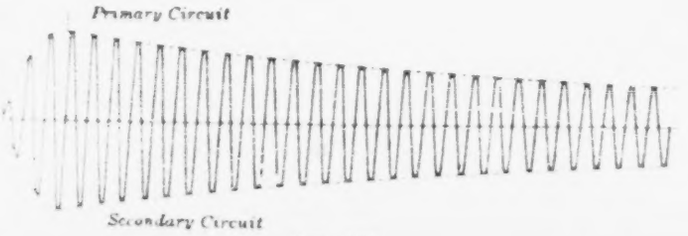


FIG. 131.

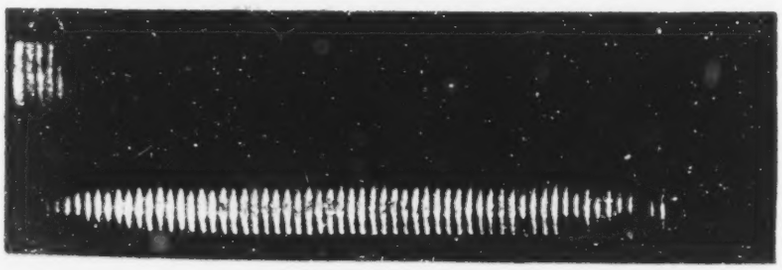


FIG. 132.

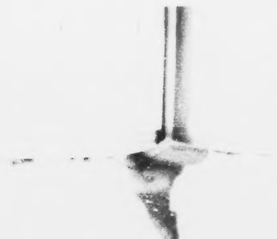
so long as that the EMF induced by the secondary is no longer sufficient to restart or "ignite" a spark discharge across the gap. As a result the spark gap remains quenched — whence the terms "quenching

Claimant's Exhibit No. 245

WEAGANT SKETCH #1

PRIMARY

SECONDARY



Claimant's Exhibit No. 244

...ance that the primary oscillatory and the antenna circuits ... identical time periods. For this it is necessary that the ... of one circuit equal the L_2C_2 value of the other. This does ... that L_1 must equal L_2 and C_1 equal C_2, but it does mean that ... of L_1 and C_1 expressed in henries and farads, or convenient ... must equal the product of L_2 and C_2 expressed in the same ...

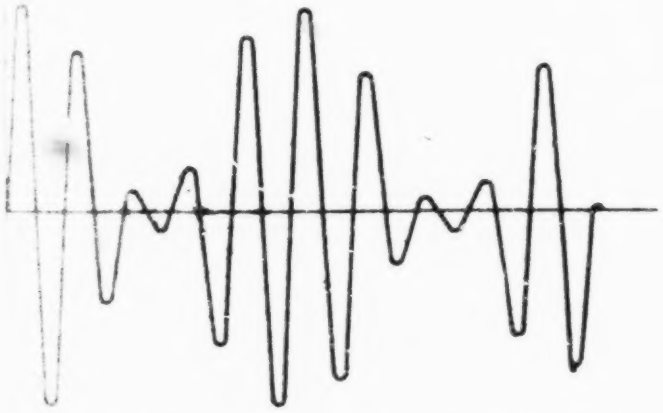


FIG. 274.—Oscillations, Primary Oscillatory Circuit

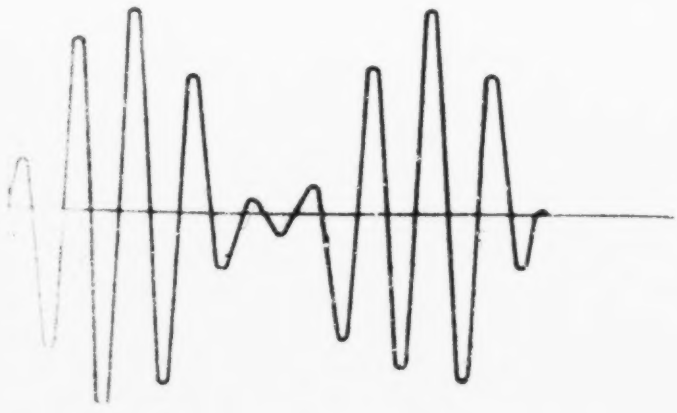


FIG. 275.—Oscillations, Secondary Oscillatory Circuit

...272 and 273 indicate the absence of any further interaction ... circuits once the transfer of energy has taken place ... oscillatory to the antenna circuit. There is, however, ... the antenna circuit to return energy to the primary

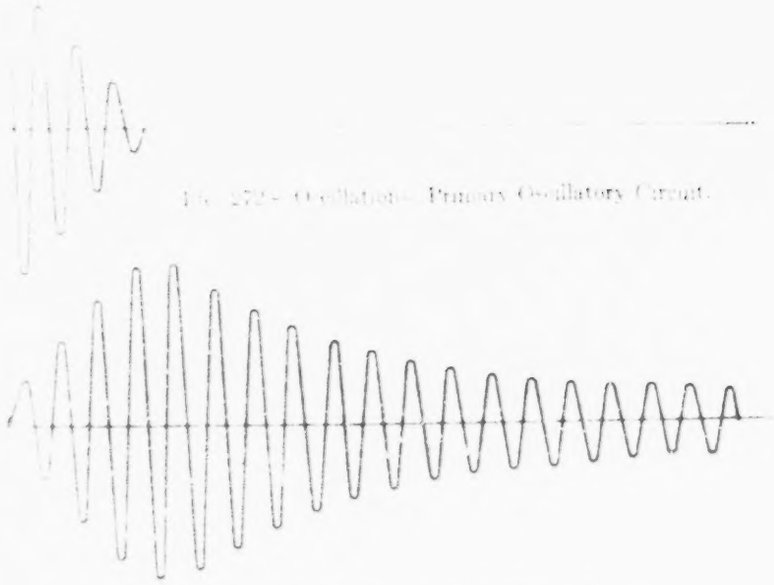
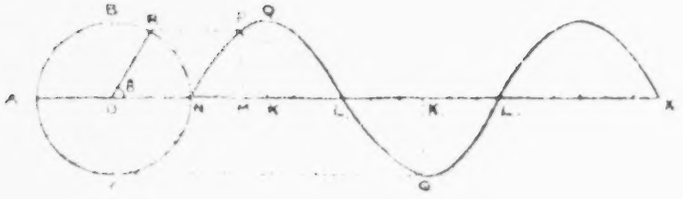
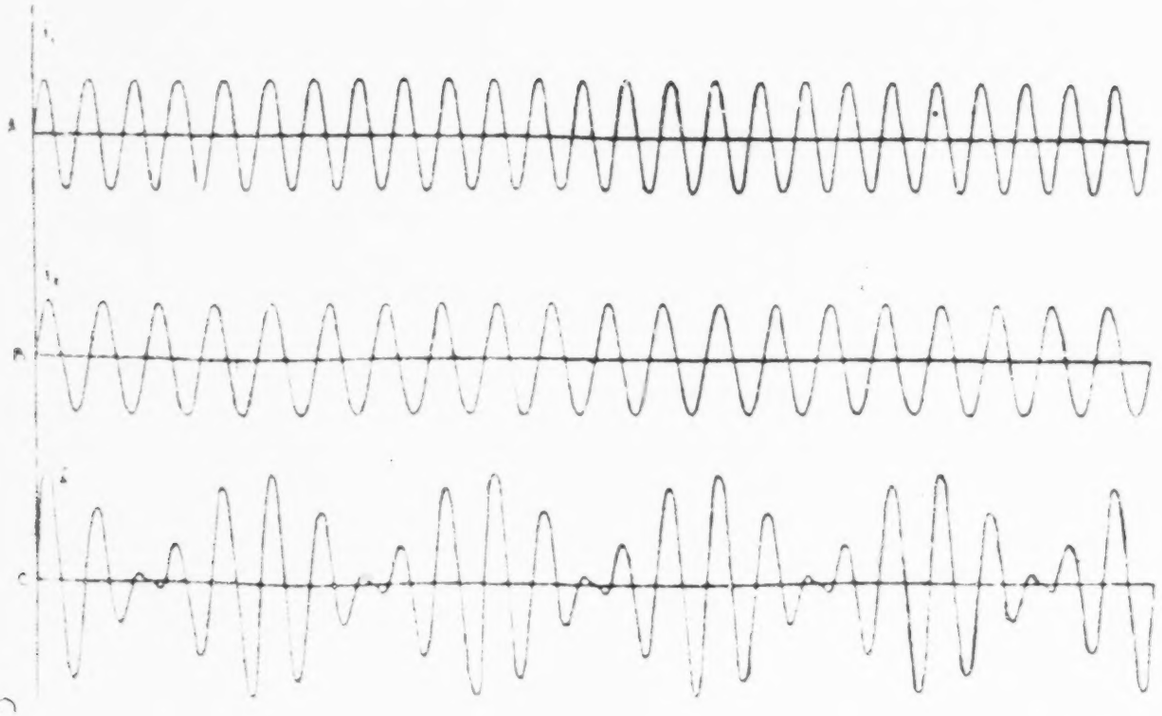


Fig. 272—Oscillations, Primary Oscillatory Circuit.

Claimant's Exhibit No. 246



Weagant Sketch No 2



An Experiment On Impulse Excitation

By John H. Morecroft

(Associate Professor in Electrical Engineering, Columbia University, New York City)

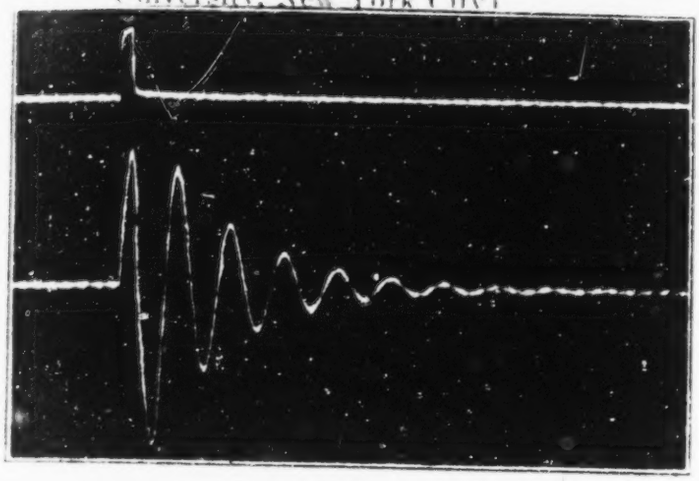


Figure 2

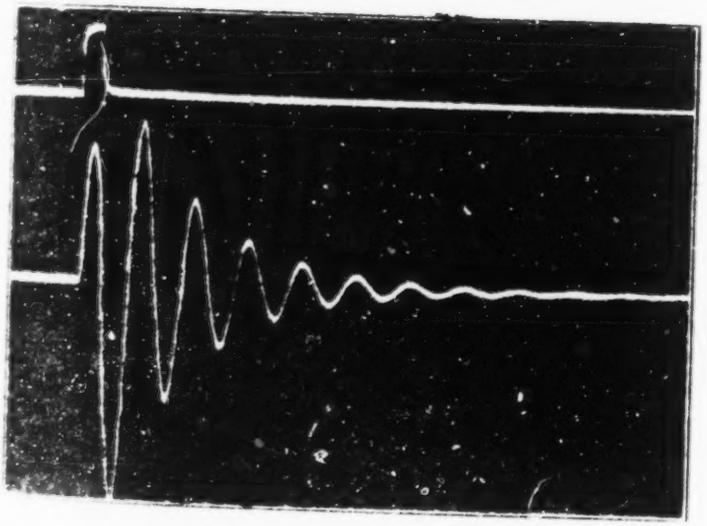


Figure 3

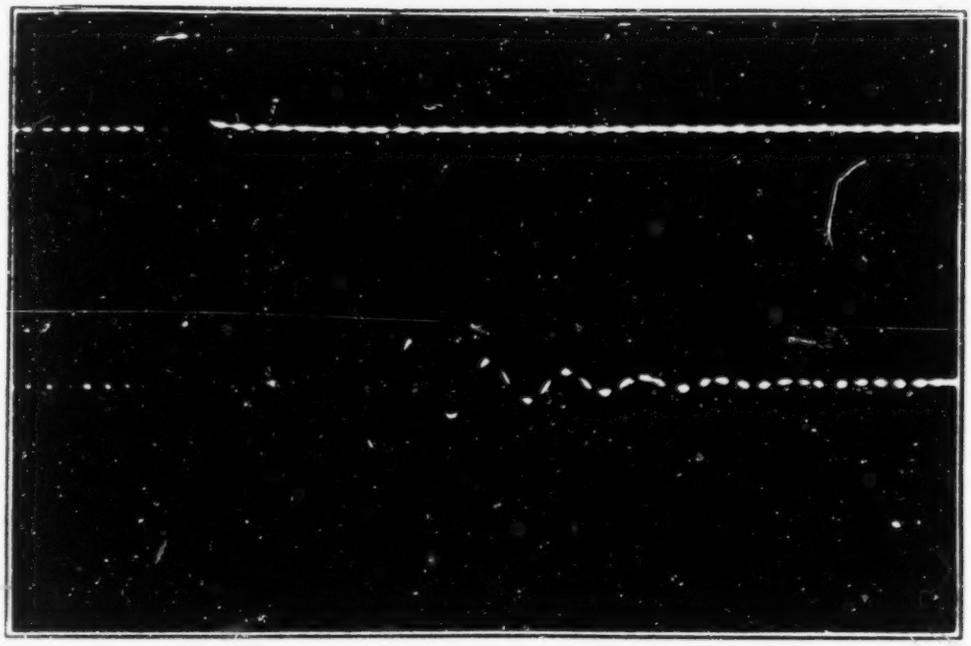


FIGURE 4

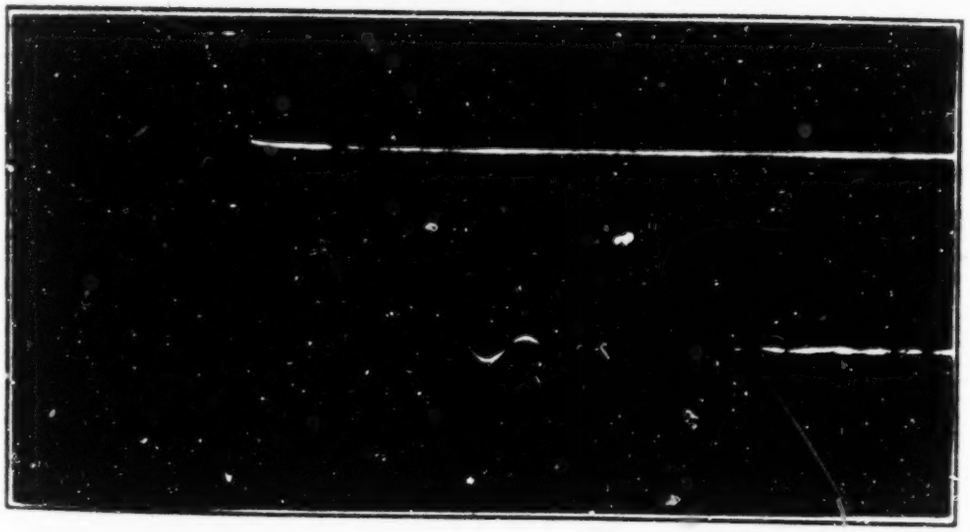


FIGURE 5

3085

Patented August 19, 1902.

UNITED STATES PATENT OFFICE.

JOHN STONE STONE, OF CAMBRIDGE, MASSACHUSETTS, ASSIGNOR TO WILLIAM W. SWAN, TRUSTEE, OF BROOKLINE, MASSACHUSETTS.

SPACE TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 707,976, dated August 19, 1902.

Application filed November 18, 1901. Serial No. 82,844. (No model.)

To all whom it may concern:

Be it known that I, JOHN STONE STONE, a citizen of the United States, and a resident of Cambridge, in the county of Middlesex and State of Massachusetts, have invented a certain new and useful Improvement in Space Telegraphy, of which the following is a specification.

My invention relates to the art of transmitting intelligence from one station to another by means of electromagnetic waves without the use of wires to guide the waves to their destination; and it relates more particularly to the system of such transmission in which the electromagnetic waves are developed by producing electric vibrations in an elevated conductor, preferably vertically elevated.

In my Letters Patent Nos. 714,756 and 714,757, granted December 2, 1902, I have described a system of selective space telegraphy in which a sonorous or persistently-oscillating circuit is associated with an elevated transmitting-conductor for developing in said conductor forced simple harmonic electrical oscillations. The forced simple harmonic electrical oscillations thus developed in the elevated conductor cause the radiation of simple harmonic electromagnetic waves, which, to distinguish them from waves guided to their destination by wires, I have termed "free or ungoided electromagnetic waves," although the earth, water, or other natural media over which they pass exerts a guiding influence upon them. In said Letters Patent I have also described a receiving system consisting of a resonant circuit attuned to the frequency of the transmitted waves and associated with an elevated receiving-conductor. I have furthermore described means whereby the system consisting of a complex of circuits is reduced to the equivalent of a system the circuits of which are the equivalent of circuits having a single degree of freedom, said means broadly consisting of an auxiliary inductance for neutralizing the effect of the mutual inductance between the sonorous circuit and the elevated transmitting-conductor or between the resonant circuit and the elevated receiving-conductor, said inductance being supplied by auxiliary coils or by the windings of the coil which associates the sonorous circuit with the elevated conductor.

In the drawing, which accompanies and forms a part hereof, the figure represents in diagram a transmitting system embodying my invention.

In the figure, V is an elevated conductor connected to earth at E. V I E is an elevated conductor system. M M' are transformers. I I' are respectively the primary and secondary windings of the transformer M. C C' are condensers. L is an inductance. S is a spark-gap. A is an alternating-current generator or other source of periodically-varying electromotive force. *k* is a key.

For the construction of parts and the operation thereof reference may be had to my hereinbefore-mentioned Letters Patent.

It has long been known that in spark-producing devices—such as static machines, Ruhmkorff coils, &c.—the spark is made larger or "fatter"—*i. e.*, that it has more energy—if a condenser be connected across the terminals of a spark-gap. Such use of a condenser in wireless-telegraph transmitting apparatus has been described by Dr. Mavin Tietz in the *Elektrotechnische Zeitschrift*, Vol. 19, No. 33, August 18, 1898, page 562, and a condenser for this purpose has been shown in Patents Nos. 706,735 and 706,739, dated August 12, 1902, and in Patent No. 711,130, dated October 14, 1902.

I have found it advantageous to connect across terminals of the spark-gap S of the sonorous circuit S C I, L a large condenser C' for the purpose of increasing the size of the spark and for increasing the energy of the disruptive discharge of the condenser C across this gap and also to form a path of low impedance to the electrical oscillations resulting from said disruptive discharge of the condenser C. As I have explained in my Letters Patent hereinbefore referred to, the condenser C in the oscillation-circuit S C I, L should be devoid of dielectric hysteresis if the oscillations developed in said circuit are to be accurately simple harmonic oscillations, and for this purpose the condenser C may

ductor of the period of the fundamental of said elevated conductor. The effect may be roughly compared to a stretched cord in a viscous medium vibrated by means of a tuning-fork. Forced vibrations are thereby developed in the stretched cord which are of frequency corresponding with that of the tuning-fork irrespective of the fundamental or natural period of the cord; but if the fundamental of the cord (which corresponds in this analogy to the elevated conductor system described herein) corresponds with the period of the tuning-fork (which corresponds in this analogy to the sonorous circuit associated with the elevated conductor) it will be found that the amplitude of vibrations executed by the cord are greater, other things being equal, than they would be without such correspondence in period.

I claim

1. In a system for developing free or unguided simple harmonic electromagnetic signal-waves of a definite frequency, an elevated-conductor system the fundamental of which has a period equal to the period of the waves to be transmitted, and means for developing the enforced simple harmonic electric vibrations of corresponding frequency.

2. In a system of space telegraphy an elevated conductor, a sonorous circuit, associated therewith and containing a condenser, and a condenser of capacity large as compared with the capacity of the condenser in said sonorous circuit, connected across the terminals of a spark-gap in said sonorous circuit.

3. In a system of space telegraphy, a sonorous circuit adapted to develop electric vibrations of a definite frequency, and elevated-conductor system associated therewith, the fundamental period of which is the same as the period of said sonorous circuit, and means for swamping the effect of the mutual inductance between said sonorous circuit and the elevated-conductor system.

4. In a system of space telegraphy, an elevated conductor, a sonorous circuit associated therewith and a condenser connected across the terminals of a spark-gap in said sonorous circuit.

5. In a system for developing free or unguided simple harmonic electromagnetic signal-waves of a definite frequency, an elevated-conductor system and a sonorous circuit associated therewith and adapted to develop simple harmonic electrical vibrations corresponding in period with the fundamental period of said elevated-conductor system.

6. In a system of space telegraphy, a transmitting system comprising a persistently-oscillating circuit, a good radiating-circuit, the fundamental period of which is equal to the period of said persistently-oscillating circuit, and means whereby said transmitting system is reduced to the equivalent of a system of a single degree of freedom.

7. In a system of space telegraphy, a transmitting system comprising a persistently oscillating circuit, a good radiating-circuit, attuned as to its fundamental to the period of said persistently oscillating circuit, and an auxiliary inductance for swamping the effect of the mutual inductance between said circuits.

8. As a means for developing electrical oscillations, a sonorous circuit containing a spark-gap and a condenser of large capacity connected across the terminals of said spark-gap by conductors of low impedance.

9. In a system of space telegraphy, an elevated conductor, a sonorous circuit, containing a spark-gap, associated therewith and a condenser connected across the terminals of said spark-gap by conductors of low impedance.

10. In a system of space telegraphy, an elevated conductor, a sonorous circuit, containing a spark-gap, associated therewith and a circuit consisting of large capacity and low resistance for affording a path of low impedance to the electrical oscillations developed in said sonorous circuit, connected across the terminals of said spark-gap.

11. In a system of space telegraphy, a transmitting system comprising a persistently-oscillating circuit containing the primary of a step-up transformer, a good radiating-circuit containing the secondary of said transformer, the fundamental period of said radiating-circuit being equal to the period of the persistently-oscillating circuit, and means whereby said transmitting system is reduced to the equivalent of a system each of whose circuits has a single degree of freedom.

12. In a system of space telegraphy, a sonorous circuit adapted to develop electrical vibrations of a definite frequency, an elevated-conductor system associated therewith by means of a step-up transformer, the fundamental of the elevated-conductor system being equal to the period of the persistently-oscillating circuit, and means for swamping the effect of the mutual inductance between said sonorous circuit and said elevated-conductor system.

13. In a system for developing free or unguided, simple harmonic, electromagnetic signal-waves of definite frequency, an elevated-conductor system the fundamental of which has a period equal to the period of the waves to be transmitted, means for developing simple harmonic electrical oscillations of corresponding frequency and means for impressing said electrical oscillations on said elevated-conductor system at increased potential.

14. In a system of space telegraphy, an elevated conductor, the fundamental of which has a period equal to the period of the waves to be transmitted, a sonorous circuit associated with said elevated conductor and adapted to develop electrical oscillations of corre-

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sponding period and a condenser or other capacity connected across the terminals of the spark-gap of said sonorous circuit.

15. In a system of space telegraphy, a persistently-oscillating circuit, and a good radiating-circuit, attuned as to its fundamental to the period of said persistently-oscillating circuit, in combination with means for increasing the amplitude of the electrical oscillations developed in said persistently-oscillating circuit.

16. In a system of space telegraphy, a persistently-oscillating circuit containing a spark-gap, a good radiating-circuit, attuned as to its fundamental to the period of said persistently-oscillating circuit, and a condenser connected across the terminals of said spark-gap.

17. In a system of space telegraphy, a sonorous circuit, a good radiating-circuit, attuned as to its fundamental to the period of said sonorous circuit, and means for impressing the oscillations created in said sonorous circuit upon said good radiating-circuit at increased potential, in combination with means for increasing the persistency of the oscillations developed in said sonorous circuit.

In testimony whereof I have hereunto subscribed my name this 23d day of November, 1903.

JOHN STONE STONE.

Witnesses:
G. ADELAIDE HIGGINS
ELLEN B. TOMLINSON

2677

PLAINTIFF'S EXHIBIT 258

No. 823,402 PATENTED JUNE 12, 1906

L. DE FOREST.

STATIC VALVE FOR WIRELESS TELEGRAPH SYSTEMS.

APPLICATION FILED DEC 9 1905

2 SHEETS SHEET 1

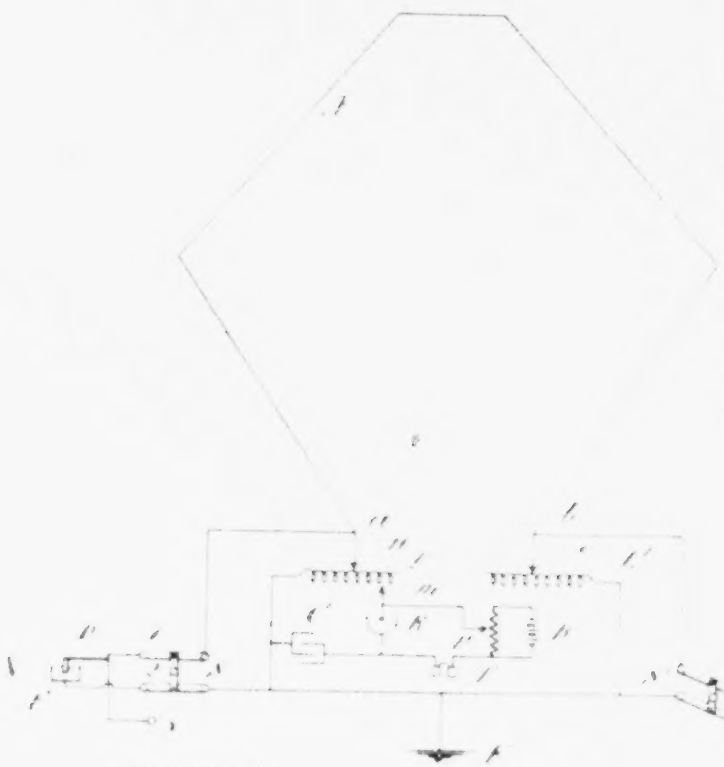

Fig 1

Fig 3

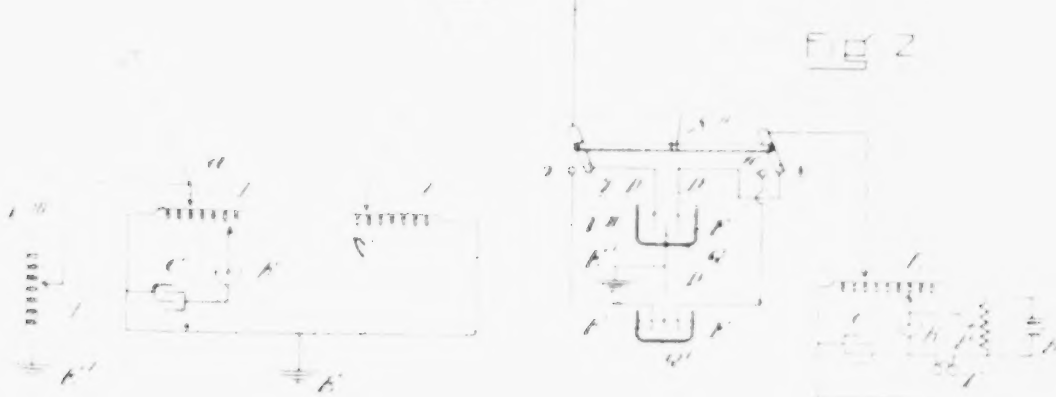

Fig 2

WITNESSES:

INVENTOR:

Lee de Forest

No. 823,402. PATENTED JUNE 12, 1906.

L. DE FOREST.

STATIC VALVE FOR WIRELESS TELEGRAPH SYSTEMS.

APPLICATION FILED DEC. 9, 1904.

2 SHEETS—SHEET 1.

Fig. 4.

Fig. 4a.

Fig. 5.

Witnesses:

Inventor,

Lee de Forest

by Cleveland & Wilkinson

Atty's.

UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y.

STATIC VALVE FOR WIRELESS-TELEGRAPH SYSTEMS.

No. 823,402 Specification of Letters Patent. Patented June 12, 1906.

Application filed December 3, 1905. Serial No. 291,067.

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented a new and useful Improvement in Static Valves for Wireless-Telegraph Systems, of which the following is a specification.

My invention relates to wireless-telegraph receiving systems, and more especially to apparatus and circuit arrangements whereby atmospheric electricity or static disturbances may be minimized or elimnated.

It is well known that the receiving antennæ of commercial wireless-telegraph systems often become charged with static electricity by such natural causes as the passage of charged clouds in the vicinity of the antennæ, lightning discharges which may be even far distant from the receiving-station, the impingement upon the antennæ of winds, especially hot winds, laden with ionized air, &c. Very often such static charges so accumulated by the antennæ seriously interfere with the reception of signals transmitted by electromagnetic waves from distant stations, and sometimes, especially in tropical and semitropical climates, these static effects become so pronounced as to entirely prevent the reception of such signals.

The object of the present invention is to provide means for preventing by static valves or leaks any deleterious effect on the reception of signals by static or other natural or artificial electrical forces.

My invention may best be understood by having reference to the drawings which accompany and form a part of this specification and which conventionally represent various forms of static valves or leaks which I have found efficient for carrying out the hereinbefore-stated objects, although it is to be understood that I do not limit myself to the specific embodiments of my invention shown in said drawings, inasmuch as many other embodiments thereof may be devised by those skilled in the art without departing from the spirit of my invention.

In the drawings, Figure 1 represents a wireless-telegraph receiving system provided with two forms of static valve or leak. Fig. 2 represents a wireless-telegraph receiving system provided with an electrolytic static valve or leak. Fig. 3 represents a wireless-telegraph receiving system in which an iron spiral is employed as a static leak. Fig. 4 represents a wireless-telegraph receiving system in which a flame is used as a static valve or leak. Fig. 4ª shows a modification of the device illustrated in Fig. 4, and Fig. 5 represents a wireless-telegraph receiving system in which heated mineral wool or the like is employed as a static leak.

For the purpose of more fully disclosing the present invention I have shown in Fig. 1 two embodiments of the same applied to a receiving system of my invention which comprises a loop antenna, although, as shown in Figs. 2, 4, and 5, the present invention is not limited to any particular kind of receiving system, being capable of application to any type of receiving system.

In Fig. 1, A is a loop antenna, the two sides of which are adjustably connected to the inductances L L′, which are connected to earth at E. Across any desired portion of the inductance L the tuned receiving-circuit C R L, including the variable condenser C and responder or oscillation-detector R, is adjustably connected, and by means of the adjustable contact *m* and said variable condenser C the natural period of said tuned receiving-circuit is made equal to that of the loop antenna while by means of the adjustable contacts *n* and *o* the natural period of said loop antenna is made equal to that of the electromagnetic waves to be received. Across the terminals of the responder R is connected the local receiving-circuit, including the telephone T and any desired portion of the potentiometer resistance P, which regulates the potential of the battery B to be impressed upon the responder. A static leak V or V′ is connected between the earth E and any suitable point *a* or *b* of the antenna located between the top of the antenna and the adjustable contacts *n* or *o*, and preferably near said adjustable contacts. One static leak only may be employed with a loop antenna, as shown in Fig. 3, and if two are used they may be of the same or of different types. If the receiving system is provided with an open antenna, only one static leak is used, as shown in Figs. 2, 4, and 5.

A variety of devices may be used as static leaks, and I shall now specifically describe the six devices V, V′, V″, V‴, V⁗, V⁗′, and V⁗″, shown in the drawings, although it is to be understood that many other devices may be employed.

V is a static valve or leak consisting of an electrolytic cell comprising an electrode F,

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which may form a cup of aluminium, tantalum, iron, or other suitable metal an electrode D of carbon, platinum, or other suitable material and an electrolyte cooperating with said electrodes and consisting of aluminium phosphate, caustic soda or potash, or any other suitable chemical solution. A cell so constructed has the well known property of permitting electric currents of given polarity to pass through it in one direction for example from the carbon electrode to the aluminium electrode more readily than in the opposite direction in short, such a cell is an electric valve or asymmetric resistance.

The reversing-switch S cooperates with the contacts 1 and 3, which are connected to the electrode D, and the contact 2, which is connected with the cup F, and enables the operator to connect either the electrode D to the antenna and the electrode F to earth or the electrode F to the antenna and the electrode D to earth. For the purpose of describing the operation of the cell V it will be assumed that the electrode D, which is connected to the antenna in the position of the switch shown in Fig. 1, is carbon and that the electrode F, which is connected to earth in said position of the switch is aluminium. With a cell so constructed and so connected a positive charge of electricity developed in the antenna will readily pass through the cell to earth and will therefore be prevented from affecting the responder R, but a negative charge of electricity developed in the antenna will not pass through the cell to earth and might, therefore, affect the responder R. If with the switch set in the position shown in Fig. 1 the operator should detect the effects of static disturbances, he would throw the switch so as to coöperate with the contacts 2 and 3, thereby connecting the aluminium electrode F to the antenna and the carbon electrode to earth, in which position of said switch a negative electric charge developed in the antenna would pass to earth. Thus the position of the switch must be determined empirically by the operator in accordance with observed phenomena.

It will be noted that when the switch is set so that the cell will conduct a positive charge to earth the positive half waves developed in the antenna by the electromagnetic waves to be received will also be conducted to earth and will not assist in producing signals and that when the connections of the cell are reversed so as to conduct negative electric charges to earth the negative half-waves developed in the antenna by said electromagnetic waves will also be conducted to earth, so that the static valve results in wasting approximately half the received energy. I have found, however, that the remaining energy absorbed by the antenna from the electromagnetic waves is sufficient to operate the responder, and I have been enabled with a system provided with said static valve employed as above set forth to receive signals under conditions of static disturbance which otherwise would have rendered such reception impossible.

It will be noted that if, as indicated in Fig. 1, two static valves are employed with one antenna, each must be connected so as to pass currents or charges of the same polarity, for if they were connected so as to pass currents or charges of opposite polarities one-half the energy of the waves would pass to earth by way of one valve and the other half by way of the other. Generally but one valve will be sufficient, and while it may be connected to earth from either the point *a* or the point *b* (see Fig. 1) it is preferred to connect it to earth from the point *a*, so that its circuit will form a shunt around that portion of the antenna with which the responder circuit is associated.

The static valve shown at V' in Fig. 2 is another form of electrolytic asymmetric resistance consisting of two cups Q Q of insulating material, the cup Q containing two electrodes D D of the same materials as above set forth in connection with the static valve V of Fig. 1 and also containing the electrode F of the same materials as the electrode F of the said valve V, and the cup Q containing one electrode D and two electrodes F F of the same materials, respectively, as the electrodes of the cup Q.

The operation is as follows: When the receiving operator perceives that static effects are interfering with the reception of signals he throws the switch S' over to the contacts 7 8 of the device Q and if the static effects are positive they will pass to earth E' by way of contact 7, carbon electrode D, and aluminium electrode F, while the negative half waves developed in the antenna by the electromagnetic signal-waves will pass to earth E by way of the contact 7, electrode D, the electrolyte, electrode D, contact 8, and inductance L, thereby causing oscillations in the tuned receiving-circuit C R L and operating the receiver. If, however, the said static effects continue to interfere with the reception of signals when the device Q is connected in circuit as above set forth, the receiving operator will know that the static effects are negative and will therefore proceed to throw the switch over to the contacts 9 10, in which case said negative static effects will pass to earth E' by way of the contact 9, aluminium electrode F, and carbon electrode D, while the positive half-waves developed in the antenna by the electromagnetic signal-waves will pass to earth E by way of the contact 9, electrode F, the electrolyte, electrode F, contact 10, and inductance L, thereby creating oscillations in the tuned receiving-circuit C R L and operating the receiver.

It will be seen in view of the foregoing that

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any electrical rectifier, asymmetric resistance, or "electric valve," electrolytic or otherwise, may be utilized in carrying out the above-stated objects of my invention, and I shall now describe several forms of electric valve that are not electrolytic in nature.

The device V', (shown in Fig. 1,) connected between the antenna at the point *b* and earth, is an asymmetric resistance or electric valve which has been fully described by J. A. Fleming in a paper published in the *Proceedings of the Royal Society of London*, March 16, 1905, to which reference may be had for a more complete description thereof than need be set forth herein. Suffice it to say that the exhausted glass vessel Q'' contains the filament F', heated to incandescence by the battery B', and a metal cylinder D', which surrounds said filament F'. This type of valve passes positive electricity from the cold terminal D' to the heated terminal F' more readily than in the opposite direction, and hence when the switch S' makes contact, as shown in Fig. 1, with the contacts 5 and 6 positive static effects will pass to earth by way of the elements D' and F' of said valve, while if the connections be reversed by throwing the switch so as to contact with 4 and 5 negative static effects will pass to earth by way of the elements F' and D' of said valve.

In Figs. 4 and 4ª the valves V^IV and V^V depend upon somewhat the same principle as the valve V'. In these figures H is a lamp or Bunsen burner, the flame of which may be made more conducting by the addition of sodium or other salts, and J is a conductor placed near said flame. M is a bunch of asbestos or mineral wool which may be attached to said conductor J. In these devices positive electricity passes more readily from the element J to the flame, and hence to earth E', than in the opposite direction. S''' is a reversing-switch whose function is the same as that of the switch S.

In Fig. 5 the device M' consists of mineral wool or asbestos placed between two plates and heated by the lamp H. This device is practically non-conducting when cold, but becomes a partial conductor when heated. The oscillations developed in the antenna by the electromagnetic signal-waves will have but little tendency to pass to earth by way of the shunt *a'* M' E', but heavy static charges induced in the antenna have an effect on the device M' somewhat analogous to the phenomenon of coherence (although it is not a contact device) in that they increase the conductivity of said device, so that the latter becomes a very efficient static leak. The passage of the heated gases from the lamp H through the fibrous material of the device M' maintains said device in its sensitive high-resistance condition, and thereby prevents the shunting around to inductance L of the oscillations intended to operate the responder.

In Fig. 3 I have shown still another static leak V^VI, which I have effectively employed for the purpose of carrying my invention into effect. In this figure the arrangement of receiving-circuits is the same as in Fig. 1, and from the point *a* I connect to earth E a shunt circuit including the adjustable inductance-coil, I of iron or other paramagnetic material or of a non-magnetic material plated with a paramagnetic material or of a non-magnetic material having a paramagnetic core. Such an inductance opposes enormous impedance to the passage of the high-frequency oscillations developed in the receiving system by the electromagnetic signal-waves, but offers but little impedance to the passage of the slow-frequency or practically unidirectional currents resulting from the static charges induced in said system by atmospheric electricity, and hence eliminates the effect of said currents on the receiver.

By the term "static valve" as used in the specification and claims of this application I desire to be understood as meaning means offering greater opposition to electric currents of one character than to electric currents of different character—such, for example, as the asymmetric resistances described in connection with Figs. 1, 2, 4, and 4ª, the spiral I, described in connection with Fig. 3, and the coherer-like device M, described in connection with Fig. 5; but it is to be understood that the particular devices hereinbefore specifically described are merely examples of a few of the static valves which may be employed for the purposes of the present invention.

I claim—

1. In a wireless-telegraph receiving system, the combination with an oscillation-detector of an electrolytic static valve.

2. In a wireless-telegraph receiving system, an oscillation-detector and an electrolytic static valve so associated therewith as to protect the same from static effects.

3. In a wireless-telegraph receiving system, a receiving-antenna, an inductance included therein, a tuned receiving-circuit associated with said inductance, an oscillation-detector in said tuned receiving-circuit, and means offering greater opposition to electric currents of one character than to electric currents of different character connected between the earth and a point in said antenna above the point of connection of said inductance to said antenna.

4. In a wireless-telegraph receiving system, an oscillation-detector, and means offering greater opposition to electric currents of one polarity than to electric currents of the opposite polarity so associated with said detector as to protect said detector from the effects of the currents of that polarity to which said means offers the greater opposition.

5. In a wireless-telegraph receiving system, an oscillation-detector, and an asymmetric resistance so associated therewith as to protect the same from static effects.

6. In a wireless-telegraph receiving system, an oscillation-detector, a static valve connected therewith and means for reversing the connections of the terminals of said static valve with said oscillation-detector.

7. In a wireless-telegraph receiving system, an oscillation-detector, an asymmetric resistance so connected therewith as to protect the same from static effects, and means for reversing the connections of the terminals of said asymmetric resistance with said oscillation-detector.

8. In a wireless-telegraph receiving system, an oscillation-detector, and an electrolytic asymmetric resistance so associated therewith as to protect the same from static effects.

9. In a wireless-telegraph receiving system, an oscillation-detector, an electrolytic asymmetric resistance so connected therewith as to protect the same from static effects, and means for reversing the connections of the terminals of said electrolytic asymmetric resistance with said oscillation-detector.

10. In a wireless-telegraph receiving system, a receiving-antenna, an oscillation-detector associated therewith, and an electrolytic static valve connected between the earth and a point in said antenna above the point of association of said detector with said antenna.

11. In a wireless-telegraph receiving system, a loop antenna, an inductance included in each side thereof, an oscillation-detector associated with said loop antenna, a connection from each side of said loop antenna around each said inductance to earth and a static valve in each said connection.

12. In a wireless-telegraph receiving system, a loop antenna, an oscillation-detector associated therewith, a static valve associated with each side thereof, and means for reversing the connections of each said static valve with its respective side of said loop antenna.

13. As a static valve for a wireless-telegraph receiving system, an electrolytic asymmetric resistance.

14. As a static valve for a wireless-telegraph receiving system, an asymmetric resistance.

15. In a wireless-telegraph receiving system, a loop antenna, an inductance included in each side thereof, an oscillation-detector associated with said loop antenna, a connection from one side of said loop antenna around one inductance to earth and a static valve in said connection.

16. In a wireless-telegraph receiving system, a loop antenna, an inductance included in each side thereof, a tuned receiving-circuit associated with said loop antenna, an oscillation-detector in said tuned receiving-circuit, and a static valve connected between the earth and a point in said antenna above the point of connection of said inductance to said antenna.

17. In a wireless-telegraph receiving system, a receiving-antenna, an inductance included therein, a tuned receiving-circuit associated with said inductance, an oscillation-detector in said tuned receiving-circuit, and a static valve connected across the terminals of said inductance.

In testimony whereof I have hereunto subscribed my name this 6th day of December, 1905.

LEE DE FOREST

Witnesses:
LESTER TESTEET,
PHILIP FARNSWORTH.

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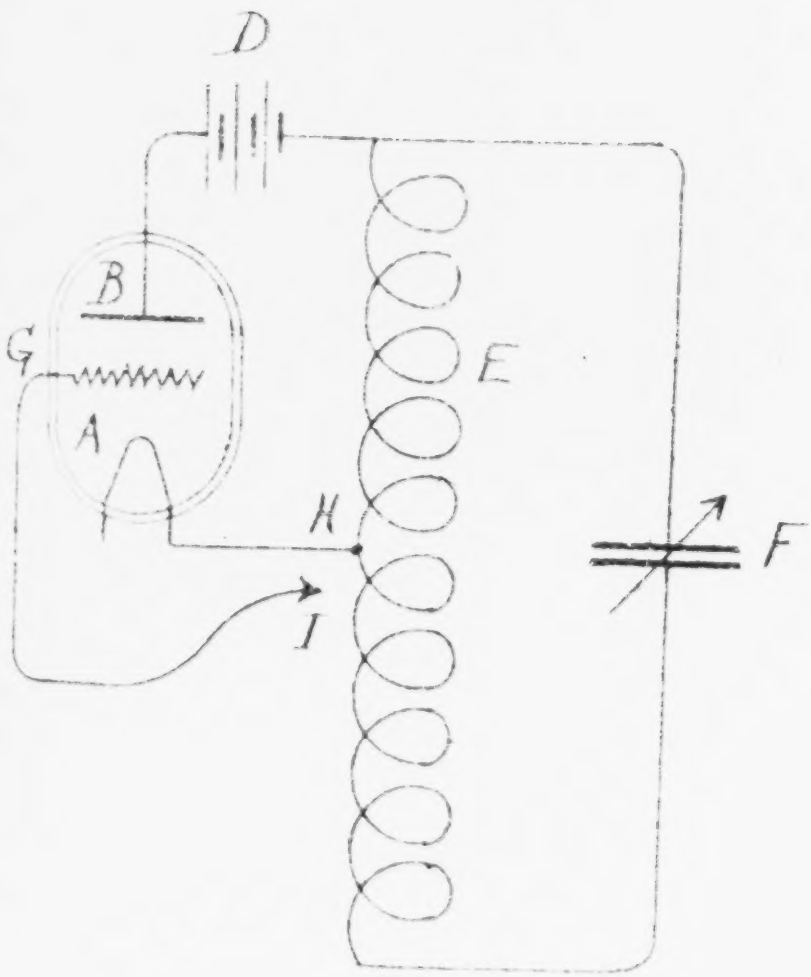
Claimant's Exhibit No. 259



Weagant Sketch No 4

PLAINTIFF'S EXHIBIT 260

M. I. PUPIN AND E. H. ARMSTRONG.

ELECTRIC WAVE TRANSMISSION.

APPLICATION FILED SEPT. 17, 1915.

1,334,165. Patented Mar. 16, 1920.

6 SHEETS—SHEET 1.

Fig. 1.

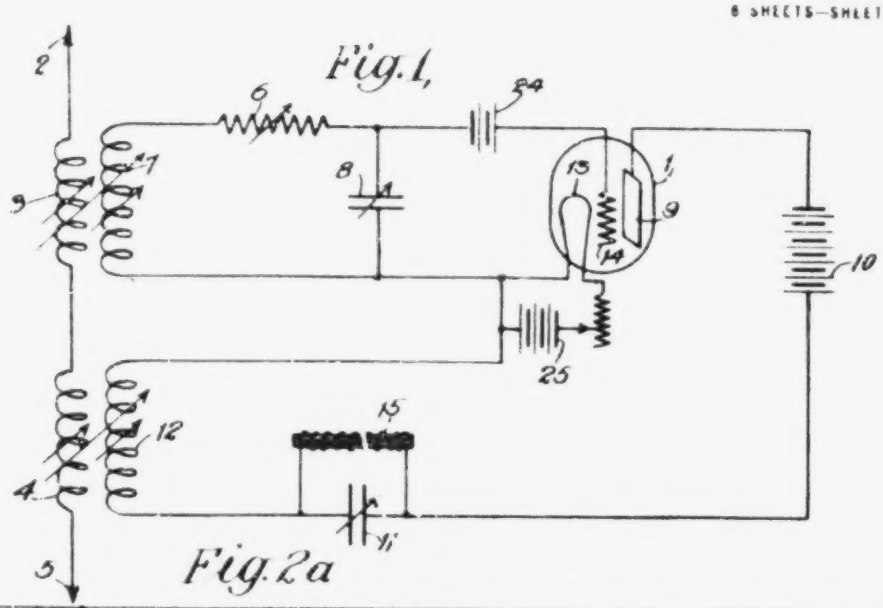
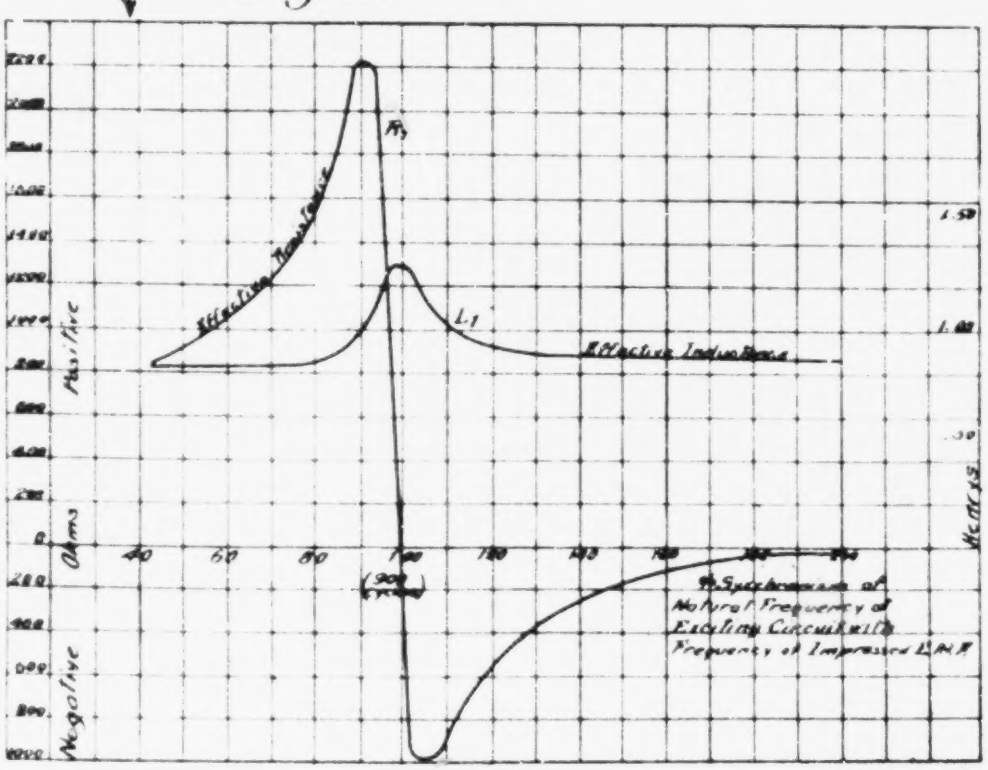


Fig. 2a



INVENTORS
Michael I. Pupin
Edwin H. Armstrong
BY
Pierce Davis & Mann
ATTORNEYS

M. I. PUPIN AND E. H. ARMSTRONG.
ELECTRIC WAVE TRANSMISSION.
APPLICATION FILED SEPT. 17, 1915.

1,334,165. Patented Mar. 16, 1920.
5 SHEETS—SHEET 2

Fig. 2b.

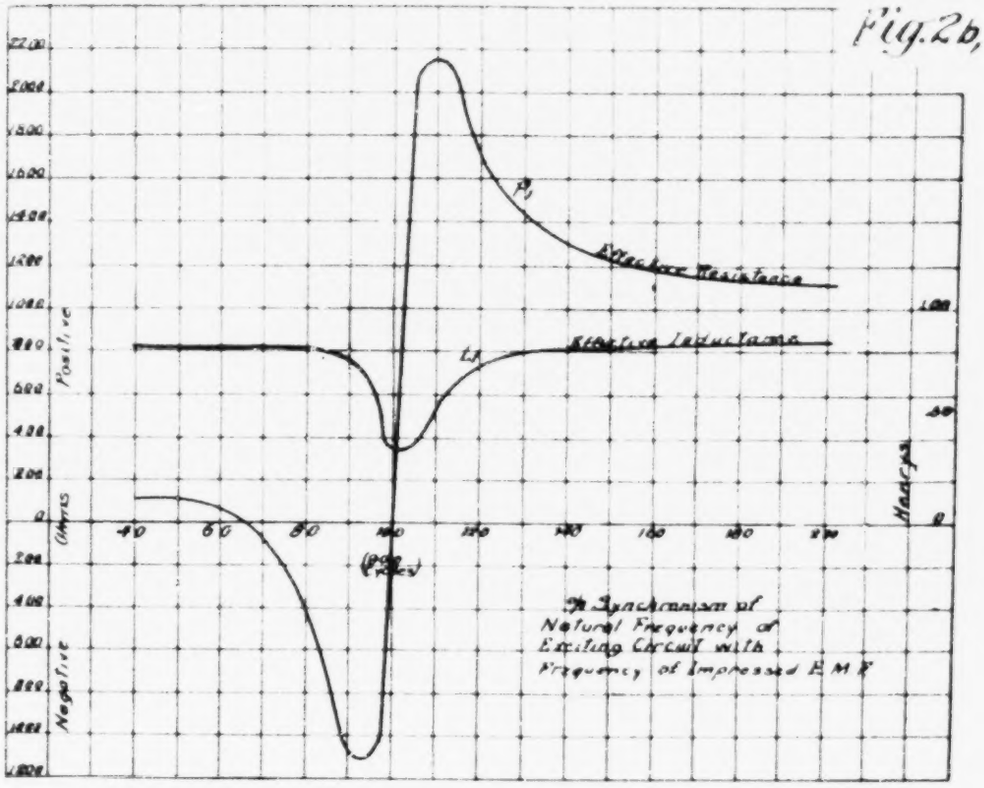
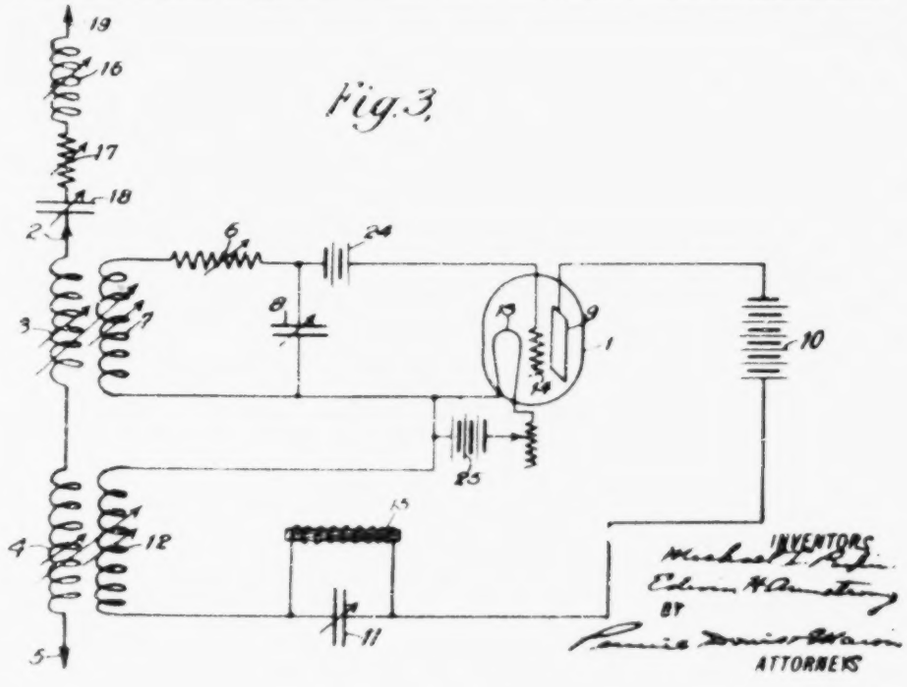


Fig. 3.



M. I. PUPIN AND E. H. ARMSTRONG.

ELECTRIC WAVE TRANSMISSION.

APPLICATION FILED SEPT. 17, 1915.

1,334,165.

Patented Mar. 16, 1920.

6 SHEETS—SHEET 3

Fig. 4.

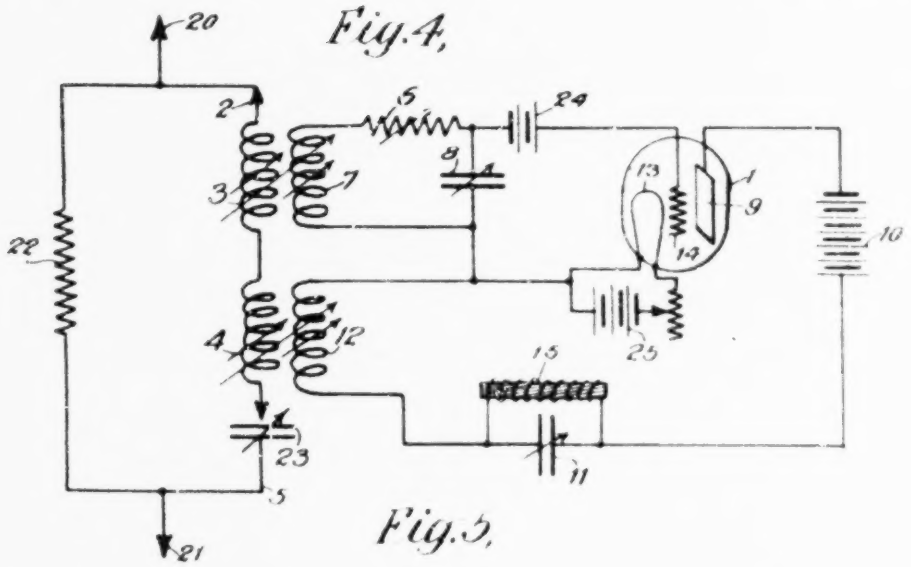
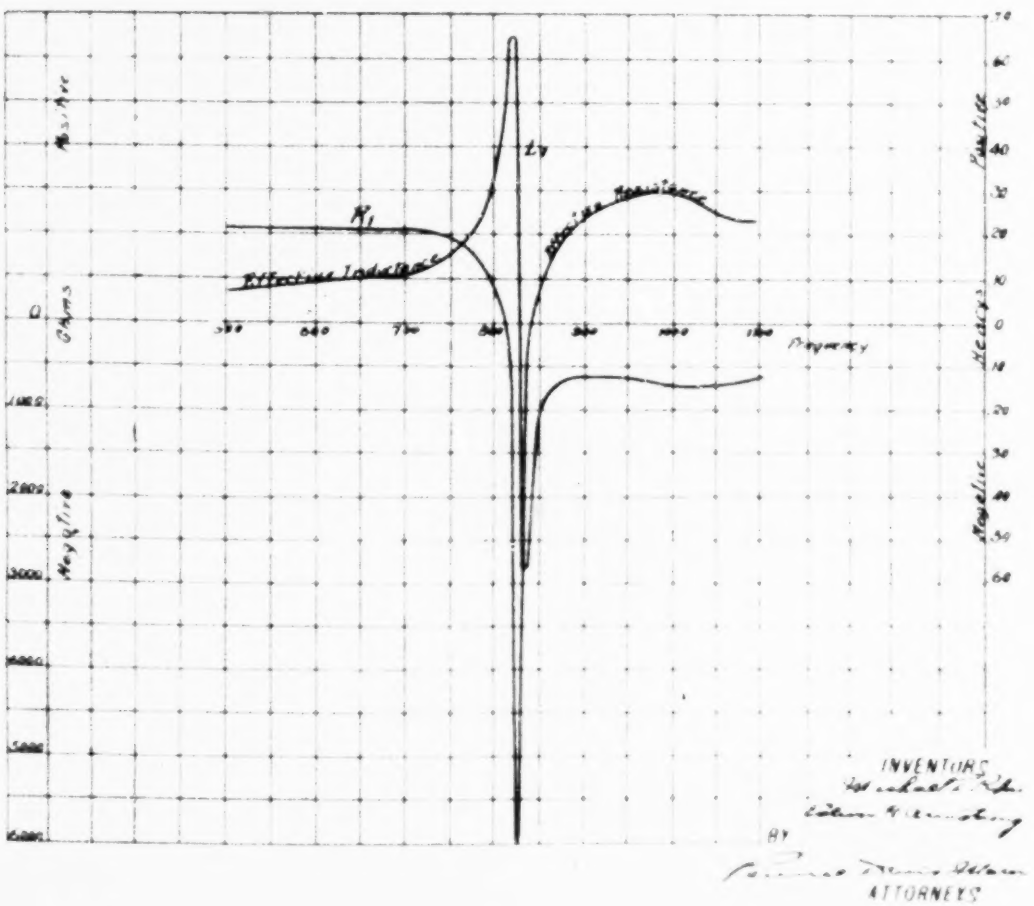


Fig. 5.



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ATTORNEYS

2857

1,334,165. Patented Mar. 16, 1920.

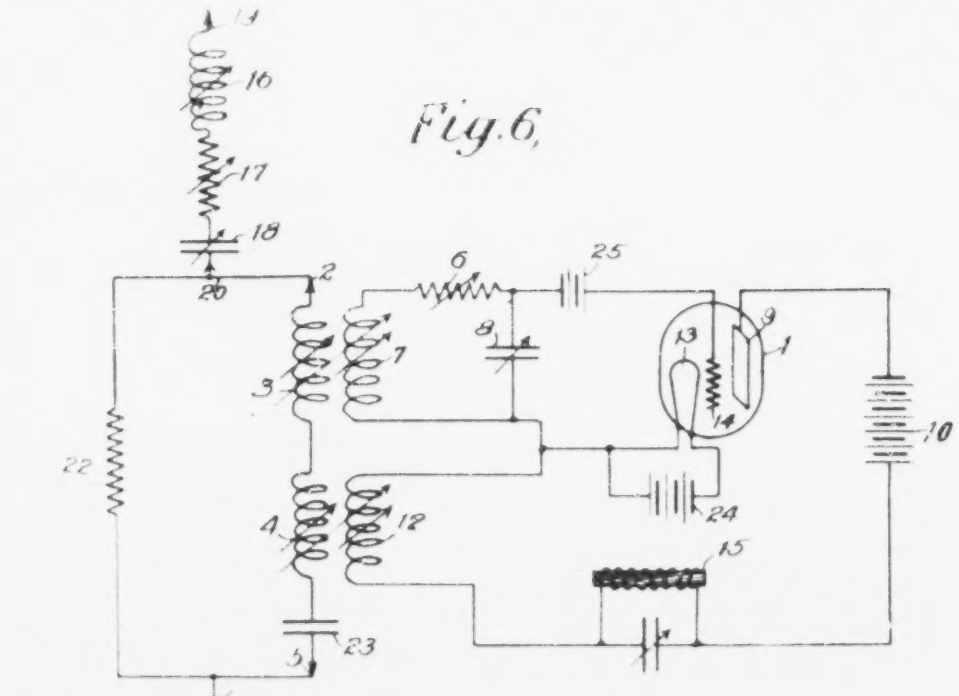

Fig. 6.

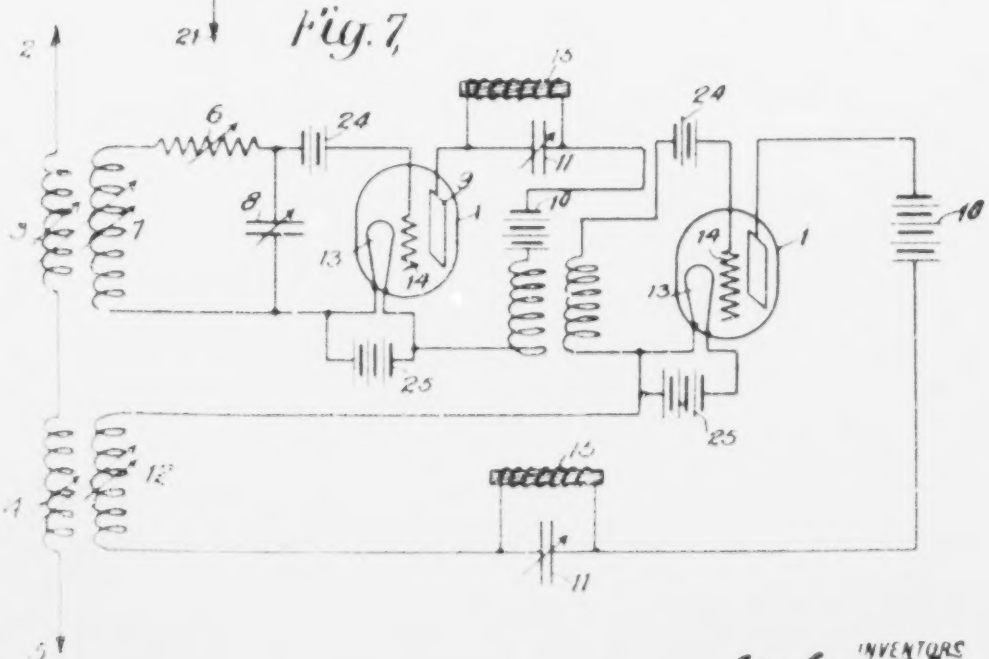

Fig. 7.

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ELECTRIC WAVE TRANSMISSION.

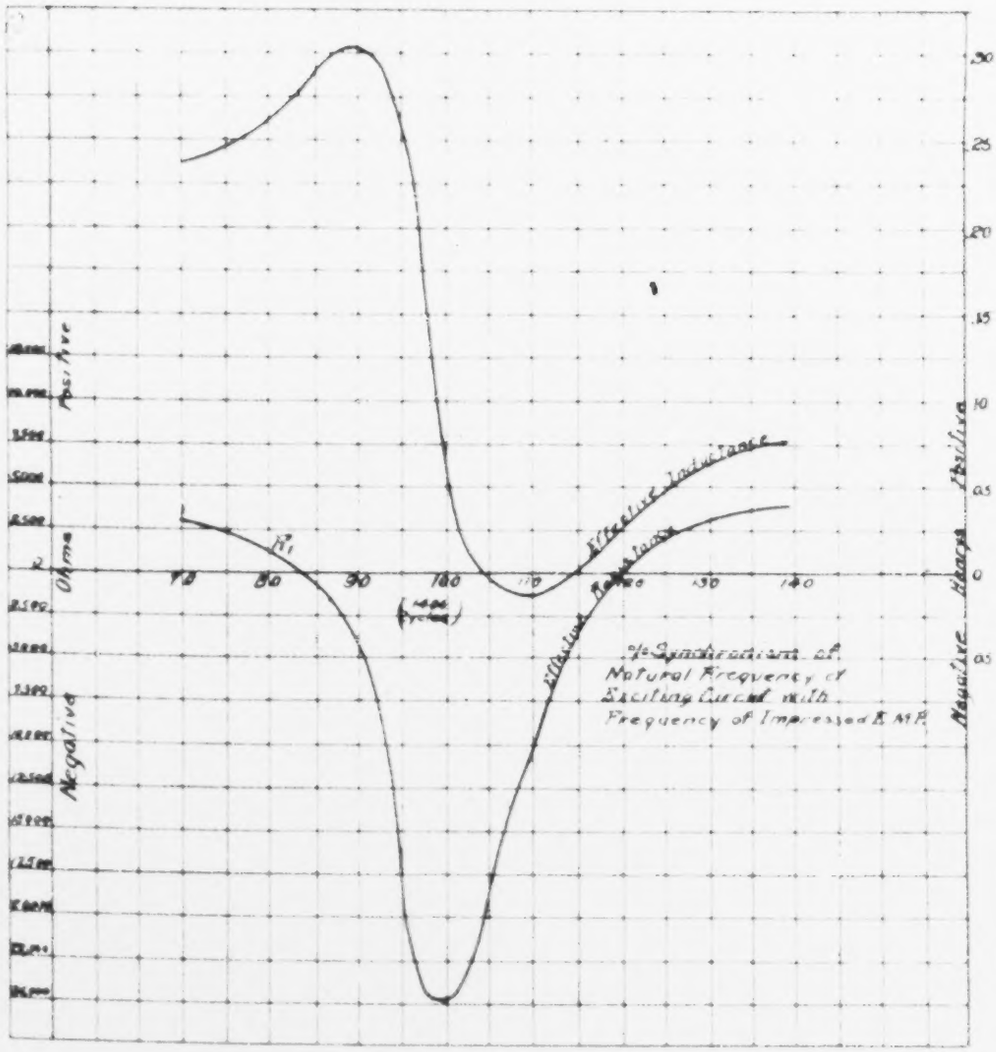
APPLICATION FILED SEPT. 17, 1915.

1,334,165.

Patented Mar. 16, 1920.

6 SHEETS—SHEET 5

Fig. 8,



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ELECTRIC WAVE TRANSMISSION.

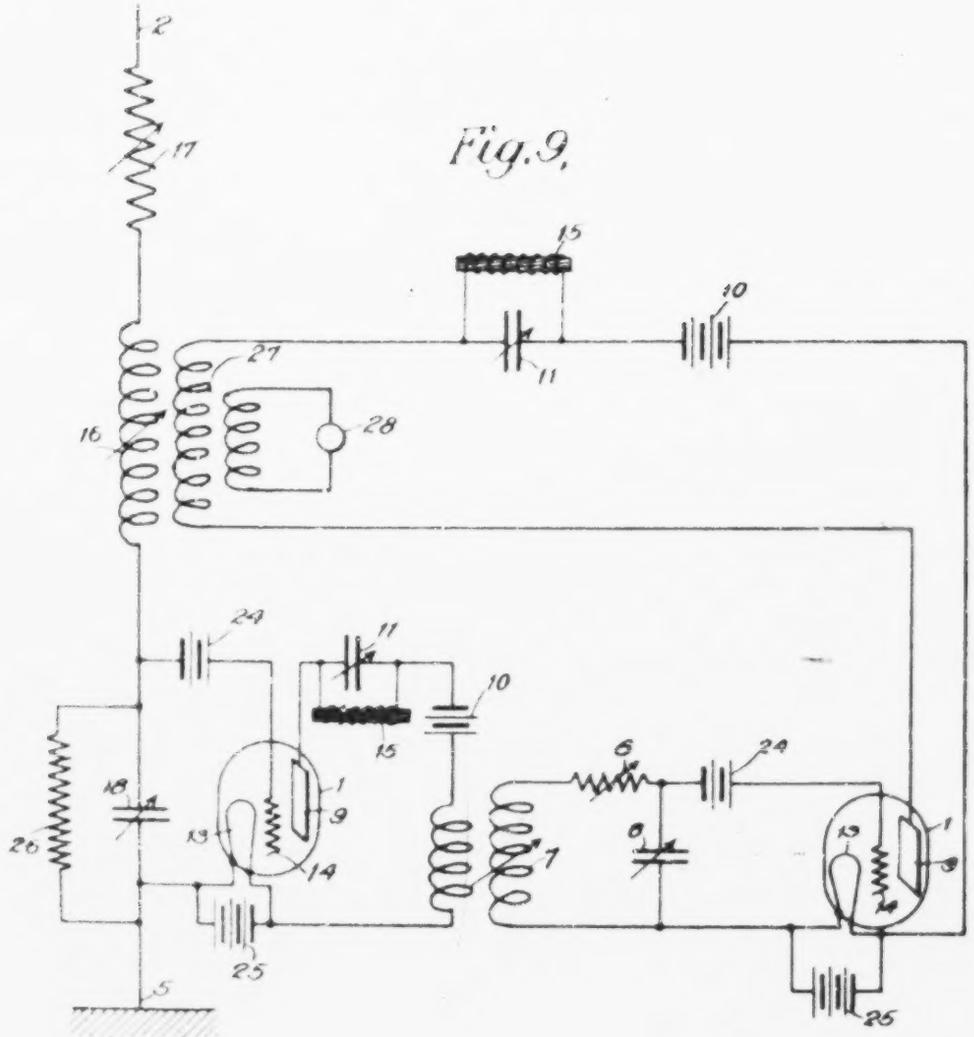
APPLICATION FILED SEPT. 17, 1915.

1,334,165.

Patented Mar. 16, 1920.

6 SHEETS—SHEET 6

Fig. 9.



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2690

UNITED STATES PATENT OFFICE.

MICHAEL I. PUPIN, OF NORFOLK, CONNECTICUT, AND EDWIN H. ARMSTRONG, OF YONKERS, NEW YORK.

ELECTRIC-WAVE TRANSMISSION.

1,334,165. Specification of Letters Patent. Patented Mar. 16, 1920.

Application filed September 17, 1915. Serial No. 51,151.

To all whom it may concern:

Be it known that we, MICHAEL I. PUPIN, a citizen of the United States, residing in Norfolk, county of Litchfield, State of Connecticut, and EDWIN H. ARMSTRONG, a citizen of the United States, residing in Yonkers, county of Westchester, State of New York, have invented certain new and useful Improvements in Electric-Wave Transmissions; and we do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to the production of a negative resistance reaction by means of a system of circuits containing a local source of electrical power with means for controlling it, and the application of this negative resistance reaction to the compensation of the resistance reaction of electrical conductors in order to make them responsive to sustained electrical waves of a predetermined frequency and not responsive to electromotive forces of a disturbing character. The apparatus described here is, briefly stated, a new form of resistance compensator operating in a generic sense similarly to the resistance compensator described by Michael I. Pupin in his copending application, Serial No. 51,150 filed September 17, 1915.

Referring to the diagrams which form a part of our specification, Figure 1 illustrates a system for producing the aforesaid negative resistance reaction, and Figs. 2^a and 2^b show curves of its resistance and reactance characteristics for various frequencies. Fig. 3 shows a method of applying the resistance compensator to reduce the effective resistance of a conductor. Fig. 4 shows a system of magnifying the negative resistance reaction produced by the system of Fig. 1 by means of a magnifying shunt placed around the main conductor of the compensator, and Fig. 5 illustrates the resistance and reactance characteristics obtained with a shunted compensator. Fig. 6 illustrates the method of applying the shunted compensator to the tuning of a conductor. Fig. 7 represents a compensator consisting of a plurality of parts connected in cascade system for the purpose of producing very large values of negative resistance. The characteristics of this system are illustrated by the curves of Fig. 8. Fig. 9 illustrates the application of the resistance compensator to a wireless antenna.

In the particular arrangement illustrated in Fig. 1, an electrical valve 1 is coupled with the main conductor 2, 3, 4, 5 on the input side by means of the circuit 6, 7, 8, and on the output side by the circuit 9, 10, 11, 12. The electrical valve illustrated here is the well known vacuum tube containing a hot cathode 13 and a cold anode 9, between which a direct current flows, and a third electrode or "grid" 14 between them modifying the normal direct current between the hot cathode and the cold anode. The external impulses are conveyed to the valve by the circuit 6, 7, 8, which will be referred to as the "exciting circuit." By adjusting the constants of the exciting circuit 6, 7, 8, with respect to the frequency of the incoming waves, the excitation of the valve is regulated. The other circuit 13, 12, 15, 10, 9, contains an electrical battery 10 which maintains a direct current between the hot cathode 13 and the cold anode 9. The incoming waves vary the electrical potential of the grid 14 and thereby the direct current. This variation produces an electromotive force in the main conductor 2, 3, 4, 5, by mutual induction between 4 and 12, whereby energy is transferred from the battery 10 to the main circuit. It is this transfer of energy which manifests itself through a reaction between 2, 5, which has all the properties of a negative resistance reaction. This second circuit with its battery 10 through which the electrical valve is connected to the main conductor will therefore be referred to in this specification as the "energizing circuit."

It will be seen that in the arrangements described herein we have produced results by operations which are generically similar to those of the induction motor resistance compensator described in the above mentioned Pupin application, in which the primary circuit of the induction motor receives the incoming waves and produces thereby the magnetic excitation, whereas the rotating secondary by its electromagnetic reactions transfers by expenditure of mechanical energy electrical energy to the primary and thereby produces in it a negative resistance reaction. The amount of the negative resistance reaction produced by the means employed in the present case depends upon the

relation of the constants of both the exciting and energizing circuits to the frequency of the incoming waves, and for the purpose of adjusting these constants, variable inductances 7 and 12 and capacities 8 and 11 and a variable resistance 6 are employed. In other words, these circuits are capable of tuning.

The effective resistance and the effective inductance of the system of Fig. 1 between the points 2 and 5 as measured by a Wheatstone bridge employing an alternating electromotive force of suitable frequency, may be either as in Fig. 2ª or Fig. 2ᵇ, depending on the polarity of connection of the transformers 3, 7, and 4, 12. In Fig. 2ª the maximum negative resistance in the main conductor is developed at a frequency below, and in Fig. 2ᵇ the maximum negative resistance is developed at a frequency above the frequency for which the exciting circuit when taken by itself is non-reactive.

The negative resistance reaction in the main conductor 2, 5, is produced in the system of Fig. 1 by the following operations. [illegible] the main conductor 2, 3, 4, 5, induces in the circuit 6, 7, 8, an electromotive force which charges the condenser 8 and the grid connected to it. The charged grid produces a variation in the amplitude of the plate current flowing through the inductive element 10, 15, 12, 13. The current variation then induces an [illegible] in the main conductor. [illegible] current in the main conductor and the electromotive force determines the reactions which are produced in the main conductor. If the electromotive force thus produced in the main conductor is so constituted in phase that one of its two components is in the same phase with the current in the main conductor then a resultant negative resistance reaction between 2 and 5 appears when this electromotive force component is greater than the effective positive resistance reaction of the coils 3 and 4. The value of this negative resistance reaction depends only upon the amount of current variation produced by the action of the grid 14 and upon the process of mutual induction between the main circuit and its secondaries. The law in accordance with which this value of the negative resistance reaction may be varied, and given any assigned limit, is discovered by connecting the terminals 2, 5, of the main conductor as represented in Fig. 1 into an arm of a Wheatstone bridge employing alternating electromotive force of suitable frequency and intensity. The curves illustrated by Figs. 2ª and 2ᵇ are a result of a study of this kind. In these figures, the ordinates of curve R represent the effective resistance and of curve L, the effective inductance between the terminals 2, 5, for various frequencies. It will be seen that these curves are in their main features, similar to those obtained with the induction motor compensator described in the previous application referred to. No exact general mathematical formulæ can be given which will express the relation between the effective resistance and effective reactance of the main conductor and the electromagnetic constants of the various parts of the system and the impressed frequency. But an experimental study by means of a Wheatstone bridge enables one to construct easily an empirical formula for any particular case.

To apply this negative resistance reaction to the compensation of the resistance reaction of an electrical conductor, we proceed in the manner indicated in Fig. 3. Here 16, 17, 18, is a conductor containing resistance, inductance and capacity and which is to be tuned to the frequency of an impressed simple harmonic electromotive force. The main conductor 2, 3, 4, 5, of the [illegible] compensator is placed in series [illegible] the conductor 16, 17, 18, and the [illegible] 6, 7, 8, adjusted to produce negative [illegible] between the points 2, 5, at [illegible] for which the conductor 19, 5, [illegible] selective. The value of the [illegible] resistance between 2 and 5 is adjusted to be slightly less than the positive [illegible] of the conductor 19, 2, so that the resultant effective resistance of the conductor 19, 5 is very much reduced for the correct frequency. This has been explained at greater length in the previous application referred to. The negative resistance may be varied by adjusting the coupling between 4 and 12, or 3 and 7, or by varying the power of the valve to vary the load direct current, or by varying the value of the resistance 6. As the main function of the resistance 6 is to control the steepness of the resistance curves R, in Figs. 2ª and 2ᵇ in the vicinity of their negative maxima and thereby vary the sharpness of tuning of the system, it is better to vary one of the couplings to obtain the required variation in negative resistance. The reactance of the main conductor is adjusted to zero for the same frequency by means of the inductance 16 or the condenser 18.

For the right frequency, the conductor 19, 5, therefore, has zero reactance, and an effective resistance which is only a small fraction of the resistance added to it, but for all other frequencies, both the resistance and the reactance are relatively very large. The amount of positive resistance that can be added in this way is limited by the capacity of the resistance compensator and by nothing else.

The arrangement of the present application lends itself to magnification of the resistance reaction by means of a shunt or by [illegible]

other well known means of potential magnification by transformation in the same manner as the arrangement of the Pupin application referred to, does.

This may be done by the arrangement represented by the diagram of Fig. 4. In this arrangement which is the counterpart of the arrangement of Fig. 3 of the previous application referred to above, a non-inductive shunt containing resistance 22 is placed across the conductor in which the negative resistance is produced. This conductor is provided with a series condenser 23 for the purpose of adjusting the effective reactance of the conductor. When the shunt positive resistance is made slightly greater than the shunted negative resistance, a large multiplication of the original negative resistance is obtained in the manner explained in the previous application. A shunt of 1200 ohms placed across the conductor having the characteristic of Fig. 2 gives a multiplication of above six times. The characteristic resistance and reactance curves are shown in Fig. 5.

To apply the shunted valve system for the purpose of compensating the resistance reaction of a conductor, we connect the conductor 20, 21, in series with the conductor 16, 17, 18, as illustrated in Fig. 6. The adjustments of resistance and reactance of the main conductor are made in the manner previously described for the simple resistance compensator.

Another method of producing a high negative resistance is by means of a resistance compensator consisting of a plurality of parts in cascade as depicted in Fig. 7. Two parts are shown here, but any number of parts may be used to produce any required value of negative resistance reaction in the main conductor providing due regard is paid to the proper adjustment of the phase of the mutual inductance reaction between the energizing circuit and the main conductor. The characteristics of the particular arrangement of Fig. 7 are illustrated by the curves of Fig. 8.

In the present application, as in the previous application referred to, the arrangement for producing negative resistance should preferably be such that the full value of the negative resistance cannot be produced instantaneously; that is, a certain definite length of time should elapse after the arrival of the initial impulse of a train of waves before the transient electrical state has passed into the stationary state in which the full maximum value of negative resistance is established. This length of time is determined by the duration of the transient state of the exciting circuit, and may be regulated by suitable adjustment of the resistance of this circuit which determines the rate of damping of its free oscillation.

To apply the resistance compensator to the reduction of atmospheric disturbances, we prefer to arrange the apparatus as in Fig. 9, in which a resistance compensator containing a plurality of electron discharge elements is arranged to produce in the antenna a high negative resistance reaction. The first part is connected to the antenna by means of a condenser 18 which is located at the base of the antenna and is shunted by a resistance 26 which constitutes a leakage path for electrostatic charges accumulating on the antenna. The particular advantage of the specified connection of 17, 16 and 18 is that the condenser 18 is shielded by the high resistance 17 and the inductance 16 from pulses of short duration which are unable to develop any appreciable reaction across the condenser and thereby excite the compensator. The second part of the resistance compensator is connected to the antenna through the transformer 16, 27, and an electrostatic transformer 28 or any other detecting device is inductively associated with the coil 27.

As explained in the previous application, the shunt employed for magnifying the negative resistance reaction offers a means for shielding the induction motor from the direct effects of electrical impulses. We find the same advantages are secured by the use of the shunt with the present form of resistance compensator in the manner previously described.

What we claim is:

1. In a receiving system for electromagnetic waves, a receiving conductor into which is introduced a resistance sufficiently high to screen the system effectively against disturbing electromagnetic waves impressed upon the conductor in combination with a resistance compensator consisting of an electrical power source and means for selectively transferring power from this source to the conductor by producing in the conductor a negative resistance reaction sufficiently large to compensate to any desirable limit the losses due to the dissipative resistance introduced into the receiving conductor.

2. In a wireless receiving system a wave conductor for the reception of electrical waves into which is introduced a resistance sufficiently great to make its resistance reaction large in comparison with its inductance reaction for all frequencies which are important in wireless wave transmission in combination with a resistance compensator consisting of an electrical power source and controlling means excited by the incoming waves for transferring power from the power source to the conductor to supply it with a compensating negative resistance, the resistance compensator being responsive to a sustained impressed electromotive force

and substantially unresponsive to an impressed electromotive force of short duration.

3. In a wireless receiving system a wave conductor for the reception of electrical waves into which is introduced a resistance sufficiently great to make its resistance reaction large in comparison with its inductance reaction for all frequencies which are important in wireless wave transmission in combination with a resistance compensator consisting of an electrical power source and controlling means excited by the incoming waves for transferring power from the power source to the conductor to supply it with a compensating negative resistance, the resistance compensator being selectively responsive to a sustained impressed electromotive force and substantially unresponsive to an impressed electromotive force of short duration.

4. A receiving system for electrical waves consisting of a receiving conductor with which has been associated a resistance sufficiently large to screen the system effectively against disturbing electromagnetic waves impressed upon the antenna and a resistance compensator having an exciting circuit which is connected across a condenser in series with the receiving conductor so that the direct effect of electrical impulses of short duration on the compensator is greatly reduced.

5. A receiving system for electrical waves consisting of a receiving conductor with which has been associated a resistance sufficiently large to screen the system effectively against disturbing electromagnetic waves impressed upon the antenna, a resistance compensator deriving its power from an electrical power source and connected to said conductor and a magnifying shunt across the said compensator containing a resistance of such value that the resultant negative resistance reaction of the combined circuits will be greater than the original negative resistance reaction to magnify the negative resistance reaction introduced into the main conductor and to shield the compensator from the direct effect of electrical impulses.

6. A resistance compensator consisting of a plurality of parts connected in cascade each part having an exciting circuit and an energizing circuit with an electrical power source, the exciting circuit of the first part being connected to a wave conductor, and the energizing circuit of each part being connected to the exciting circuit of the succeeding part, except the last part, the energizing circuit of which is connected to the wave conductor, and in which at least one of the exciting circuits is tuned, whereby there is selectively imparted to the wave conductor a high negative resistance reaction.

7. A resistance compensator consisting of a plurality of parts connected in cascade each part having an exciting circuit and an energizing circuit with an electrical power source, the exciting circuit of the first part being connected to a wave conductor, and the energization circuit of each part being connected to the exciting circuit of the succeeding part, except the last part, the energizing circuit of which is connected to the wave conductor, and in which at least one of the exciting circuits is tuned, and one of them having the characteristic that impulses imparted to it produce their full exciting effect after a predetermined time interval only.

8. A receiving conductor into which has been introduced a resistance sufficiently high to make its resistance reaction large as compared with its inductance reaction for all frequencies which are important in wireless wave transmission in combination with a resistance compensator consisting of a source of electrical power and means for transferring from the power source to the receiving conductor wave energy of substantially the same wave form as selected incoming waves and of potential sufficiently high to produce in the receiving conductor a negative resistance reaction which substantially compensates the losses due to the positive resistance introduced into said conductor.

In testimony we affix our signatures.

MICHAEL I. PUPIN.
EDWIN H. ARMSTRONG.

PLAINTIFF'S EXHIBIT 261

W. C. WHITE.

MEANS FOR PRODUCING HIGH FREQUENCY OSCILLATIONS.

APPLICATION FILED JUNE 3, 1918.

1,393,594. Patented Oct. 11, 1921.

Fig. 1.

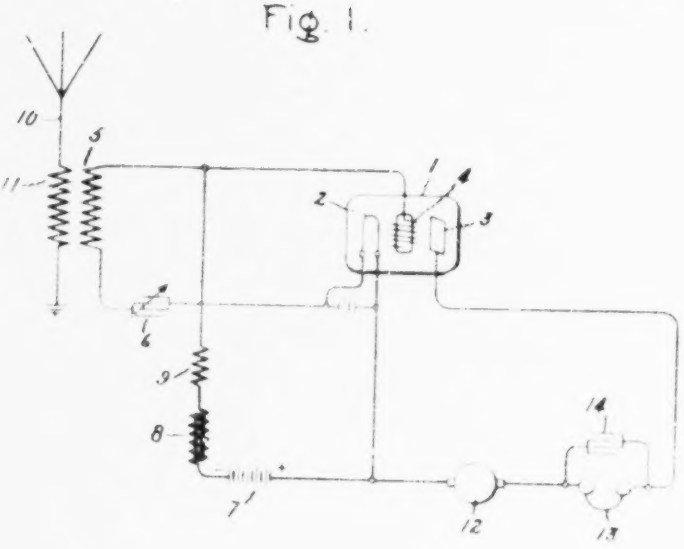
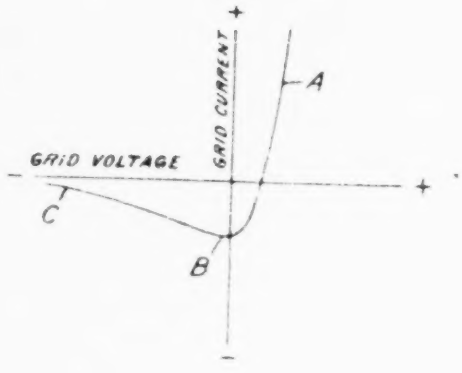


Fig. 2.



Inventor:
William C. White,
by Albert G. Davis
His Attorney.

UNITED STATES PATENT OFFICE.

WILLIAM C. WHITE, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

MEANS FOR PRODUCING HIGH-FREQUENCY OSCILLATIONS.

1,393,594. Specification of Letters Patent. Patented Oct. 11, 1921.

Application filed June 3, 1918. Serial No. 237,845.

To all whom it may concern:

Be it known that I, WILLIAM C. WHITE, a citizen of the United Seates, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Means for Producing High-Frequency Oscillations, of which the following is a specification.

My present invention relates to the production of high frequency oscillations by means of an electron discharge relay or amplifier, and more particularly to the application of oscillations thus produced in a radio receiving system of the well-known heterodyne type.

Electron discharge devices of the type comprising an evacuated container inclosing a filamentary cathode, a plate-shaped anode and a grid, interposed between cathode and anode, are well known. Various connections have also been employed with such devices to cause them to operate to produce high frequency oscillations. In all of the connections which have previously been used, however, so far as I am aware, the same fundamental principle has been employed, that is, a portion of the amplified energy in the plate circuit of the device has been fed back to the grid circuit by some form of coupling so as to make the system self-exciting.

In carrying my invention into effect, however, I employ a materially different principle. I have found that under certain conditions with devices of this type the current in the grid circuit may have a dropping characteristic, that is, as the voltage impressed upon the grid increases the current in the grid circuit will decrease. With the proper conditions for operation a circuit having current characteristic of the type described may be so organized that oscillations will be produced therein, the essential condition for the production of oscillations being that the circuit shall contain capacity and inductance and that the resistance of the circuit shall be less than $2\sqrt{\frac{L}{C}}$ where L represents the inductance and C the capacity of the circuit. Hence in carrying my invention into effect I provide the connections necessary to render the grid circuit resonant and thus cause the production of oscillations therein. While the current in the grid circuit is in all cases comparatively small and hence the amplitude of the oscillations produced will be small the amplifying effect of the device will cause oscillations of much greater amplitude to be produced in the plate circuit. The maintenance of the oscillations, however, will be entirely independent of any coupling between the two circuits.

In utilizing my invention in a radio receiving system of the heterodyne type I produce in the grid circuit of the device oscillations of slightly different frequency from those which are to be received. The received oscillations may also be impressed upon the grid circuit and the two sets of oscillations be combined in that circuit to produce what are technically known as "beats." These beats will be reproduced in the plate circuit of the device and produce an audible response in the usual telephone receiver which is included in the plate circuit.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation will best be understood by reference to the following drawing in which Figure 1 illustrates diagrammatically the connections which may be employed in carrying my invention into effect, and Fig. 2 shows a characteristic curve of the current in the grid circuit of an electron discharge device which is so constructed and adjusted as to be suitable for carrying out my invention.

In the system illustrated in Fig. 1 I have indicated an electron discharge device 1 having the usual filamentary cathode 2, an anode 3 which may be plate shaped as shown or of any other desired form and a discharge-controlling grid 4 inclosed in a well evacuated receptacle. The grid circuit of this device includes an inductance 5 and a variable capacity 6. A battery 7 is provided for applying to the grid a potential at which the operation of the device may be suitable for the desired purpose.

Referring now to Fig. 2 the curve A indicates the current in the grid circuit of the device 1, with varying voltages on the grid. The abscissæ of the curve represent voltage and the ordinates current. It will be noted that over a considerable range of voltage when the grid voltage is negative the cur-

rent in the grid circuit decreases with an increase of the negative grid voltage. That is, at the point B on the current curve which represents a very small negative voltage the current in the grid circuit is greater than at the point C, which represents a much larger negative grid voltage. This characteristic of the current curve is probably due to the effect of slight traces of residual gas in the device and the consequent positive ionization. The greater the negative grid voltage the lower the plate current and therefore the lower the amount of positive ionization in the device due to residual gas therein. As a result, therefore, the grid current will decrease by reason of the smaller number of positive ions which may reach the grid.

If the battery 7 is of such potential that the grid current will fall upon some portion of the current curve between the points B and C, oscillations will be produced in the grid circuit. The frequency of the oscillations produced may be readily varied by adjusting the condenser 6. Inductances 8 and 9 should be employed in series with battery 7 of such value that there will be no damping of the oscillating circuit due to the connection of the battery 7 across the circuit. With the device producing oscillations of the desired frequency oscillations received upon the antenna 10 may be impressed upon the inductance 5 by means of the coupling coil 11 which is included in the antenna circuit. The received oscillations will combine in the grid circuit with the locally produced oscillations in the well-known manner and produce beats. In other words, the potential of the grid 4 will oscillate and the amplitude of the oscillations will vary at a frequency corresponding with the beat frequency produced. As a result a beat current will be produced in the plate circuit of the device, energy for which is supplied by the direct current generator 12, and the beats in the plate current may be detected by the usual telephone receiver 13. The telephone receiver 13 may, if desired, be shunted by a capacity 14 for by-passing the radio frequency component of the current in the plate circuit.

I have found that in most cases fairly high potentials must be employed in the plate circuit in order to secure the desired operation. For example, with one particular device I have found that a plate potential of about 375 volts was necessary in order to secure the desired operating characteristic.

While I have illustrated only one circuit connection whereby oscillations may be produced, and have indicated but one use for the oscillations, it will be apparent that many modifications in the circuit connection employed as well as in the use to which the oscillations are applied may be made without departing from the scope of my invention as set forth in the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. Means for producing high frequency oscillations comprising an electron discharge device having an electron emitting cathode, an anode and a discharge controlling grid inclosed in an evacuated receptacle, a plate circuit which includes the cathode and anode of said device and a source of potential, a resonant grid circuit which includes the cathode and grid of said device, said device and its associated circuits being so constructed and adjusted that the current in the grid circuit will vary inversely as the applied potential over a given operating range of negative potential and a source of potential connected to the grid circuit of such value that the normal potential of the grid is within said operating range, whereby oscillations will be produced in said grid circuit independently of any coupling between grid and plate circuits.

2. Means for producing high frequency oscillations comprising an electron discharge device having a plate circuit and a resonant grid circuit, said device and its associated circuits being so constructed and adjusted that the current in the grid circuit will vary inversely as the applied potential over a given operating range of negative potential and a source of potential connected to the grid circuit of such value that the normal potential of the grid is within said operating range, whereby oscillations will be produced in said grid circuit independently of any coupling between grid and plate circuits.

3. The combination in a radio receiving system of an electron discharge device having a plate circuit and a grid circuit which is resonant to a frequency differing by an amount within the range of audibility from the waves to be received, means for impressing received waves upon said grid circuit, said device and its associated circuits being so constructed and adjusted that the current in the grid circuit will vary inversely as the applied potential over a given operating range of negative potential, a source of potential connected to the grid circuit of such value that the normal potential of the grid is within said operating range whereby oscillations will be produced in said grid circuit independently of any coupling between grid and plate circuits which will combine with the received oscillations to produce beats and means for detecting the beats thus produced.

4. The combination in a radio receiving system of an electron discharge device having a plate circuit and a grid circuit which is

resonant to a different frequency from that of the waves to be received, means for impressing received waves upon said grid circuit, said device and its associated circuits being so constructed and adjusted that the current in the grid circuit will vary inversely as the applied potential over a given operating range of negative potential, a source of potential connected to the grid circuit of such value that the normal potential of the grid is within said operating range whereby oscillations will be produced in said grid circuit independently of any coupling between grid and plate circuits which will combine with the received oscillations to produce beats and means for detecting the beats thus produced.

5. The combination in a radio receiving system of an electron discharge device having a plate circuit and a grid circuit which is resonant to a frequency differing by an amount within the range of audibility from the waves to be received, means for impressing received waves upon said grid circuit, said device and its associated circuits being so constructed and adjusted that the current in the grid circuit will vary inversely as the applied potential over a given operating range of negative potential, a source of potential connected to the grid circuit of such value that the normal potential of the grid is within said operating range whereby oscillations will be produced in said grid circuit independently of any coupling between plate and grid circuit which will combine with the received oscillations to produce beats and means in the plate circuit of the device for detecting the beats thus produced.

6. The method of operating an electron discharge device having an electron emitting cathode, an anode and a discharge controlling grid inclosed in an evacuated receptacle and having a plate circuit and a resonant grid circuit associated therewith which consists in generating high frequency oscillations in said grid circuit independently of any transfer of energy to said grid circuit from other circuits.

7. The method of receiving signals in a receiving system comprising an electron emitting cathode, an anode and discharge controlling grid inclosed in an evacuated receptacle and having a plate circuit and a resonant grid circuit associated therewith which consists in impressing received signaling currents upon said grid circuit, generating oscillations in said grid circuit of a frequency differing from that of the signaling currents independently of any transfer of energy to said grid circuit and thereby producing a beat current in said grid circuit and amplifying and detecting the beats thus produced.

8. The method of operating a signal receiving system comprising an electron emitting cathode, an anode and a discharge controlling grid inclosed in an evacuated receptacle and having a plate circuit and a resonant grid circuit containing a source of energy associated therewith which consists in generating high frequency oscillations in said grid circuit independently of any transfer of energy to said grid circuit from other circuits, and producing by the conjoint action of the locally generated oscillations and received oscillations an audio frequency current in the plate circuit.

In witness whereof, I have hereunto set my hand this 1st day of June, 1918.

WILLIAM C. WHITE.

Claimant's Exhibit No. 262

the behavior of the dynatron in any circuit containing resistance, capacity, inductance and electromotive force can be accurately calculated by treating the dynatron as a linear conductor with negative resistance r. Examples of such calculations are given below.

The term i_0 in the above equation disappears if the dynatron is connected in series with a battery, of voltage equal to that at which the dynatron current is zero (point B, Figure 3). The combination is a *true* negative resistance, for which $i = \frac{E}{r}$. For example, if the dynatron of Figure 1 be put, with its batteries, in a box, and two wires be brought out thru the box as terminals,

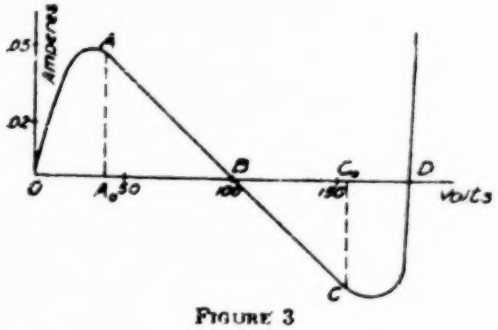


FIGURE 3

one from the plate P and one from a point V_0 of the battery corresponding to the point B of Figure 3, this "negative resistance box" would behave in all respects like a conductor with negative resistance, over the range of voltage, positive and negative, represented by BC_0 and BA_0 in Figure 3.

The magnitude of the negative resistance, which is the slope of the current voltage curve, Figure 3, and the range of voltage $A_0 - C_0$ over which it can be used, depends upon the anode voltage, the temperature of the filament, and, to some extent, on the shape and material of the electrodes. The effect of varying anode voltage alone is shown for two different types of tube in Figures 4 and 5, and the effect of varying filament temperature in Figure 6. It is seen that the effect of varying anode voltage is, in general, to shorten or lengthen the range of the negative resistance part of the curve, without changing the value of the negative resistance. A slight shift in the voltage V_0 at which the curves cross the axis is, for one tube, to the right with increasing voltage, and for the other, to the left. It is

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varied by varying any of the applied voltages. Another condition for equation (4) is that the grid should not become sufficiently positive to distort the characteristic. Under these conditions I have generally found this equation to hold sufficiently well, to a first approximation at least, and have been using it in connection with work on the amplifier tube. The above equation does, however, not hold sufficiently accurately for purposes of radiodetection, since this is determined by second order quantities.

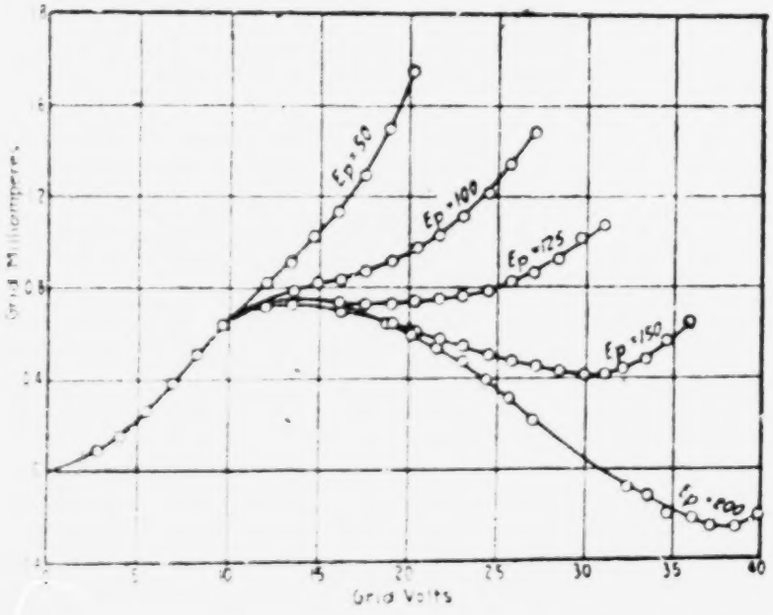

FIG. 78.

Latour[1] has derived some equations for the "relay effect" of audion tubes. He starts from the general functional expressions for the plate and grid currents: $I_p = F(E_p, E_g)$ and $I_g = f(E_g, E_p)$. In the expansion of these equations he neglects all quantities of the second and higher order, thus assuming that the current and voltage variations are very small, or that the characteristic is linear over the operating range.

[1] M. Latour, Electrician, December, 1916.

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the internal resistance of the battery B, but not the internal plate resistance R of the tube. The grid G is connected to the filament through a battery C which determines the operating point of the tube on the static characteristic curve, and through an alternator D which impresses between the grid and the filament the emf. to be amplified.

In order to facilitate reference, the following letter symbols used are tabulated.

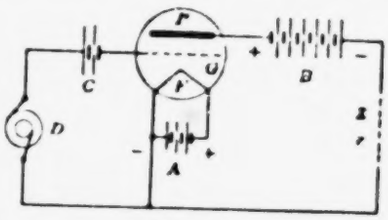

FIG. 145.

R = internal plate resistance of the tube.

E_g = instantaneous difference of potential between grid and filament.

E_p = instantaneous difference of potential between plate and filament.

e_g = instantaneous alternating grid emf.

E_b = plate battery emf.

E_c = grid battery emf.

I_p = instantaneous total current in the plate circuit.

I_p = direct current component of the plate current.

i_p = alternating current component of the plate current.

Z = impedance of the external plate circuit.

r = resistance of the external plate circuit.

k = amplification factor of the tube.

It was seen in Chapter VI that the current in the plate circuit for various values of plate and grid emf's., as represented by the static characteristic of the tube, may be expressed by the relation

$$I_p = a(E_p + kE_g)^m$$

where m was seen to be equal to 2 or $3/2$. If however only the straight central portion of the characteristic curve is considered, as is generally the case for amplification, or if the operation extends only over a small part of the curve, then m may be made equal to unity, and the equation becomes

$$I_p = a(E_p + kE_g) \tag{25}$$

and the internal plate resistance of the tube is

$$R = \frac{E_p + kE_g}{I_p}, \tag{26}$$

e_g produces synchronous variations of the plate current along the static characteristic curve of the tube corresponding to the plate voltage E_b. Thus, if the tube is operating at a plate potential of 200 volts, its characteristic curve will be the curve of Fig. 146 for a plate potential of 200 volts, and if the grid emf. is varied between -20 and $+20$ volts, the plate current will vary along the curve "200," from 3 to 67 milliamperes.

Suppose now, Fig. 145, that the plate circuit contains a resistance r. That is, to simplify the problem, suppose that the impedance Z of the external plate circuit is a resistance of value

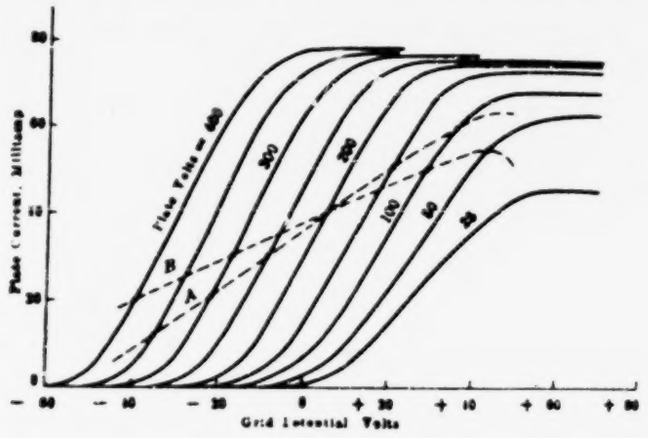

FIG. 146.

r. The emf. E_b of the battery B is then equal to the potential drop rI_p along the resistance r plus that, $I_pR = E_p$, between the filament F and the plate P of the tube, I_p being the current flowing in the plate circuit. Thus,

$$E_b = E_p + rI_p$$

from which

$$E_p = E_b - rI_p \tag{30}$$

which expresses the difference of potential between the plate and filament of the tube.

If now the grid potential E_g is varied so as to increase the current I_p in the plate circuit, it is seen that the resistance drop rI_p in the external plate circuit will correspondingly increase. It then follows from equation (30) that, with the battery voltage E_b remaining constant, *the plate potential* E_p *will de-*

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creases. Conversely, if the current I_p is decreased by decreasing the grid potential, the plate potential E_p will increase. Thus, on account of the external resistance of the plate circuit, the plate potential is no longer constant, but is a function of the plate current, and varies in opposite direction to the latter. In other words, the tube, operated under such conditions, has a *negative plate resistance reaction* as defined in connection with the oscillating arc, Chapter V. This will be taken up in greater detail in a later paragraph.

It follows from the above discussion, that when the external plate circuit has resistance and the grid potential is varied, the operating point of the tube no longer follows the static characteristic curve of the tube, which corresponds to a constant value of plate potential, but follows a different curve, called the *dynamic characteristic*. The shape of this characteristic curve depends on that of the static characteristic of the tube (and therefore on the tube construction and constants) and also on the resistance or impedance of the external plate circuit. This is shown in Fig. 146. The solid line curves are the static characteristic curves of the tube, while the dotted lines A and B represent the dynamic characteristics of the tube having an external plate circuit resistance of 5000 and 10,000 ohms, respectively. Thus, with an alternating grid potential and no resistance in the plate circuit, the tube follows the static characteristic curve corresponding to the potential E_b of the battery B. With an external plate circuit resistance of 5000 ohms, the operating point follows curve A, and with a resistance of 10,000 ohms, it follows curve B. Each of the curves A and B corresponds to a certain value of plate battery voltage. If this is changed, then the dynamic characteristic curve for a given external plate impedance will be shifted accordingly.

As expressed by the last equation, the greater the resistance r of the external plate circuit, or, more generally, the greater its impedance Z, the greater the variation of plate potential E_p resulting from a given change of plate current I_p brought about by a given variation of grid potential. This is shown in the curves of Fig. 146, where it may be seen that the slope of the dynamic characteristic curve decreases as the resistance (or impedance) of the external plate circuit is increased. As an extreme case, for infinite impedance, the curve would be parallel to the grid voltage axis of Fig. 146, showing that variations of grid

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PLAINTIFF'S EXHIBIT 265

No. 727,331. PATENTED MAY 5, 1903.

R. A. FESSENDEN.

RECEIVER FOR ELECTROMAGNETIC WAVES.

APPLICATION FILED APR. 9, 1903

NO MODEL. 2 SHEETS—SHEET 1.

FIG. 1.

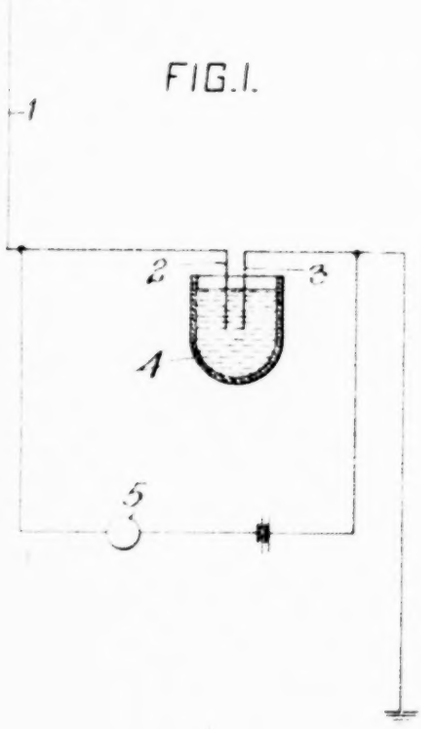


FIG. 2.

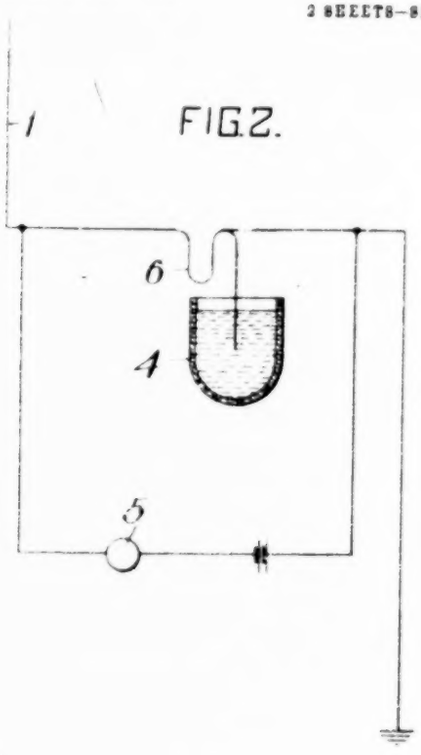
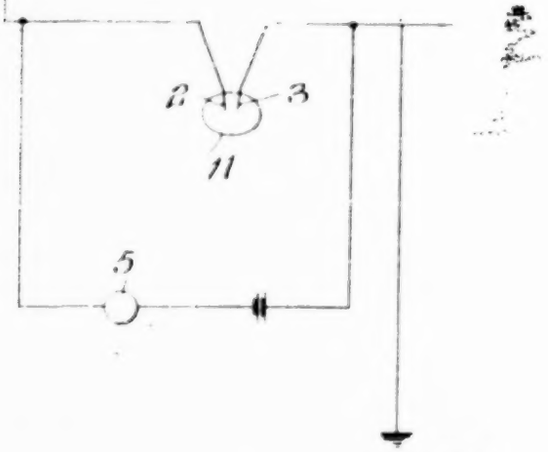


FIG. 3.

FIG. 4.



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Reginald A. Fessenden
by Dennis & Wolcott Att'ys

3120

No. 727,331. PATENTED MAY 5, 1903.

R. A. FESSENDEN.

RECEIVER FOR ELECTROMAGNETIC WAVES.

APPLICATION FILED APR. 4, 1903.

NO MODEL. 2 SHEETS—SHEET 2.

FIG. 5.

FIG. 6.

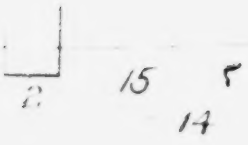


FIG. 7.

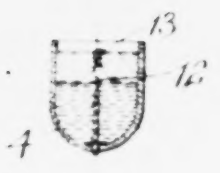
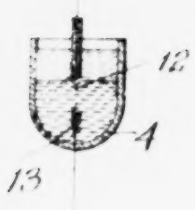


FIG. 8.



WITNESSES:
Robert Bradley
Fred Kirchner

INVENTOR
Reginald A. Fessenden
by Lamont & Wolcott Att'ys

2705

Patented May 5, 1903.

UNITED STATES PATENT OFFICE.

REGINALD A. FESSENDEN, OF PITTSBURG, PENNSYLVANIA.

RECEIVER FOR ELECTROMAGNETIC WAVES.

SPECIFICATION forming part of Letters Patent No. 727,331, dated May 5, 1903.

Application filed [illegible], 1903. Serial No. 151,617. (No model.)

To all whom it may concern:

Be it known that I, REGINALD A. FESSENDEN, a citizen of the United States, residing at Pittsburg, in the county of Allegheny and State of Pennsylvania, have invented or discovered certain new and useful Improvements in Receivers for Electromagnetic Waves, of which improvements the following is a specification.

The invention described herein relates to certain improvements in current-actuated wave-responsive devices of the class or kind described and claimed in Letters Patent No. [illegible], granted to me August 12, 1902, and which may be so affected by currents generated by electromagnetic waves as to produce a material variation of the conductivity of the receiving-circuit, of which said device forms a part.

The invention is hereinafter more fully described and claimed.

In the accompanying drawings, forming a part of this specification, Figure 1 is a sectional view of a form of receiver embodying my invention. Figs. 2, 3, 4, and 5 are sectional views of modified forms of receiver. Fig. 6 is a diagrammatic view illustrating the operation of the receiver. Fig. 7 is a detail illustrating further modifications in the construction of the receiver.

In the use of the hot-wire receiver described in the above-cited patent referred to, and which is sometimes termed a "barretter," that portion of the electromagnetic waves is utilized which heats a body of small mass, and which thereby causes a small amount of energy to produce such an extent as to change its conductivity. Heretofore metals, such as platinum and silver, have been employed, as described in the patent referred to; but I have found that in instances other substances are available for this purpose, as, for example, liquids, and of the latter class electrolytes have given even better general results than metals, for the following reasons: first, for the reason that they are not, by reason of their nature, subject to excessive discharges; second, because the specific resistance of liquids is much greater, in some cases as much as a million times greater, than that of metals, and consequently to obtain the same resistance a very much smaller mass, which is capable of being heated to a much larger extent, may be used; third, because the amount of change of resistance per degree of centigrade is very much greater—for example, the resistance of sulfuric acid when not quite concentrated changes approximately twelve per cent. per degree centigrade, while the change in platinum is only about one-third of one per cent. per degree centigrade. For all these reasons the results produced are very much greater and the action of the receiving device is much more reliable.

A liquid barretter or current-actuated wave-responsive device may be constructed in several ways. For instance, it is found that if the loop of a metal barretter such as described in the patent be broken while it is immersed in nitric acid it will nevertheless act even more efficiently than before, and hence a barretter may be formed consisting of two thin platinum wires 2 and 3, as shown in Fig. 1, having their ends immersed in a liquid contained in a suitable vessel 4 and forming, together with such liquid, a part of a receiving-circuit, including an indicating device 5. This barretter may be connected either directly or indirectly with a receiving-vertical 1. A second method is to moisten a minute fiber—for example, a cotton thread—and to use it as the loop of a barretter. A desirable construction for this form of barretter is shown in Fig. 2 and consists of a fiber loop 6, having one end immersed in a liquid, which will be caused to travel along the fiber by capillary action and maintain the fiber in a saturated condition. A third method consists in forming a minute hole through a diaphragm 7, conveniently done by drawing down a very thin capillary tube to about three one-thousandths (.003) of an inch internal diameter, cementing it into a hole in the center of a thick glass disk, and then grinding off the ends of the glass tube until they are flush with the surface of the diaphragm. The diaphragm is so arranged in a suitable vessel 4 as to form a partition between two portions of the solution in the cup or holder shown in Fig. 3, said portions being thus separated except by the thin column of the liquid contained in the capillary tube, said column forming the barretter. A ter-

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minal 9, preferably of platinum, connected to the vertical, is immersed in one portion of the liquid, and a second terminal 10, preferably of platinum also, is connected to ground and has one end immersed in the other portion of the liquid. These platinum wires, with the liquid, are to be connected either directly in series with the vertical or in the secondary of a transformer, and the barretter thus formed is adapted to be used in the manner described in prior patents granted to me. A fourth method is to connect two platinum wires by a thin film or small body of conducting liquid, as indicated in Fig. 4. This can be done conveniently by inserting the wires into a bubble 11, formed of such liquid. A fifth method is to insert a small piece 12, of platinum or similar material, into a liquid, such as nitric acid, so that only its point is immersed. Fig. 5 shows such an arrangement, the platinum wire being covered with silver. The silver wire has a diameter of about .003 of an inch, and the platinum core inclosed therein has a diameter of about .00004 of an inch. The silver is removed or eaten off from the lower extremity, and the platinum core projects into the solution of nitric acid. This solution of nitric acid, which preferably contains nitrous acid, is covered by a layer of kerosene-oil, so as to prevent evaporation of the acid and to prevent the platinum from being fused. A second platinum wire 13 is also immersed in the liquid, preferably by inserting it through the bottom of the vessel 4, and these wires are connected to the vertical and to ground and also included in the indicating-circuit. It follows from the well-known electrical formula giving the resistance of a cylindrical body in a conducting medium that practically all the resistance is concentrated within a short distance of the point where the platinum wire 12 projects into the acid. For example, if the platinum has a diameter of .00004 of an inch, and it is immersed in the acid to a depth of .00002 of an inch, practically all the temperature effected will take place inside of a hemisphere of liquid whose radius is .00004 of an inch. Such a hemisphere is indicated in Fig. 6, where 2 represents the tip of the platinum, and represents the hemisphere referred to. That this is true will be seen by considering a second hemispheric shell 14, having the thickness of .00004 of an inch outside of the hemisphere 15. The quantity of liquid in this shell 14 will be more than eight times that in the shell 15, and consequently it will take eight times the amount of heat to raise it to this same extent. At the same time the resistance of the shell 14 will be roughly the same as that of 15. Hence it follows that the effect of the shell 14 will be only one eighth that of 15, and consequently that although the effect of the different parts of the liquid within the boundary of 15 does not vary much and all parts are almost equally efficient, as soon as we pass the boundary of 15 the effect of the variations of liquid beyond the boundary begins to fall off very rapidly, and at a distance of two or three times the diameter of the wire it may be neglected. This may be deduced at once from the proposition that the electrical resistance between two copper disks laid on a plate of sheet-copper is conditioned almost entirely by the size of the disk, and by the conductivity of the copper sheet; while it is not affected except to an unappreciable extent by the distance between them. As shown in Fig. 7, the terminal 12 may be inserted through the bottom of the vessel 4, in which case an indicating liquid, such as bisulfid of carbon, having a greater specific gravity than the nitric acid is used in connection with the latter. As indicated in Fig. 8, the wire 12 may be surrounded with glass, so as to prevent any gas given off from adhering to the wire, and thereby decreasing its effective area.

The arrangement of circuits used with the liquid barretter is practically the same as that with the metal barretter described in the patent referred to.

It is found that certain liquids act better than others—as, for example, though carbonate of soda, caustic soda, nitrate of potash, and other substances give good results, it is preferred to use nitric acid, for the reason that the effects are stronger with it than with most other liquids, and in the case of a burn-out it is sufficient to screw down the platinum wire until it is again immersed. The burn-out is not liable to occur, on account of the cooling effect of the liquid on the wire. When using silver-coated platinum wire, the screwing down of the wire into the nitric acid will subject the silver to the action of the acid, which will remove it from the platinum. If, however, a high voltage—*e. g.*, seven or eight—be used in the local circuit, carbonate of soda will give larger effect than nitric acid.

It is to be noted that in the case of the liquid barretter the action of the electromagnetic waves is to cause a greater current to pass in the local circuit, owing to the fact that the conductivity of electrolytes increases instead of decreases with heat. With a liquid barretter having a resistance of between six hundred and two thousand ohms the increase of conductivity when the liquid is heated is so marked as to permit of the operation of a siphon recorder or relay, though a telephone may be used.

It is to be noted that there are several distinct methods in which metal and liquid can be used in conjunction to form a receiver for electromagnetic waves. First, the case of a conductor, such as oxidized silver, in contact with a liquid like mercury, where the action is apparently a true coherer action caused by the voltage produced by the electromagnetic waves breaking down the insulating-oxid and making a good electrical contact between the silver and mercury. This effect does not oc-

is not utilized in my form of liquid barretter, for, in the first place, the resistance of the apparatus, if constant and definite, does not alter by shock or jar, returns to the same value no matter what the strength of the wave, and an entirely new piece of wire immersed to the same depth when a burnout has occurred allows the same current to pass as any other similar piece of wire. Again, the increase of conductivity is always the same in amount under the same conditions and is exactly what calculations show should be produced by the heating of the liquid. Secondly, the change of resistance is exactly proportional to the energy of the electromagnetic waves, thus differing from the operation of the coherer. Third, if the size of the platinum wire be increased, the effect falls off very rapidly, as it should do according to theory, while in the case of coherer this is not true.

A second method of using liquid and metal is illustrated in Fig. 3 of Letters Patent No. 706,748, dated August 12, 1902, for rectifying the alternating currents produced by the electromagnetic waves. This effect does not occur when using my improved form of receiver, as may be readily shown by substituting such receiver for the electrolytic cell shown in the patent, in which case no such rectification will be found to occur. The evident reason for this is the fact that the resistance of the liquid barretter is so arranged as to absorb the energy and not to allow any of it to pass through. The energy by being absorbed none of it can be rectified. A second reason is that the polarization capacity of the barretter is too small to permit of such rectification. A third proof of this consists in the fact that the signals are obtained almost as well when both terminals consist of similar pieces of platinum, in which case, according to theory, there should be no rectification.

A third method consists in utilizing the depolarization of the electrode caused by the heating of the liquid. While there is no doubt that such an effect is probably produced, it is masked, and when in actual working practically the entire effect seems to be due to the change in resistance. An effect which appears when the voltage of the local circuit is raised to such a point as to cause the gases to bubble off from the point gives rise to a fourth method. When this is the case, the waves effect an increase in resistance instead of diminution, possibly by first causing the bubble of gas to be deposited, which decreases the area of contact between the liquid and the platinum wire. This action is, however, irregular and occurs only at a certain critical point, and as it does not always occur and regularly it is not available for actuating an indicating mechanism.

While the liquid receiver will work well no matter which pole is connected to the platinum, it is found in practice that better results are obtained when the platinum point is made negative, probably because bubbles of gas which may come off are dissolved in the liquid and tend to maintain the conductivity.

I claim herein as my invention—

1. A receiver for electromagnetic waves having a small heat capacity and consisting of a small quantity of liquid, substantially as set forth.

2. A receiver for electromagnetic waves consisting of a small quantity of liquid, the conductivity of which is affected by the action of electromagnetic waves, substantially as set forth.

3. A receiver for electromagnetic waves consisting of a small quantity of liquid adapted to have its resistance decreased by the action of electromagnetic waves, substantially as set forth.

4. A receiver for electromagnetic waves consisting of a material increasable in conductivity by currents produced by electromagnetic waves, substantially as set forth.

5. A receiver for electromagnetic waves consisting of a liquid and rapidly responsive as regards temperature to effects produced by electromagnetic waves, substantially as set forth.

6. A receiver for electromagnetic waves consisting of a small quantity of nitric acid, substantially as set forth.

7. A receiver for electromagnetic waves, having in combination a small quantity of nitric acid, and terminals formed of platinum immersed in said liquid, substantially as set forth.

8. A receiver for electromagnetic waves having all its contacts perfect contacts and formed of a material increasable in conductivity by currents produced by electromagnetic waves, substantially as set forth.

9. A receiver for electromagnetic waves, having in combination a small quantity of nitric acid, and terminals formed of platinum immersed in said liquid, the positive terminal having an external covering, substantially as set forth.

In testimony whereof I have hereunto set my hand.

REGINALD A. FESSENDEN.

Witnesses:
JESSIE E. BENT,
F. L. SCLAVER.

PLAINTIFF'S EXHIBIT 266

No. 780,842. PATENTED JAN. 24, 1905.

F. K. VREELAND.

METHOD OF RECEIVING ELECTROMAGNETIC WAVES OR OTHER FEEBLE SIGNAL IMPULSES.

APPLICATION FILED AUG. 1, 1904.

2 SHEETS—SHEET 1

Fig. 1

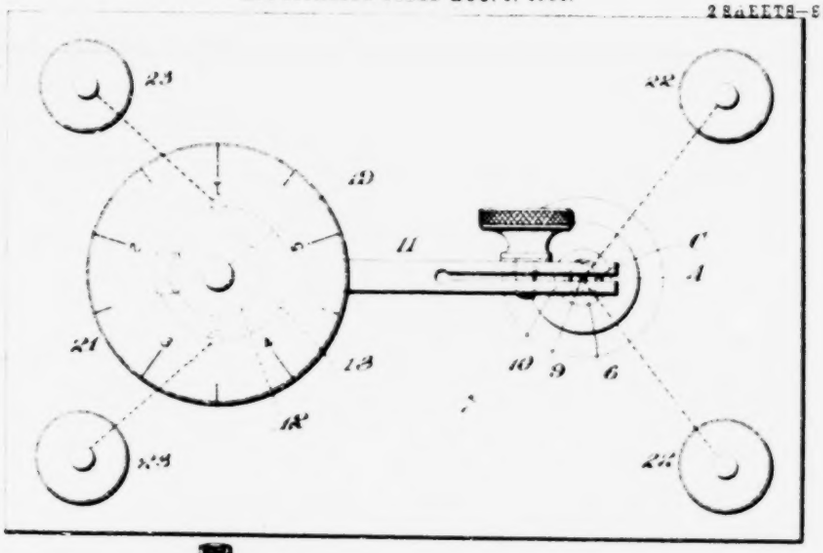
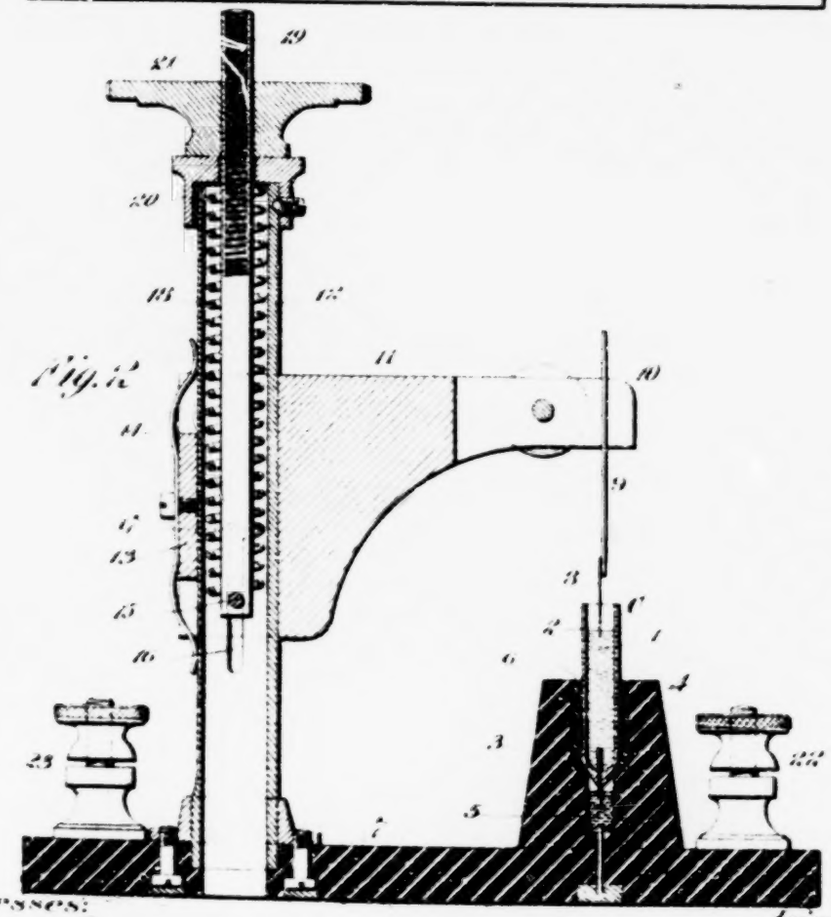


Fig. 2



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Jno. Robt. Taylor

Inventor
Frederick K. Vreeland
By Wright Brown & Quinby
Attorneys.

3125

No. 780,842. PATENTED JAN. 24, 1905.

F. K. VREELAND.

METHOD OF RECEIVING ELECTROMAGNETIC WAVES OR OTHER FEEBLE SIGNAL IMPULSES.

APPLICATION FILED AUG. 1, 1904.

2 SHEETS—SHEET 1.

Fig. 1

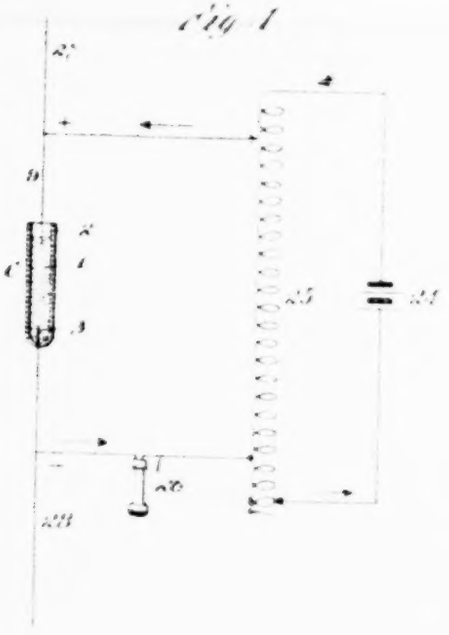


Fig. 3

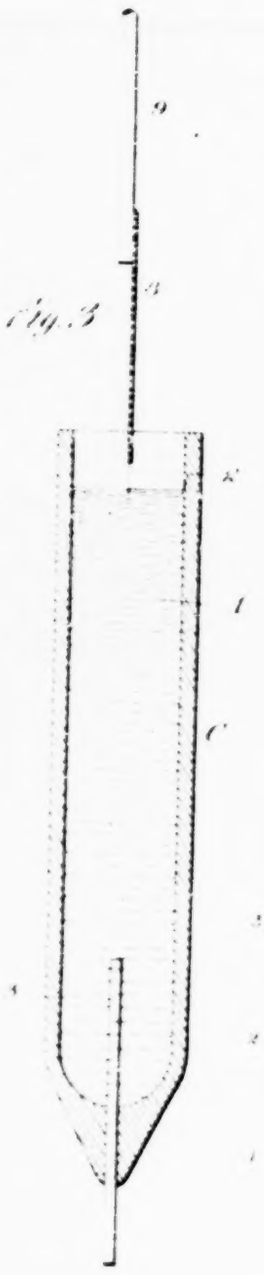
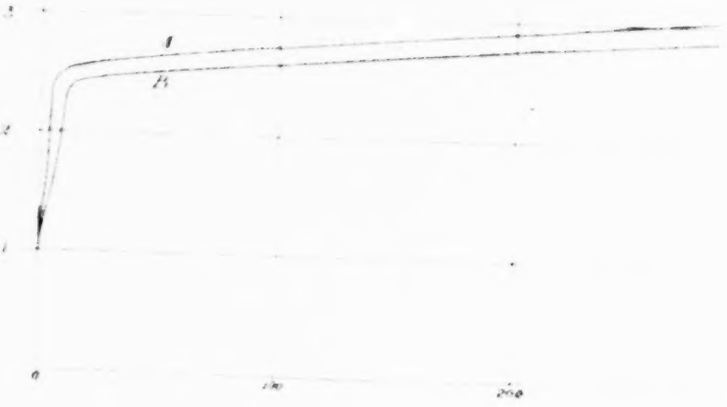


Fig. 5



Witnesses:

Geo. F. Gilman

Inventor

Attorneys.

2710

No. 780,842. Patented January 24, 1905.

UNITED STATES PATENT OFFICE.

FREDERICK K. VREELAND, OF MONTCLAIR, NEW JERSEY, ASSIGNOR TO WIRELESS TELEGRAPH EXPLOITATION COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

METHOD OF RECEIVING ELECTROMAGNETIC WAVES OR OTHER FEEBLE SIGNAL IMPULSES.

SPECIFICATION forming part of Letters Patent No. 780,842, dated January 24, 1905.

Application filed August 1, 1904. Serial No. 219,013.

To all whom it may concern:

Be it known that I, FREDERICK K. VREELAND, a citizen of the United States, residing at Montclair, in the county of Essex and State of New Jersey, have invented a certain new and useful Method of Receiving Electromagnetic Waves or other Feeble Signal Impulses, of which the following is a description.

The object I have in view is the production of a method for the detection of electromagnetic waves or other feeble electrical signal impulses.

The invention has been found especially useful for the reception of signals in wireless telegraphy.

My invention depends upon the discovery made by me that an electrolytic cell of a special character when polarized to the proper critical point by a local battery is extremely sensitive to transitory or rapidly-oscillating currents from another source which when passed through it tend to depolarize the cell and cause it to offer less opposition to the passage of the local current, which rises and falls in value with the presence and absence of the transitory waves or impulses and affords an effective means for operating a telephone or other signal receiver. The polarized cell is one of special character, particularly in the respect that the anode of the cell (i. e., the electrode connected with the positive pole of the local battery) presents to the electrolyte a minute surface, producing a cell of minute electrolytic capacity. This I have found enables the cell to be depolarized sufficiently by electromagnetic waves or other feeble signal impulses to cause variations of the local current therethrough great enough effectively operate a telephone or other signal receiver. The anode of the cell may be made of any suitable metal or other conducting material which is not changed by the electrolyte or attacked by the gaseous ions which are produced thereat. It may consist of a minute platinum wire having a diameter approximately .0001 inch and immersed in the electrolyte a few thousandths of an inch or the diameter may be .0005 of an inch, as it may be, the surface presented to the electrolyte is approximately .001 square millimeter. The size of this minute surface may be varied considerably in the region of this value. To obtain the best results, the area of contact-surface between the anode and the electrolyte should be properly proportioned to the intensity of the impulses to be detected. In general the apparatus becomes more sensitive to feeble impulses as the size of the anode is diminished; but when stronger impulses are received an increased effect may be obtained in the receiving instrument by increasing the area of the anode. For a given strength of impulse there is usually a certain size of anode which gives the maximum effect. If the anode be made larger than this, the apparatus becomes less sensitive. If it be made smaller, the strength of the impulse is more than sufficient to effect the depolarization of the cell and the remaining energy is wasted. In practice, however, an anode small enough to be sensitive to the most feeble impulses to be received will usually work well with any stronger impulse. I have found that a platinum wire of .0001 inch in diameter immersed in the electrolyte a few thousandths of an inch will meet this practical condition. This minute wire may be produced by drawing down a large silver wire with a platinum core, after which the end of the platinum core is exposed by dissolving the silver in nitric acid. As the useful action of polarization occurs at the anode, the size of the cathode is of little importance, though it should be preferably much larger than the anode. I use ordinarily a cathode of platinum wire .01 inch in diameter sealed into the bottom of a small glass vessel and projecting into the electrolyte one-quarter of an inch. If the cathode be made as small as the anode, the device will still operate, but less efficiently owing to the increased resistance of the cell. The distance between the anode and the cathode is also immaterial except as it affects the resistance of the cell. Ordinarily I prefer to place them about one-half inch apart, though this distance may be decreased to a few thousandths of an inch or increased to several inches without greatly affecting the result.

creases under the influence of the oscillations from .000003 to .000009 of an ampere. These are the steady values of the current. The momentary increase while the cell is readjusting itself to the changed conditions is very much greater and being of a sudden and transitory character has a much larger effect upon a telephone connected in the circuit than would be indicated by the values derived from the curve. For these reasons the apparatus is most sensitive when used with a telephone for receiving audible signals; but the constant increase of current indicated by the curve may also be utilized to operate a siphon-recorder or other recording apparatus. The terminal voltage of the cell produced by the local battery at which the cell is most sensitive to electromagnetic waves or other feeble impulses varies with different electrolytes and with different strengths of the solution. The cell is sensitive to oscillations over a considerable range of electromotive force; but it works most efficiently at a point a little below the bend of the curve, where a decided evolution of gas begins to occur. At this point the cell is less stable than at other voltages, and any stimulus gives a greater change in the state of polarization, and hence in the local current. This best voltage is about 1.8 volts for strong nitric acid, is higher for dilute acid, and may reach four or five volts or more in dilute caustic-kali solutions. Where the feeble impulses to be detected are unidirectional, care should be taken that they are passed through the cell in a direction opposite to the flow of the current from the local battery. These impulses will then have the effect of momentarily diminishing or even entirely annulling the existing polarization, resulting in the flow of a largely-increased current from the local battery through the depolarized cell. The apparatus is thus useful for detecting the feeble and transitory currents employed in cable telegraphy or for similar uses. If the polarity of the local battery is reversed—*i. e.*, its negative pole is connected to the electrode of minute surface—the apparatus becomes inoperative for the detection of electromagnetic waves or other feeble signal impulses. In this case the large terminal becomes the anode and the currents to be detected are too feeble to effect any appreciable change of polarization over its large surface. The apparatus will work with a voltage of the local battery considerably below the decomposition voltage of the cell, especially when the impulses to be detected are strong; but under these conditions the apparatus is less sensitive. I prefer, however, to produce by the local battery a difference of potential at the terminals of the cell somewhat higher than the decomposition voltage of the cell, but below the point where violent evolution of gas is caused.

My detector of electromagnetic waves, the method of operation of which and those principal constructional features have already been described, possesses numerous advantages over apparatus heretofore employed for the same purpose. It is extremely sensitive and responds to the most rapid impulses, being practically instantaneous in action. It is reliable and permanent in adjustment, does not require delicate handling or adjustment in operation, is not injured by lightning discharges or by the transmitting apparatus, lends itself readily to tuning—*i. e.*, selective signaling—is capable of being used either for the production of audible signals by a telephone or for the recording of signals, and, finally, it is characterized by extreme simplicity of construction.

In the drawings, Figure 1 is a top view of the cell-support and its constructional adjuncts. Fig. 2 is a vertical section of the apparatus of Fig. 1, the size of the minute anode being necessarily exaggerated. Fig. 3 is an enlarged view of the cell. Fig. 4 is a diagram illustrating the connections of the cell for receiving electromagnetic waves, and Fig. 5 represents curves illustrating the action of the cell.

The cell C is a small glass vessel containing the electrolyte 1, into which dips the minute anode 2. The cathode 3 of larger area is sealed into the glass bottom of the vessel C, projecting inwardly into the electrolyte and outwardly beyond the bottom of the vessel. The cell C is removably mounted in a socket 4, terminating in a mercury-cup 5, into which the outer end of the cathode 3 projects for making connection with the cathode. A bushing 6, of soft-rubber tubing, is inserted in the socket 4 to make a tight fit with the glass cell, so as to hold it firmly in place and prevent spilling of the mercury. The socket 4 is mounted upon a base 7, both the socket and base being preferably of a material not affected by the electrolyte. The minute anode 2 is supported by a silver jacket 8, which is attached to a copper wire 9, held by a screw-clip 10 on the end of a horizontal arm 11. This arm is mounted upon a standard 12 on the base 7 by a long sleeve 13. Springs 14, attached to the arm 11, bear against the flat face of the standard 12, so as to take up lost motion. The arm 11 is guided in its movement on the standard 12 by a pin 15, working in slots 16, the upper ends of these vertical slots 16 being extended into lateral slots 17, so as to permit the arm 11 to be swung to one side when moved to its uppermost position and after the anode is clear of the cell. The standard 12 is hollow, and within it is placed a spiral spring 18, pressing downwardly on the cross-pin 15 and surrounding a screw 19, which extends upwardly from the cross-pin through a cap 20 on the top of the standard 12. The cap 20 confines the spring 18, which spring exerts a downward pressure on the cross-pin 15, tending to keep the arm

H in its lowermost position. The arm H is lifted by means of a nut 21 turning upon the screw 19 and bearing upon the cap 20. The top of the nut 21 may be graduated to show the degree of adjustment. Binding-posts 22 are connected with the mercury-cup 5 and through it with the cathode of the cell, while binding-posts 23 are connected with the standard 12 and through it with the anode of the cell.

Referring to Fig. 4, which shows the connections of the apparatus for use as a receiver in wireless telegraphy, 24 is the local battery, having its positive pole connected to the anode of the cell and its negative pole connected to the cathode. 25 is an adjustable resistance-coil or potentiometer connected in shunt to the battery and cell, whose function is to regulate the voltage across the terminals of the cell. This coil is wound inductively to prevent the escape of the oscillations through itself or through the battery, a sufficient length of the coil for this purpose being always maintained in circuit between the battery and the cell. 26 is a telephone-receiver which is connected in the battery-circuit between the potentiometer and the cell. 27 is the antenna or aerial wire, and 28 is the ground-wire, which are connected, respectively, with the anode and cathode of the cell, but may have reverse connections with the cell.

The operation of the apparatus is evident from the description already given.

The apparatus described is not claimed herein, but will be made the subject of a divisional application.

What I claim is

1. The method of detecting electromagnetic waves or other feeble electrical impulses, which consists in polarizing an electrolytic cell of minute electrolytic capacity, effecting by such waves or impulses a partial or complete depolarization of such cell, and observing increases in current caused by the depolarization of the cell by said waves or impulses.

2. The method of detecting electromagnetic waves or other feeble electrical impulses, which consists in polarizing an electrolytic cell having a minute anode, effecting by such waves or impulses a partial or complete depolarization of such cell, and observing increases in current caused by the depolarization of the cell by said waves or impulses.

3. The method of detecting electromagnetic waves or other feeble electrical impulses, which consists in polarizing an electrolytic cell having a minute anode at which gas is evolved, effecting by such waves or impulses a partial or complete depolarization of such cell, and observing increases in current caused by the depolarization of the cell by said waves or impulses.

4. The method of detecting electromagnetic waves or other feeble electrical impulses, which consists in polarizing an electrolytic cell having a minute anode at which oxygen is evolved, effecting by such waves or impulses a partial or complete depolarization of such cell, and observing increases in current caused by the depolarization of the cell by said waves or impulses.

5. The method of detecting electromagnetic waves or other feeble electrical impulses, which consists in polarizing, by a local source of electromotive force, an electrolytic cell, passing the waves or impulses to be detected through said cell in such manner as to wholly or partially depolarize the cell and thereby increase the current in the local circuit, and observing the variations in flow of the local current.

6. The method of detecting electromagnetic waves or other feeble electrical impulses, which consists in polarizing, by a local source of electromotive force, an electrolytic cell having a minute anode, passing the waves or impulses to be detected through said cell in such manner as to wholly or partially depolarize the cell and thereby increase the current in the local circuit, and observing the variations in flow of the local current.

7. The method of detecting electromagnetic waves or other feeble signal impulses, which consists in polarizing by a local source of electromotive force an electrolytic cell, passing the waves or impulses to be detected through said cell in parallel with the polarizing current, and observing the variations in flow of the local current.

8. The method of detecting electromagnetic waves or other feeble signal impulses, which consists in polarizing by a local source of electromotive force an electrolytic cell having a minute anode, passing the waves or impulses to be detected through said cell in parallel with the polarizing current, and observing the variations in flow of the local current.

9. The method of detecting electromagnetic waves or other feeble electrical impulses, which consists in polarizing an electrolytic cell by an impressed voltage higher than the decomposition voltage of the cell but lower than the voltage at which a violent evolution of gas is caused, effecting by such waves or impulses a partial or complete depolarization of such cell, and observing changes in the polarization of the cell caused by said waves or impulses.

10. The method of detecting electromagnetic waves or other feeble electrical impulses, which consists in polarizing an electrolytic cell having a minute anode by an impressed voltage higher than the decomposition voltage of the cell but lower than the voltage at which a violent evolution of gas is caused, effecting by such waves or impulses a partial or complete depolarization of such cell, and observing changes in the polarization of the cell caused by said waves or impulses.

11. The method of detecting electromagnetic waves or other feeble electrical impulses, which

consists in polarizing an electrolytic cell by means of a local source of electromotive force producing at the cell a voltage above the decomposition voltage of the cell but below the point where a violent evolution of gas is caused, passing the waves or impulses to be detected through said cell and thereby wholly or partially depolarizing the same whereby the current in the local circuit will be increased, and observing the variations in flow of the local current.

12. The method of detecting electromagnetic waves or other feeble electrical impulses, which consists in polarizing an electrolytic cell having a single anode by means of a local source of electromotive force producing at the cell a voltage above the decomposition voltage of the cell but below the point where a violent evolution of gas is caused, passing the waves or impulses to be detected through said cell and thereby wholly or partially depolarizing the same whereby the current in the local circuit will be increased, and observing the variations in flow of the local current.

This specification signed and witnessed this 28th day of July, 1904.

FREDERICK K. VREELAND.

Witnesses:
Jno. Robt. Taylor,
Jorx L. Jensen.

Corrections in Letters Patent No. 780,842.

It is hereby certified that in Letters Patent No. 780,842, granted January 24, 1905, upon the application of Frederick K. Vreeland, of Montclair, New Jersey, for an improvement in "Methods of Receiving Electromagnetic Waves or other Feeble Signal Impulses," errors appear in the printed specification requiring correction, as follows: In line 25, page 2, the word "disposition" should read *deposition*; and in line 54, same page, the comma after the word "liquids" should be stricken out; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 7th day of March, A. D., 1905.

[SEAL.]

E. L. ALLEN,
Commissioner of Patents.

[fol. 2716] PLAINTIFF'S EXHIBIT 268

II. "On Electric Discharge between Electrodes at different Temperatures in Air and in High Vacua." By J. A. Fleming, M. A., D.Sc., Professor of Electrical Engineering in University College, London. Communicated by Professor G. C. Foster, F.R.S. Received December 16, 1889.

(Preliminary Notice)

It has been known for some time that if a platinum plate or wire is sealed through the glass bulb of an ordinary carbon filament incandescent lamp, this metallic plate being [fol. 2717] quite out of contact with the carbon conductor, a sensitive galvanometer connected between —s insulated metal plate enclosed in the vacuum and the external *positive* electrode of the lamp indicates a current of some milliampères passing through it when the lamp is set in action, but the same instrument when connected between the *negative* electrode of the lamp and the insulated metal plate indicates no sensible current. This phenomenon in carbon incandescence lamps was first observed by Mr. Edison, in 1884, and further examined by Mr. W. H. Preece, in 1885.*

* See 'Roy. Soc. Proc.,' vol. 38, 1885, p. 219. "On a Peculiar Behaviour of Glow Lamps when raised to High Incandescence."—In this paper Mr. Preece describes a very careful series of observations carried out with Edison incandescence lamps, and which cover the same ground as a portion of the experiments here described. The results given in (4), (7), and (11) confirm the facts which were first ascertained by him. He also arrived at the general conclusion that the phenomena so observed are due to an electric convection by matter projected from the incandescent carbon. By carrying up the working electromotive force of the lamp to a point productive of very high incandescence, he was able to measure the resulting current through a galvanometer connected between the positive lamp electrode and the middle plate corresponding to every degree of incandescence, and showed that, whilst increasing up to a certain point, the galvanometer current fell off rapidly soon after a certain critical temperature was reached, which corresponded to the appearance of a blue light or haze in the glass receiver.—[Jan. 14th, 1890.]

The primary object of the experiments described in this paper was the further examination of this effect, but the inquiry has extended itself beyond this range and embraced some general phenomena of electric discharge between electrodes at unequal temperatures, and in particular has revealed some curious effects in the behaviour of an electric arc taken between carbon poles towards a third insulated carbon or metal poles.

The first series of experiments had reference to the nature of the effect observed in the incandescence lamps having an insulated wire or plate placed in the vacuum.

If a platinum wire is sealed through the glass bulb of an ordinary carbon filament lamp and carries at its extremity a metal plate, so placed as to stand up between the legs of the carbon horseshoe without touching either of them, then when the lamp is actuated by a continuous current it is found that:

(1.) This insulated metal plate is brought down instantly to the potential of the base of the negative leg of the carbon, and no sensible potential difference exists between the insulated metal plate and the negative electrode of the lamps, whether the test be made by a galvanometer, by an electrostatic voltmeter, or by a condenser.

(2.) The potential difference of the plate and the positive electrode of the lamp is exactly the same as the working potential difference of the lamp electrodes, provided this is measured electrostatically, *i.e.*, by a condenser, or by an electrostatic voltmeter taking no current, but if measured [fol. 2718] by a galvanometer the potential difference of the plate and the positive electrodes of the lamp is something less than that of the working lamp electrodes.

(3.) This absolute equality of potential between the negative electrode of the lamp and the insulated plate only exists when the carbon filament is in a state of vivid incandescence, and when the insulated plate is not more than an inch or so from the base of the negative leg. When the lamp is at intermediate stages of incandescence, or the plate is considerably removed from the base of the negative leg, then the plate is not brought down quite to the same potential as the negative electrode.

(4.) A galvanometer connected between the insulated plate and the *positive* electrode of the lamp shows a current

increasing from zero to four or five milliampères, as the carbon is raised to its state of commercial incandescence. There is not any current greater than 0.0001 of a milliampère between the plate and *negative* electrode when the lamp has a good vacuum.

(5.) If the lamp has a bad vacuum this inequality is destroyed, and a sensitive galvanometer shews a current flowing through it when conected between the middle plate and either the positive *or* negative electrode.

(6.) When the lamp is actuated by an *alternating* current a *continuous* current is found flowing through a galvanometer, connected between the insulated plate and *either* terminal of the lamp. The direction of the current through the galvanometer is such as to show that negative electricity is flowing from the plate through the galvanometer to the lamp terminal. This is also the case in (4); but, if the lamp has a bad vacuum, then negative electricity flows *from* the plate through the galvanometer *to* the positive terminal of the lamp, and negative electricity flows *to* the plate through the galvanometer from the negative terminal of the lamp.

(7.) The same effects exist on a reduced scale when the incandescent conductor is a platinum wire instead of carbon filament. The platinum wire has to be brought up very near to its point of fusion, in order to detect the effect, but it is found that a current flows between the positive electrode of a platinum wire lamp and a platinum plate placed in the vacuum near to the negative end of that wire.

(8.) The material of which the plate is made is without influence. Platinum, aluminium, and carbon have been indifferently employed.

(9.) The active agent in producing this effect is the *negative* leg of the carbon. If the negative-leg of the carbon is covered up by enclosing it in a glass tube this procedure entirely, or nearly entirely, prevents the production of a current in a galvanometer connected between the middle plate and the positive terminal of the lamp.

(10.) It is a matter of indifference whether a glass or [fol. 2719] metal tube is employed to cover up the negative leg of the carbon; in any case this shielding destroys the effect.

(11.) If, instead of shielding the negative leg of the carbon, a mica screen is interposed between the negative leg and the side of the middle plate which faces it, then the

current produced in a galvanometer connected between the positive terminal of the lamp and the middle plate is much reduced. Hardly any effect under the same circumstances is produced when the mica screen is interposed on that side of the metal plate which faces the positive leg of the carbon.

(12.) The position of the metal plate has a great influence on the magnitude of the current traversing a galvanometer connected between the metal plate and the positive terminal of the lamp. The current is greatest when the insulated metal plate is as near as possible to the base of the negative leg of the carbon, and greatest of all when it is formed into a cylinder which embraces without touching the base of the negative leg.

The current becomes very small when the insulated metal plate is removed to 4 or 5 inches from the negative leg, and becomes practically zero when the metal plate is at the end of a tube forming part of the bulb, which tube has a bend at right angles in it. Copious experiments have been made with metal plates in all kinds of positions.

(13.) The galvanometer current is greatly influenced by the surface of the metal plate, being greatly reduced when the surface of the plate is made small, or when the plate is set edgeways to the negative leg, so as to present a very small apparent surface when seen from the negative leg. In a lamp having the usual commercial vacuum, the effect is extremely small when the insulated metal plate is placed at a distance of 18 inches from the negative leg, but even then it is just sensible to a very sensitive galvanometer.

(14.) If a charged condenser has one plate connected to the insulated metal plate, and the other plate connected to any point of the circuit of the incandescent filament, this condenser is instantly discharged if the positively charged side of the condenser is connected to the insulated plate, and the negative side to the hot filament. If, however, the negative leg of the carbon horseshoe is shielded by a glass tube, this discharging power is much reduced, or altogether removed.

(15.) If the middle plate consists of a separate carbon loop, which can itself be made incandescent by a separate insulated battery, then, when this middle carbon is rendered incandescent and employed as the metal plate in the above experiment, the condenser is discharged when the nega-

tively charged side of it is connected to the hot middle carbon, the positively charged side of it being in connexion with the principal carbon horseshoe.

[fol. 2720] (16.) If this last form of lamp is employed as in (4) the subsidiary carbon loop being used as a middle plate, and a galvanometer being connected between it and either the positive or negative main terminal of the lamp, then when the subsidiary carbon loop is cold, we get a current through the galvanometer only when it is in connexion with the positive main terminal of the lamp, but when the subsidiary carbon is made incandescent by a separate insulated battery, we get a current through the galvanometer when it is connected either to the positive *or* to the negative terminal of the lamp. In the first case the current through the galvanometer is a negative current, flowing from the middle carbon to the positive main terminal, and in the second case it is a negative current, from the negative main terminal to the middle subsidiary hot carbon.

(17.) If a lamp having a metal middle plate held between the legs of the carbon loop has a galvanometer connected between the negative main terminal of the lamp and this middle plate, we find that when the carbon is incandescent there is no sensible current flowing through the galvanometer. The vacuous space between the middle plate and the hot negative leg of the carbon possesses, however, a curious unilateral conductivity. If a single Clark cell is inserted in series with the galvanometer, we find that this cell can send a current deflecting the galvanometer when its negative pole is in connexion with the negative main terminal of the lamp, but if its positive pole is in connexion with the negative terminal of the lamp, then no current flows. The cell is thus able to force a current through the vacuous space when the direction of the cell is such as to cause negative electricity to flow across the vacuous space from the hot carbon to the cooler metal plate, but not in the reverse direction.

(18.) If a vacuum tube is constructed, having at each end horseshoe carbon filaments sealed into it, and which can each be made separately incandescent by an insulated battery, we find that such a vacuum tube, though requiring an electromotive force of many thousands of volts to force a current through it when the carbon loops are used as elec-

trodes and are *cold*, will yet pass the current from a single Clark cell when the carbon loop which forms the negative electrode is rendered incandescent. It is thus found that a high vacuum terminated electrically by unequally heated carbon electrodes possesses an unilateral conductivity, and that electric discharge takes place freely through it under an electromotive force of a few volts when the *negative* electrode is made highly incandescent.

(19.) These experimental results above described led the writer to investigate, in the same manner, the electric arc between carbon poles taken in air. If an electric arc is formed, in the usual way, between carbon poles, and a third insulated carbon pole is allowed to dip into or touch the electric arc, or, better still, has the electric arc projected against [fol. 2721] it by a magnet, it is found that this third or insulated pole is brought down almost to the potential of the negative carbon of the arc, and that a galvanometer connected between the third insulated carbon and the negative carbon of the arc indicates no current, but that if joined up between the positive carbon and the middle carbon a strong current of about an ampère or so is found to be passing. If an electric bell or an incandescent lamp is joined up between the third carbon and the *negative* carbon of the arc, they do not work; but if the bell or the lamp is joined between the *positive* carbon of the arc and the third carbon, they are set in action by a strong current passing through them. These effects are produced, although the third carbon (which is best held at right angles to the other two forming the arc) is half or three-quarters of an inch away from the positive and negative carbon, the sole condition being that the flame of the arc must touch or be projected by a magnet so as to touch this third carbon. We have, therefore, similar phenomena in the case of the arc and incandescence lamps.

(20.) When the electric arc is being projected against the third carbon, and has brought it down to the same potential, a galvanometer joined in between the two carbons shows no current; but this space between the negative carbon of the arc and the third carbon possesses a unilateral conductivity, and will pass the current from a small battery of secondary cells one way, but not the other. The secondary battery when joined in series with the galvanometer sends a current, if its negative pole is in connexion with the negative carbon of the arc, and its positive pole, through the

galvanometer, with the third carbon; but if the secondary battery is reversed in position it sends no current. Negative electricity can pass along the flame-like projection of the arc *from* the hot negative carbon *to* the cooler third carbon, but not in an opposite direction.

(21.) If the arc is projected by means of a magnet for a long time against the third insulated carbon, it *craters* it out in the same fashion as the crater of the positive carbon, and the tip of this third carbon, where it has received the flame-like blast of the arc, is converted into graphite.

The same effects are observed if an iron rod is used as a third pole, and in this case the end is converted into *steel*, and rendered so hard as to be scarcely touched by the file when it has been quenched in water.

In seeking for an hypothesis to connect together these observed facts, the one which suggests itself as most in accordance with the facts is as follows:—

In the case of a carbon incandescence lamp when at vivid incandescence, carbon particles are being projected from all parts of the filament, but chiefly from the negative half of [fol. 2722] the loop. These carbon molecules carry *negative* charges of electricity, and when they impinge upon a metal plate placed in the vacuum they can discharge themselves if this plate is positively electrified, either by being in metallic connexion with the positive electrode of the lamp or with a separate positively charged body. When the plate is simply insulated the stream of negatively charged carbon molecules brings down this insulated plate to the potential of the base of the negative leg, or to the potential of that part of the carbon conductor from which it is receiving projected molecules. These carbon molecules projected from an incandescent conductor can carry negative charges, but either cannot be positively charged, or else lose a positive charge almost instantly when projected off from the conductor.

In the case of the electric arc we must suppose that the negative carbon is projecting off a torrent of negatively electrified carbon molecules, and these, impinging against the positive carbon, wear out a crater in it by a sand-blast-like action.

The higher temperature of the positive carbon in a continuous current arc is thus explained as due to the impact of the carbon molecules projected from the negative carbon.

If the electric arc is diverted against a third insulated lateral carbon, the carbon blast from the negative carbon wears out a crater in it and brings it down to the same potential as itself. The actions going on in an electric arc may be considered to be somewhat as follows:—When the carbons are first put together, the resistance at the point of contact renders the extremities incandescent. When thus incandescent and separated, the electrification of each carbon is sufficient to begin the projection of molecules from both positive and negative carbons, probably most largely from the latter. The impact of the molecular stream from the negative pole raises the temperature of the positive carbon, and this again by radiation raises the temperature of the negative carbon end. The electromotive force is thus able to keep up a projection of negatively charged carbon molecules from the end of the negative carbon, which molecules are loosened from the mass by heat, and then move away by electric repulsion from the surface in virtue of the electric charge which they retain. It would seem as if a hot carbon molecule cannot retain a positive charge, and hence the potential difference between a third insulated carbon and the positive carbon of the arc is nearly the same as the potential difference of the positive and negative carbons of the arc. The rise of potential along the arc takes place very suddenly just in the neighbourhood of the crater of the positive carbon.

It has often been suggested that the electric arc contains a counter electromotive force. It is questionable whether such experiments as those of Edlund ('Phil. Mag.,' vol. 36, 1868, p. 352) are entirely conclusive on this point.

[fol. 2723] It has been shown by other experimenters * that for arcs of varying length, but the same current, beyond a certain small initial length, the potential difference necessary to maintain the arc is proportional to the length of the arc plus a constant. This might thus be interpreted to mean that a certain proportion of the work-electromotive force of the arc was employed in detaching the carbon molecules from the mass of the poles, and that the excess alone is represented by the current produced in an arc of definite length.

* See Professors Ayrton and Perry, "Proceedings of the Physical Society," vol. 5, p. 201.

In the case of the incandescence lamps the hypothesis of the projection of negatively charged carbon molecules from the incandescent conductor, to which the name of *molecular electrorection* may be given, will suffice to explain all the various different effects produced by varying the surface, position, and distance of the metal plate against which they impinge, and also the nullifying effect of shielding this plate from the negative leg of the carbon.

That this molecular discharge goes on chiefly from the negative leg is additionally proved by the greater erosion which takes place in the deposit of carbon on the negative leg when the carbon is uniform and traversed by a continuous current.

The hypothesis that a carbon molecule detached from an incandescent carbon surface in a high vacuum can only convey away a negative charge, reconciles also the above described observed effects in which a negative discharge can be made *out* of a hot surface of carbon more easily than a positive discharge. When an electromotive force is applied to two metallic terminal or electrodes sealed into a good vacuum, it is well known that a certain initial electromotive force has to be applied before any electric current begins to flow through the gas at all. It seems conclusively proved by Mr. Crookes's researches that the nature of an electric discharge through a high vacuum consists in a torrent of electrified particles proceeding from the negative electrode. If this is the case the initial electromotive force required to begin a discharge through such rarefied gas would naturally be reduced by heating the negative electrode, so as to favour and assist the detachment of the charged molecules of that electrode. The effect of heating the negative electrode in facilitating discharge through vacuous spaces has previously been described by W. Hittorf ('Annalen der Physik und Chemie,' vol. 21, 1884, p. 90-139), and it is abundantly confirmed by the above experiments. We may say that a vacuous space bounded by two electrodes —one incandescent, and the other cold—possesses a unilateral conductivity for electric discharge when these electrodes are within a distance of the mean free path of projection of the molecules which the impressed electromotive [fol. 2724] force can detach and send off from the hot negative electrode.

This unilateral conductivity of vacuous spaces having unequally heated electrodes has been examined by MM. Elster and Geitel (see 'Wiedemann's Annalen,' vol. 38, 1889, p. 40), and also by Goldstein ('Wied. Ann.,' vol. 24, 1885, p. 83), who in experiments of various kinds have demonstrated that when an electric discharge across a vacuous space takes place from a carbon conductor to another electrode, the discharge takes place at lower electromotive force when the carbon conductor is the negative electrode and is rendered incandescent.

[fol. 2725] PLAINTIFF'S EXHIBIT 269

"On the Conversion of Electric Oscillations into Continuous Currents by means of a Vacuum Valve." By J. A. Fleming, M.A., D.Sc., F.R.S., Professor of Electrical Engineering in University College, London. Received January 24.—Read February 9, 1905.

An electric oscillation being an alternating current of very high frequency, cannot directly affect an ordinary movable coil or movable needle galvanometer.

Appliances generally used for detecting electric waves or electric oscillations are, therefore, in fact alternating current instruments, and must depend for their action upon some property which is independent of the direction of the current, such as the heating effect or magnetizing force. The coherer used in Hertzian wave research is not metrical, since the action is merely catastrophic or accidental, and bears no very definite relation to the energy of the oscillation which starts it. Even the demagnetising action of electric oscillations, though more definite in operation than the contact action at loose joints, is far from being all that is required for quantitative research. It is obvious it would be an advantage if we could utilize the direct current mirror galvanometer for the detection and measurement of feeble electric oscillations. This can be done if we can discover a medium with perfect unilateral conductivity.

Some time ago, I considered the use of the aluminium-carbon electrolytic cell with this object. It is well known that a cell containing a plate of aluminium and carbon, immersed in some electrolyte which yields oxygen, such as

dilute sulphuric acid or an aqueous solution of any caustic alkali, or salt yielding oxygen, has a unilateral conductivity within limits. An electric current under a certain electromotive force can pass through the cell from the carbon to the aluminium, but not in the reverse direction.

This action has been much studied and is the basis of many technical devices, such as the Nodon electric valve.

The electrochemical action by which this unilateral conductivity is produced involves, however, a time element, and after much experimenting I found that it did not operate with high frequency currents. My thoughts then turned to an old observation made by me in 1889, communicated to the Royal Society, amongst other facts, in a Paper in 1889, and also exhibited experimentally at the Royal Institution in 1890.* This was the discovery: that if a [fol. 2726] carbon filament electric glow lamp contains a pair of carbon filaments or a single filament and a metallic plate sealed into the bulb, the vacuous space between possesses a unilateral conductivity of a particular kind when the carbon filament, or one of the two filaments, is made incandescent. I have quite lately returned to this matter, and have found that this unilateral conductivity exists even with alternating currents of high frequency and is independent of the frequency. Hence, in a suitable form, it seemed possible that such a device would provide us with a means of rectifying electric oscillations and making them measurable on an ordinary galvanometer. The following experiments were, therefore, tried:—

Into a glass bulb, made like an incandescent lamp, are sealed in the ordinary way two carbon filaments, or there may be many filaments. On the other hand, one carbon filament may be used and a platinum wire may be sealed into the bulb terminating in a plate or cylinder of platinum, aluminium or other metal surrounding the filament. It is

* See 'Roy. Soc. Proc.,' vol. 47, p. 122, 1890, "On Electric Discharge between Electrodes at different Temperatures in Air and High Vacua," by J. A. Fleming, communicated December 16, 1889; see also 'Proceedings of the Royal Institution,' vol. 13, Part LXXXIV, p. 45, Friday evening discourse on February 14, 1890, "Problems on the Physics of an Electric Lamp," when this unilateral conductivity was experimentally shown.

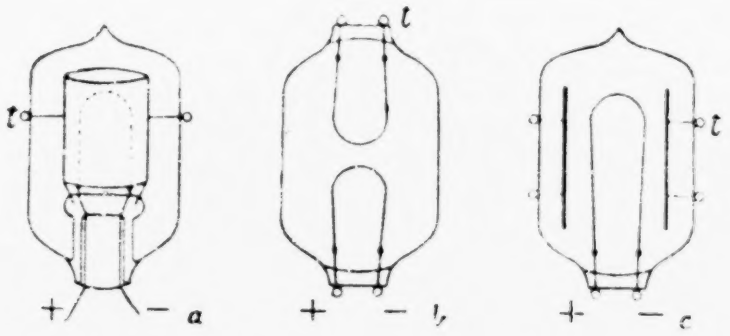
preferable to use a metal plate carried on a platinum wire sealed into the glass bulb, the plate being bent into a cylinder which surrounds both the legs of the carbon loop. The diagrams in fig. 1 show various forms of the arrangement. Diagram *a* shows a bulb with a single carbon filament surrounded by a metal cylinder, *b* shows one with two carbon filaments, and *c* a carbon filament and two insulated metal plates. The ends of the carbon filament which is rendered incandescent are marked + and − and the terminal of the other electrode of the valve is marked *t*. The bulb must be highly exhausted to about the pressure usual in the case of carbon filament incandescent lamps, and the metal cylinder or plate must be freed from occluded air.

Suppose that we employ such a bulb containing one carbon filament surrounded by a metal cylinder (see *a*, fig. 1). The filament may be of any voltage, but I find it most convenient to employ filaments of such a length and section that they are brought to bright incandescence by an E.M.F. of 12 volts. The voltage and section of the filament should be so arranged that the temperature of the filament corresponds with an "efficiency," as a lamp-maker would say, of 2·5 or 3 watts per candle. The filament is conveniently brought to incandescence by a small insulated battery of secondary cells. A circuit is then completed through the vacuous space in the bulb between the cylinder and the filament by another wire which joins the external terminal of the metal cylinder and that terminal of the carbon filament which is in connection with the negative pole of the heating battery. In this last circuit is placed a sensitive mirror galvanometer of the movable needle or movable coil [Sol. 2727] type, and also a coil which may be the secondary circuit of an air core transformer in which electric oscillations are set up. As is now well known, the vacuous space in the bulb permits negative electricity to move in it from the hot filament or cathode through the vacuous space to the cylinder or anode and back through the galvanometer or coil, but not in the reverse direction, as long as the cylinder is cool and the carbon filament not at a temperature much above the melting point of platinum. To illustrate the action of the bulb as an electrical valve, the following experiments can be shown:

Electric oscillations are set up in a metal wire circuit by the discharge of a Leyden jar, as usual. This circuit

takes the form of a thick wire of one or more turns, bent into the form of a circle or square. Some distance from this, we place another wire, of several, say eight or ten

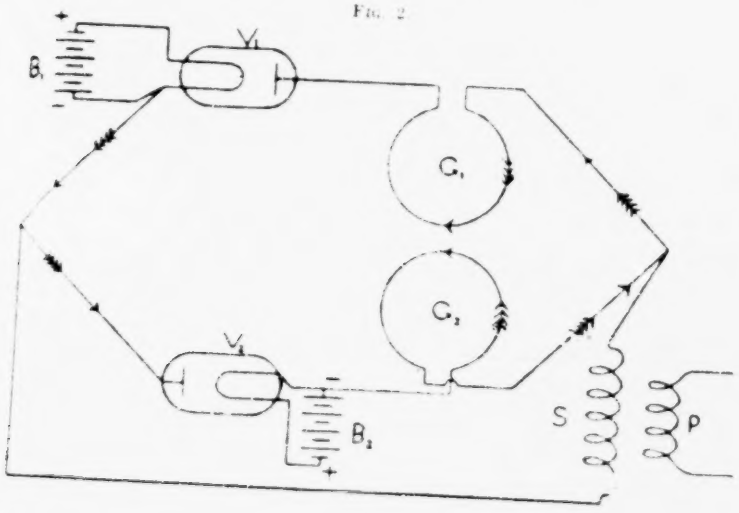
Fig. 1.



turns, also bent into the form of a circle, and connect this last wire into the circuit of a galvanometer and vacuum bulb made as described, so that it is a circuit having unilateral conductivity. On exciting the oscillations in the primary circuit by an induction coil we have an alternating high frequency magnetic field produced, which affects the secondary circuit at a distance. The oscillations in this last are, however, able to flow only in one direction. Hence, the galvanometer is acted upon by a series of intermittent but unidirectional electromotive forces, and its needle or coil deflects. Since the field is a high frequency field, we can show the screening effect of a sheet of tin foil or silver paper in a very simple and effective manner by the effect it produces in cutting down the galvanometer deflection when the metal sheet is interposed between the primary secondary circuits. Also, if we move the secondary coil away from the primary coil or turn the two coils with their planes at right angles to one another, then the galvanometer deflection diminishes or falls to zero because the induction is decreased. Accordingly, we have in this vacuum valve and associated [fol. 2728] mirror galvanometer a means of detecting feeble alternating electric currents or oscillations. Another method is to employ a differential galvanometer and two vacuum valves. These must then be arranged, as shown in fig. 2, one circuit G_1 of the differential galvanometer is in series with one valve V_1, and the other circuit G_2, with the other valve V_2, but so joined up that currents flowing through the valves in opposite directions pass round the two galvanom-

eter wires in the same direction as regards the needle and, therefore, their effects are added together on the galvanometer needle. Each valve must then have its own separate insulated battery to ignite the filament. Also, it is necessary that the connection with the oscillatory circuit must be made in both cases to the hot filament by that terminal which is in connection with the negative pole of the local battery used to ignite the filament (see fig. 2).

FIG. 2.



This arrangement of a differential galvanometer and two valves transforms, of course, more of the alternating oscillation into direct current than when one valve alone is used. It provides us with a means of detecting electrical oscillations not merely in closed circuits but in open electrical circuits.

When so using it, it is necessary to associate with the oscillation valve and galvanometer an oscillation transformer for raising the voltage. The resistance of these valves, when in operation, may be anything from a few hundred ohms up to some megohms, depending on the state of incandescence of the filament and upon the electromotive force employed to drive the current through the vacuous space, as well as upon the size of the filament and [fol. 2729] the plate. This resistance does not obey Ohm's law, but the current increases to a maximum and then slightly decreases as the voltage progressively increases. The form of oscillation transformer employed with the device is as follows: A small air-core induction coil has

a primary circuit, which consists of 52 turns of gutta-percha covered wire, wound in a helical groove cut on an ebonite rod 0·5 inch in diameter and 6 inches in length. The primary circuit is made of a No. 20 or No. 22 S.W.G. copper wire. The secondary circuit consists of 36,000 turns of fine silk-covered wire, No. 36, wound in six coils, each having about 6000 turns, and all joined in series. This secondary circuit has one terminal connected to one common terminal of the galvanometer and the other to the common terminal of the two oscillation valves (see fig. 4). The primary coil of this oscillation transformer has one terminal connected to earth and the other to a long insulated rod which acts as an aerial or electric wave collector. To prevent the direct action of the transmitter upon the secondary coil by simple electromagnetic induction, it is best to wind the secondary coil in two equal parts in opposite directions and to wind the primary in a corresponding manner.

If an electric wave sent out from a similarly earthed transmitter falls upon the rod, then an electrical oscillation is set up in the receiving circuit and therefore in the primary coil of the oscillation transformer inserted in series with it. This oscillation is raised in voltage by the secondary coil of the transformer, and by reason of the unilateral conductivity of a vacuum valve, placed in series with the coil, one part of the oscillation, viz., the positive or the negative current, passes round the galvanometer coils and affects it.

If we employ a sensitive dead beat galvanometer of the type called by cable engineers a "Speaking Galvanometer," then intelligible signals can be sent by making small and larger deflections of the galvanometer corresponding to the dot and dash of the Morse alphabet; anyone who can "read mirror" can read off the signals as quickly as they can be sent on an ordinary short submarine cable with this arrangement.

The arrangement, although not as senitive as a coherer or magnetic detector, is much more simple to use. Also it has one great advantage, viz., that it enables us to examine the behaviour of any particular form of oscillation producer. By means of it we can detect changes in the wave making power or uniformity of operation of the transmitting arrangement, by the variation of the deflection of the galvanometer. Thus, for instance, if a spark-ball transmitter is being employed and the deflection of the galvanometer in association with the receiving aerial is steady, if we put the

slightest touch of oil upon the spark-balls of the transmitter, their wave-making power is increased and the deflection of the galvanometer at once increases. Since the current through the galvanometer is the result of the groups [fol. 2730] of oscillations which are created in the receiving circuit, and since in the ordinary transmitter these oscillation groups are separated by wide intervals of silence, it is obvious that we can increase the sensitiveness of the above described arrangement by employing a very rapid break or interruptor with the induction coil. If, for instance, we employ a Wehnelt break with the induction coil or a high speed mercury break or alternating current transformer, we get a far better result as indicated by the deflection of the galvanometer than when employing the ordinary low frequency spring or hammer break.

The point of scientific interest in connection with the device, however, is the question how far such unilateral conductivity as is possessed by the vacuous space is complete. The electrical properties of these vacuum valves have accordingly been studied.

A bulb containing a 12 volt carbon filament rendered brightly incandescent by a current of about 2.7 to 3.7 amperes was employed. The filament was surrounded by an aluminium cylinder. The length of the carbon filament was 4.5 cm., its diameter 0.5 mm., and surface 70 square mm.

The aluminium cylinder had a diameter of 2 cms., a height of 2 cms., and a surface of 12.5 square cms. The filament was shaped like a horse shoe, the distance between the legs being 5 mm. This filament was rendered incandescent to various degrees by applying to its terminals 8, 9, 10, and 11 volts respectively. Another insulated battery of secondary cells was employed to send a current through the vacuous space from the cylinder to the filament, connection being made with the negative terminal of the latter. The current through the vacuous space and the potential difference of the cylinder and negative end of the hot carbon filament were measured by a potentiometer. The effective resistance of the vacuous space is then taken to be the ratio of the so observed potential difference (valve P.D.) to the current (valve current) through the vacuum.

The following table records the observations. The column headed P.D. gives the potential difference between the hot filament and the cylinder, that headed A gives the

current through the vacuous space in milliamperes, that headed R the resistance of the space in ohms, and that headed $K10^6$ is 1000,000 times the conductivity.

The result is to show that the vacuous space does not possess a constant resistance, but its conductivity increases rapidly up to a maximum and then decreases as the valve potential difference progressively increases. If we plot the current-values as ordinates and potential difference of the valve electrodes as abscissæ, we find that the current curve quickly rises to a maximum value and then falls again slightly as the potential difference increases steadily. The conductivity curve also rises to a maximum and then decreases (see fig. 3).

The facts so exhibited are well-known characteristics of [fol. 2731] gaseous conduction in rarefied gases.* It may be noted that there is in these current-voltage and voltage

Table I.—Variation of Current through, and Conductivity of, a Vacuum Valve with varying Electromotive Force, the Electrodes being an Incandescent Carbon Cathode and Cool Aluminium Anode

Carbon filament at 11 volts, 3·77 amp., 41·47 watts

Vacuum Space

P.D.	A.	R.	$K10^6$
0·6	0·024	25·000	4·0
5·4	0·264	20·550	4·86
8·8	0·480	18·330	5·45
18·2	3·880	4·691	21·4
22·9	26·790	·855	118·1
29·1	28·02	1·038	96·1
37·1	28·426	1·305	76·6
49·0	26·50	1·719	58·0
70·2	26·87	2·613	38·3
100·0	24·36	4·105	25·0

Carbon filament at 10 volts, 3·44 amps., 34·45 watts.

Vacuum Space

P.D.	A.	R.	$K10^6$
0·7	0·014	50·000	2·0
2·8	0·073	38·360	2·6
8·2	0·392	20·920	4·76
12·8	0·824	15·530	6·56
16·2	1·739	9·316	10·70
20·1	5·352	3·756	26·6
23·3	9·68	2·407	41·4
35·9	10·037	3·577	28·0
49·7	9·794	5·075	20·0
71·6	8·920	8·027	12·5
100·08	8·331	12·010	8·32

Carbon filament at 9 volts, 3·112 amps., 28·0 watts

Vacuum Space

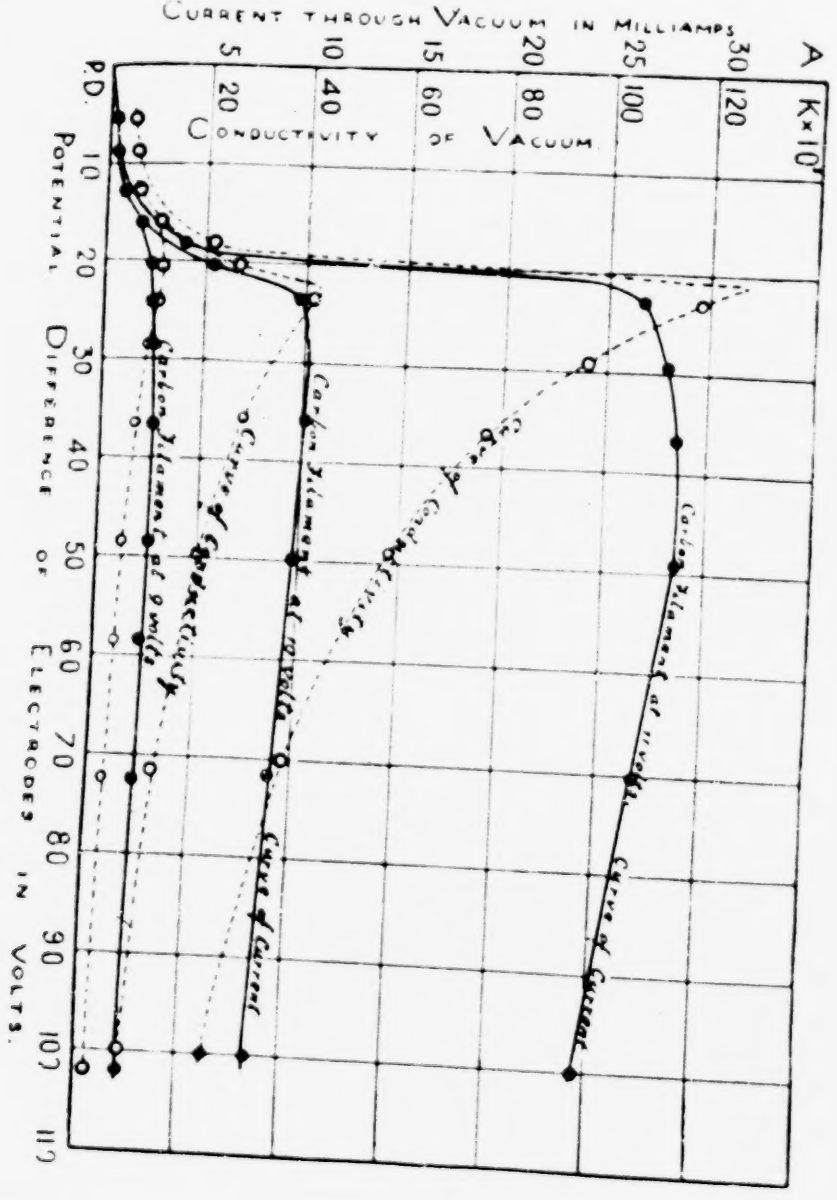
P.D.	A.	R.	$K10^6$
0·5	0·005	100·000	1·0
2·5	0·049	50·020	2·0
5·2	0·128	40·625	2·46
8·3	0·324	25·620	4·0
8·8	0·361	24·380	4·1
12·6	0·70	17·970	5·5
16·4	1·735	9·452	10·5
20·4	2·351	8·677	11·2
24·2	2·389	10·130	10·0
28·2	2·437	11·650	8·6
36·6	2·508	14·590	6·86
48·6	2·535	19·170	5·0
58·5	2·374	24·640	4·0
72·5	2·253	32·180	3·0
102·0	2·067	49·350	2·0

* See J. J. Thomson, 'Conduction of Electricity through Gases,' Chap. VIII.

conduction curves a general resemblance to the magnetisation and permeability curves of iron.

To examine further the nature of this conduction, the following experiments were made. If a vacuum bulb, as described, is joined up in series with a galvanometer and an electrodynamometer and an alternating electromotive force applied to the circuit, the two instruments will be both affected. The galvanometer is, however, affected only by

FIG. 3



[fol. 2732] the resultant flux of electricity in one direction. It measures the unidirectional current. The dynamometer is affected by the bilateral flux of electricity and it measures the total or alternating current. If, therefore, the vacuous space is totally non-conducting in one direction, one half [fol. 2733] of the alternating current will be cut out. The galvanometer will read the true mean (T.M.) value of the remanent unidirectional current, and the dynamometer will read the root-mean-square (R.M.S.) value. If the conductivity in one direction is not zero, then the galvanometer will read the T.M. value of the difference of the positive and negative currents, but the dynamometer will read the R.M.S. value of their sum.*

In the last case, the current through the valve may be considered to be a continuous current superimposed upon an alternating current.

If we call I the maximum value of the nearly sinoidal current in one direction, and I′ the maximum in the opposite direction, then we may say that the dynamometer reading (D) expressed in true current value is equal to $g\,(\mathrm{I}+\mathrm{I}')$ where g is the *amplitude factor*, and also that the galvanometer reading (G) in true current value is equal to $g\,f\,(\mathrm{I}-\mathrm{I}')$, where f is the *form factor* of the current.† Hence—

$$\frac{\mathrm{D}}{\mathrm{G}} = f\frac{\mathrm{I}+\mathrm{I}'}{\mathrm{I}-\mathrm{I}'}, \text{ or } \frac{\mathrm{D}}{\mathrm{G}}\frac{2f}{+f} = \frac{\mathrm{I}}{\mathrm{I}-\mathrm{I}'}.$$

The fraction $\frac{2f}{\mathrm{D}\,\mathrm{G}+f}$, say B_1 expressed as a percentage may be called the *rectifying* power of the valve, for it expresses the percentage which the actual unilateral electric flow or continuous current through the valve is of that con-

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* If i is the instantaneous value of a periodically varying current with maximum value I and periodic time T, then the root-mean-square value (R.M.S. value) of i is defined to be $\left(\frac{1}{\mathrm{T}}\int_0^{\mathrm{T}} i^2 dt\right)^{\frac{1}{2}}$ and the true mean value (T.M. value) of i is defined to be $\frac{2}{\mathrm{T}}\int_0^{\frac{1}{2}\mathrm{T}} i\,dt$.

† The *form factor* f and *amplitude factor* g are the names given by the author (see 'Alternating Current Transformer,' J. A. Fleming, vol. I. p. 585, 3rd edit.) to the ratio of the R.M.S. to the T.M. value of the ordinates of a single valued periodic curve, and to the ratio of the R.M.S. value of the ordinates to the maximum avlue during the period.

tinuous current which would flow if the unilateral conductivity were perfect.

Perfect rectifying power, however, does not exist. There is not an infinite resistance to movement of negative electricity from the metal cylinder to the hot filament through the vacuum, although this resistance is immensely greater than that which opposes the movement of negative electricity in the opposite direction. This point was examined, as follows: A very sensitive electrodynamometer was skilfully constructed by my assistant, Mr. G. B. Dyke, the fixed coil having 2000 turns of No. 47 silk-covered copper wire and the movable coil 1000 turns. The suspension of the movable coil was by a fine flat phosphor-bronze wire at top and bottom. The deflection was observed by a mirror and scale.

[fol. 2734] This dynamometer was placed in series with a shunted movable coil galvanometer of Holden-Pitkin pattern, and the two together placed in series with a variable section of an inductionless coil through which an alternating current was passing. A vacuum valve as above described was in series also with the galvanometer and dynamometer. The alternating current was derived from an alternator giving a nearly true sinoidal electromotive force. The form factor of the electromotive force curve of this alternator was determined and found to be 1.115, that for a true sine curve being 1.111.

The vacuum valve sifted out the alternating current flow and allowed the currents in one direction to pass, but nearly stopped those in the opposite direction. The indications of the electrodynamometer were proportional to the root-mean-square (R. M. S.) value of the sum of the two opposite currents, and that of the galvanometer to the true mean value (T. M.) of their difference. The galvanometer and dynamometer were both calibrated by a potentiometer by means of continous current, and curves constructed to convert their scale readings to milliampères. Then with various alternating current electromotive forces, their readings were taken when in series with a vacuum valve and recorded in the following tables. The letter D denotes current in milliampères as read by the so calibrated dynamometer and G that read by the galvanometer. The ratio D/G is denated by s, and the rectifying power, viz., $2f \cdot s - f$ by p.

The table shows that the value of α is not constant, but for each state of incandescence of the filament reaches a maximum which, however, does not greatly differ from the mean value for the range of currents used. If we set out the mean values of β in a curve (see fig. 4), in terms of the power expended in heating the carbon filament, we see that the rectification is less complete in proportion as the temperature of the carbon filament increases. This is probably due to the fact that as the filament gets hotter, it heats the enclosing cylinder to a higher temperature and enables negative electricity to escape from the latter.

Hence, I feel convinced that if the metal cylinder could be kept quite cool by water circulation the rectification would reach 100 per cent. or be complete.

An ideal and perfect rectifier for electric oscillations may, therefore, be found by enclosing a hot carbon filament and a perfectly cold metal anode in a very perfect vacuum. With a bulb such as that used for the above experiments all we can say is that the current passed through the vacuum is from 80 to 90 per cent. continuous, 100 per cent. implying that the vacuum is perfectly non-conducting in one direction and permits the flow of negative electricity only from the hot to the cold electrode. The necessity for keeping the cathode cold is shown by the following experiment:—An alternating-current arc was formed between

[Jul. 27.35]

Table II.—Ratio of Electrodynamometer (D) to Galvanometer (G) Reading in Milliampères. Form Factor of E. M. F. Curve = 1·115 = f.

Carbon filament at 11 volts, 3·77 amps., 41·7 watts.

D	G.	D/G = α.	$2f\alpha + f = \beta$.	
0·85	0·57	1·49	0·85	
1·33	0·85	1·56	0·83	
1·87	1·16	1·61	0·82	
2·30	1·40	1·64	0·81	Mean
3·20	1·88	1·73	0·78	= 0·82
3·52	2·19	1·68	0·80	
4·54	2·81	1·62	0·82	

Carbon filament at 10 volts, 3·44 amps., 34·43 watts.

0·50	0·34	1·47	0·86	
1·34	0·86	1·56	0·83	
2·28	1·48	1·54	0·84	
2·72	1·68	1·62	0·82	Mean
2·78	1·71	1·63	0·81	= 0·83
3·02	1·87	1·62	0·82	
3·53	2·17	1·63	0·81	
4·30	2·92	1·47	0·86	
4·25	2·88	1·48	0·86	

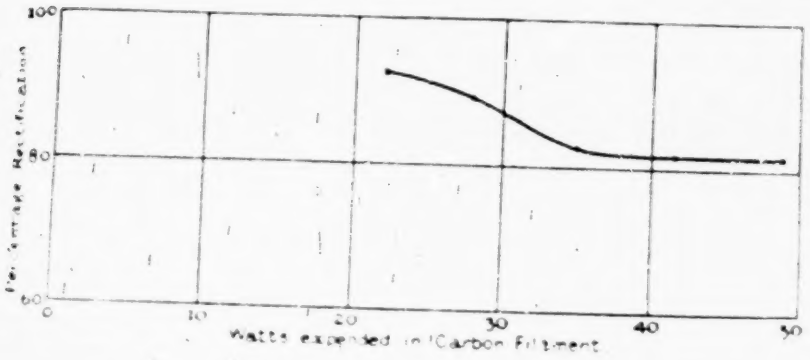
Carbon filament at 9 volts, 3·112 amps., 28·0 watts.

0·30	0·31	1·29	0·93	
0·73	0·50	1·46	0·87	
1·28	0·83	1·54	0·84	
1·65	1·15	1·43	0·88	
1·82	1·26	1·44	0·87	Mean
1·78	1·26	1·41	0·88	= 0·89
1·93	1·35	1·43	0·88	
1·94	1·41	1·38	0·80	
1·87	1·41	1·38	0·91	
1·83	1·39	1·32	0·92	
1·73	1·37	1·26	0·94	

carbon rods, and an iron rod was placed so that its end dipped into the arc. An ammeter was connected in between either carbon and the iron rod, and indicated a continuous current of negative electricity flowing through the ammeter from the iron rod to the carbon pole. This current was, however, greatly increased by making the iron rod of a piece of iron pipe closed at the end and kept [fol. 2736] cool by a jet of water playing in the interior. In this manner I have been able to draw off a continuous current of 3 or 4 ampères from an alternating-current arc using 15 alternating-current ampères.

Returning, then, to the vacuum valve, we may note that the curves in fig. 3 show that the vacuous space possesses a maximum conductivity corresponding to a potential difference of about 20 volts between the electrodes, for the particular valve used. The interpretation of this fact may, perhaps, be as follows:—In the incandescent carbon there is a continual production of electrons or negative ions by atomic dissociation. Corresponding to every temperature there is a certain electronic tension or percentage of free electrons. If the carbon is made the negative electrode in

FIG. 4



a high vacuum these negative ions are expelled from it, but they cannot be expelled at a greater rate than they are produced. Therefore, there is a maximum value for the outgoing current and a maximum value for the ratio of current to electromotive force, that is for the conductivity.

This fact, therefore, fixes a limit to the utility of the device. The current through the vacuous space is, to a very large extent, independent of the electromotive force creating it, and is at no stage proportional to it, or at least only within a narrow range of electromotive force near to the maximum conductivity.

Whilst, therefore, the device is useful as a simple means of detecting electric oscillations, it has not that uniformity of conductivity which would make it useful as a strictly metrical device for measuring them. It can, however, perform the useful service of showing us how far any device for producing electric oscillations or electric waves produces a uniform or very irregular train of electric oscillations, and what changes conduce to an improvement or reduction in the efficiency of the transmitting device.

PLAINTIFF'S EXHIBIT 270

3151

No. 843,387. PATENTED JAN. 15, 1907.

L. DE FOREST.

DEVICE FOR AMPLIFYING FEEBLE ELECTRICAL CURRENTS.

APPLICATION FILED OCT. 26, 1903.

2 SHEETS—SHEET 1.

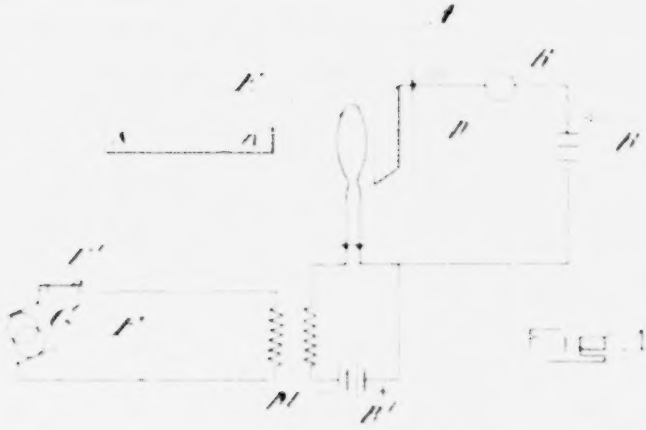


Fig. 1.

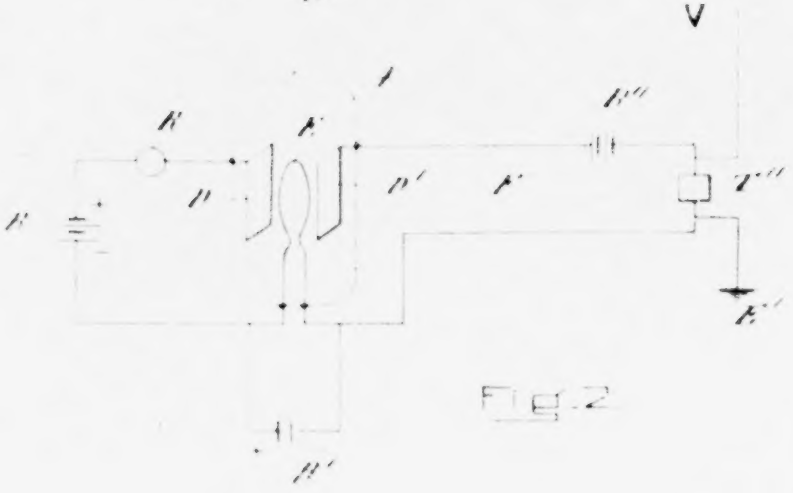


Fig. 2.

Fig. 3.

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No. 841,387 PATENTED JAN. 15, 1907.

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DEVICE FOR AMPLIFYING FEEBLE ELECTRICAL CURRENTS.

APPLICATION FILED OCT. 25, 1906.

2 SHEETS—SHEET 2.

FIG. 4.

FIG. 5.

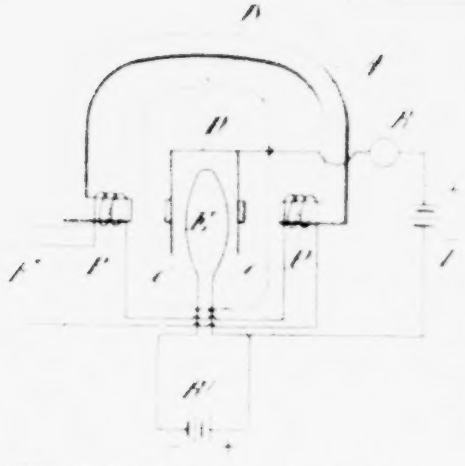

FIG. 6.

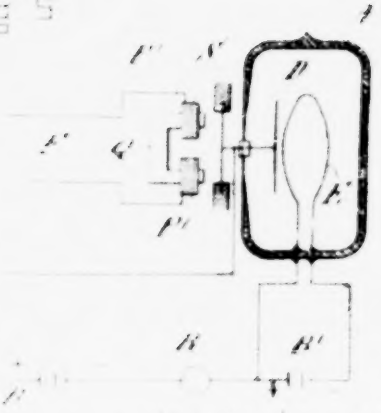

FIG. 7.

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LEE DE FOREST, OF NEW YORK, N. Y.

DEVICE FOR AMPLIFYING FEEBLE ELECTRICAL CURRENTS.

No. 841,387. Specification of Letters Patent. Patented Jan. 15, 1907.

Application filed October 25, 1906. Serial No. 340,487.

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented a new and useful Improvement in Devices for Amplifying Feeble Electrical Currents, of which the following is a specification.

My invention relates to devices for amplifying feeble electrical currents—such, for example, as telephone-currents; and its object is to produce an amplifying device of greater efficiency and simplicity than those heretofore employed.

My invention will be described with reference to the drawings accompanying and forming a part of this specification, and in which—

Figures 1, 2, 3, 4, 5, 6, and 7 represent conventionally or diagrammatically various arrangements of apparatus and circuits whereby my invention may be carried into effect.

In the figures, A represents an evacuated vessel inclosing a sensitive conducting gaseous medium maintained in a condition of molecular activity.

R is a signal-indicating device.

B B are batteries or other sources of electrical energy.

D E D′ are electrodes sealed within the receptacle A.

The circuit B R D E is a local receiving-circuit. The circuit F is a line-circuit conveying the currents to be amplified to the amplifying device. The electrode E, which may be of platinum, tantalum, carbon, or other suitable material, is heated and preferably maintained incandescent by the battery B′. The electrodes D and D′, which may be plates of platinum or other suitable material, are placed in close proximity to the electrode E, and when the electrode D′ is employed its separation from the electrode E preferably is less than that of the electrode D therefrom.

In Fig. 1, N S represent a magnet placed adjacent to the vessel A. The currents to be amplified may be impressed upon the circuit which includes the heated electrode or filament E—as, for example, by means of the transformer M—and the magnetic field set up by these currents reacts upon the field set up by the magnet N S, thereby causing a slight variation in the separation between the electrodes D E. I have found that the slightest variation in the separation of the hot and cold electrodes produces a large and disproportionately greater variation in the flux between said electrodes, especially if the latter are close together, and such variation in flux may be made manifest by the signal-indicating device R.

In Fig. 2 the current to be amplified may be impressed upon the medium intervening between the electrodes D and E, and thereby alter, by electrostatic attraction, the separation between the electrodes. In this case D′ may be a strip of platinum-foil, and the slightest approach thereof toward the filament will act to slightly cool the gaseous medium, and thereby alter the current in the local circuit, or, if D′ is rigid, the increase in electrostatic attraction between D′ and E will cause E to recede from D, and thereby alter the current in the local circuit.

In Fig. 3 the filament E is connected, by means of a minute platinum wire I, to the arm J which is secured to the coil *a*, placed between the poles of the magnet H and secured to the walls of the vessel A through the spiral springs *b b*. The line-current to be amplified in this case is passed through the coil *a* through the springs *b b*, and the resulting rotation of the coil varies the separation between the electrodes D E, thereby altering the current in the local circuit.

In Fig. 4 the currents to be amplified may be impressed upon the gaseous medium intervening between D′ and E by means of the transformer M′. A condenser C may be included in series with the secondary of said transformer and the electrodes D′ E. In this case there may or may not be a variation between the separation of the electrodes, and the currents to be amplified may vary the motions of the ions around the filament, thereby controlling to a greater degree the flux between said filament and the electrode D.

In Fig. 5 the currents to be amplified may be passed through the solenoid surrounding the magnet N S, and thereby vary the field, which by coacting with the magnetic field surrounding the electrode E determines the normal separation of the electrodes D and E. Even without creating actual movements between the electrodes D and E the varying magnetic flux produced by the line-current passing through the solenoid L will affect the motion of the ions in the gaseous medium, and thereby alter the current in the local circuit.

In Fig. 6 the electrode D may be consti-

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tuted of iron or may consist of platinum plates provided with small iron armatures G G. In either case the currents to be amplified by passing through the solenoids P P, which surround the poles of the magnet N, effect the desired variation in the separation of the electrodes D and E.

In Fig. 7 the electrode D and diaphragm S may both be rigidly secured to the inside and outside, respectively, of the glass wall of the vessel A at a point where said wall has been flattened and made very thin, like the crystal of a watch. The currents to be amplified in this case by operating upon the coils P' P', surrounding the magnet Q, effect slight movements of the diaphragm S, and these movements are mechanically transmitted through the glass wall of the vessel A to the electrode D, thereby varying the current in the local receiving-circuit.

It will be obvious that the amplifying device which constitutes the subject-matter of the present invention is not limited in its use to any particular kind of electrical circuit or apparatus, but that it is capable of general application wherever an amplifying device is required. By way of example of its application to a wire telegraph or cable system I have shown the line F in Fig. 1 as including a telegraph transmitting-key T and source of vibratory current G. In Fig. 2 I have shown the line F as constituting the local circuit of a wireless telegraph receiving system including the battery B and oscillation detector D, the latter being connected in series with an antenna V and the earth E. In Fig. 4 I have shown the line F as constituting a telephone circuit including the microphone-transmitter T and battery B. In all instances it will be understood by those skilled in the art and without going into further detail that the signal-indicating device R, which is included in the local receiving-circuit, may be any device suitable for the purpose of reproducing the signal initiated in the line F.

I do not limit myself to any of the specific embodiments of my invention herein described, inasmuch as many modifications may readily occur to those skilled in the art without departing from the principle of my invention.

I claim—

1. In a device for amplifying electrical currents, an evacuated vessel, two electrodes sealed within said vessel, means for heating one of said electrodes, a local receiving-circuit associated with said electrodes, and means whereby the separation of said electrodes may be varied by the currents to be amplified.

2. In a device for amplifying electrical currents, an evacuated vessel, two electrodes sealed within said vessel, means for heating one of said electrodes, a local receiving-circuit associated with said electrodes, and means whereby the separation of said electrodes may be varied by the currents to be amplified.

3. In a device for amplifying electrical currents, an evacuated vessel, two electrodes sealed within said vessel, a circuit including a source of electric energy connected in series with one of said electrodes, a local receiving-circuit associated with said electrodes, and means whereby the separation of said electrodes may be varied by the currents to be amplified.

4. In a device for amplifying electrical currents, an evacuated vessel, three electrodes sealed within said vessel, means for heating one of said electrodes, a local receiving-circuit including two of said electrodes, and means for passing the current to be amplified between one of the electrodes which is included in the receiving-circuit and [illegible] electrode.

5. In a device for amplifying electrical currents, an evacuated vessel inclosing a gaseous medium, means other than the received energy for maintaining said gaseous medium in a condition of molecular activity, means for impressing the currents to be amplified upon said gaseous medium, and a local receiving-circuit having its electrodes sealed within said vessel.

6. In a device for amplifying electrical currents, an evacuated vessel, a heated electrode and two non-heated electrodes sealed within said vessel, the non-heated electrodes being unequally spaced with respect to said heated electrode, a local receiving-circuit including said heated electrode and that one of the non-heated electrodes which has the greater separation from the heated electrode, and means for varying the current to be amplified between the heated electrode and the other non-heated electrode.

In testimony whereof I have hereunto subscribed my name this [illegible] day of [illegible], 1906.

[illegible]

Witnesses:
[illegible]

Claimant's Exhibit No. 273

MARCONI PATENT
NO. 627,650
DEFT. EXHIBIT B-6

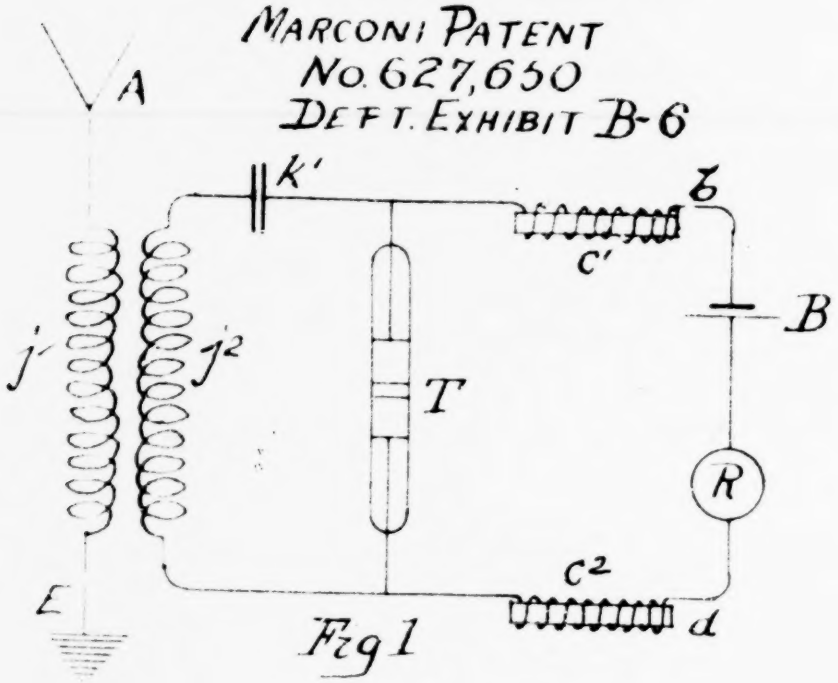


Fig 1

MILLER DRAWING L
TWO ELECTRODE TUBE
IN PN CIRCUIT

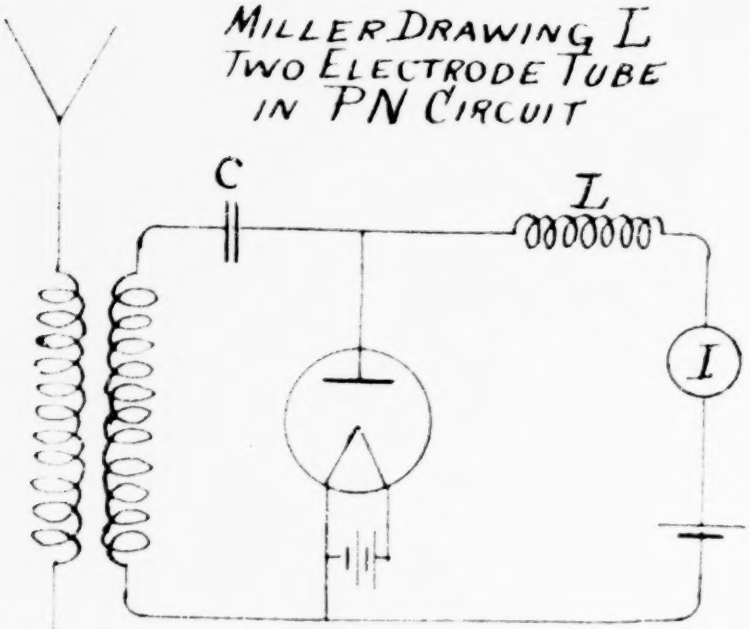
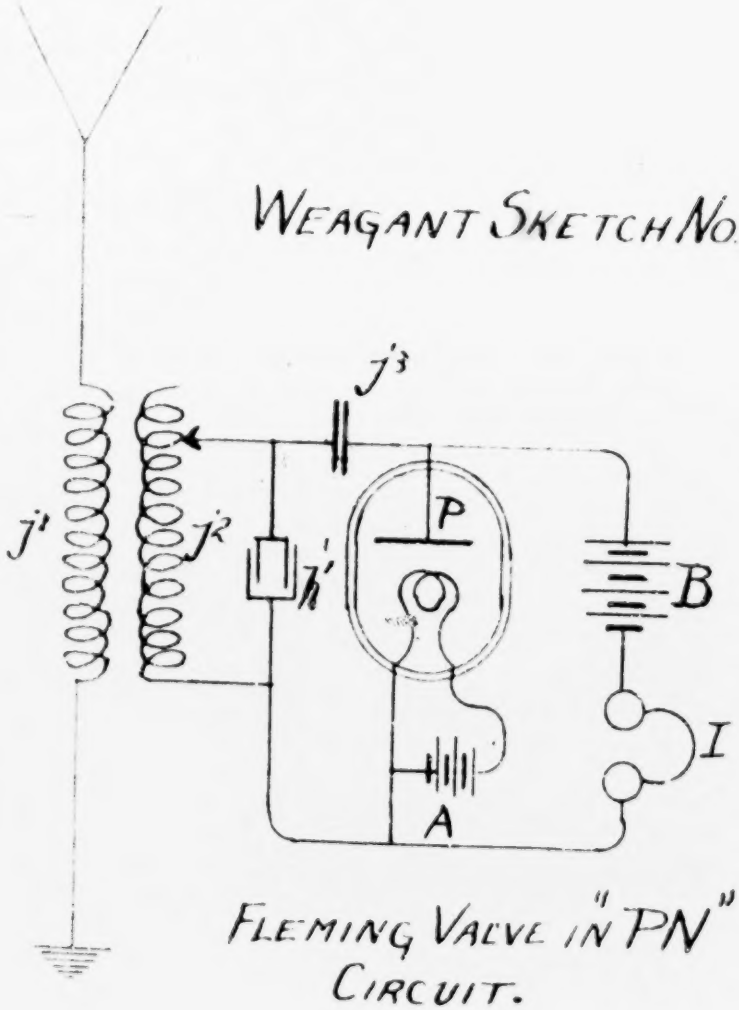


Fig 3

WEAGANT SKETCH NO 5.

Claimant's Exhibit No. 274



FLEMING VALVE IN "PN" CIRCUIT.

PLAINTIFF'S EXHIBIT 275

metal-copper pyrites, metal-chalcocite, metal-manganese dioxide, metal-tellurium. He proved that:

1. These detectors are sensitive only if the contact is limited to a point.

2. They operate without a battery in series, and when a battery is used the sensitiveness does not depend upon the value or direction of its e.m.f.

3. The direction of the current (direct) obtained under the influence of the received oscillations is always the same as the direction of the thermo-e.m.f.

With another group, however—carborundum, anatase (titanium dioxide), molybdenite and the perikon detector—TISSOT's tests established that:

1. The form of the contact is of little or no importance, even relatively large polished plates placed between two metallic electrodes make sensitive detectors.

2. The use of a battery in series with the detector, with proper value and direction of the battery e.m.f., increases the sensitiveness.

3. The sensitiveness of these detectors bears no relation whatever to the value of their thermo-e.m.f.

He, therefore, concludes that in this last mentioned group thermo-electric forces play no important part in their action as detectors.

G. W. PIERCE,[1] as the result of extensive investigations, including oscillograph records made with the BRAUN tube, concluded that with carborundum, anatase, brookite (another form of TiO_2) and silicon, thermoelectric forces were not involved, but that these detectors were better conductors in one direction than in the other, in short, act as *rectifiers* [Art. 162].

161. Incandescent Lamp Detectors, Gas Detectors.—*a.* J. A. FLEMING[264] observed the following phenomenon: An electrode (A, Fig. 340), say of cylindrical form, is fused into an incandescent lamp bulb, whose filament is made incandescent by means of a battery, B.* A circuit containing a galvanometer, G, (or telephone) and a coil, S_2, is joined to the electrode, A, at one end and to the lamp filament, at the other, K. The aerial coil S_1 is coupled with S_2; hence if oscillations pass through S_1, the oscillations induced in the circuit AGS_2K will cause the galvanometer to deflect (or produce a sound in the telephone). The galvanometer needle will return to its zero position as soon as the oscillations cease, *i.e.*, the arrangement is a self-restoring wave indicator.

Several years ago C. TISSOT[265] used this wave indicator for measurements over considerably long ranges but he complains of the irregularity

* A choke coil [Art. 163] should be inserted in the leads from the battery to the lamp.

Claimant's Exhibit No. 275 3161

of the deflections.* But in the more recent form of FLEMING's "oscillation-valve," the anode being a cylinder of carbon and the cathode a tungsten wire, this detector seems to have met all reasonable requirements as to sensitiveness and reliability. This is borne out by the fact that MARCONI has been using it, in conjunction with an EINTHOVEN string galvanometer, in his transatlantic stations.

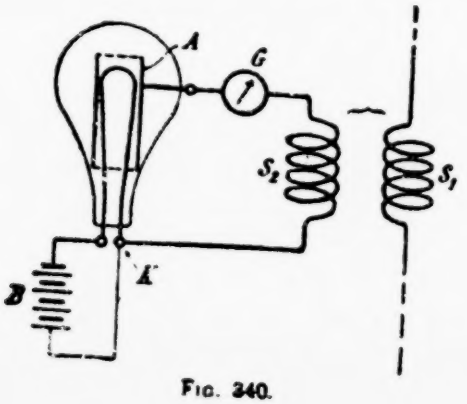


FIG. 340.

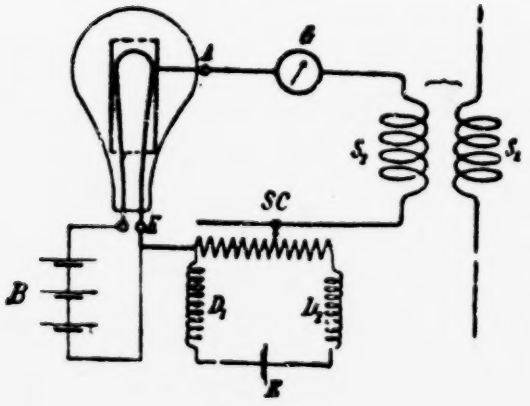


FIG. 341.

The incandescent lamp may be replaced by the tube devised by A. WEHNELT[266] which operates in the same manner. The incandescent cathode of this tube is a wire coated with a metallic oxide, and the anode is a hollow aluminium cylinder, concentric with the cathode.

b. H. BRANDES[267] has found that it is very advantageous to insert an auxiliary battery or cell, *E*, about as shown in Fig. 341,† when using

* TISSOT[265] describes a wave indicator using rarified air (as in the ZEHNDER tube), which he found to be less sensitive but better adapted for measuring purposes.

† D_1 and D_2 are inductive coils.

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[fol. 2745] PLAINTIFF'S EXHIBIT 276

Chapter III

Valve Detectors and Detector Relays

In the previous Chapter it has been pointed out that the plate current curve of a hard valve is of such a shape that the valve has got rectifying properties. When functioning as a detector at the lower bend of the curve the grid potential in the general case is negative compared with the filament and the grid current is zero; the grid circuit has infinite resistance and hence the valve abstracts no energy from the oscillating circuit to which it is connected, the necessary pulses of telephone current coming from the plate circuit battery. *Thus a valve employed in this way as a detector has very little damping effect on the oscillating circuit*, therefore tuning will be sharp, and loose coupling to the aerial circuit can be employed so that jamming by interference is reduced.

The damping effects of the valve are not entirely zero, for there is a small capacity effect between the grid and the other electrodes which allows some oscillating energy to pass; on account of this the valve may not be as good a detector as a good crystal on short waves at high frequencies.

Before discussing further the methods of using a hard valve for rectification it may be interesting to briefly consider some of the earlier types of valves which were used on wireless receiver circuits.

Fleming Valve.—The first valve detector was patented by Dr. J. A. Fleming in 1904; it had no grid, and simply made use of the unilateral conductivity effect between a heated filament and a plate enclosed together in a vacuum. At that time it was considered so reliable and robust compared to crystal detectors that it was largely adopted on wireless installations by the Marconi Company.

The detector consisted of a small electric lamp with a single hairpin filament of tungsten or carbon, surrounded by a cylinder of sheet or gauze copper, or nickel, which was attached to a third terminal on the lamp.

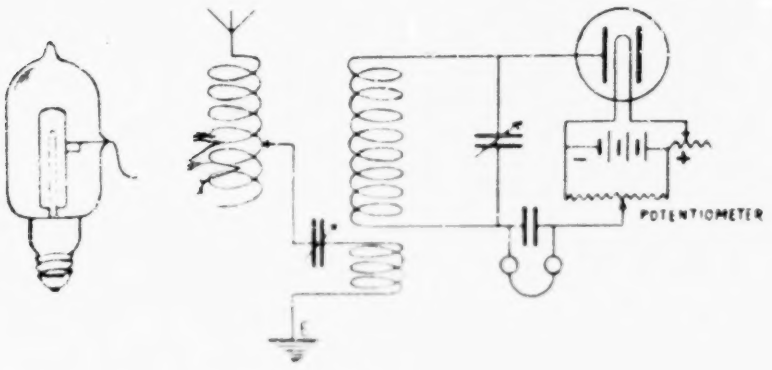
[fol. 2746] The filament was heated to incandescence by means of a battery, of from 4 to 12 volts depending on the size of the valve, in series with a regulating resistance. The

negative side of the filament was connected in series with a potentiometer voltage and telephone receivers to one side of the wireless receiver circuit, the copper plate or anode to the other side of the circuit.

The valve had a soft vacuum and was what we would now call a "gas valve"; its sensitiveness to signals was not so good as that of a good crystal combination, but the sensitiveness was not impaired by strong signals and atmospherics.

Fig. 12 shows a Fleming Valve as supplied by the Marconi Company: also its connections to a receiving circuit.

Fleming was the first to use the unilteral conductivity



effects of an electron discharge, from a heated filament to a plate at a higher potential than the filament, so that his patent may be considered as the parent one of all valves used in wireless receiver circuits.

Lieben Reisz Valve. The use of a grid between the plate and filament seems to have been first applied commercially by Lieben and Reisz in their valve relay, which was used by them for relaying low frequency, or telephonic, current pulses. It is described in Chapter VI, dealing with Low Frequency Amplification.

"Audion" Valve.—Dr. De Forest introduced a grid consisting of a perforated cylinder, or plate, between the filament and anode of what was virtually a Fleming valve, thus producing a relaying valve which he called an {fol. 2747} "Audion." In De Forest's circuit, which is shown in Fig. 13, the valve is used as a detector relay; the small pulses of potential set up in the receiver circuit act on the grid and cause corresponding pulses of plate circuit

current; these are also rectified by employing the valve at the proper point on its characteristic curve.

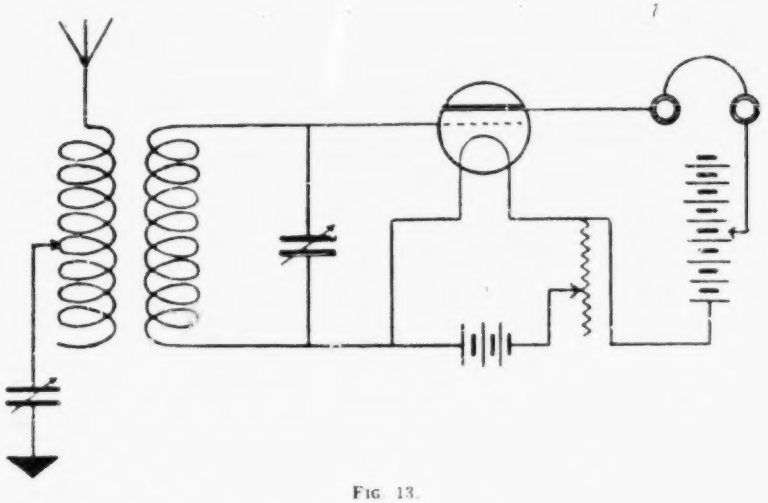


FIG. 13.

Round's Valve.—The soft vacuum Round valve was much superior to any which had preceded it, and was of such a size that comparatively large current pulses were dealt with in the plate filament circuit. It had a hairpin platinum filament coated with a mixture of barium and calcium oxides; completely surrounding the filament was a thimble of fine mesh nickel wire which formed the grid, while a nickel cylinder surrounded this again to form the plate. Like all soft valves it was very sensitive to grid potential, which was regulated by a potentiometer in series with the grid; it was also very sensitive to the degree of vacuum, in other words its sensitiveness depended greatly on the ionisation effects, as has been described in the previous Chapter.

In order to counteract the tendency of the valve to harden with continued use a pellet of asbestos was enclosed in a small neck at the top of the valve; heating this by a match would drive from it gas molecules into the body of the valve, and thus the vacuum could be brought to the proper degree of softness. The necessity of thus regulating the vacuum was a disadvantage, also the facts that when started up the valve did not come into proper

PLAINTIFF'S EXHIBIT 282

BRITISH PATENT

~~No. 22,256. A.D. 1896.~~

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~~*Improvements in Means of Telegraphing or Telephoning without Wires.*~~

~~sound signal when the Apparatus is used for Telegraphing, instead of Telephoning as described in the first portion of this Specification.~~

~~Dated this 14th day of September 1896.~~

~~A. C. BROWN.~~
~~GEO. R. NEILSON.~~

5

COMPLETE SPECIFICATION.

Improvements in Means of Telegraphing or Telephoning without Wires.

ALFRED CHARLES BROWN, Electrician, and GEORGE RICHARD NEILSON, Secretary to Public Company, both of 50 Old Broad Street in the County of London do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

It has been known for some time past that waves of Electric energy of certain periodicities or numbers of vibrations per second, known usually as Hertzian waves, are capable of being radiated or projected so as to act on other Electric circuits placed at a distance, and produce certain effects therein, such as sparking between disconnected conductors, and the alteration in resistance of loose contacts or "Coherers" *etc.* It has been known too that these effects are manifested through considerable distances in space and through various media which are in some cases opaque to ordinary light.

The purpose of the present invention is to render the above-mentioned phenomena more practicably applicable to certain purposes of signalling, and for Telephoning without wires.

For this purpose when a signalling Telegraph only is required we provide at, or in connection with, the Transmitting Station a set of Apparatus for producing the rays, such as a current generator and induction coil, or a high tension Electric Machine, and a Hertzian Oscillator or Radiator, that is a pair of Electrodes, having an inductive action on one another, and designed to suddenly equilibriate opposite electric charges, impressed on them by an outside source (the induction coil or electric machine) by violent electric surgings preferably across a spark gap, or number of gaps thereby radiating energy into space. Any existing form of such Oscillator or Radiator may be used for the present purpose, as the three ball variety, consisting of one large central and two smaller charging balls, one on each side, but we prefer to use a modification of the form, designed by Professor Righi, wherein the spark is taken between a pair of balls, or electrodes, immersed in an insulating liquid, such as oil. In place of using balls for the Electrodes, however, we prefer to use more elongated rods with convex rounded, or half ball ends, as we find that the radiation from these is stronger than from balls & this form of electrode is useful whether immersed in liquid or not. We prefer however to incline these rods upwards or else to curve them upwards somewhat crescent-shaped, so that they may stand on insulating supports in a vessel of the insulating liquid, and their outer ends (that is those most distant from the pair of ends which oppose one another) project up out of the liquid, so that the charging sparks from the machine, or induction coil may more conveniently be impressed upon them. Our improved Radiator, constructed on this principle, is shewn in Fig. 1, wherein A A

are the elongated Electrodes, (the dotted lines indicating the optional straight form) B the vessel made of insulating material and containing the oil or other insulating liquid and C C the two small charging balls or Electrodes connected to the poles of the machine or induction coil secondary. It will be seen that this construction gives great facility for adjusting the spark gaps and is simple and the vessel not requiring any special shaping is not liable to leak and so release the liquid.

Similar letters are used to indicate all similar parts throughout the drawings.

We prefer to enclose the Radiator bodily in a metallic box, closed on all sides, but having an opening in front, the back of the box being preferably mirror-shaped or carrying a separate metallic mirror, and the front hole being either left open or preferably closed with a plate or lens of ebonite, pitch, or other suitable material to assist in rendering the rays approximately parallel, or of concentrating them into a beam.

To further render the beam parallel and cut off more of the diverging rays, so as to prevent them from operating other receivers out of their direct line, we may surround the front hole with a metallic pipe or tube, extending forward for any desired distance, and preferably having its front end closed with an insulating plate, or another lens, and having optionally other lenses in the course of its length. Fig. 2 is a side view of the exterior of the entire projector, shewing the focussing tube at E. The receiving instrument may also be enclosed in a similar box with tube.

The wires of the generating circuit or Oscillator may pass through suitably insulated holes in the back or other part of the metallic screen or projector box. The projector we place in such position as to project or concentrate as much as possible the beam or bundle of rays on to the Receiving Station. Or the Radiator may, in some cases, be used alone without any metallic projector-box and its outer charging knobs may be connected through condensers or otherwise to pipe systems or to earth, or one connected directly to earth and the other to an insulated surface, preferably elevated in the atmosphere. Or, and preferably, another separate pair of balls or knobs may be placed near the ends of the Electrodes A A as shewn at F F in Fig. 7, and these, instead of the charging knobs themselves, be connected via condensers or otherwise to pipe systems, to earth, or one directly to earth and the other to the elevated insulated surface. The second pair of balls are then preferably placed at such distance that they are not sparked into, together with each charging spark, passing from the charging knobs into the Electrodes A A, but a spark is precipitated into them by the more violent disruption occuring every time a spark passes across beween the Electrodes A A. This method has a great advantage in reducing leakage, but they may also be placed closer if preferred and charged together with the main electrodes.

In the battery, current generator, or primary circuit (where an induction coil is used) at the Transmitting Station we place a Morse or other Key convenient for signalling, so as to produce the waves intermittently in the form of dots and dashes. Or we may cause the signalling key, by means of a light long range arm or similar discharger, to open and close a short circuit across the secondary circuit of the induction coil, or of the poles or Electrodes of the high tension machine where such is employed for producing the charge, or to make and break the direct high tension circuit itself. A suitable construction for the key when used in this way is shewn in Fig. 3, wherein K is the Key, and L L Knobs communicating with the high tension electrodes. Or the key may operate a metallic screen, capable of covering part or all of the opening in front of the poles of the Oscillator, thereby alternately shielding and exposing the beam or pencil of rays from or on to the distant station, as shewn in Fig. 4, wherein M is the Key or operating handle, and N the screen.

At the Receiving Station for detecting the radiant energy we then provide a second oscillating circuit connecting inductive surfaces, or a road along which electric surgings can take place, or a metallic loop, open or closed, and in either case preferably syntonised as nearly as possible to the generating oscillating

circuit or radiator, and having in its path a "Lodge" Coherer, or set of loose contacts, or other light loose contact, through which a battery current is tending, the path of said battery current continuing on, either directly through the electric signalling instruments desired to be worked, or else through a relay or other similar instrument, capable of operating a local circuit in response to variations of resistance in the Coherer or set of loose contacts, produced by the varying impact of the Hertzian or Electric waves. A vibrator, operated mechanically or electrically, is also applied to the Coherer to continually restore its normal equilibrium or resistance after the latter has been changed by the impact of Electric waves.

We do not limit ourselves to any particular form of light contact for the Coherer but we prefer to employ a tube, made of glass, ebonite or other insulating material, shewn in Fig. 5 at O O, with stout conducting Electrodes, P P, sealed or otherwise fixed in, which Electrodes may terminate inside as either stout rods or tubes (shewn in the latter form at R R) extending near together, the remaining space in the tube being loosely filled with the conducting granules, or cohering contacts S and the air preferably exhausted to a very low tension, say through a small tubulure as T, the tube being then hermetically sealed.

The outwardly extending rods from the tube may have tubular conductors U U sliding on them and terminating in balls or other collecting or inductive surfaces. The object of the telescopic slides is to tune the receiver or adjust its rate to that of the Transmitting Oscillator when used for short distance work, or for longer distances the conductors may be connected to other extensions or circuit arrangements, or to pipe-systems, or to earth, or to insulated systems of collecting points placed at an adjustable distance apart, or one pole to such system and the other to earth, and for these connections, both from the Transmitting Radiator (or additional sparking knobs near same) and Receiving Coherer, we find broad strips far better than ordinary round wires, as possessing less self-induction and therefore offering far less impedance to the passage of the rapid electric surgings, or oscillating currents. The strips should be well insulated except when connected to earth.

Any metallic granules will answer, but we find the most effective consist of very fusible metals or alloys, the effect of cohering appearing to consist of a minute fusing together of the contact points or surfaces. For most signalling purposes, therefore, we prefer to use granules of soft solder, lead or tin, or alloys of lead and tin, with or without Bismuth or Cadmium or all together. For other purposes, however, we find Carbon granules very effective, especially when the Telephone is used as the receiving instrument as herein-after described.

V Fig. 5 shews the restoring vibrator consisting of an electro-magnet W and ordinary make and break contact X all enclosed in a tight metal box, Y, which may have extending tubes to enclose the battery wires. The armature pivot *x* extends through the box and carries the rod of a light tapper D, arranged to vibrate against the Coherer tube O. Or any other form of vibrator may be used and it may shake the Coherer in other ways without directly tapping it.

Another form of Receiver, which we sometimes use, is shewn at Fig. 6 and consists of the proper collectors and conductors E E formed of metallic strips or rods terminating in balls, or other suitable Electrodes, (the system being tunable for short distance working by bending the extremities more or less near together) or which strips or rods may be connected for longer distance working as above described with reference to the alternative granule tube, and the approaching ends being fixed to an insulating block G and bridged across by a very thin piece of wire H, preferably platinum or aluminium, bent tripod fashion, so as to rest lightly on three points, two being preferably on one Electrode and one on the other. The cohering contact surfaces and wire may also be covered by a suitably packed glass or other bell cover J, from which the air may be exhausted, as by a closable tube through the block G underneath, or otherwise. A vibrator V is also mounted preferably on the same base to restore the equilibrium. Fig. 7 is a diagram of connections of the complete set of Trans-

mitting and Receiving Apparatus, the electrical connections shewn in full lines being arranged for ordinary signalling and working, say, on a Morse Sounder or Printer. The connections shewn in dotted lines relate to another requirement to be described further on and should be ignored when considering plain Morse signalling only. In this figure the spirals lettered I represent the generating induction coil and *g* its make and break contact with preferably a condenser *h*. *a* represents the signalling Key at the Transmitting Station. A A, B and C C represent respectively the same parts as indicated by similar letters and described in reference to Fig. 1. F. F. are the pair of additional knobs for connecting respectively to elevated surfaces and to earth or to other arrangements as already described, and O O, P P, U U represent the receiving Coherer and V the vibrator as described in detail with reference to Fig. 5. *b* represents the relay and *c* the Morse Instrument, both of which may be of any ordinary form, and the latter either a Sounder or Printer. The shunt roads lettered *r* shewn across the Electro-magnets of the Morse Instrument and relay in Fig. 7 and of the Vibrator in Fig. 5 represent ordinary spark shunts or condensers which it is desirable to place across the Electro-magnets of all Instruments required in the vicinity of the receiving Coherer.

For certain purposes of signalling we also find it useful to produce the electric waves at the Transmitting Station in certain rated beats or series of impulses, so that, on the local circuit at the Receiving Station, being affected harmonically, in this rate, certain definite signals may be picked out and given from a series of possible signals operated by the same local circuit.

For this purpose we prefer to use the apparatus described in Patent Specification, No. 7773 of 1884, or other similar arrangements.

The Transmitting Pendulums or Reeds then take the place of or are used in conjunction with the Signalling Keys described above, at the Transmitting Station (operating as the Keys, but isochronously, to either open and close the electric circuit or to oscillate a screening shield) and the electro-magnetic Receiving Reeds or Pendulums being included in the local circuit at the Receiving Station, so as by their respective accumulation or interference to pick out and make the proper desired signals. A method of applying such synchronised vibrators, for both Transmitting and Receiving, is indicated by the dotted lines in Fig. 7, wherein on the transmitting side of the diagram *i* represents the transmitting pendulum or reed or its equivalent, the full line connection between the points *d* and *e* being now considered as broken, and the Key *a* being optional may be replaced by the direct connection *f*.

On the receiving side of the diagram *k k* represents in a typical form two of any number of the synchronised receiving pendulums or reeds (but of which any ordinary kind may be used) with their proper connections and *m* an electric bell or other signalling device arranged to be put into action locally by the synchronised vibrators.

As will be seen from the dotted connections the electro-magnetic coils of the synchronised vibrators now replace those of the Morse or other Telegraph Instrument which are now considered as absent, and a local current is applied to the bell or signal on the accumulation or effective operation of any of the synchronised vibrators, or the vibration of the latter alone (or of their equivalents) may also of course for some purposes suffice to make the signals.

This method of signalling is especially adapted and advantageous for Fire and Police Alarms and other Municipal Telegraphs, and is also useful for many other purposes.

For Telephoning we may place a Telephone Transmitter in the primary, or battery, or generator circuit at the Transmitting Station, either in place of or as a shunt for or in series with, the ordinary make and break *g* of the induction coil indicated at I Fig. 7, which make and break should then be rapid. Or (as shewn in Fig. 8) we may employ a moving shield *n* connected to a diaphragm and having a slit or slits to alternately expose more or less of the radiation emerging from a

similar slit or slits in a fixed metallic shield otherwise then completely, or nearly completely covering the front of the projector box *p*, containing the electrodes of the electric wave generating apparatus, so as to successively vary the intensity of the radiation in response and in proportion to sound waves thrown upon the diaphragm.

In both these cases it is desirable for the vibrating make and break in the primary circuit of the generating induction coil to be of high rate, and the transmitting oscillator circuit designed to give a considerable number of oscillations for each break, as, for instance, by connecting across by a loop of wire of some length the Electrodes A A of the transmitting radiator shewn in Fig. 1 or its equivalent, whereby it it less damped, although rendered less powerful, so that the received stream of energy shall be as continuous as possible, subject to the varying mechanism described above.

At the Receiving Station for reproducing or rendering the varying rays re-apparent as sound waves we may use any substance, or set of loose contacts, which will vary its, or their, electrical resistance, or resistances, in response to the impact of such radiation, (when properly collected and concentrated thereon, as herein-before described with reference to the Receiving arrangements for Telegraph Signalling) placed in the circuit of a Battery and suitable Telephone Receiver. This arrangement is shewn in Fig. 9 wherein *s* is the Coherer or tube containing loose contacts of the desired substance, and which Coherer may be constructed similarly to Fig. 5. This arrangement can also be used for receiving conventional signals, as produced by the operations of the Morse Key, depicted in Fig. 7 in the transmitting part of the apparatus. We find that a Telephone Receiver used in this way, in conjunction with a Coherer, having preferably but not necessarily, carbon granules, forms a very sensitive receiving set for detecting very weak radiant energy as when coming from a long distance *etc.*, because the Telephone is able to appreciate far more minute and temporary (but sudden) changes in the resistance of the Coherer than are required to vary a battery current sufficiently to operate any other telegraphic instrument. Used in this way also no restoring vibrator is required for the coherer, or at most only an arrangement to give a few momentary taps at long intervals, but this can be conveniently done by hand. Or instead of the Receiving Telephone being in direct circuit with the Coherer it may be connected across the secondary of an induction coil, whose primary is included in the battery and coherer circuit.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, We declare that what We claim is

1. A transmitting radiator of Electric energy, consisting of a pair of elongated rods, having their ends opposed to one another, and either inclined upwards at an angle, or else curved in a somewhat crescent shape, so that in either case the bulk of their surface, and especially their opposed ends, may be and are immersed in oil or other insulating liquids, contained in an electrically insulating vessel, while their opposite ends project out of said liquid conveniently for being charged by sparks sent across from knobs or Electrodes opposed thereto and connected to a source of high potential electricity, as and for the purposes above described.

2. A receiving Coherer, arranged as above described, advantageously for detecting electric radiation and consisting of a tube or vessel containing between or in contact with the Electrodes of the collecting conductors granules of very fusible metals or alloys as above enumerated and to accomplish the above-mentioned objects.

3. The use and employment for the purpose of confining a stream of electric radiation within narrow limits and so preventing it from operating other receivers not intended to be operated thereby, or for the purpose of picking out more closely and responding to the radiation coming from one better defined point only, a metallic tube extending out from the front and surrounding a hole in an otherwise

closed metallic box containing the radiation producing device or the radiation receiving device respectively, as and for the purposes above described.

4. Where an electro-magnetic vibrator is used to tap back or restore the normal equilibrium of resistance of a Coherer after its having been changed by electric radiation; the use and employment of a metallic box or case to cover in and enclose the said vibrator entirely with the exception of the projecting tapping hammer, or an axle on which this may be mounted, for the purpose of screening the radiation generated by the vibrator away from the receiving Coherer.

5. An electro-magnetic vibrator fulfilling the conditions mentioned in claim 3. above, and constructed as above described and illustrated in Fig. 5.

6. The use and employment in conjunction with an oscillator or radiator of electric energy of a second pair of knobs opposed to the main pair of Electrodes or surfaces, between which the oscillating currents or electric surgings are set up, and connected to pipe-systems, or earth, either with or without the interposition of condensers, or one to earth and the other to a radiating surface, preferably elevated in the atmosphere. Or the use of one separate knob, so connected, in conjunction with an earth connection or a connection to another of the above-mentioned systems, applied to the opposite charging knob.

7. The use and employment for the purpose of connecting the charging knobs or the surface of an Electric Radiator, or other knobs inductively opposed to them, to earth, or to other systems for increasing the radiation, of a conductor composed of a broad strip instead of a round wire, as heretofore used, as and for the purposes above described.

8. The combination with an induction coil or other high tension electric generator and an oscillator or radiator of electric energy, of Reeds or Pendulums for opening and closing the circuits of the induction coil or generator isochronously, or otherwise producing the rays intermittently, or of alternately exposing and shielding a beam of them, in an isochronous rate, for the purpose of actuating tuned or synchronous electro-magnetic Reeds or Pendulums, placed in the receiving circuit.

9. The combination with a Coherer, granule tube or loose contact system used for the purpose of detecting electric radiation of one or more synchronised electro-magnetic Reeds or Pendulums for the purpose of picking out a signal or one of a set of signals made by one transmitter without responding to others which may be acting simultaneously or successively, as and for the purposes above described.

10. The use and employment of a Telephonic Transmitter or Microphone in place of the ordinary make and break, or as a shunt for or in series with a rapidly vibrating make and break of the primary circuit of an induction coil used for producing Hertzian waves or high rate electric radiation capable of operating a receiver at a distance, as and for the purposes above described.

11. The means above described of varying the intensity of a very rapidly produced set, or nearly continuous stream of electric waves by means of a slotted screen covering and uncovering similar slots in a fixed screen in front of the electric projector, proportionately to sound waves thrown upon a diaphragm actuating such screen as and for the purposes above described.

12. The combination with a Coherer or set of loose contacts used for detecting electric radiation of a battery and telephone placed in the same circuit, whether the said telephone is used to re-produce speech or other sounds, or only conventional signals, as and for the purposes above described.

13. In a receiving set used for the purpose of reproducing signals or sounds from a varying stream of electric radiation, the combination of a Telephone, Induction coil, battery and Coherer, or set of loose contacts, the Telephone being connected to one coil, say the secondary, of the Induction coil and the other coil, say the primary, being connected in circuit with the Battery and Coherer or set of loose contacts.

14. Where a Telephone is used in conjunction with a Coherer or set of loose contacts and Battery as a receiving set for detecting and responding to variations of

electric radiation, the use and employment for the purpose of such Coherer or set of loose contacts of granules or subdivided particles composed of carbon.

15. The use and employment of a pointed conductor, or of a system of points projecting into the atmosphere and connecting to an apparatus for either transmitting or receiving electric waves.

Dated this 15th day of September, 1897.

(Signed)

A. C. BROWN.
GEO. R. NEILSON.

Redhill: Printed for Her Majesty's Stationery Office, by Malcomson & Co., Ltd.—1898.

A.D. 1896 Dec. 17. N° 28,953

BROWN & another's Complete Specification

[This Drawing is a reproduction of the original on one sheet.]

FIG 1

FIG 3

FIG 5

FIG 2

FIG 4

FIG 6

FIG 7

FIG 9

FIG 8

Malby & Sons, Photo-Litho

PLAINTIFF'S EXHIBIT 287

BRITISH PATENT

N° 13,518.—A.D. 1908.

Improvements in Instruments for Detecting Electric Oscillations.

other plate of this condenser with the sliding contact on the resistance across the glow lamp battery terminals. In this circuit I also include a telephone or current detecting instrument. A current then flows from the battery through the filament rendering it incandescent and also in virtue of the emission of negative electricity from the filament a current flows from it through the vacuous space to the metal cylinder and through the telephone or other current detector. The conductivity of this vacuous space or ionised rarefied gas is a function of the electromotive force acting to drive the current through it. I find that if the position of the sliding contact on the resistance across the terminals of the battery is so adjusted that corresponding thereto the conductivity curve of the ionised gas has a very sudden change in curvature, the superposition of an oscillatory potential difference between the filament and cylinder upon the steady potential difference causes very sudden changes in the current strength through the telephone and therefore an emission of sound.

The arrangement described is therefore a very sensitive detector of oscillations in the condenser circuit to which the glow lamp is attached and therefore can serve as an electric wave detector in inductive or radiotelegraphy, since the sound in the telephone or indication of the equivalent current detector can be controlled from the transmitting end and cut up into Morse or other signals as required, to transmit by electric waves or magneto electric induction intelligence to a distance.

Dated this 25th day of June, 1908.

J. A. FLEMING.

PROVISIONAL SPECIFICATION.

No. 26,832, A.D. 1908.

"Improvements in Instruments for Detecting Electric Oscillations."

I, JOHN AMBROSE FLEMING, of University College, Gower Street, in the County of London, Doctor of Science, do hereby declare the nature of this invention to be as follows:—

My invention has reference to that type of electrical oscillation detector described by me in a British Patent Specification No. 24,850, of November 16th 1904, entitled "Improvements in instruments for detecting and measuring alternating electric currents."

According to this invention I employ a carbon cylinder as the cold conductor in the vacuous bulb in place of the metallic cylinders heretofore employed.

Dated this 10th day of December 1908.

J. A. FLEMING.

COMPLETE SPECIFICATION.

"Improvements in Instruments for Detecting Electric Oscillations."

I, JOHN AMBROSE FLEMING, of University College, Gower Street, in the County of London, Doctor of Science, do hereby declare the nature of this

invention and in what manner the same is to be performed to be particularly described and ascertained in and by the following statement:—

My invention has reference to that type of electrical oscillation detector described by me in a British Patent Specification No. 24,850 of November 16th 1904, entitled "Improvements in instruments for detecting and measuring alternating electric currents."

In this specification I described an oscillation detector subsequently called an oscillation valve or glow lamp detector, which consists of an electric glow lamp of the ordinary type, but having within the glass bulb a metal plate or cylinder carried on an insulated terminal sealed through the glass. When the filament is rendered incandescent by an electric current, it emits negative ions or corpuscles or electrons and these ionise the residual gas in the bulb, and give to the space a unilateral conductivity by which negative electricity can pass from the hot filament to the cold insulated plate or cylinder within the bulb, but not in the opposite direction. I employed this device as an electric wave detector in radiotelegraphy by connecting the insulated plate or cylinder to one terminal of an oscillation transformer inserted in the receiving circuit of the radiotelegraphic apparatus, and the other terminal of this oscillation transformer was connected through a galvanometer or telephone to the negative terminal of the filament.

I have discovered after many experiments that tungsten in various forms and particularly in a form in which it is employed as the filament in a glow lamp is highly efficient for this purpose, since the amount of negative electricity emitted at the highest possible working temperature may be from 10 to 20 times as great as that emitted by carbon in an ordinary carbon filament. I am unable to explain the reason of this superiority; it is not merely that a tungsten filament can be raised to a higher temperature than a carbon filament, for metals such as tantalum which are closely analogous to tungsten and which can be raised to an equally high temperature are not much superior to carbon at any temperature at which they can be worked in practice.

I find that a cylinder of carbon acts better as the cold conductor in the bulb than a metallic cylinder.

I construct such a metallic or semi-metallic filament glow lamp with a tubular glass bulb and a cylinder of carbon sealed into the bulb, surrounding but not touching the filament, and connected to a platinum wire sealed through the glass. Furthermore, I employ this glow lamp as an oscillation detector as follows:—The filament is rendered incandescent by an insulated battery having in series with it a rheostat or variable resistance for controlling the current. Across the terminals of this battery I place another high resistance having a sliding contact in it, so as to make contact with any desired point on this resistance. In using this detector in wireless telegraphy the receiving circuit must comprise a closed circuit having inductance and containing a condenser. If the telegraphy is conducted by electric waves it is necessary also to connect an antenna either directly or indirectly with this condenser circuit. I then connect the insulated cylinder included within the bulb of the lamp with one plate of the condenser in the oscillation circuit, and I connect the other plate of this condenser with the sliding contact on the resistance across the glow lamp battery terminals. In this circuit I also include a telephone or current detecting instrument. A current then flows from the battery through the filament rendering it incandescent, and also in virtue of the emission of negative electricity from the filament a current flows from it through the vacuous space to the metal cylinder and through the telephone or other current detector. The conductivity of this vacuous space or ionised rarefied gas is a function of the electromotive force acting to drive the current through it. I find that if the position of the sliding contact on the resistance across the terminals of the battery is so adjusted that corresponding thereto the conductivity curve of

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the ionised gas has a very sudden change in curvature, the superposition of an oscillatory potential difference between the filament and cylinder upon the steady potential difference causes very sudden changes in the current strength through the telephone and therefore an emission of sound provided that the steady potential difference is of the necessary critical value.

The arrangement described is therefore a very sensitive detector of oscillations in the condenser circuit to which the glow lamp is attached and therefore can serve as an electric wave detector in inductive or radiotelegraphy, since the sound in the telephone or indication of the equivalent current detector can be controlled from the transmitting end and cut up into Morse or other signals as required, to transmit by electric waves or magneto electric induction intelligence to a distance.

In carrying my invention into effect, I employ a tubular form of glass bulb *a* which may be an inch or more in diameter and 5 or 6 inches in length. In this I insert a cylinder *b* of carbon which is sprung into the glass tube so as to fit the walls tightly. This cylinder has a platinum wire *c* twisted or welded to it which is sealed through the glass, so as to make an external electrical connection. The bulb *a* should have a good vacuum such as is usually employed with lamps having metallic filaments.

The metallic filament *d* is formed of tungsten in the form used as a filament in ordinary glow lamps and is connected to conductors *e* carried on a glass tubular stem *f* sealed into the bulb. The filament *d* should be of such a length that it is entirely covered by the metal cylinder *b*.

It is convenient to have the filament of such length and thickness that the voltage required to bring it to incandescence at which its duration may not be less than several hundred hours, is of the order of 18 volts or so.

In applying this glow lamp as a detector in radiotelegraphy I arrange it as follows:—

A battery *g* of secondary cells is provided which may conveniently be a dozen or more cells, and wires *h* are brought from the terminals of this battery to the terminals *e* of the filament of the lamp, a variable resistance *j k* being inserted in the circuit. It is convenient to divide this resistance into two, one namely *j* of from say 0 to 120 ohms being for coarse adjustment and the other *k* of from say 0 to 5 ohms being for fine adjustment. By means of these resistances the current of the lamp may be adjusted to have any required value. A voltmeter *l* should also be placed across the terminals of the filament to regulate the voltage. In addition I place across the terminals of the battery *g* a high resistance *m* of the potentiometer type, that is to say, a resistance which may be two or three hundred ohms or more, the terminals of which are connected to the terminals *h* of the battery. A double high resistance telephone *n* (the resistance of each telephone being at least five or six hundred ohms) has one terminal connected to a slider *o* which can make contact with any required point on the resistance *m* and the other terminal connected to one plate of a condenser *p*. The other plate of the condenser *p* is connected with the metal cylinder or the lamp. The condenser *p* is inserted in a circuit possessing inductance, which is directly or inductively connected with a receiving antenna. As shown the circuit connecting the two plates of the condenser *p* contains an adjustable inductance *q* and the secondary of the jigger *r* the primary of which is in the aerial *s*. When electric waves fall upon the receiving antenna they excite oscillations in the condenser circuit and oscillations are thus imposed upon the telephone circuit connecting the metal cylinder or plate in the lamp with the sliding contact and high resistance connected across the terminals of the battery or other source of continuous electric current.

In operating the arrangement, the first step is to bring the filament to a high incandescence at which it would be working approximately at one watt per candle and at which it will have such a temperature, approximately 2800° C.

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that it will diffuse into the vacuous space negative ions discharged from the incandescent filament.

The filament having been rendered incandescent to this temperature, the observer applies the telephone to his ear and if electric wave trains are falling upon the receiving antenna *s*, it will be found that on moving the slider *o* along the potentiometer resistance *m* from one end to the other, there is a certain point at which sounds will be heard in the telephone better than at any other point. The exact position of the slider *o* must be determined by trial for it varies with every valve owing to slight differences in the vacuum and temperature of the filament. The detector above described is suitable as the receiver in radiotelephony, as well as for signals on the Morse or other alphabetic code.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. An oscillation valve in which the hot conductor is a filament of tungsten substantially as described.

2. An oscillation valve in which the hot conductor is a filament of tungsten and the cold conductor is a cylinder of carbon substantially as described.

3. The combination of an oscillation valve, a source of electricity heating the filament of the valve, a resistance across the terminals of the source, a circuit connected at one end to the cold conductor of the valve and at the other to an adjustable point of the resistance, and means for producing oscillations and detecting electric current in the circuit substantially as described.

4. Instruments for detecting electric oscillations substantially as described and illustrated in the drawing.

Dated this 10th day of December 1908.

J. A. FLEMING.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1909.

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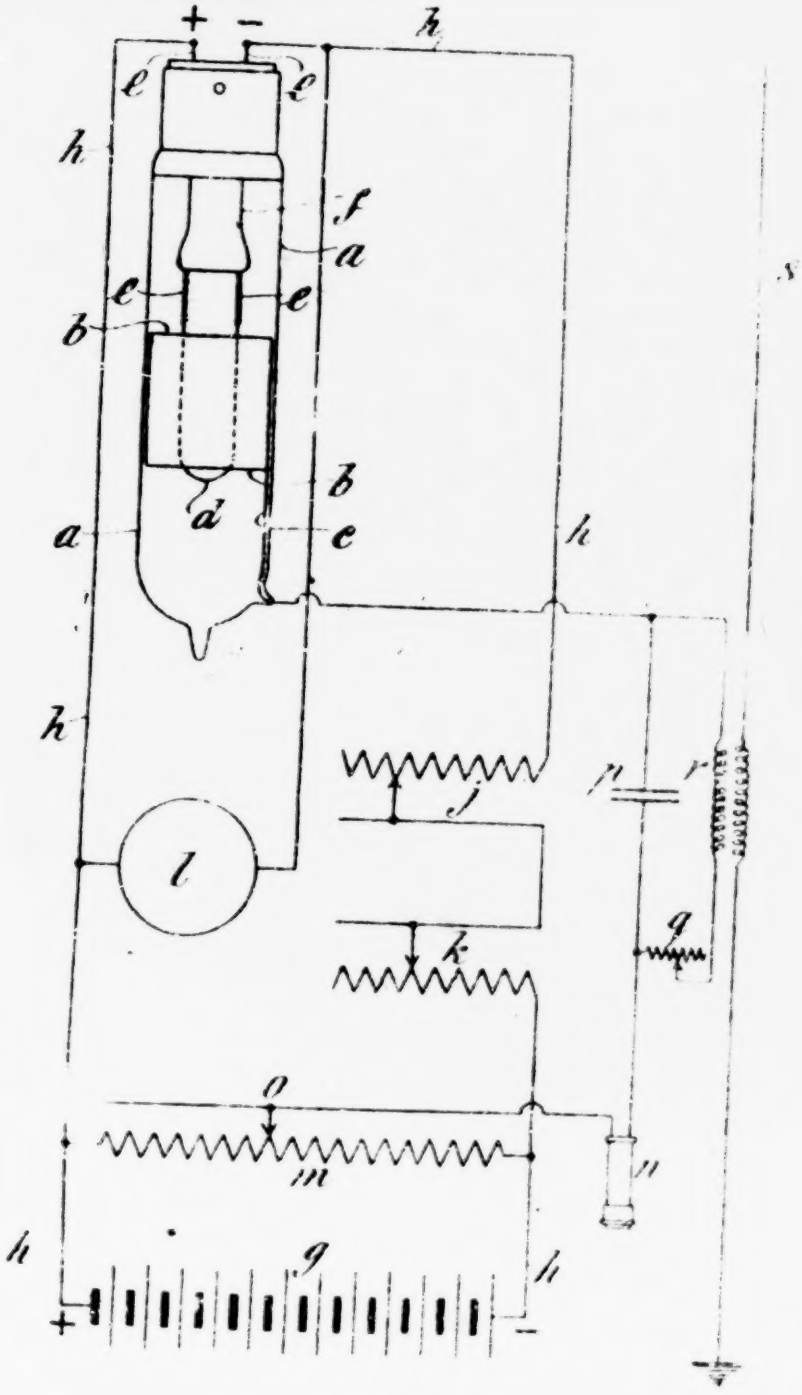
Claimant's Exhibit No. 287

A.D. 1908. JUNE 25. N° 13,518.

FLEMING'S COMPLETE SPECIFICATION. (1 SHEET)

(2nd Edition)



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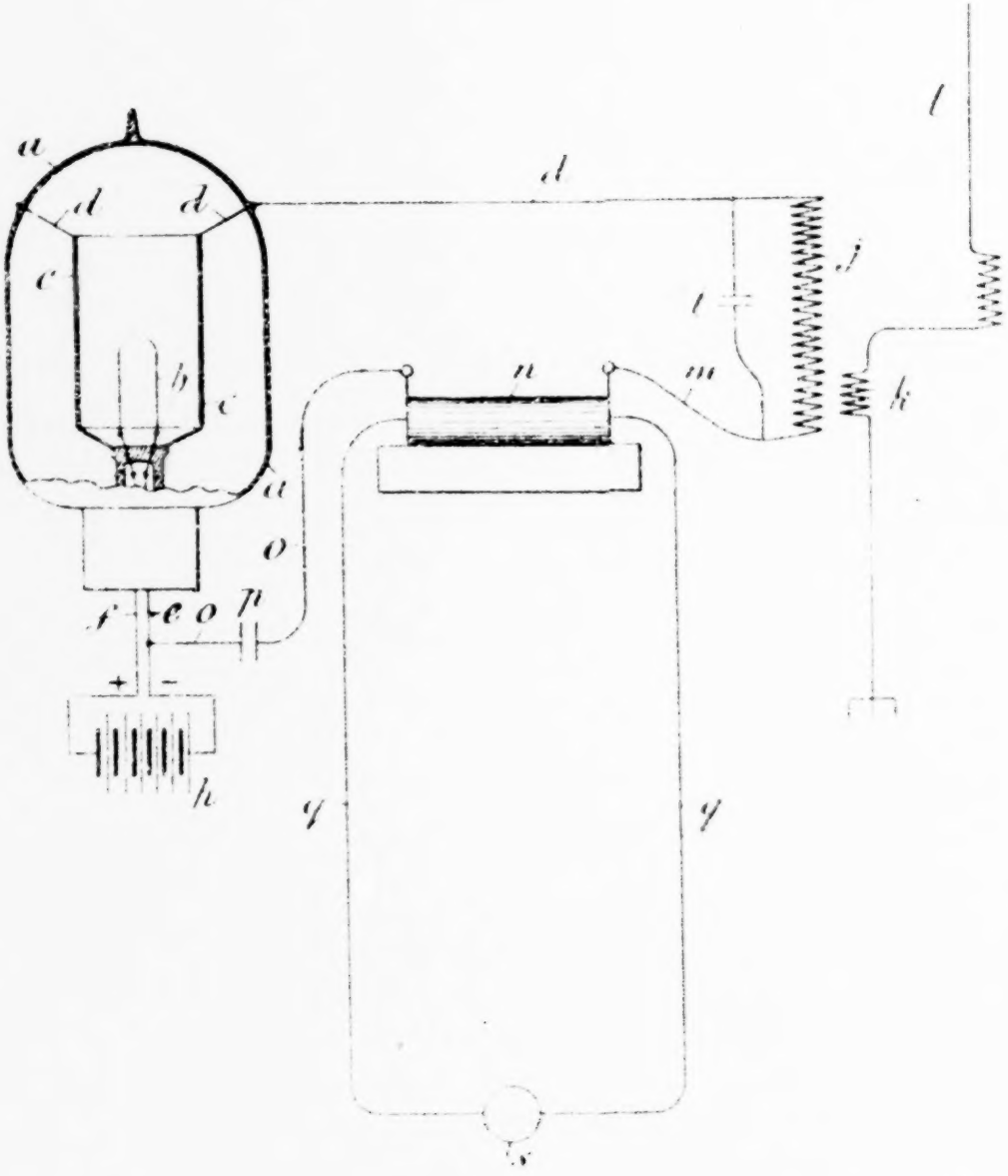
PLAINTIFF'S EXHIBIT 289

No. 896,130. PATENTED AUG. 18, 1908.

G. MARCONI.

RECEIVER FOR WIRELESS TELEGRAPHY

APPLICATION FILED MAR 13, 1907.



Witnesses
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Wm. Tatham

Inventor
Guglielmo Marconi
By Samuel R. Betts
his Attorney

UNITED STATES PATENT OFFICE.

GUGLIELMO MARCONI, OF LONDON, ENGLAND, ASSIGNOR TO MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA, OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.

RECEIVER FOR WIRELESS TELEGRAPHY.

No. 896,130. Specification of Letters Patent. Patented Aug. 18, 1908.

Application filed March 13, 1907. Serial No. 362,121.

To all whom it may concern:

Be it known that I, GUGLIELMO MARCONI, LL. D., D. Sc., a subject of the King of Italy, residing at 18 Finch Lane, in the city of London, England, have invented new and useful Improvements in Receivers for Wireless Telegraphy, of which the following is a specification.

This invention relates to a method of employing the well known Fleming's oscillation valve (described in the U. S. A. specification No. 803,684) in wireless telegraphy. This valve consists of a vacuous vessel having in it two conductors adjacent to but not touching each other one conductor being heated in any convenient manner while the other is connected to an external circuit.

The oscillation valve is preferably placed in shunt with the secondary of the step-up transformer or jigger which is, as usual, connected with the aerial. The circuit including the secondary coil of the jigger and the oscillation valve, also includes the primary or fine wire winding of the induction coil or step-down transformer, the secondary winding of which is connected with a telephone receiver, relay, or other suitable wave responsive device for detecting the received signals.

A condenser may be placed in series between the valve and the induction coil and a second condenser in a shunt across the ends of the secondary of the jigger.

The condenser last mentioned together with the secondary winding of the jigger forms a closed oscillatory circuit when the capacity of this condenser is properly adjusted for syntonism.

The values of the inductance and capacity of the transformer or jigger and the value of the capacities of the condensers associated to it should be such as to bring the receiving circuit, including said jigger into resonance with the period of the transmitted oscillations.

The drawing is a diagram of the arrangement it is preferred to adopt.

a is a glass bulb, and *b* is a carbon filament like the carbon filament of an incandescent lamp, suitable say for taking a current of 6 to 8 volts and 2 to 4 amperes. *c* is a cylinder of aluminium opened at the top and bottom which surrounds but does not touch the filament. The cylinder *c* is supported and steadied by platinum wires *d*, and the ends of the filament *b* are connected to platinum wires connected to the leads *e* and *f*. The platinum wires are sealed through the glass in the ordinary manner. *h* is a battery by which the filament *b* is heated. This arrangement is one form of the oscillation valve described in the said former specification.

One of the wires *d* is connected to the secondary *j* of the jigger the primary *k* of which is connected to the ordinary aerial *l* and to earth. The other end of the secondary *j* is connected by a wire *m* to one end of the fine wire winding of an induction coil *n* (which should be such as usually manufactured to give say a 10 inch spark) the other end of its fine wire winding being connected by a wire *o* through a condenser *p* to the lead *e*. When the induction coil is thus connected, the fine wire winding, usually operating as a secondary winding, becomes the primary coil, while the course wire winding, usually operating as the primary winding, becomes the secondary coil. The ends of the secondary of the coil *n* are connected to a circuit *q* containing a detector *s* of any ordinary type such as a telephone or a relay operating a printing instrument. *t* is a condenser in a shunt across the secondary *j* of the jigger.

By using a condenser, such as the condenser *t*, in the resonant circuit, the receiving circuit not only may be more easily brought into syntonism with the received oscillations, but such condenser permits the oscillations in the resonant circuit to accumulate to such an extent that their electromotive force is sufficient to overcome the resistance of the space between the filament *b* and the cylinder *c* in the oscillation valve, thereby increasing the strength of the waves rectified by said valve. Inasmuch as the electromotive force of the oscillations rectified by the oscillation valve is high, while its current value is small, the induction coil *n* transforms the current so that it acts upon the detecting device as one of lower potential and higher current value. These conditions are, therefore, the reverse of those usually found in detectors for electromagnetic waves heretofore used.

Inasmuch as the fine wire winding of the inductance coil *n* introduces a large amount of inductance into the receiving circuit, the condenser *p* is introduced to counteract the same.

The pulsating current produced in the

parts of the receiving circuit comprising the filament *f* the wire *e*, the wire *o*, the condenser *p* the fine wire winding of the induction coil *r*, and the wire *m*, results in an alternating current in the wires *q* and the detector *s*, the latter current being of comparatively large volume and low potential.

The term "aerial" is intended to embrace any conductor in which oscillations are set up by the incoming Hertzian waves.

What I claim is:

1. In a receiving apparatus for wireless telegraphy, the combination with an oscillatory circuit, of an oscillation valve, an induction coil, the oscillation valve and the primary winding of the induction coil being connected in series and operatively connected with said oscillatory circuit, and a detecting device connected with the secondary winding of said induction coil.

2. In a receiving apparatus for wireless telegraphy, the combination with an oscillatory circuit including a condenser, of an oscillation valve, an induction coil, the oscillation valve and the primary winding of the induction coil being connected in series with each other but in shunt with said condenser, and a detecting device connected with the secondary winding of said induction coil.

3. In a receiving apparatus for wireless telegraphy, the combination with an oscillatory circuit, of an oscillation valve, an induction coil and a condenser, said valve, condenser and the primary winding of the induction coil being connected in series and operatively connected with said oscillatory circuit, and a detecting device connected with the secondary winding of said induction coil.

GUGLIELMO MARCONI.

Witnesses:

ROBERT B. RANSFORD,

ARTHUR CARPMAEL, Jun.

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PLAINTIFF'S EXHIBIT 290

The same considerations apply to the mutual conductance which can be taken approximately to be equal to the slope of the line joining the extreme point of the characteristic over which the operation takes place.[1]

The problem of setting up the conditions for oscillation, therefore, reduces to the solution of a network involving the oscillation circuit, LCr, a fictitious generator giving a voltage equal to μe_g and a resistance r_p, as defined above. By adopting this procedure, we do not entirely ignore the curvature of the characteristic. If the resistance r_p were not dependent on the intensity

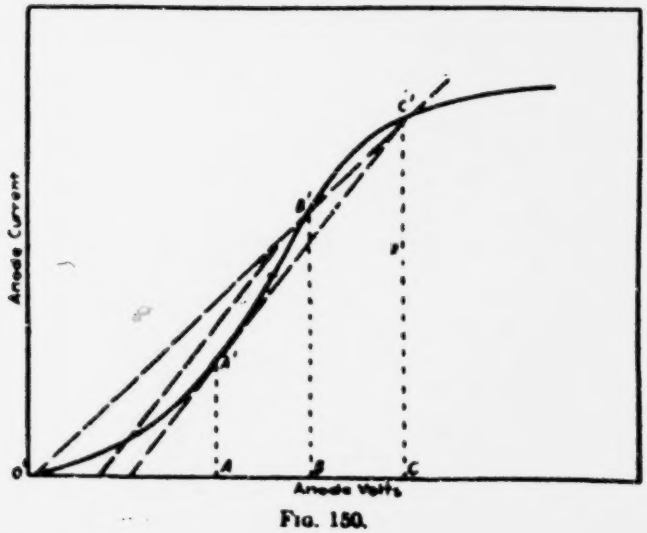

FIG. 150.

of the oscillations, the solution of the network involving the quantities enumerated above would not give an indication of the amplitude of the oscillations; however, both r_p and the mutual conductance g_m are dependent on the intensity of the oscillations. The condition for oscillation will require that r_p and g_m have values lying within certain limits, and since their values depend on the extent of the characteristic over which operation takes place, the amplitude of the oscillations will be determined by the shape of the characteristic and the constants of the external circuit.

81. Conditions for Oscillation in a Two-element Device. Let us first consider the simple case of a device containing two

[1] L. A. HAZELTINE, Proc. I.R.E., Vol. 6, p. 63, 1918.

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Claimant's Exhibit No. 290

electrodes and having a resistance r, and see what are the conditions that must be satisfied in order that this device, when connected to an oscillation circuit may produce sustained oscillations. The circuit is shown diagrammatically in Fig. 151. The device is supplied with a direct current by means of the battery E, through the choke coil Ch. The oscillation circuit is represented by LC.

The condition for oscillation in such a circuit can be obtained by the simple process of setting the differential equation for the circuit and equating the damping factor to zero. In doing so we need, of course, only to consider the a-c. circuits, that is, the

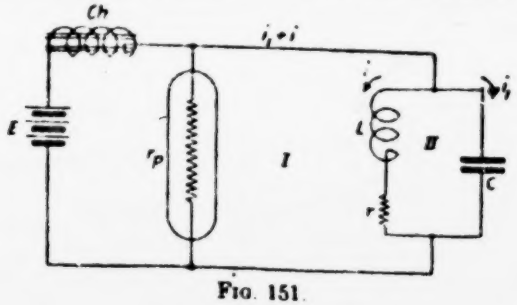

FIG. 151.

two branches I and II. Thus, summing the electromotive forces for circuit I, we get

$$r_p(i_1+i)+ri+Lpi=0, \quad \ldots\ldots\ldots \quad (1)$$

where $p=\frac{d}{dt}$

For branch II we have

$$Lp^2i+rpi=\frac{i_1}{C} \quad \ldots\ldots\ldots \quad (2)$$

Putting the value of i_1 given by equation (1) into (2) we get:

$$p^2i+\left(\frac{r}{L}+\frac{1}{Cr_p}\right)pi+\frac{i}{LC}\left(1+\frac{r}{r_p}\right)=0. \quad \ldots \quad (3)$$

This is an equation of the well-known form from which it follows directly that in order that the current i shall be oscillatory, the coefficient of the linear term must be zero. That is:

$$r_p=-\frac{L}{Cr} \quad \ldots\ldots\ldots \quad (4)$$

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From this we see that in order to obtain sustained oscillations from a device having only two electrodes, it is necessary that the device shall have a negative resistance. Examples of negative resistances have already been given in the previous pages. Thus an arc may have a negative resistance, its characteristic being of the form shown by the curve AB in Fig. 34. The resistance is given by the slope of the characteristic and this is a negative quantity for a characteristic of the kind shown. Fig. 16, page 48, shows another characteristic which over a region ABC has a negative slope and is obtained as the result of the emission of electrons from metals under the impact of electrons. Such characteristics as these are sometimes referred to as "falling characteristics."

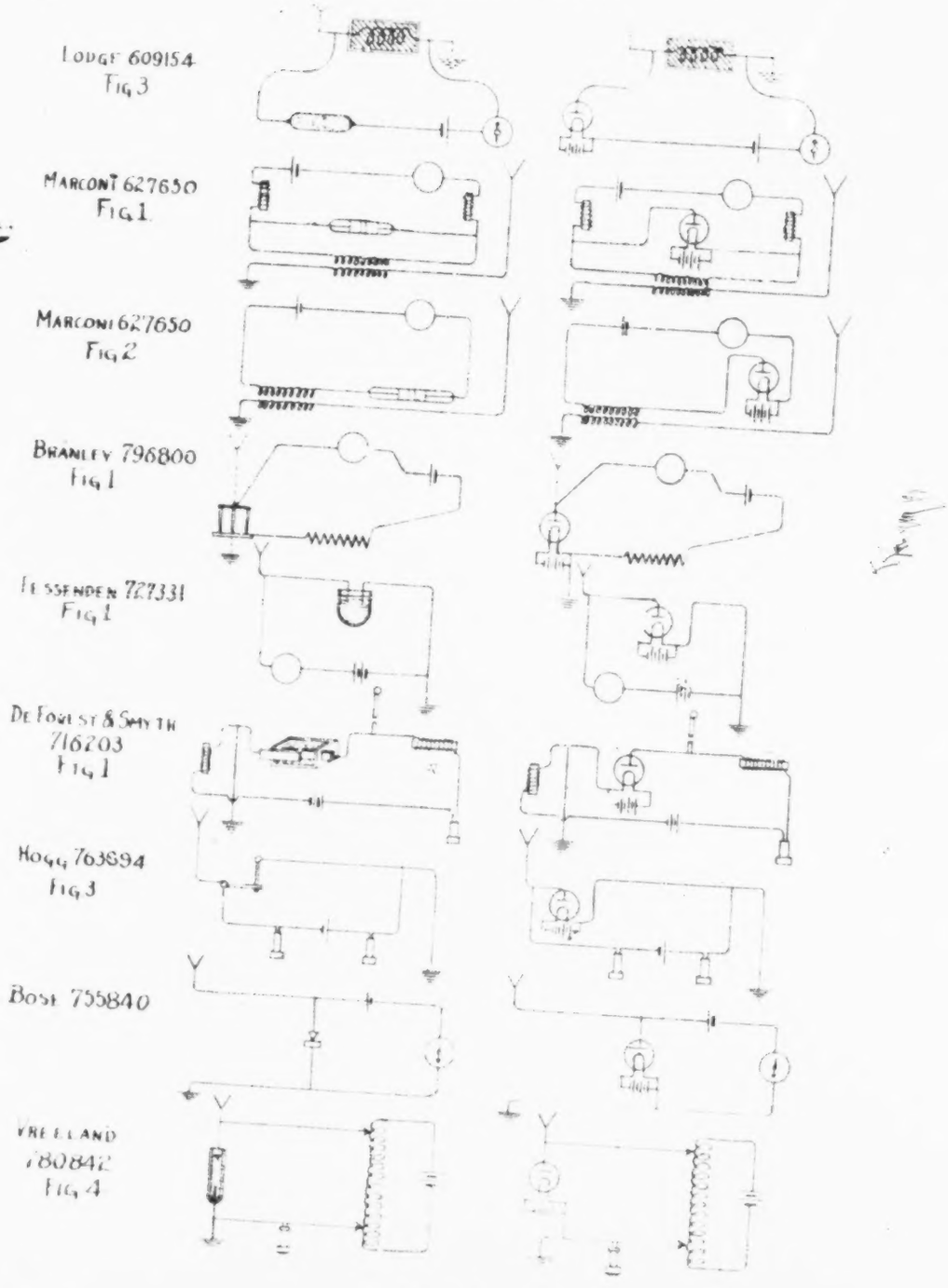
The thermionic valve does not show a falling characteristic like the curve AB of Fig. 34, when it is sufficiently well evacuated to prevent the effects of ionization by collision from appreciably influencing the discharge. The characteristics of thermionic valves are those given and discussed in the previous chapters and it will be seen that for such devices the resistance is always positive. It is, therefore, impossible to obtain sustained oscillations from a well-evacuated thermionic valve containing only two electrodes. If such a device contains an appreciable amount of gas during the operation, the characteristic becomes unsteady and sometimes, especially at the higher voltages, exhibits regions over which the slope is negative, and when operated over that region it is, of course, possible to obtain sustained oscillations. The condition which makes this possible in a two-electrode device is unfortunately due to the cause which makes such a device unsatisfactory; namely, the presence of too much gas in the device, thus causing unsteadiness of the discharge and making reproducibility practically impossible. If a controlling electrode or grid be added to the two electrodes of a valve, the operation becomes different and we now have a device which can produce sustained oscillations with facility while at the same time satisfying all the conditions that are necessary to secure satisfactory operation in every respect, namely, freedom of gas with consequent steadiness and reproducibility of results, and comparatively long life.

82. Condition for Oscillation for Three-Electrode Tube. Let us now consider a circuit like that shown in Fig. 152. This is one of a large number of possible oscillation circuits. It is

3186

Claimant's Exhibit No. 298 3185

USE OF A LOCAL BATTERY OBVIOUS.



2767

CLAIMANT'S EXHIBIT NO. 300.

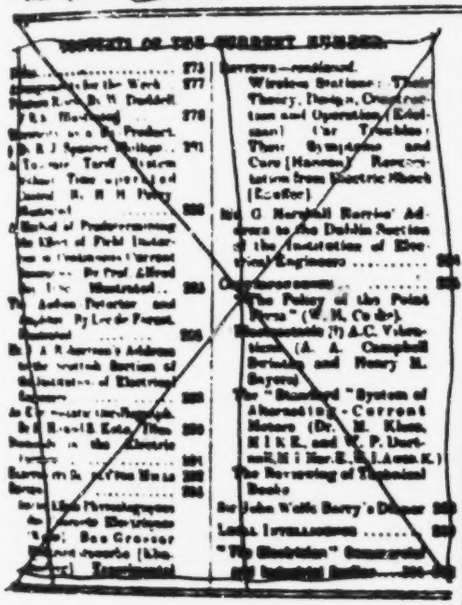
THE ELECTRICIAN:

THE OLDEST WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY, SCIENCE AND FINANCE.

ESTABLISHED FIRST SERIES—MAY 1861—SECOND SERIES—MARCH 1878.

No. 1853. [illegible] FRIDAY, NOVEMBER 21, 1913. [illegible]



CONTENTS OF THIS CURRENT NUMBER.

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distinct from the electrode A in the Fleming valve), the relay circuit being joined to this electrode and to the filament in series with a considerable pressure (15 to 20 volts). When electrical oscillations pass between the A electrode and the filament there is a marked alteration in the current flowing between the B electrode and the filament. This alteration is found to be so marked that it can be used for relay purposes, the relay consisting of two or more audions in series with transformers between them, current from the B electrode of the first being supplied to the primary of a transformer whose secondary supplies oscillations to the A electrode of the second, and so on. By this means an amplification of 120 times has been obtained by using three audions in cascade, and the current thus becomes sufficiently large to operate a moderately sensitive contact relay which, in its turn, can be used to operate a calling device; or the audion may be used with its amplified current in connection with a telegraphone. The latter seems to give promise of interesting developments as it provides a simple means of recording. For this purpose it has been used at the new stations of the Federal Telegraph Company, recording messages between San Francisco and Los Angeles, but it is not limited to new stations. Further, there are possibilities that the instrument may be used as a telephone relay. In passing we must confess we have no affection for the name "audion," to which exception was taken at the time it was introduced, and we think that Dr. DE FOREST might be more generous in his acknowledgment of the work by Dr. J. A. FLEMING. Our readers generally will probably agree that the audion, although differing widely from the Fleming valve, is an offshoot of it.

The Status of the Engineer.

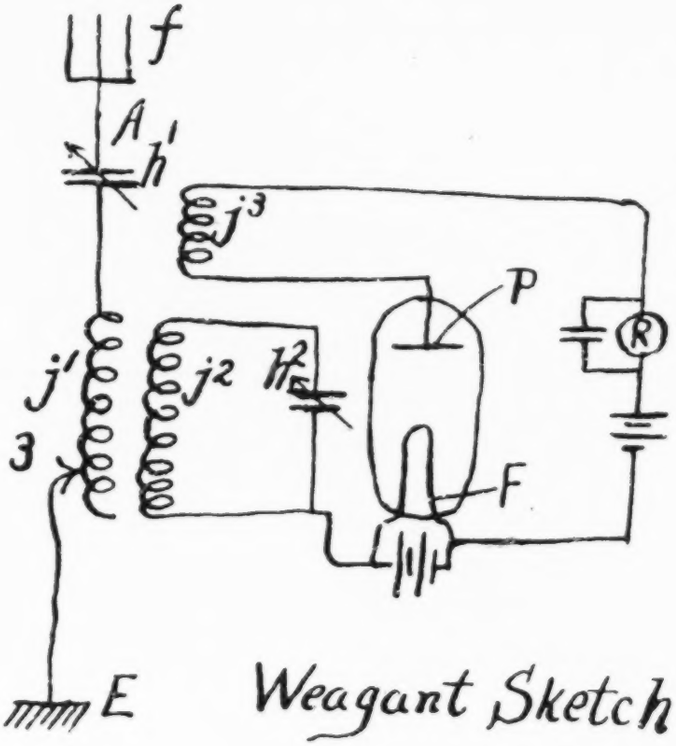
In his inaugural address to the Dublin Local Section of the Institution of Electrical Engineers last week, Mr. G. MARSHALL HARMONY gave some interesting details of the way in which the medical profession many years ago raised the status of its members and excluded undesirables from its ranks. The obvious deduction is that electrical engineers should go and do likewise. Now, it cannot be denied that at the present time the electrical profession and industry are much too loosely organized. It nominally contains within its ranks many who are not engineers at all, and many whose lack of what is right and proper brings discredit on the body as a whole. And though we wish that this state of things might be changed, we feel that what the medical men did in 1858 cannot be taken as a precedent or as an example which electrical engineers may profitably follow. The medical profession adopted a course which was the best for them, but we do not think it would necessarily be the best for electrical engineers. There are two reasons for this. In the first place, engineering, especially electrical engineering, is divided against itself, with the result that it would be almost impossible at the present time to draft a Bill similar to that of the Medical Act of 1858 on lines with which even a majority of those engaged in electrical work would agree. This statement must not be taken as reflecting on either class; it simply implies that the professions and trade, and even separate branches of [illegible] impossible to reconcile them. Another and [illegible] is that caused by the conditions under which [illegible] electrical engineering work is carried on. Indeed, it is [illegible] difficulty which prevents an almost insuperable [illegible] to electrical engineers following the example of the [illegible] profession.

In the medical profession a [illegible] either [illegible] qualified man or he is not. Moreover, the profession is a homogeneous body. It is, therefore, easy to draw a hard-and-fast line, and to say that those who are on one side of this line are professionally equal and those who are on the other side are nowhere. This, however, cannot be done with electrical engineering as a whole owing to the presence of a numerous rank and file. Moreover, in this army, commissioned and non-commissioned officers are often very closely connected, those in one class merging very nearly into those of the other, so that, while it is possible to take one man and say here is a fully qualified engineer, and to take another and say here is a fully unqualified engineer, there are many others whose status is notwithstanding, [illegible] such that a division between those on one side the line and those on the other is indeterminate. This being so, it is difficult to see how anybody connected with electrical engineering can be prevented from calling himself an electrical engineer, though, as BARRY PAIN says, "to be an electrical engineer is another matter."

The question is, therefore, a very difficult one, for though it is possible to regulate matters among the [illegible] class, as is being successfully done by the Association of Consulting Engineers, the same procedure cannot be followed throughout the trade where a man's status cannot be definitely defined. It may be urged that trade unions do what we say cannot be done; but it should be pointed out that, after all, they [illegible] single class, and in our view often impose restrictions which are not for the public good. But even if this contention were correct it would not affect our argument, because neither legislation nor consulting engineers can [illegible] somehow that very large middle class which prides itself at the present time most requires enlightenment. And it is here to [illegible] that legislation must fail, for a while at least, to be effective. It rather requires that every man should perform his own work in accordance with the highest principles, and with the purest ethical aim, so that electrical engineering may be cleansed from within and the charlatan quelled.

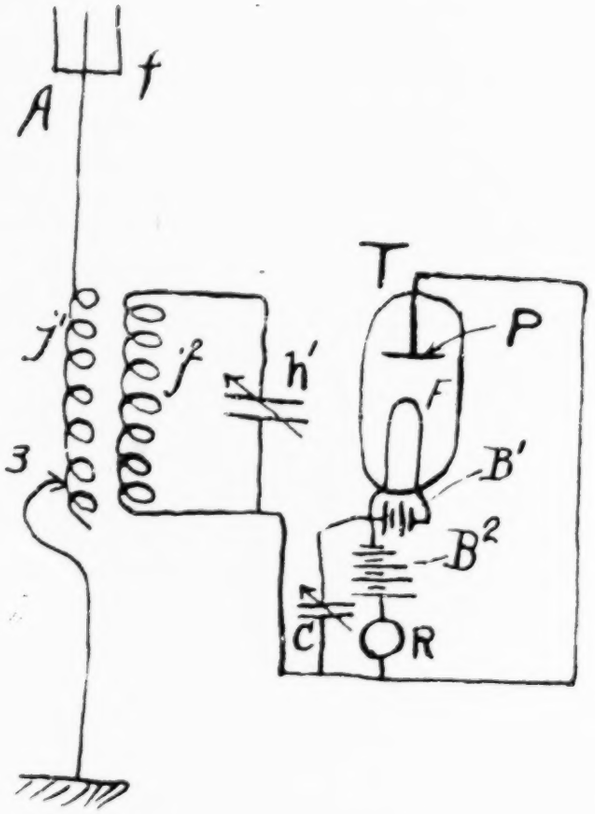
Sun Power.—An interesting [illegible] of the [illegible] power plant was shown this week at the Shaftesbury Pavilion. This plant has been laid down in Egypt for irrigation purposes, and consists of five long semi-cylindrical mirrors, which concentrate the rays of the sun on a small iron boiler in the focus of a pipe running along the axis of the cylinder. The mirrors are automatically turned by a thermostat to catch the sun's rays to the maximum extent. This plant is capable of supplying 1,000 lb. of steam per hour. [illegible] the Empire there is said to be a great saving with this type of plant. The mirrors are 330 ft. long and are spaced 20 ft. apart. It is estimated that 220 H.P. can be obtained for every acre of ground covered with mirrors.

Claimant's Exhibit No. 301



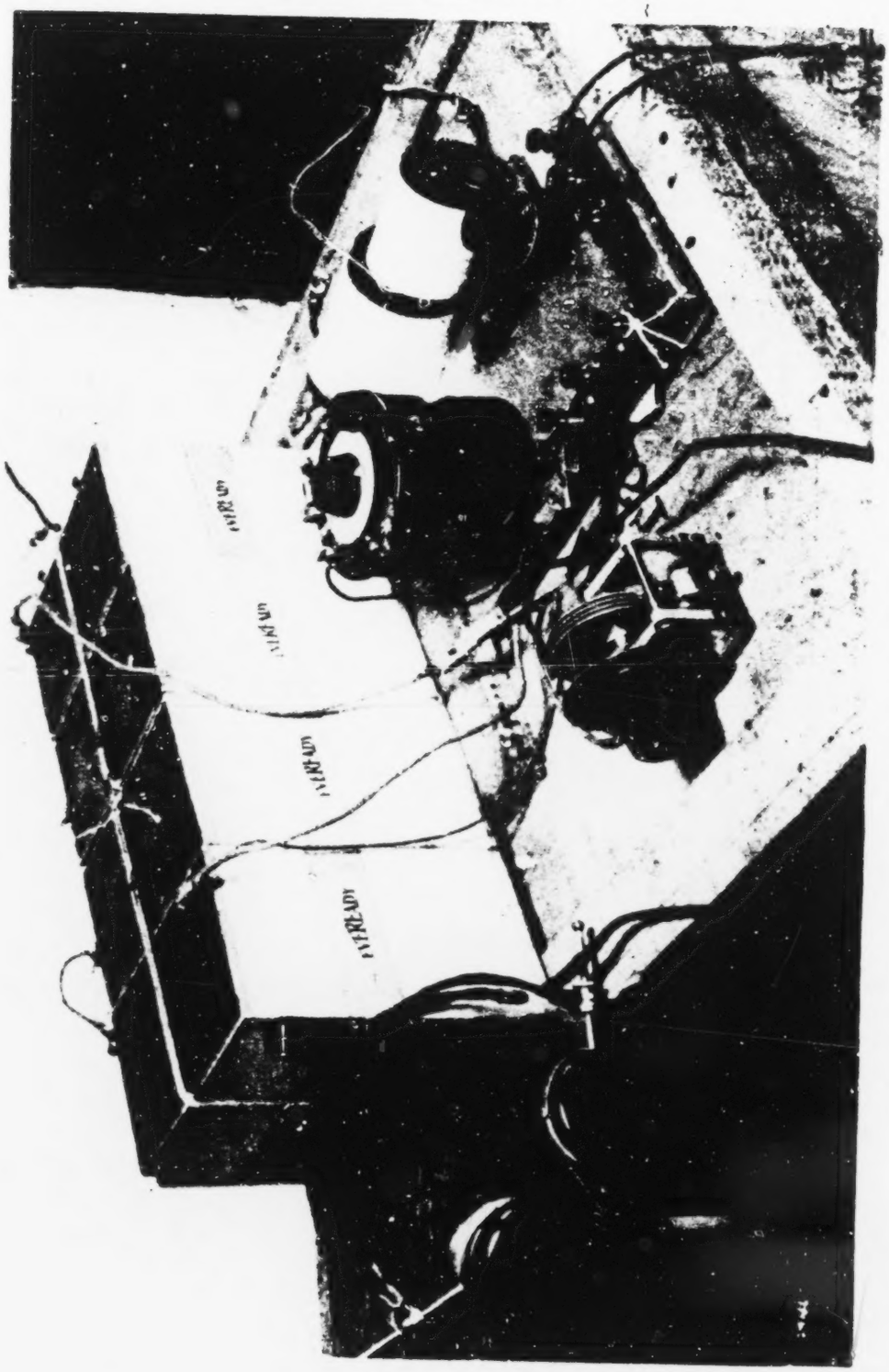
Weagant Sketch no 7.

Claimant's Exhibit No. 302



Weagant Sketch No 8.

Claimant's Exhibit No. 315



Plaintiff's Exhibit 317

3191

Claimant's Exhibit No. 318

3192

Marconi's Sketch
on Cross Examination

Fig 1

2774

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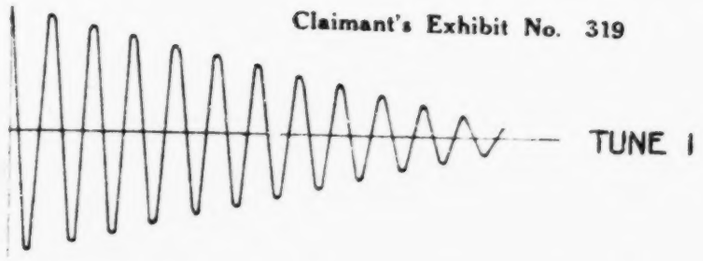
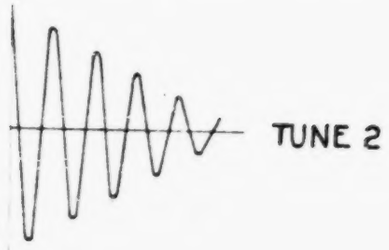
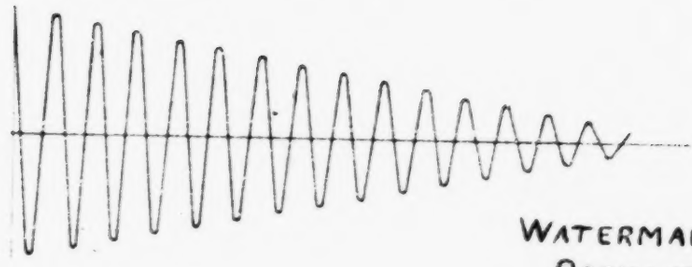
[redacted]

1933

Claimant's Exhibit No. 319

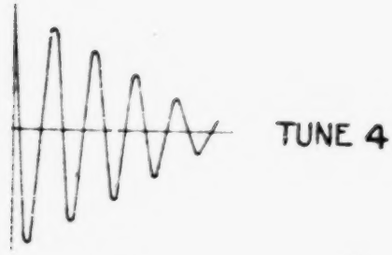






WATERMAN DRAWING NO. 4
OSCILLATIONS IN
PRIMARY CIRCUIT WHEN
NOT COUPLED TO
ANTENNA

MARCONI U.S. PAT. 763772



[redacted]

2781

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Claimant's Exhibit No. 322

WATERMAN DRAWING Nº 5.

FIG. 1.

FIG. 2.

FIG. 3.

2776

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Claimant's Exhibit No. 323

WATERMAN DRAWING Nº 6.

FIG. 1.

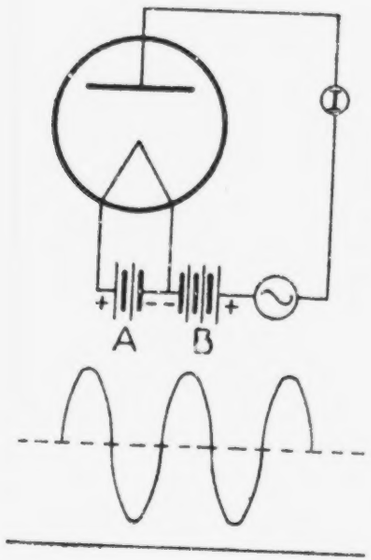


FIG. 2.

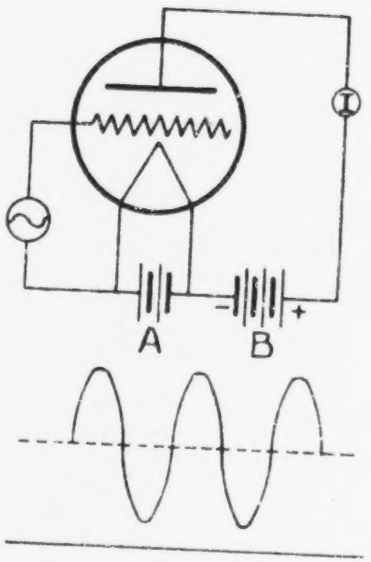
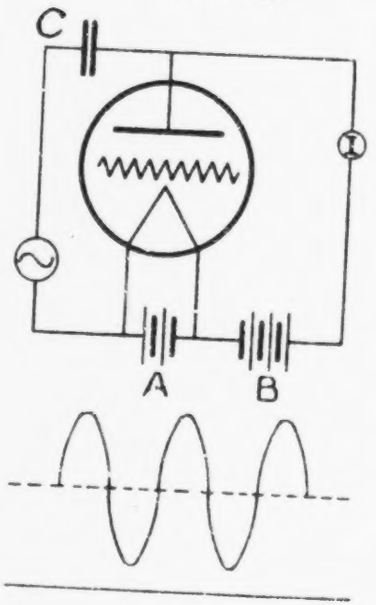


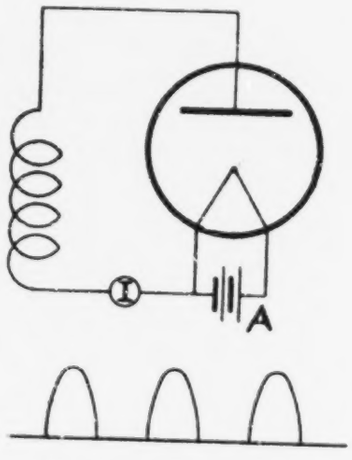
FIG. 3.



Claimant's Exhibit No. 324

WATERMAN DRAWING Nº 7.

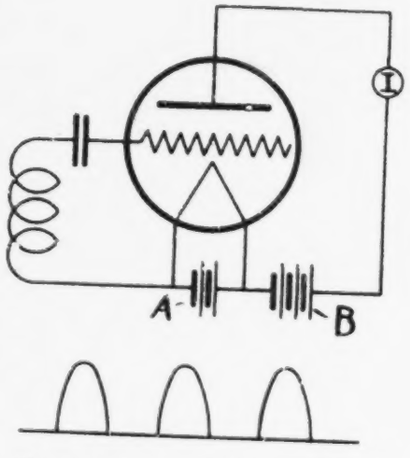
FIG. 1.



ELECTRON FLOW

CURRENT IN TELEPHONES

FIG. 2.



ELECTRON FLOW TO GRID

CURRENT IN TELEPHONES

COMPARISON:

2-ELECTRODE TUBE WITHOUT BIAS BATTERY.

3-ELECTRODE TUBE "GRID RECTIFICATION".

2778

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Claimant's Exhibit No. 325

WATERMAN DRAWING Nº 8.

FIG.1

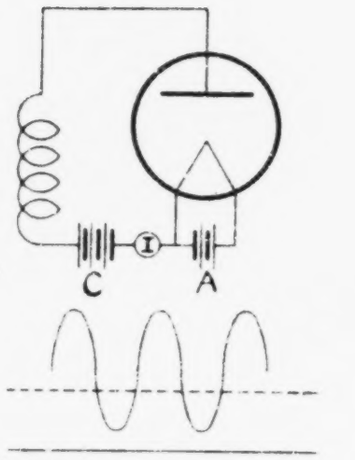
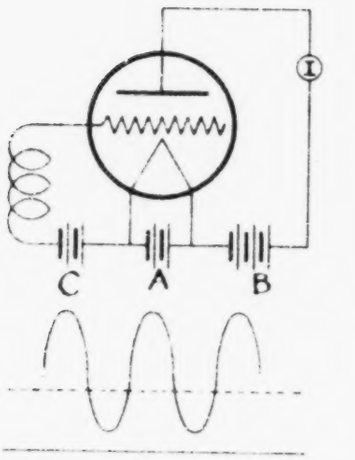


FIG.2



COMPARISON:
2-ELECTRODE TUBE WITH BIAS BATTERY.
3-ELECTRODE TUBE (WITH BIAS BATTERY) "PLATE RECTIFICATION."

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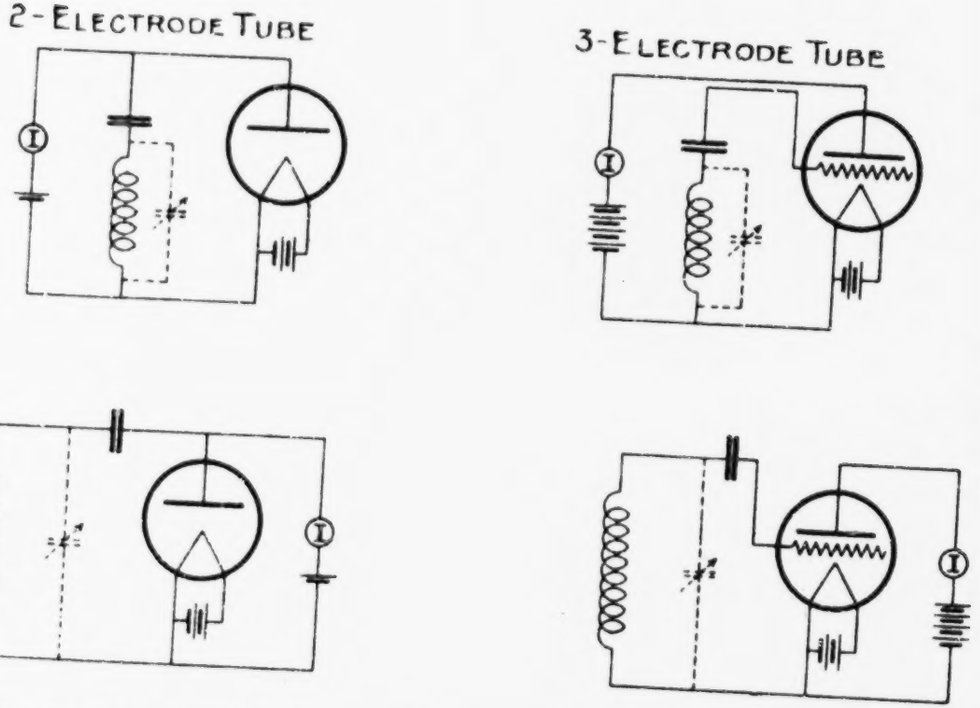
Claimant's Exhibit No. 326

WATERMAN DRAWING Nº 9.



COMPARISON OF 2 AND 3 ELECTRODE TUBES IN PN CIRCUIT

3199

PLAINTIFF'S EXHIBIT 327 (1)

No. 824,637. PATENTED JUNE 26, 1906.

L. DE FOREST.

OSCILLATION RESPONSIVE DEVICE.

APPLICATION FILED JAN 16, 1906

2 SHEETS—SHEET 1

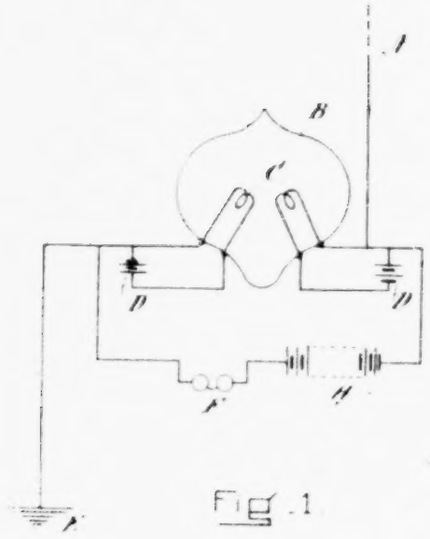


Fig. 1

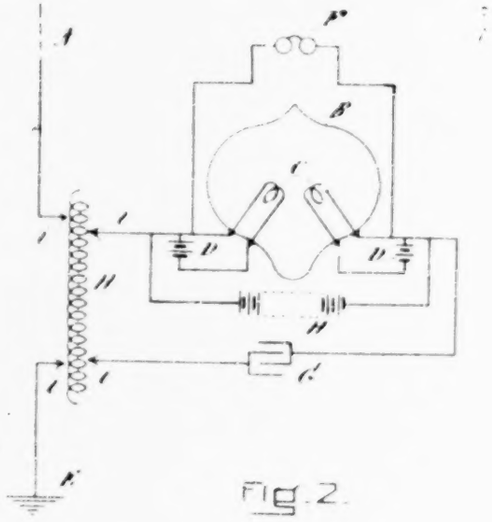


Fig. 2

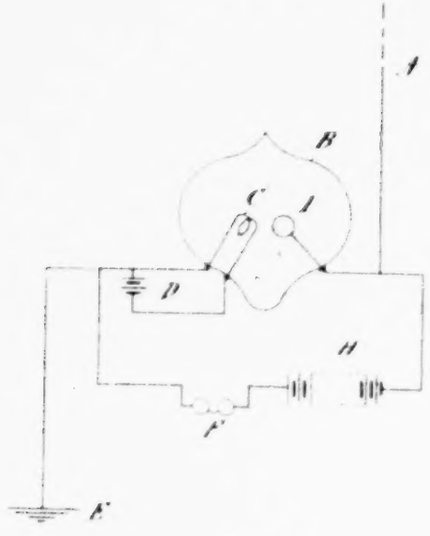


Fig. 3

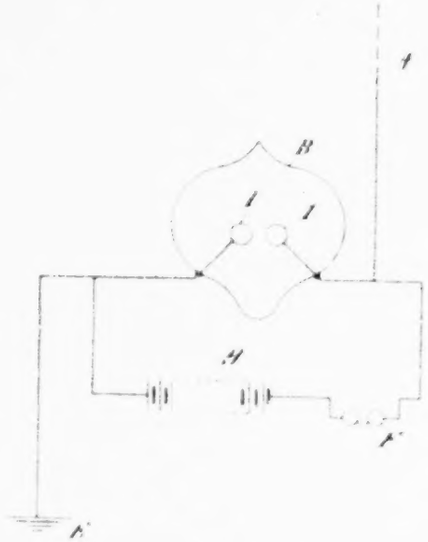


Fig. 4

WITNESSES:
John Buckler
Adolph C. Kaiser

INVENTOR:
Lee de Forest
by Crosby Woodworth
Atty

3200

No. 824,637. PATENTED JUNE 26, 1906.

L. DE FOREST.

OSCILLATION RESPONSIVE DEVICE.

APPLICATION FILED JAN. 18, 1906.

2 SHEETS—SHEET 2.

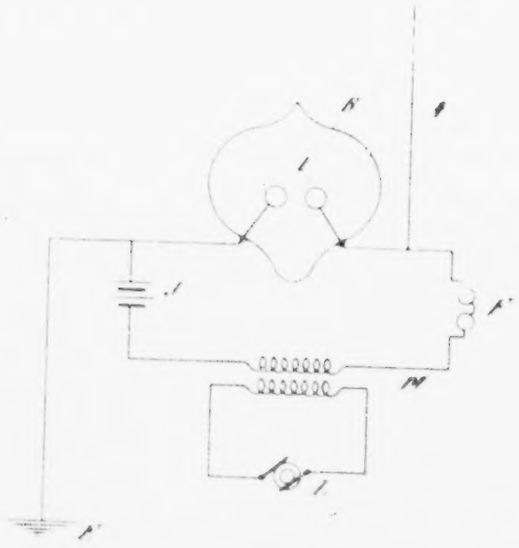


Fig. 5.

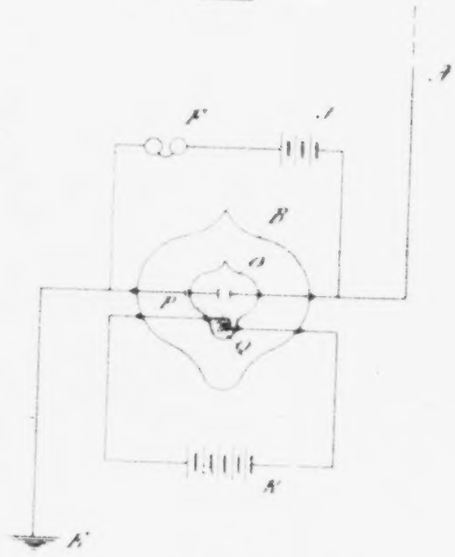


Fig. 6.

WITNESSES:
Thos. Buckler
Adolph C. Kaiser

INVENTOR:
Lee de Forest
by Geo. H. Woodworth
Atty.

UNITED STATES PATENT OFFICE. 3201

LEE DE FOREST, OF NEW YORK, N. Y.

OSCILLATION-RESPONSIVE DEVICE.

No. 824,637. Specification of Letters Patent. Patented June 26, 1906.

Application filed January 18, 1906. Serial No. 296,615.

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented a new and useful Improvement in Oscillation-Responsive Devices, of which the following is a specification.

My invention relates to devices for detecting feeble electrical currents or oscillations in general, and especially such currents or oscillations which are developed in wireless-telegraph receiving systems.

The object of my invention is to provide an oscillation detector or responder of great simplicity and sensitiveness and one which, inasmuch as it does not depend for its operation upon any variation of resistance of an imperfect electrical contact or any variation of the apparent resistance or counter electromotive force of a polarization-cell, requires no adjustment when employed for receiving wireless-telegraph signals.

With these objects in view my invention comprises a receptacle inclosing a sensitive gaseous conducting medium, the conductivity of which does not necessarily depend upon the heat of combustion, although such conductivity may be increased by heating said gaseous medium, and which in some cases requires practically no heating at all, a wave-intercepting means associated with said gaseous conducting medium, whereby the feeble electrical currents or oscillations resulting from the energy absorbed from electromagnetic signal waves may be impressed upon said gaseous conducting medium to alter its conductivity, and a signal-indicating device operatively connected with said gaseous conducting medium, whereby alterations in the conductivity of the latter may be made manifest.

My invention may best be understood by having reference to the drawings which accompany and form a part of this specification and which illustrate diagrammatically several simple and effective means whereby my invention may be practiced.

In the drawings, Figures 1, 2, 3, 4, 5, and 6 represent wireless-telegraph receiving systems provided with various forms of the oscillation responsive device which forms the subject-matter of the present invention.

In each figure, A represents a receiving antenna connected to earth at E and associated with the receptacle B. In Figs. 1, 3, 4, 5, and 6 the sensitive gaseous conducting medium inclosed in said receptacle is shown interposed between the antennæ and their earth connections, while in Fig. 2 said medium is shown interposed between the terminals of the tuned receiving-circuit *i C G i H*, which is inductively associated, by means of the autotransformer H, with the antenna A. By means of the four adjustable contacts *i* said tuned receiving-circuit and antenna may each be attuned to the frequency of the waves to be received. My invention, however, is not limited to any particular wireless-telegraph system, nor is it limited to wireless telegraphy, for it may be employed as a detector of feeble electrical impulses however produced.

I have discovered that the gaseous medium intervening between two separated electrodes if put into a condition of molecular activity will become highly sensitive to electrical oscillations, so that the passage across such medium of said oscillations will alter the conductivity thereof, and thereby create current variations in a circuit including said electrodes. The means which may be employed for putting said gaseous medium into a condition of molecular activity may consist of means whereby the medium is heated either by radiation, conduction, or by the actual combustion of gases. An electric current from any suitable source may be employed to heat two highly-resistant electrodes, and thereby to heat the gas intervening between said electrodes without having recourse to the heat of combustion. Said gas may be air, or the electrodes may be inclosed and surrounded by any suitable gas. The heating of the gas may also be affected by radiation from said electrodes. In fact, in the invention disclosed in the present application any suitable means for producing a heated gas with properly dissociated and conducting ions may be employed.

In all the embodiments of the present invention the electrodes are inclosed and are surrounded by suitable gas, and they may be inclosed in a receptacle which may be partially exhausted. Said gas may be rendered sensitive to electrical oscillations by slightly heating the same, preferably by electrical means, or by any other suitable means; but in those embodiments of my invention shown in Figs. 4, 5, and 6 practically no heating at all is required, while if in place of the potassium or other salt hereinafter described as

suitable for use in Fig. 6 some radio-active substance, such as radium bromid, be employed absolutely no heating is necessary.

In Fig. 1 two filaments C, which may be ordinary incandescent-lamp carbon filaments, are sealed into the receptacle B and each is connected to a separate battery D. The local-circuit battery H and telephone F connect said filaments C. One filament is connected with the antenna A and the other is connected to earth E, although the said filaments may be associated with the antenna in any manner in which existing wireless-telegraph receivers are associated with their receiving antennæ. In lieu of connecting the telephone F in series with the local-circuit battery H said telephone may be connected in shunt to the circuit including the filaments C, which form the electrodes of the oscillation responsive device, and local battery H, as shown in Fig. 2, and such arrangement of telephone-receiver may be employed, if desired, in those embodiments of the present invention which are shown in Figs. 3 to 6, inclusive.

The potential to be impressed upon the electrodes C by the battery H depends upon the nature of the gas intervening between said electrodes and upon the degree of exhaustion maintained within the receptacle B. I have found that from twenty-five to one hundred and ten volts is sufficient, and by employing a higher degree of exhaustion a much smaller voltage may be used. The conductivity of the gas, which may be air or a gas containing compounds of the halogens or halogen salts or which may be mercury vapor, is increased by the heat resulting from the passage of the current from the batteries D through the filaments C, and a leak-current of relatively small value continually flows in the circuit containing the battery H and the electrodes C across the gap intervening between said electrodes. The passage of electrical oscillations across said gap alters the conductivity of the gas in said gap, probably by changing the speed of the ions in said gas, and thereby current variations are produced in the circuit containing the battery H, the electrodes C, and the telephone F, causing said telephone to respond. When the telephone is in series with the battery H and electrodes C, the passage of oscillations across the gap between the electrodes causes an increase of current through the telephone, and when the telephone is in shunt to said electrodes, as shown in Fig. 2, the passage of oscillations across the gap causes a diminution of current through the telephone.

It is not necessary to employ two heated electrodes in carrying out my invention, for, as shown in Fig. 3, one electrode may be replaced by a conductor I, herein shown as a disk, of platinum or other suitable material. In this case the conductivity of the gaseous medium between the two electrodes I and C is sufficiently increased to render the same sensitive to the electrical oscillations by the radiation of heat from the electrode C.

In that embodiment of my invention shown in Fig. 4 I dispense with both heated electrodes C and substitute therefor two electrodes I, of platinum or other material, and connect the same in circuit with the battery H and telephone F. In Fig. 4 the telephone F may be connected in shunt to the battery-circuit in the manner shown in Fig. 2 of the present case.

In Fig. 5, L represents a source of alternating electromotive force of a frequency so high that a high-pitch note is constantly heard in the telephone F or else so high as to exceed the limit of response of the telephone-diaphragm. The advantage in using the source of alternating electromotive force is that the voltage may be stepped up by a transformer M to any desired amount—for example, from fifty to one thousand volts—and impressed upon the electrodes I. In lieu of an alternating-current generator such as shown in Fig. 5 any source of vibratory electromotive force may be employed. The telephone F may be included in series with the circuit containing the secondary of the transformer M and electrodes I, or it may be connected in shunt to said circuit, as above stated in connection with Fig. 2, and the effect of the passage of high-frequency oscillations across the gap between the electrodes I may be increased in the telephone by including a battery J in series with the telephone. In such case the conductivity of the gas in said gap effected by the high-potential alternating current will allow the relatively low potential direct current from the battery J to flow in the circuit containing the telephone and the electrodes, and the passage of electrical oscillations across the gap between the electrodes will produce sudden changes in the conductivity of said gas, and therefore in the amplitude of the current flowing in the telephone-circuit.

A convenient way of producing a gaseous medium containing compounds of suitable salts is shown in Fig. 6, in which a globule of a solution of some such salt is placed in the bottom of a vessel O, as shown at Q, and a heating-coil P is associated with said globule in such a way that the current from the battery K will heat said coil and create a heated gas of said salt in the globe O. I prefer to employ potassium hydrate as the salt to be heated, and better effects may be obtained by inclosing the globe O inside the evacuated globe B to prevent the radiation of heat from the inner globe. The heated gas from the potassium or other salt fills the globe O, which may be exhausted to any desired degree, and completes the circuit of the battery J

and telephone F, which is connected to two electrodes, of platinum or other suitable material, in the globe O. The passage of electrical oscillations across the gap between said electrodes will alter the conductivity of the aforesaid heated gas, and thereby create current variations in the circuit of the telephone F.

All the foregoing apparatus comprises means for sensitizing the interelectrode medium, as suitable salts impregnating the said medium, as before noted, or means for producing and maintaining the medium in a state of molecular activity, as by heating, or both means for sensitizing may be concurrently employed.

I do not wish to be limited to the particular embodiments of my invention which I have herein disclosed, inasmuch as many modifications may be made therein by those skilled in the art without departing from the spirit of my invention.

I claim —

1. An oscillation-responsive device comprising a receptacle inclosing a sensitive gaseous conducting medium containing a halogen salt.

2. An oscillation-responsive device comprising a receptacle inclosing a sensitive gaseous conducting medium containing a halogen salt and means for heating said medium.

3. An oscillation-responsive device comprising a receptacle inclosing a sensitive gaseous conducting medium containing a potassium salt.

4. An oscillation-responsive device comprising a receptacle inclosing a sensitive gaseous conducting medium containing a potassium salt and means for heating said medium.

5. An oscillation-responsive device comprising a receptacle inclosing a sensitive gaseous conducting medium containing a halogen salt and means for putting said medium in a condition of molecular activity.

6. An oscillation-responsive device comprising a receptacle inclosing a sensitive gaseous conducting medium containing a potassium salt and means for putting said medium in a condition of molecular activity.

7. An oscillation-responsive device comprising a partially-exhausted receptacle, two separated electrodes sealed in said receptacle and each forming part of a separate electric circuit, a separate source of electric current for each said circuit, and means whereby electrical oscillations may be impressed upon the gaseous medium intervening between said electrodes.

8. An oscillation-responsive device comprising a partially-exhausted receptacle containing two separated electrodes, a source of electromotive force associated with said electrodes, and means whereby a relatively small electric current is caused to flow normally in the circuit including said source of electromotive force, said electrodes and the gaseous medium intervening between the latter.

9. An oscillation-responsive device comprising a partially-exhausted receptacle containing two separated electrodes, a source of electromotive force associated with said electrodes, and electrical means for heating said electrodes whereby a relatively small electric current is caused to flow normally in the circuit including said source of electromotive force, said electrodes and the gaseous medium intervening between the latter.

10. An oscillation-responsive device comprising a receptacle, two separated electrodes inclosed within said receptacle and each forming part of a separate electric circuit, a source of electric current associated with each said circuit, and means whereby electrical oscillations may be impressed upon the gaseous medium intervening between said electrodes.

11. An oscillation-responsive device comprising a receptacle inclosing a gaseous medium containing a substance the vapor of which is conducting, and electrical means for heating said medium.

12. An oscillation-responsive device comprising a receptacle inclosing a gaseous medium containing a halogen salt, two separated electrodes inclosed within said receptacle, and a source of electric current so associated with said electrodes as to render said gaseous medium sensitive to electrical oscillations.

In testimony whereof I have hereunto subscribed my name this 13th day of January, 1906.

LEE DE FOREST.

Witnesses:

LESTER TESTE,

PHILIP FARNSWORTH.

3204

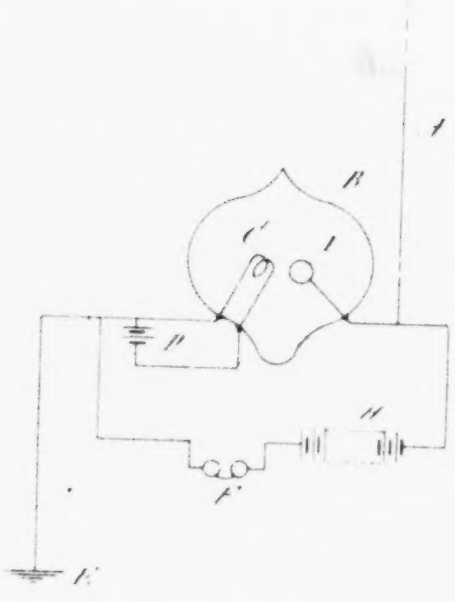
PLAINTIFF'S EXHIBIT 327 (2)

No. 836,070. PATENTED NOV. 13, 1906.

L. DE FOREST.

OSCILLATION RESPONSIVE DEVICE.

APPLICATION FILED MAY 19, 1906.



WITNESSES:

John Buechler

Frank A. Parker

INVENTOR:

Lee de Forest

by Thos. C. Woodworth

Atty.

UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y.

OSCILLATION-RESPONSIVE DEVICE.

No. 836,070. Specification of Letters Patent. Patented Nov. 13, 1906.

Original application filed January 18, 1906. Serial No. 296,615. Divided and this application filed May 19, 1906. Serial No. 317,721.

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented a new and useful Improvement in Oscillating Responsive Devices, of which the following is a specification.

My invention relates to devices for detecting feeble electrical currents or oscillations, in general, and especially such currents or oscillations which are developed in wireless-telegraph-receiving systems.

The object of my invention is to provide an oscillation detector or responder of great simplicity and sensitiveness and one which inasmuch as it does not depend for its operation upon any variation of resistance of an imperfect electrical contact or any variation of the apparent resistance or counter electromotive force of a polarization-cell, requires no adjustment when employed for receiving wireless-telegraph signals.

With these objects in view, my invention comprises a receptacle inclosing a sensitive, gaseous conducting medium; a wave-intercepting means associated with said gaseous conducting medium whereby the feeble electrical currents or oscillations resulting from the energy absorbed from electromagnetic signal-waves may be impressed upon said gaseous conducting medium to alter its conductivity; and a signal-indicating device operatively connected with said gaseous conducting medium whereby alterations in the conductivity of the latter may be made manifest.

My invention may best be understood by having reference to the drawing which accompanies and forms a part of this specification and which illustrates diagrammatically one embodiment of my invention.

In the drawing, the figure represents a wireless-telegraph-receiving system provided with one form of the oscillation responsive device which constitutes the subject-matter of the present invention.

In the figure, A represents a receiving-antenna connected to earth at E and associated with the receptacle B. Two electrodes C and I are inclosed within said receptacle, which may be partially exhausted, and, as shown, they are sealed in said receptacle. The electrode C may be an ordinary incandescent-lamp-carbon filament, which is connected with a battery or other source of electrical energy D. The electrode I may be any suitable conductor and is herein shown as a disk of platinum or other material. The gaseous medium inclosed between the electrodes C and I is rendered sensitive to electrical oscillations by the radiation of heat from the electrode C, said electrode being heated by the source of energy D. The local circuit containing the battery H or other source of electrical energy and the telephone F or other signal-indicating device is electrically connected with the electrodes C and I, and as shown is connected in series therewith. The antenna A may be associated with either electrode and in such case the other electrode may be connected to earth. It will be understood, however, that the particular mode of associating the oscillation responsive device with the antenna forms no part of my invention and that any suitable system of circuits may be employed with said oscillation responsive device.

The potential to be impressed upon the electrodes C and I by the battery H depends upon the nature of the gas intervening between said electrodes and upon the degree of exhaustion maintained within the receptacle B. I have found that from twenty-five to one hundred and ten volts is sufficient and by employing a higher degree of exhaustion a much smaller voltage may be used. The conductivity of the gas, which may be air, or a gas containing compounds of the halogens or halogen salts or which may be mercury vapor, is increased sufficiently to render said gas sensitive to the passage of electrical oscillations across the gap by the radiation of heat from the electrode C. The passage of electrical oscillations across said gap alters the conductivity of the gas in said gap, probably by changing the speed of the ions in said gas, and thereby current variations are produced in the circuit containing the battery H, the electrodes C and I, and the telephone F, causing said telephone to respond. When the telephone is in series with the battery H and the electrodes C and I, the passage of oscillations across the gap between said electrodes causes an increase of current through the telephone and if the telephone is connect-

ed in shunt with said electrodes, the passage of oscillations across the gap decreases the current through the telephone.

I do not wish to be limited to the particular embodiment of my invention which I have disclosed herein inasmuch as many modifications may be made therein by those skilled in the art without departing from the spirit of my invention.

This application is a division of my application, Serial No. 296,615, filed January 18, 1906.

I claim—

1. An oscillation-responsive device comprising a partially-exhausted receptacle, two separated electrodes sealed in said receptacle, means for heating one only of said electrodes, means whereby electrical oscillations may be impressed upon the gaseous medium intervening between said electrodes, and a local circuit including a source of electrical energy and a signal-indicating device electrically connected with said electrodes.

2. An oscillation-responsive device comprising a partially-exhausted receptacle, two separated electrodes sealed in said receptacle, means for heating one only of said electrodes, means whereby electrical oscillations may be impressed upon the gaseous medium intervening between said electrodes, and a local circuit including a source of electrical energy and a signal-indicating device connected in series with said electrodes.

3. An oscillation-responsive device comprising a partially-exhausted receptacle, two separated electrodes sealed in said receptacle, a source of electric current so associated with one only of said electrodes as to render the gaseous medium intervening between said electrodes sensitive to electrical oscillations, and a local circuit including a source of electrical energy and a signal-indicating device electrically connected with said electrodes.

4. An oscillation-responsive device comprising a partially-exhausted receptacle, separated electrodes sealed in said receptacle, means for heating one only of said electrodes, and a local circuit including a source of electrical energy and a signal-indicating device electrically connected with said electrodes.

5. An oscillation-responsive device comprising a receptacle, two separated electrodes inclosed within said receptacle, means for heating one only of said electrodes, means whereby electrical oscillations may be impressed upon the gaseous medium intervening between said electrodes, and a local circuit including a source of electrical energy and a signal-indicating device electrically connected with said electrodes.

6. An oscillation-responsive device comprising a receptacle, two separated electrodes inclosed within said receptacle, means for heating one only of said electrodes, means whereby electrical oscillations may be impressed upon the gaseous medium intervening between said electrodes, and a local circuit including a source of electrical energy and a signal-indicating device connected in series with said electrodes.

7. An oscillation-responsive device comprising a receptacle, two separated electrodes inclosed within said receptacle, a source of electric current so associated with one only of said electrodes as to render the gaseous medium intervening between said electrodes sensitive to electrical oscillations, and a local circuit including a source of electrical energy and a signal-indicating device electrically connected with said electrodes.

8. An oscillation-responsive device comprising a receptacle, two separated electrodes inclosed within said receptacle, means for heating one only of said electrodes, and a local circuit including a source of electrical energy and a signal-indicating device electrically connected with said electrodes.

In testimony whereof I have hereunto subscribed my name this 10th day of May, 1906.

LEE DE FOREST

Witnesses:
PHILIP FARNSWORTH,
GEO. L. LEWIS.

PLAINTIFF'S EXHIBIT 327 (3)

No. 867,876. PATENTED OCT. 8, 1907.

L. DE FOREST.

OSCILLATION RESPONSIVE DEVICE.

APPLICATION FILED APR. 4, 1906.

WITNESSES:
Frank L. Parker
John Buckler

INVENTOR:
Lee de Forest
by Woodworth
Attorney.

UNITED STATES PATENT OFFICE.

LEE DE FOREST OF NEW YORK, N. Y., ASSIGNOR TO GEORGE K. WOODWORTH OF BOSTON, MASSACHUSETTS.

OSCILLATION-RESPONSIVE DEVICE.

No. 867,876. Specification of Letters Patent. Patented Oct. 8, 1907.

Original application filed February 2, 1905, Serial No. 243,913. Divided and this application filed April 4, 1906. Serial No. 309,762.

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented a new and useful Improvement in Oscillation-Responsive Devices, of which the following is a specification.

My invention relates to an improvement in the sensitive member used in systems of wireless telegraphy to detect electrical waves or oscillations and comprises the novel features hereinafter shown and described and particularly pointed out in the claims.

In the accompanying drawing I have shown, and in the description thereof will point out, one form of construction which may be employed in carrying out my invention.

The figure represents a receiving set for a wireless telegraphic system, having a sensitive member embodying the principles of my invention.

In the figure, A is an antenna or receiving conductor or wave intercepting means, E, the earth connection, P, the electrodes of the oscillation responsive device shown in the present case as included in series with the antenna and earth connection, G, a source of current, such as a dynamo, and T, the receiving or indicating instrument, which is herein shown as a telephone receiver, the same being shown only as typical of any form of indicating apparatus capable of being employed for such purpose.

I have discovered that if two bodies adapted for use as electrodes or conductive members be electrically separated, the separation between them may be neutralized sufficiently to enable them to act as a detector of electrical oscillations, if the intervening or surrounding gaseous medium be put into a condition of molecular and ionic activity, such, for instance, as would be caused by heating it in any manner, as by radiation, conduction or by the combustion of gases in the space which surrounds the electrodes. Such condition of molecular and ionic activity causes what would otherwise be a non-sensitive device to become sensitive to the reception of electrical influences. I am thus enabled to employ as such sensitive member devices which would otherwise be of no value and which comprise electrodes separated by a gaseous medium. This principle is embodied in the apparatus shown in the drawing in which the electrodes P are of sufficiently great resistance to be heated by a current from a dynamo G and by their radiation heat the gas between them. This gas may be air or the electrodes may be inclosed and surrounded by any suitable gas as shown, R being a receptacle inclosing said electrodes.

The influence of the oscillations upon the gaseous medium intervening between the electrodes P, which medium is maintained in a condition of molecular and ionic activity by the electrical means described, seems to vary the insulating quality of the gap so that while the influence of the oscillations lasts, the current of the local circuit is varied, thus affecting the indicating device T thereon to produce a signal. This may be due to ionization of the gas intervening between the electrodes which greatly increases the conductivity of said gas, said ionization being accomplished in the present instance by putting said gas in a condition of intense molecular activity.

This application is a division of my application Serial No. 243,913 filed February 2, 1905.

I claim:—

1. An oscillation responsive device comprising a receptacle inclosing a sensitive gaseous conducting medium, means for increasing the electrical conductivity of said gaseous medium, means for impressing electrical oscillations upon said medium, and means operatively connected therewith and responsive to alterations in the conductivity thereof.

2. An oscillation responsive device comprising a receptacle inclosing a sensitive gaseous conducting medium, electrical means for heating said gaseous medium, means for impressing electrical oscillations upon said medium and means operatively connected therewith and responsive to alterations in the conductivity thereof.

3. An oscillation responsive device, comprising a receptacle inclosing a gas, electrical means for rendering said gas sensitive to electrical oscillations, means for impressing electrical oscillations upon said gas and means operatively connected therewith and responsive to alterations in the conductivity thereof.

4. An oscillation responsive device comprising a receptacle inclosing a gas, electrical means for putting said gas in a condition of molecular and ionic activity, means for impressing electrical oscillations upon said gas and means operatively connected therewith and responsive to alterations in the conductivity thereof.

5. An oscillation responsive device comprising a receptacle inclosing a gaseous medium, means for rendering said gaseous medium sensitive to electrical oscillations and means for impressing electrical oscillations upon said gaseous medium.

6. An oscillation responsive device comprising a receptacle inclosing a gaseous medium, means for putting said medium in a condition of molecular and ionic activity whereby it will become the sensitive element of said oscillation responsive device, and means for impressing electrical oscillations upon said gaseous medium.

7. An oscillation responsive device comprising a receptacle inclosing a gaseous medium, electrical means for heating said medium and means for impressing electrical oscillations upon said gaseous medium.

8. An oscillation responsive device comprising a receptacle inclosing a gaseous medium, electrical means for rendering said medium sensitive to electrical oscillations and means for impressing electrical oscillations upon said gaseous medium.

9. An oscillation responsive device comprising an inclosed partially conducting gaseous medium, means for

PLAINTIFF'S EXHIBIT 327 (4) 3210

No. 867,877. PATENTED OCT. 8, 1907.

L. DE FOREST.

ART OF DETECTING OSCILLATIONS.

APPLICATION FILED JUNE 12, 1907.

Fig. 1.

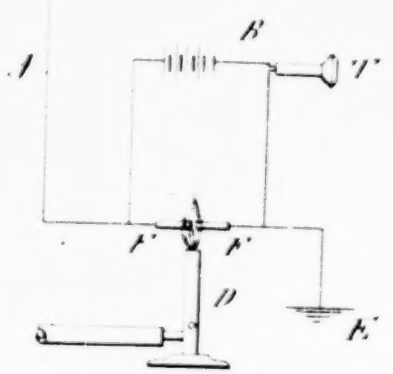


Fig. 2.

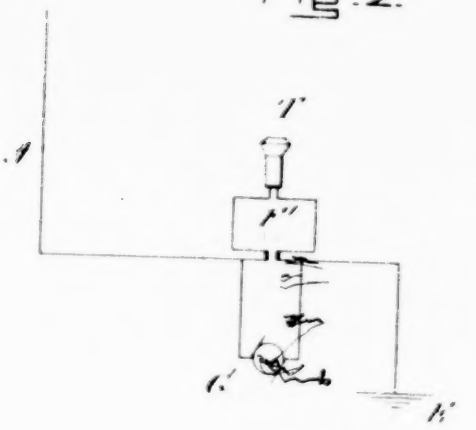


Fig. 3.

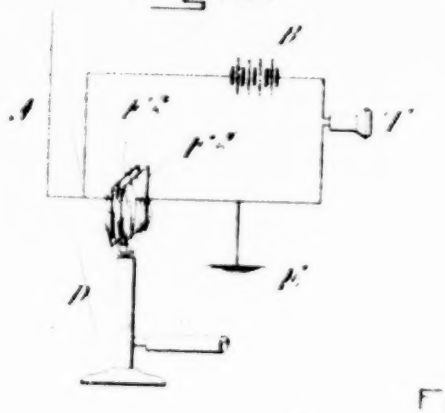


Fig. 4.

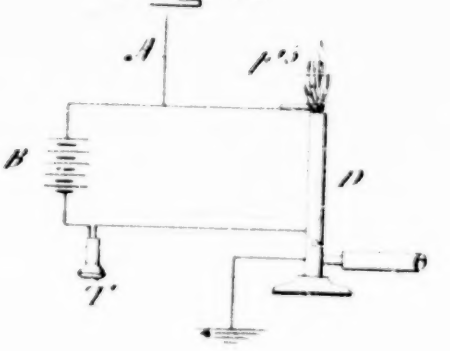
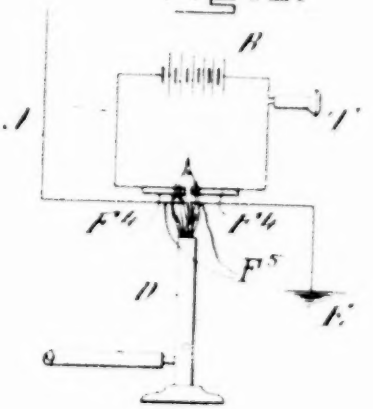


Fig. 5.



WITNESSES:

INVENTOR:
Lee de Forest
by Geo. W. Wentworth
atty.

UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y., ASSIGNOR TO GEORGE K. WOODWORTH, OF BOSTON, MASSACHUSETTS.

ART OF DETECTING OSCILLATIONS.

No. 867,877. Specification of Letters Patent. Patented Oct. 8, 1907.

Original application filed February 2, 1905, Serial No. 243,913. Divided and this application filed June 12, 1907. Serial No. 378,503.

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented a new and useful Improvement in the Art of Detecting Oscillations, of which the following is a specification.

My invention relates to an improvement in the art of receiving intelligible signals transmitted from distant stations by means of electric waves.

In the drawings which are hereto annexed and form a part of this specification, I have shown several forms of apparatus and circuit arrangements whereby my invention may be carried into effect, but it will be understood that my invention is not limited to the specific arrangements shown, as it may be variously embodied and applied.

Figure 1 is a diagrammatic view of a receiving circuit and apparatus embodying my invention. Fig. 2 is a similar view showing a modification. Fig. 3 is a similar view showing another modification. Fig. 4 is a similar view showing another modification. Fig. 5 is a similar view showing another modification. Fig. 6 is a similar view showing another modification. Fig.

...ionic activity and having dissociated and conducting ions.

I make no claim herein to the apparatus and circuit arrangements whereby my method may be carried into effect, inasmuch as such apparatus and circuit arrangements constitute the subject matter of my application Serial No. 283,913, filed Feb. 2, 1906, of which the present application is a division.

I claim:

1. As an improvement in the art of receiving electric signal waves, the method herein described which consists in establishing in a circuit a gaseous medium normally in a condition of molecular and ionic activity, impressing the electrical oscillations resulting from the waves to be received upon said gaseous medium and thereby altering the electrical condition of the circuit in which said gaseous medium forms a part and translating the resulting current variations into signal indications.

2. As an improvement in the art of receiving electric signal waves, the method herein described which consists in establishing in a circuit a gas having dissociated and conducting ions altering by the energy of the electric oscillations resulting from the waves to be received the conductive properties of said gas and translating the resulting current variations into signal indications.

32133

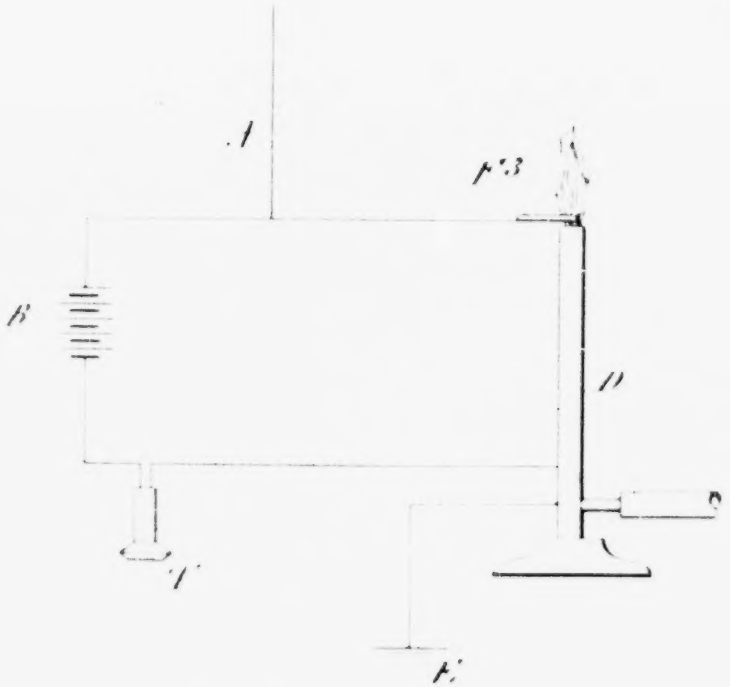
PLAINTIFF'S EXHIBIT 327 (5)

No. 867,878. PATENTED OCT. 8, 1907.

L. DE FOREST.

OSCILLATION DETECTOR.

APPLICATION FILED JUNE 12, 1907.



WITNESSES:

INVENTOR:
Lee de Forest
by Church & Church
Attys.

UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y., ASSIGNOR TO GEORGE K. WOODWORTH, OF BOSTON, MASSACHUSETTS.

OSCILLATION-DETECTOR

No. 867,878. Specification of Letters Patent. Patented Oct. 8, 1907.

Original application filed February 2, 1905, Serial No. 243,813. Divided and this application filed June 12, 1907. Serial No. 378,504.

3796

Correction in Letters Patent No. 867,878.

It is hereby certified that in Letters Patent No. 867,878, granted October 8, 1907, upon the application of Lee de Forest, of New York, N. Y., for an improvement in "Oscillation-Detectors," an error appears in the printed specification requiring correction, as follows: In line 85, page 1, the word "patent" should read *parent;* and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 29th day of October, A. D., 1907.

[SEAL.]

E. B. MOORE,

Commissioner of Patents.

3216

PLAINTIFF'S EXHIBIT 327 (6)

No. 841,386 PATENTED JAN. 15, 1907.

L. DE FOREST.

WIRELESS TELEGRAPHY.

APPLICATION FILED AUG. 29, 1900.

2 SHEETS—SHEET 1.

Fig. 1

Fig. 2

WITNESSES:

Frank L. Barton

J. Lincoln Ewer

INVENTOR:

Lee de Forest

by Brock & Woodworth

Attys.

3708

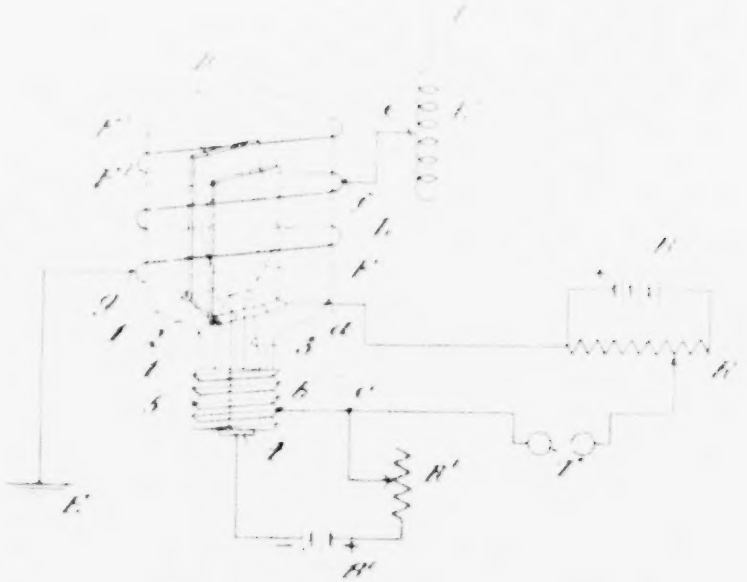


Fig. 4.

WITNESSES:
Frank L. Parker
John Ernecker

INVENTOR:
Lee de Forest
by Geo. K. Woodworth
Atty.

3218

UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y.

WIRELESS TELEGRAPHY.

No. 841,386. Specification of Letters Patent. Patented Jan. 15, 1907.

Application filed August 27, 1906. Serial No. 332,213.

To all whom it may concern.

Be it known that I, LEE DE FOREST, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented a new and useful Improvement in Wireless Telegraphy, of which the following is a specification.

My invention relates to wireless telegraphy and more particularly to an oscillation-detector which, in addition to performing the usual functions of such detectors, may be used as a tuning device and as a static valve, and which has a variety of other uses.

I have discovered that if the gaseous medium intervening between separated electrodes be put into a condition of molecular activity, as by heating the same or otherwise, said medium becomes highly sensitive to electrical oscillations, as more fully set forth in my application, Serial No. 243,913.

I have shown in my application, Serial No. 300,975, that the sensitiveness of an oscillation-detector comprising electrodes separated by such sensitive gaseous medium may be varied by the action of a magnetic field, so that the response of said detector *per se* is a function of a characteristic, such as the frequency, of the electrical oscillations operating upon the same. Thus, for certain frequencies a magnetic field of given strength will greatly decrease the sensitiveness of the detector and render it practically non-responsive, while for other frequencies the same magnetic field will greatly increase the sensitiveness of the detector. In short, said detector *per se* may be made selectively responsive without having recourse to tuned or resonant circuits, so that the use of such circuits may be dispensed with and the detector itself employed to perform the functions heretofore effected by said circuits.

The subject-matter of the present invention is an oscillation-detector which, like that above referred to, may be made selectively responsive to electrical oscillations having a given frequency or electrical rate of vibration but which does not require a proximate magnetic field for this purpose, and which also may be made selectively responsive to electrical oscillations having a given spark, or wave-train, frequency—that is to say, may be so adjusted that its response to electrical oscillations is a function of the number of groups or trains of waves per second, irrespective of the electrical frequency of such waves.

By virtue of the selective properties of my oscillation-detector as above set forth, I am enabled to employ said detector as a tuning device and also as a static valve or leak; and on account of its indestructibility I am enabled to employ the detector in those systems where large amounts of energy are created in the immediate proximity of said detector, such, for example, as the duplex systems described in my United States Letters Patent No. 772,879, dated October 18, 1904, and in the systems which permit "breaking" between two operators as set forth in my United States Letters Patent Nos. 827,523 and 827,524, dated July 31, 1906.

My invention may best be understood by having reference to the drawings which accompany and form a part of this specification and which diagrammatically illustrate four embodiments thereof which have successfully been employed; but I do not wish to limit myself to the details shown therein inasmuch as many other forms of construction and arrangement of circuits embodying the principles of my invention, as particularly pointed out in the appended claims, will readily occur to those skilled in the art.

In the drawings, Figure 1 represents a simple form of my oscillation-detector conductively connected with a receiving-antenna. Fig. 2 represents a detail of construction used in connection with the detectors shown in Figs. 1, 3 and 4. Fig. 3 represents a modification of the detector shown in Fig. 1 in which the detector is energized by an electric field developed by the oscillations to be detected. Fig. 4 represents a further modification in which the detector is energized by a magnetic field created by the oscillations to be detected.

In the figures, A is a receiving-antenna.

E is an earth connection.

M is a transformer, of which I, and I, are the primary and secondary windings.

B B' are batteries.

R R' are resistances.

L L' are inductances.

T is a telephone or other signal-indicating device.

D represents an evacuated vessel of glass or other suitable material having two separated electrodes F and F' between which intervenes the gaseous medium which, when sufficiently heated or otherwise made highly conducting, forms the sensitive element of

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...oscillation-detector. While various means may be employed for heating said gaseous medium, I find it convenient to employ electrical means and therefore I prefer to employ as the electrode F a filament of carbon or metal and to connect the same in series with a battery B and a rheostat R. I have discovered that a filament of metal especially one of platinum renders the oscillation-detector much more sensitive than one of carbon.

The electrode F may consist of a non-heated metallic body such as shown in the present instance as the wings or plates F' F'' secured to the metallic base 2, which may be supported by the upwardly extending portion 3 of the vessel D, although any suitable means may be used to support the electrodes F within said vessel.

While I have shown and described the electrode F as consisting of two wings or flat plates, it will be understood that said electrode may have any other form suitable for the purpose, although I have found that better results are obtained by using two flat plates or wings than by using a flattened cylinder or other such, a flattened cylinder gives better results than a cylinder of circular section. The reason for this is that the sensitiveness of the device, other things being equal, depends to a considerable upon the distance between the electrodes F F, and the greatest separation can be obtained by using flat plates for the electrode F. As will be obvious, the electrode F may consist of more flat plates.

The evacuated vessel D may be provided with a screw-socket 5, after the manner of ordinary incandescent lamps, and one end of the filament F may be conductively connected thereto, while the other end may be insulated therefrom and conductively connected to the contact-piece 4 in the base of the socket. In such case the terminals of the heating-battery B are connected respectively to the socket at 6 and to the contact-piece 4.

The terminals of the local circuit, which includes the battery B and signal-indicating device, such as the telephone T, are connected respectively to the electrodes F and F' at *a* and *b*. Means may be included in or associated with the local circuit for varying the potential developed by the local circuit B between the points *a* and *b*. For this purpose the number of cells which make up the battery B may be varied, or the adjustable resistance R, which, with the battery, constitutes a potentiometer, may be used.

The oscillation-detector, as above described, may be associated with the receiving system in a variety of ways now well known in the art by connecting the electrode F to one of the terminals of the source of oscillations and the electrode F' to the other terminal thereof. In the present instance the antenna A is connected to the electrode F' by a leading-in wire which is connected to the base 2 and which is sealed in the vessel D at *c*, and the earth-connector is connected to the electrode F through the socket 5 and the conductor 6*a*.

It is preferable that the positive pole of the battery B should be connected to the electrode F, and better results are obtained if the negative pole of the battery B be connected to that end of the filament F to which the positive pole of the battery B is connected, as shown in Figs. 1, 3, and 4, as that end of said filament which is connected to the screw-socket.

By regulating and adjusting the amount of heating-current flowing in the circuit of the battery B, the sensitiveness of my detector may be varied, so that the response of the detector *per se* will be a function of the frequency of the electrical oscillations operating upon the same, and said detector itself, as distinguished from the circuit in which it is included, will be selectively responsive to oscillations having a given electrical frequency. For regulating and adjusting the heating-current flowing through the filament F, I may employ the rheostat R or any other means suitable for the purpose.

For tuning the oscillation-detector to oscillations of given electrical frequency, the amplitude of the heating-current must be determined empirically, as by adjusting the rheostat R, because a number of factors such, for example, the separation of the electrodes F F, and the difference of potential developed by battery B across the points *a* *b* are involved.

By regulating and adjusting the potential impressed by the battery B across the electrodes F F', the sensitiveness of the detector may be varied so that the response of the detector *per se*, other things being equal, will be a function not only of the electrical frequency or wave length of the oscillations operating upon the detector, but also of the spark frequency which, *ceteris paribus*, is a measure of the total energy received, and the detector itself, as distinguished from a circuit tuned electrically to electrical or to spark frequency and from a mechanism tuned mechanically or acoustically to spark frequency, will be selectively responsive to oscillations having a given electrical frequency, and also to oscillations having a given spark frequency irrespective of their electrical frequency or wave length. Thus, with a given separation of the electrodes F F and a given amplitude of heating-current flowing through the filament F, I have been able by merely varying the potential of the battery B to attune the oscillation-detector to the oscillations developed in the receiving system by one of several transmitting systems and to receive the energy there-

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of to the exclusion of the energies of the oscillations developed therein by the other of said transmitting systems, even when the several sets of oscillations had the same electrical frequency and wave length, but differed in spark frequency or in average energy conveyed per unit of time. Here also the adjustment of the potential impressed by the battery B upon the electrodes F F' must be determined empirically.

By virtue of the selective properties of my detector, as above set forth, I am enabled to effect by the detector itself a method of double-tuning which affords the greatest security from waves the energy of which is not intended to affect the detector as well as from atmospheric or "static" electricity and other disturbing electrical forces.

As above mentioned, the sensitiveness of my oscillation detector, which in common with others of my invention employing a conducting gaseous medium as the sensitive element I call the "audion," is a function of the separation of the electrodes or of the length of the sensitive conducting gaseous medium; but I find that here again the frequency is a determining factor, so that by varying the separation of the electrodes I can make the response of the audion a function of the frequency. In other words, by suitably varying the length of the interelectrode medium, other adjustments, such as those of the batteries B B', remaining unchanged, I am enabled to make the audion *per se* selectively responsive to oscillations of a given frequency independently of the usual tuned or resonant circuit heretofore employed in wireless telegraphy as a current or oscillation selector.

A convenient means of varying the distance between the electrodes F F' is to hinge the wings which constitute the electrode F' to the base 2 as by the hinges 1 1. By approaching the magnets 6 6 to the inverted tube, as shown in Fig. 2, the wings, which may be made wholly or partly of iron, will open outwardly away from the filament and thereby increase the path of the conducting ions in the interelectrode medium.

When the audion is to be attuned to oscillations of a given frequency by varying the separation of the electrodes, the adjustment produced by the magnets 6 6 must be empirically determined, just as the adjustments of the batteries B B, above referred to are purely empirical.

It will be understood that each of the three methods above set forth for varying the response of the audion in accordance with the electrical frequency and the spark frequency of the oscillations to be detected may be separately employed and also that any two or all three of said methods may be used conjointly. For example, by appropriately varying the separation of the electrodes F F' and the amplitude of the heating-current from the battery B', the audion may be made selectively responsive to waves of a given electrical frequency, and then by the regulation and adjustment of the potential impressed upon the audion by the battery B, the audion may be made to select a particular one of a number of sets of waves all having the said electrical frequency and wave length, but each set having a spark frequency different from that of any other set.

The oscillation-detectors shown in Figs. 3 and 4 are identical in construction with those above described in connection with Figs. 1 and 2, and differ therefrom merely in the manner in which they are associated with the source of oscillations to be detected.

In Fig. 3, 7 represents a metallic member brought into proximity with the vessel D and shown in the present instance as a cylinder surrounding said vessel. In this case one terminal of the oscillation source which in the present instance is shown as a circuit including the secondary of the transformer M, is conductively connected to the cylinder 7 at the point *d*, while the other terminal may be connected to either one of the electrodes F or F' and in the present instance is shown as connected to the electrode F through the socket 5 and conductor *b c*. In this case the oscillating electric field developed by the electrical oscillations in the secondary circuit, which includes the secondary winding I_2, operates to alter the conducting properties of the sensitive conducting gaseous medium in the vessel D and thereby to vary the current flowing in the local circuit which includes the telephone T, just as in the case of the system shown in Fig. 1 in which the terminals of the oscillation source are connected directly to the interelectrode medium.

The arrangement shown in Fig. 3 affords a fourth method of rendering the audion selectively responsive, for in addition to the three methods above set forth in connection with Figs. 1 and 2 I find that, other things being equal, the response of the audion to oscillations of a given frequency is a function of the area of the surface of the number 7 and of the separation thereof from the elements within the vessel D.

If the form shown in Fig. 3 be employed, the cylinder 7 may be moved with respect to the axis of the vessel D until, *cæteris paribus*, the response of the audion is a maximum for oscillations of a given frequency. It will be understood of course that the separation of the electrodes F, F', and the values of the resistances R, R', of the audion shown in Fig. 3 may all be varied in the manner above explained in connection with Figs. 1 and 2.

When the connections shown in Fig. 3 are used I find that the quality of the sound produced in the telephone T is quite different

from that produced therein when the connections shown in Fig. 1 are used, although the sounds may be, and under the same conditions are, of equal intensity. When the connections shown in Fig. 1 are employed, the sounds produced by the telephone are sharp and crackling, as is the case where various other forms of oscillation-detector are employed, but when the connections shown in Fig. 3 are used, the sounds produced by the telephone, under the same conditions as before, are muffled or drummy. This latter sound is distinctive and is not produced by the use of any other form of oscillation-detector so far as I am aware. The advantage of obtaining the latter sound in the telephone is that it may readily be distinguished from the sounds produced therein by atmospheric electricity, whereas the sharp crackling sounds produced in the telephone by the signal-waves when other types of oscillation-detector are used very nearly imitate the sounds produced therein by static disturbances or atmospheric electricity.

In the arrangement shown in Fig. 4 the audion is energized by the oscillating magnetic field developed by the passage of the oscillations to be detected through the coil L, which surrounds the sensitive conducting gaseous medium and which in the present instance is wound around the outside of the tube. This coil preferably is made adjustable, as by the contacts *f* and *g*, and the antenna A may include an inductance L' having an adjusting-contact *e*. It will be understood that the adjustments of the separation of the electrodes F, F', of the amplitude of the heating-current and of the value of the potential impressed between the points *a* and *b*, as set forth above in connection with Fig. 1, may also be employed to render the audion shown in Fig. 4 selectively responsive. I have ascertained also that the variation of the magnetic field created by the passage of oscillations through the coil L varies the response of the audion, other things being the same, and furthermore that this variation also is a function of frequency. In other words, having adjusted the audion to be most responsive to oscillations of given frequency in the manner above described in connection with Fig. 1, there may be found empirically a certain position for the contacts *f* or *g*, at which for oscillations of a said frequency the response of the detector is a maximum.

The syntonizing-inductance L', or other electrical tuning device, may be employed in connection with any of the several embodiments of my present invention so as to combine the selectivity of the antenna or tuned receiving-circuit with the selective properties of the oscillation-detector itself, and in such cases I have found the selectivity of a receiving system so constructed to be very high indeed.

It will be understood that in all cases, if desired, the vessel D may include the vapor of a halogen salt or other substance the vapor of which is conducting or a gas whose conductivity is greater than that of air under an attenuated pressure.

I claim

1. An electrical-oscillation-selecting device comprising a vessel, a filament sealed in said vessel, a source of electric current connected in series with said filament, means for varying the amplitude of said current, whereby said device is rendered selective of electrical oscillations having a given electrical frequency, a member of conducting material inclosed within said vessel and a circuit connecting said member with said filament.

2. An electrical-oscillation-selecting device comprising a vessel, a filament sealed in said vessel, a source of electric current connected in series with said filament, a member of conducting material inclosed within said vessel, a circuit connecting said member with said filament, a source of electromotive force associated with said circuit and means for varying said electromotive force, whereby said device is rendered selective of electrical oscillations having a given spark frequency.

3. An electrical-oscillation-selecting device comprising a vessel, a filament sealed in said vessel, a source of electric current connected in series with said filament, means for varying the amplitude of said current, whereby said device is rendered selective of electrical oscillations having a given electrical frequency, a member of conducting material inclosed within said vessel, a circuit connecting said member and said filament, a source of electromotive force associated with said circuit and means for varying said electromotive force, whereby said device is rendered selective of electrical oscillations having a given spark frequency.

4. An electrical-oscillation-selecting device comprising a vessel inclosing a gaseous medium maintained in a condition of molecular activity; two electrodes inclosed within said vessel, and means for varying the separation of said electrodes.

5. An electrical-oscillation-selecting device comprising a vessel inclosing a gaseous medium maintained in a condition of molecular activity, two electrodes inclosed within said vessel, and means outside said vessel for varying the separation of said electrodes.

6. An electrical-oscillation-selecting device comprising a vessel, a filament sealed in said vessel, a source of electric current connected in series with said filament, a member of conducting material inclosed within said vessel, a circuit connecting said filament and said member and means for varying the separation of said filament and said member.

7. An electrical-oscillation-selecting device comprising a vessel, a filament sealed in

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said vessel, a source of electric current connected in series with said filament, and means for varying the amplitude of said current, whereby said device is rendered selective of electrical oscillations having a given electrical frequency.

8. An electrical-oscillation-selecting device comprising a vessel, a filament sealed in said vessel, a source of electric current connected in series with said filament, a member of conducting material inclosed within said vessel, a circuit connecting said filament with said member, a source of electromotive force associated with said circuit, means for varying said electromotive force and means for varying the separation of said filament and said member.

9. An electrical-oscillation-selecting device comprising a vessel, a filament sealed in said vessel, a source of electric current connected in series with said filament, means for varying the amplitude of said current, whereby said device is rendered selective of electrical oscillations having a given electrical frequency, a conductor inclosed within said vessel, a circuit connecting said conductor and filament, a source of electromotive force associated with said circuit and means for varying said electromotive force, whereby said device is rendered selective of electrical oscillations having a given spark frequency.

10. An oscillation-detector and means whereby said detector *per se* is rendered selective of electrical oscillations having a given spark frequency.

11. An oscillation-detector, means whereby said detector *per se* is rendered selective of electrical oscillations having a given electrical frequency and means whereby said detector *per se* is rendered selective to electrical oscillations having a given spark frequency.

12. An electrical-oscillation-selecting device comprising a vessel containing a sensitive conducting gaseous medium, two electrodes within said vessel, a local circuit connecting said electrodes, a receiving-circuit having one terminal connected with one of said electrodes, a conducting member outside said vessel and movable with respect thereto, and an electrical connection from the other terminal of said receiving-circuit to said conducting member.

13. An electrical-oscillation-selecting device comprising a vessel inclosing a gaseous medium maintained in a condition of molecular activity, two electrodes inclosed within said vessel, means for impressing an electrical potential upon said electrodes, and means for varying said potential.

14. An electrical-oscillation-selecting device comprising a vessel inclosing a gaseous medium, an electrode within said vessel, means for heating said electrode, means for regulating the temperature thereof, a second electrode inclosed within said vessel and a circuit connecting said electrodes.

15. An electrical-oscillation-selecting device comprising a vessel inclosing a gaseous medium, an electrode within said vessel, means for heating said electrode, means for regulating the temperature thereof, a second electrode inclosed within said vessel, means for impressing an electrical potential upon said electrodes and means for varying said potential.

16. An electrical-oscillation-selecting device comprising a vessel inclosing a gaseous medium maintained in a condition of molecular activity, two electrodes inclosed within said vessel, a local circuit connecting said electrodes and means for varying the separation of said electrodes.

17. An electrical-oscillation-selecting device comprising a vessel inclosing a gaseous medium, an electrode within said vessel, means for heating said electrode, means for varying the temperature thereof, a second electrode inclosed within said vessel and means for varying the separation of said electrodes.

18. An electrical-oscillation-selecting device comprising a vessel inclosing a gaseous medium, an electrode within said vessel, means for heating said electrode, means for varying the temperature thereof, a second electrode inclosed within said vessel, a circuit connecting said electrodes, an adjustable source of electromotive force associated with said electrodes, and means for varying the separation of said electrodes.

19. An electrical-oscillation detector comprising a vessel inclosing a gaseous medium, means for maintaining said gaseous medium in a condition of molecular activity, a member in proximity to said vessel, and an oscillation-circuit electrically connected to said member and to said gaseous medium.

20. An electrical-oscillation-selecting device comprising a vessel inclosing a gaseous medium, means for heating said medium, and means for varying the temperature thereof, whereby said device is rendered selective of electrical oscillations having a given electrical frequency.

21. An oscillation-detector comprising two conductively-connected flat plates of conducting material inclosed within an evacuated vessel, an electrode sealed within said vessel and located between said plates, and means for heating said electrode.

22. An oscillation-detector comprising two conductively-connected flat plates of conducting material inclosed within an evacuated vessel, a metallic filament sealed within said vessel and located between said plates, and means for heating said filament.

23. An oscillation-detector comprising two conductively-connected flat plates of con-

ducting material inclosed within an evacuated vessel, a filament of tantalum sealed within said vessel and located between said plates, and means for heating said filament.

24. An oscillation-detector comprising two flat plates of conducting material inclosed within an evacuated vessel, an electrode sealed within said vessel and located between said plates, and means for heating said electrode.

25. An oscillation-detector comprising two flat plates of conducting material inclosed within an evacuated vessel, a filament sealed within said vessel and located between said plates, and means for heating said filament.

In testimony whereof I have hereunto subscribed my name this 24th day of August, 1906.

LEE DE FOREST

Witnesses:
GEO. E. TERRY,
GEO. K. WOODWORTH.

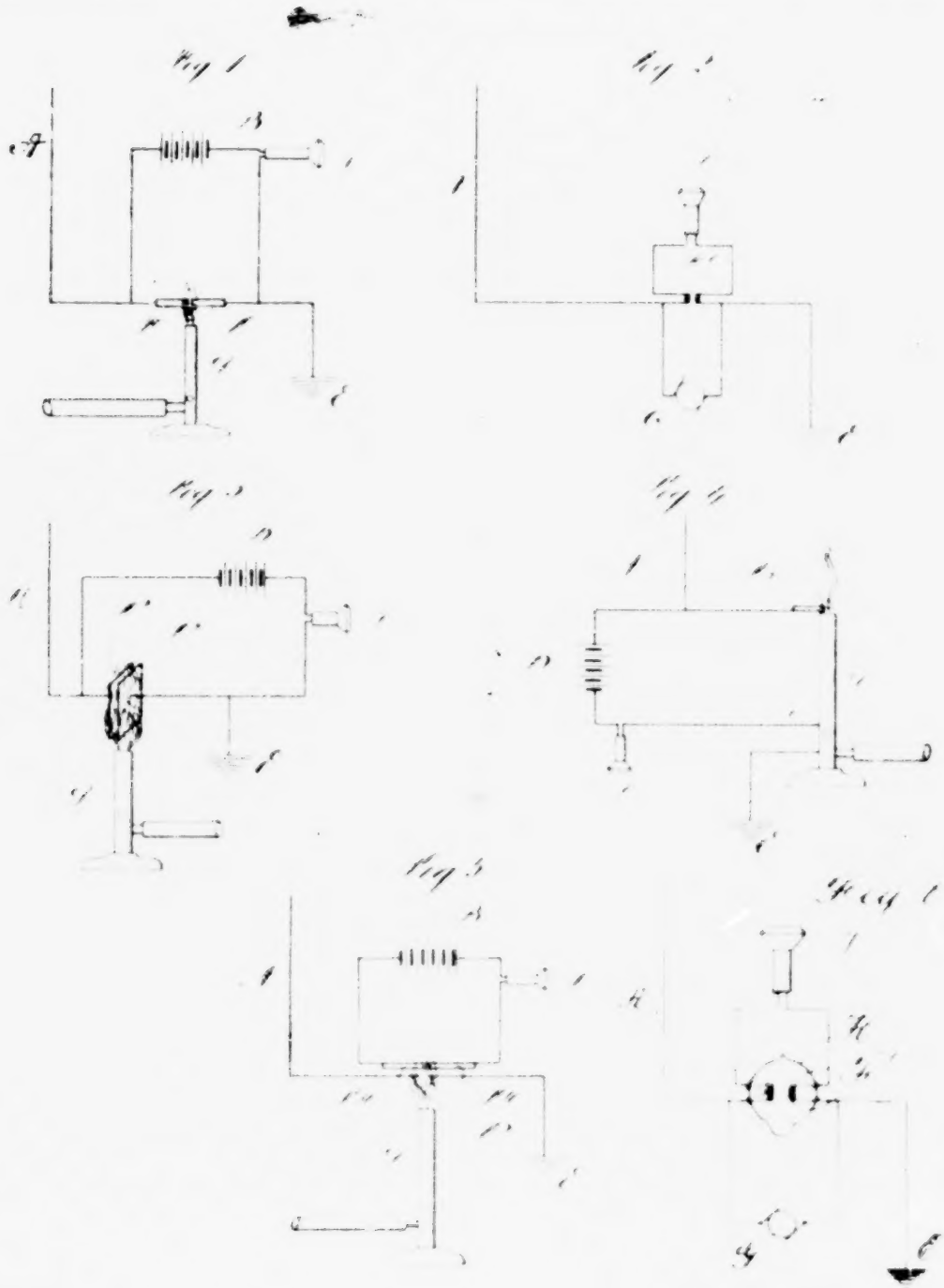
PLAINTIFF'S EXHIBIT 327 (7) 1221

L. DE FOREST.

OSCILLATION RESPONSIVE DEVICE.

APPLICATION FILED FEB 2 1905

979,275. Patented Dec. 20, 1910.



WITNESSES

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OSCILLATION-RESPONSIVE DEVICE.

979,275. Specification of Letters Patent. Patented Dec. 20, 1910.

Application filed February 2, 1905. Serial No. 243,913.

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States of America, and a resident of the borough of Manhattan, city, county, and State of New York, have invented certain new and useful Improvements in Oscillation-Responsive Devices, the principles of which are disclosed in the following specification and accompanying drawings, which explain the form of the invention which I now consider to be the best of the various forms in which the principles of the invention may be embodied.

My invention relates to an improvement in the sensitive member used in systems of wireless telegraphy to detect the electrical waves or oscillations and comprises the novel devices hereinafter shown and described and particularly pointed out in the claims.

In the accompanying drawings I have shown, and in the description thereof will point out, certain forms of construction which may be employed in carrying out my invention and in connection therewith I will point out the principle of my invention.

Although by no means all the known or possible embodiments of my invention are herein illustrated or described, sufficient are given to make clear the principle of my invention.

Figures 1 to 6 inclusive each represents a receiving set for a wireless telegraph system, each having a sensitive member differing in appearance but all embodying the principle of my invention.

I have discovered that if two bodies adapted for use as electrodes or conductive members be electrically separated partially or fully, after the manner common in ataloguing devices, the separation between them may be neutralized sufficiently to enable them to act as a detector of electrical oscillations, if the intervening or surrounding gaseous medium be put into a condition of molecular activity, such for instance as would be caused by heating it in any manner, as by radiation, conduction, or by the combustion of gases in the space which surrounds the poles. Such condition or molecular activity causes what would otherwise be a non-sensitive device to become sensitive to the reception of electrical influences. I am thus enabled to employ as such sensitive member, devices which would otherwise be of no value, or to make those devices now used more sensitive to the electrical waves. This principle is embodied in the apparatus illustrated in the various figures shown.

In each of these figures, A represents the antenna or receiving conductor, or wave intercepting means; E, the earth connection; F, F', F'', F''', F'''', and F''''', the electrodes used in their various forms; B the local battery; and T, the receiving or indicating instrument, which is herein shown as a telephone receiver, the same being shown only as typical of any form of indicating apparatus capable of being employed for such purposes.

In Fig. 1 the two electrodes F, F, are slightly separated and are within the flame of an ordinary Bunsen burner D. Under these conditions the electrodes may be adjusted so that there is normally no indication of a passing current given by the receiving instrument, such as the telephone T. The electrical separation of the electrodes is however insufficient to prevent electrical oscillations from jumping the gap. The influence of these oscillations upon the heated gas seems to break down or lower the insulating quality of the gap, so that, while the influence of the oscillations lasts, the current of the local circuit may pass between the electrodes, thus affecting the indicating instrument therein to produce a signal. This may be due to ionization of the gases surrounding the electrodes which greatly increases their conductivity, said ionization being more or less accomplished or greatly facilitated by their previous heating which has already put them into a condition of intense molecular activity.

In Fig. 2 the electrodes F', F', are of sufficiently great resistance to be heated by a current from a dynamo G, and by their radiation heat the gas between them. This gas may be air or the electrodes may be inclosed and surrounded by any suitable gas as shown, for example, in Fig. 6 in which said electrodes are inclosed in the receptacle H. The heating of the gas may also be by radiation from the electrodes F', F'.

In Fig. 3, the electrodes assume the form of two parallel plates F'', F'' which are heated by a Bunsen burner. Although I have shown a Bunsen burner for this purpose, this particular heating device is not essential, as any means of heating may be employed.

In Fig. 4 the burner itself is made one

of the electrodes, the other of which is shown at F^3.

In Fig. 5 the local circuit is provided with electrodes F^4, F^4, and the oscillation-receiving circuit with separate electrodes F^5, F^5, both being heated by the flame of the Bunsen burner. The effect in this case is the same as before stated, that is the passage of the oscillations enables the current of the local circuit to jump the gap between the electrodes F^4, F^4 and thus to operate the receiving instrument. The oscillations apparently ionize the gas and thus temporarily reduce its insulating power or in other words increase its conductivity and enable the current of the local circuit to overcome the resistance between its poles. The action described may be effected by controlling the composition of the gases between and surrounding the electrodes or poles of the sensitive member. As an instance of this the addition of sodium or salts of the halogen class in the flame increases the ionization and conductivity of the gases and increases the sensitiveness of the device. Such control of the gases I consider to be within the scope of my invention.

While I have shown and described various means for securing this result I am aware that not all the possible means have been mentioned. Sufficient have however been described to indicate of what my invention consists. Any means for producing a heated gas with properly dissociated and conducting ions may be used.

I claim:

1. In a wireless telegraph system, the combination with separated electrodes connected to a wave intercepting means and to a local circuit, said electrodes being separated by a dielectric; of means coöperating with the received electrical oscillations for causing abnormal molecular activity in the intervening dielectric.

2. In a wireless telegraph system, the combination with separated electrodes connected to wave intercepting means and to a local circuit, said electrodes being separated by a dielectric; of means other than the received electrical oscillations, for heating the intervening dielectric.

3. In a wireless telegraph system, the combination with separated electrodes connected to a wave intercepting means and to a local circuit, said electrodes being separated by a dielectric; of a flame in the intervening dielectric.

4. In a wireless telegraph system, the combination with separated electrodes connected to a wave intercepting means and to a local circuit, said electrodes being separated by a dielectric; of means other than the received electric oscillations for changing the insulating quality of the intervening dielectric for the current of the local circuit.

5. In a wireless telegraph system, the combination with separated electrodes connected to a wave intercepting means and to a local circuit, said electrodes being separated by a dielectric; of means other than the received electrical oscillations, for changing the conductivity for the current of the local circuit, of the intervening dielectric.

6. In a wireless telegraph system, the combination with separated electrodes connected to a wave intercepting means and to a local circuit, said electrodes being separated by a dielectric; of a flame in the intervening dielectric, and a substance in the flame for increasing the conductivity of the gases.

7. In a wireless telegraph system, the combination with separated electrodes connected to a wave intercepting means and to a local circuit, said electrodes being separated by a dielectric; of means other than the received electrical oscillations, for maintaining a heated gas in the dielectric.

8. A sensitive detector for electrical oscillations, which comprises two electrodes and means for maintaining a heated gas therebetween.

9. A sensitive detector for electrical oscillations, which comprises two electrodes separated by a flame.

10. The combination with a detector of electrical oscillations, having separated electrodes, of means for maintaining between said electrodes, media in abnormal molecular activity.

11. The combination with a detector of electrical oscillations, having separated electrodes, of means for heating the intervening medium, and a substance in such heated medium which increases the conductivity thereof.

12. In a system of wireless or space telegraphy, the combination with intercepting means at a receiving station for intercepting electric waves transmitted through space from a transmitting station, of a detector in coöperative relationship with said wave intercepting means, for detecting the feeble oscillations caused by the intercepted waves to traverse said wave intercepter; a local circuit in coöperative relationship with said detector; an indicating device and a source of electromotive force coöperatively associated with said local circuit; said detector comprising two electrodes separated by an intervening di-electric, whereby both the received oscillations traversing said wave intercepting means and said local source of electromotive force, are normally inoperative with respect to said detector and indicating device; and means for establishing a heated gas in the space of separation between the electrodes of said detector, to permit the received oscillations to traverse such space and to thereby cause the local circuit of the local source of electromotive force to

operate said indicating device when oscillations are caused in the wave intercepting means by transmitted waves.

15. In a system of wireless or space telegraphy, the combination with intercepting means at a receiving station for intercepting electric waves transmitted through space from a transmitting station, of a detector in cooperative relationship with said wave intercepting means, for detecting the feeble oscillations caused by the intercepted waves to traverse said wave intercepter; a local circuit in cooperative relationship with said detector; an indicating device and a source of electromotive force cooperatively associated with said local circuit; said detector comprising two electrodes separated by an intervening dielectric, whereby both the received oscillations traversing said wave intercepting means and said local source of electromotive force, are normally inoperative with respect to said detector and indicating device; a gas burner, and means for conveying a supply of gas thereto, said burner being arranged so that its flame will intervene in the space of separation between the electrodes of said detector, to permit the received oscillations to traverse such space and to thereby cause the local circuit of the local source of electromotive force to operate said indicating device when oscillations are caused in the wave intercepting means by transmitted waves.

16. In a system of wireless or space telegraphy, the combination at a receiving station with intercepting means at a receiving station for intercepting electric waves transmitted through space from a transmitting station, of a detector in cooperative relationship with said wave intercepting means, for detecting the feeble oscillations caused by the intercepted waves to traverse said wave detector; a local circuit in cooperative relationship with said detector; an indicating device and a source of electromotive force cooperatively associated with said local circuit; said detector comprising two electrodes separated by an intervening dielectric, whereby both the received oscillations traversing said wave intercepting means and said local source of electromotive force, are normally inoperative with respect to said detector and indicating device; a burner, and means for conveying a supply of combustible matter thereto, said burner being arranged so that its flame will intervene in the space of separation between the electrodes of said detector to permit the received oscillations to traverse such space and to thereby cause the local circuit of the local source of electromotive force to operate said indicating device when oscillations are caused in the wave intercepting means by transmitted waves.

17. In a system of wireless or space telegraphy, the combination with intercepting means at a receiving station for intercepting electric waves transmitted through space from a transmitting station, of a detector in cooperative relationship with said wave intercepting means, for detecting the feeble oscillations caused by the intercepted waves to traverse said wave intercepter; a local circuit in cooperative relationship with said detector; an indicating device and a source of electromotive force cooperatively associated with said local circuit; said detector comprising two electrodes separated by an intervening dielectric, whereby both the received oscillations traversing said wave intercepting means and said local source of electromotive force, are normally inoperative with respect to said detector and indicating device; and means for establishing a heated gas in the space of separation between the electrodes of said detector, to permit the received oscillations to traverse such space and to thereby cause the local circuit of the local source of electromotive force to operate said indicating device when oscillations are caused in the wave intercepting means by transmitted waves; and a substance in said space of separation, which cooperates with the heated gas to increase the conductivity thereof.

16. In a system of wireless or space telegraphy, the combination at a receiving station with a detector of feeble oscillations caused by transmitted electromagnetic waves; of a circuit for said detector, which includes a source of electromotive force and an indicating device; said detector comprising two electrodes separated by an intervening dielectric, whereby both the received oscillations and source of electromotive force are normally inoperative with respect to said detector and indicating device; and means for establishing a heated gas in the space of separation between the electrodes of the detector, to permit the received oscillations to traverse said space and to thereby cause the circuit of the source of electromotive force to operate said indicating device when oscillations are received.

17. The combination with a detector of electrical oscillations of space telegraphy, said detector having electrodes separated by a dielectric, of means for heating the intervening dielectric, and a substance in said intervening dielectric which cooperates with said heating means to increase the conductivity of said dielectric.

18. An oscillation responsive device comprising a gaseous medium, means for increasing the electrical conductivity of said gaseous medium, means for impressing electrical oscillations upon said medium, and means operatively connected to said medium and responsive to alterations in the conductivity thereof.

19. An oscillation responsive device com-

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prising a gas, means for putting said gas in a condition of molecular activity, means for impressing electrical oscillations upon said gas and means operatively connected therewith and responsive to alterations in the conductivity thereof.

20. An oscillation responsive device comprising a gaseous medium and means for heating said medium.

21. An oscillation responsive device comprising a gaseous medium and means for putting said medium in a condition of molecular activity.

22. An oscillation responsive device comprising a sensitive gaseous conducting medium containing a halogen salt.

23. An oscillation responsive device comprising a sensitive gaseous conducting medium containing a halogen salt and means for heating said medium.

24. An oscillation responsive device comprising a sensitive gaseous conducting medium containing a sodium salt.

25. An oscillation responsive device comprising a sensitive gaseous conducting medium containing a sodium salt and means for heating said medium.

26. An oscillation responsive device comprising a sensitive gaseous conducting medium containing a halogen salt and means for putting said medium in a condition of molecular activity.

27. An oscillation responsive device comprising a sensitive gaseous conducting medium containing a sodium salt and means for putting said medium in a condition of molecular activity.

28. An oscillation responsive device comprising a gaseous medium and means for rendering said gaseous medium sensitive to electrical oscillations.

29. An oscillation responsive device comprising a gaseous medium and means for increasing the conductivity of the said gaseous medium to such an extent as to render the same sensitive to electrical oscillations.

30. A self-restoring, constantly receptive oscillation responsive device comprising in its construction a sensitive conducting gaseous medium.

31. A sensitive receiving member for wireless telegraphy having two poles separated by heated gas.

32. A sensitive receiving member for wireless telegraphy having two poles and means for surrounding the same with a heated gas.

33. A sensitive receiving member for wireless telegraphy having two poles surrounded by a flame.

34. A sensitive receiving member for wireless telegraphy employing a heated gas as a part of its conductive system.

35. In a sensitive receiving member for wireless telegraphy, the combination with two separated poles, of means for producing a condition of intense molecular activity in the medium intervening between said poles.

36. The combination with a sensitive receiving member for wireless telegraphy, of two separated poles and means for surrounding said poles with a medium which is continuously in a condition of intense molecular activity.

37. The combination with a sensitive receiving member for wireless telegraphy, of means for heating the medium intervening between the poles of said sensitive member and for introducing in said medium a substance adapted to increase its conductivity.

38. A sensitive receiving member for wireless telegraphy employing a gas maintained in a condition of molecular activity as a part of its conductive system.

39. In a sensitive receiving member for wireless telegraphy, the combination with separated poles, of means maintaining a condition of molecular activity in the medium intervening between said poles.

40. A wave detector having an electro-radiant wave detecting circuit including electrodes separated by an unconfined gaseous medium.

41. A wave detector having an electro-radiant wave detecting circuit formed in part by a body of free gaseous particles.

Borough of Manhattan, city and county of New York, November 4, 1904.

LEE DE FOREST.

Witnesses:
PHILIP FARNSWORTH,
JULIET SCHWALBACH.

2810

(3229)

PLAINTIFF'S EXHIBIT 335

General. When there is a transfer of power from one circuit to another circuit, it is said that the two circuits are coupled. This transfer of power can be accomplished by electromagnetic or electric induction, or by resistance coupling. The coupling between circuits whether it is resistance, electromagnetic (inductive), or electric (capacitive), is divided into two classes, i.e., the direct and the indirect coupling.

Direct coupling refers to circuits where the coupling element is common to both circuits, whether it is an inductance, a capacity or a resistance. See figures 144, 145 and 146.

Fig. 144.—Direct Coupling by Inductance

Fig. 145.—Direct Coupling by Capacity.

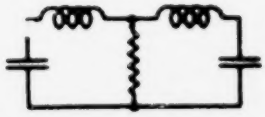


Fig. 146.—Direct Coupling by Resistance.

Indirect coupling is accomplished between circuits by magnetically coupling the inductances of each circuit or by capacitive coupling using condensers between the circuits, as shown in figures 147 and 148.

Fig. 147.

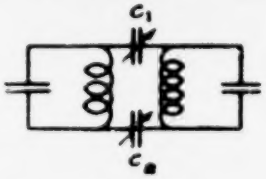


Fig. 148.

In figure 147, the transfer of power is accomplished magnetically and this power is proportioned to the distance between the two inductances, the closer the inductances the greater the transfer, while the farther apart the inductances are, the smaller the transfer. In other words, the closer the inductances the greater the electromagnetic induction while the farther apart the inductances are the smaller the electromagnetic induction.

32230

Figure 148 shows a method of indirectly coupling circuits by capacities. An increase in the value of the coupling capacities (C_1 and C_2) will increase the amount of power transferred from one circuit to another, while a decrease will reduce the power transfer.

In both methods of indirect coupling referred to, it is customary to refer to the condition of maximum power transfer as tight coupling and the condition of minimum power transfer as loose coupling. Coupling and coefficient of coupling are explained in detail in Chapter 7, Part 2.

If the coupling between two circuits is small, the two circuits will be resonant to one frequency but if the coupling is increased, both circuits, due principally to the effect of mutual inductance, will no longer be resonant to the original frequency, but will be resonant to two frequencies, one frequency being lower than the original frequency and the other being higher than the original frequency. With loose coupling it is possible to have each circuit resonant to one frequency, while if the coupling is tightened or increased in value, each circuit will be resonant to two frequencies.

The difference in frequencies referred to is dependent on the degree of coupling.

Figure 149 shows the resonance curve for a typical circuit when loosely coupled to another circuit, while figure 150 shows the same circuit under influence of a tight coupling.

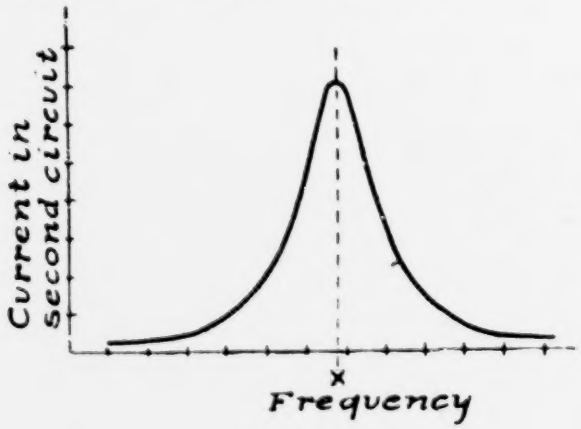


FIG. 149

In figure 149, X represents the resonant frequency of the circuit while X_1 and X_2 in figure 150 are the two frequencies to which the circuit is resonant when affected by tight coupling.

The question naturally arises why are the circuits resonant to two frequencies? The two circuits are resonant to two frequencies because of the fact that the mutual inductance of the circuits momentarily adds or subtracts from the inductance of each circuit.

The value of the inductance in each circuit varies momentarily and the circuits are resonant to two frequencies. The difference in

2812

the two frequencies depends on the value of mutual inductance or in other words on the coupling between the circuits. This may be represented

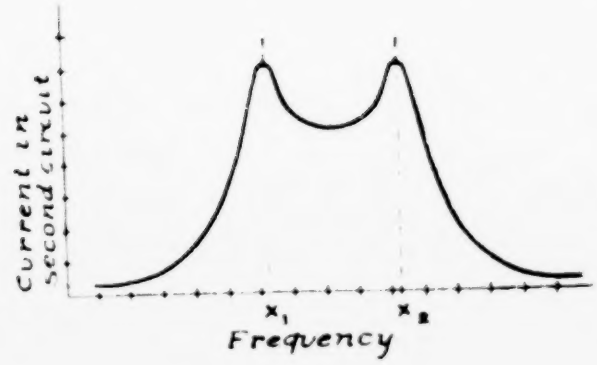


Fig. 150

by the following $L\,C$ equations which, in turn, have a definite relation to the frequency and wave length to which the circuits are resonant.

For loose coupling $$f = \frac{1}{2\pi\sqrt{L\,C}}$$

For tight coupling $$f_1 = \frac{1}{2\pi\sqrt{(L+M)\,C}}$$

and

$$f_2 = \frac{1}{2\pi\sqrt{(L-M)\,C}}$$

where

$$M = k\sqrt{L_1\,L_2}$$

L_1 being inductance of one circuit and L_2 the inductance of the other circuit.

When the coefficient of coupling is known, the two periods of resonance of the coupled circuits are found by the following:

$$\lambda_1 = \lambda\sqrt{1+k}$$

and

$$\lambda_2 = \lambda\sqrt{1-k}$$

where λ is the wave length to which the circuit is resonant to when acting singly, or very loosely coupled.

This phenomena of coupling and resonance of the circuits produces an effect in a spark transmitter where signals on two wave lengths are transmitted when tight or medium coupling is resorted to. In vacuum-tube or other undamped transmitters, although the two resonant fre-

[fol. 2814] PLAINTIFF'S EXHIBIT 343

At a Stated Term of the United States District Court for the Eastern District of New York, held in the Post Office Building in the Borough of Brooklyn, City of New York, on the 6th day of April, 1914.

Present: Hon. Van Vechten Veeder, United States Judge.

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA,
Complainant,

vs.

NATIONAL ELECTRIC SIGNALING COMPANY, Defendant

In Equity No. DE 31. On Marconi Patent No. 763,772

This cause having come on to be heard at final hearing upon pleadings and proofs taken and filed on behalf of both parties herein, and counsel for the respective parties having been heard, and due consideration having been had, it is, upon motion of Sheffield Bentley & Betts, solicitors for the complainant Ordered, Adjudged and Decreed as follows:

1. That Letters Patent of the United States in suit, issued to Guglielmo Marconi on June 28, 1904, No. 763,772, for "Apparatus for Wireless Telegraphy", are good and valid in law as to the 1st, 2nd, 3rd, 6th, 8th, 10th, 11th, 12th, 13th, 14th, 16th, 17th, 18th, 19th, and 20th claims thereof, which are as follows:

"1. At a station employed in a wireless telegraph system, a signaling instrument comprising an induction coil, the secondary circuit of which includes a condenser discharging [fol. 2815] through a means which automatically causes oscillations of the desired frequency; an open circuit electrically connected with the oscillation-producer aforesaid and a variable inductance included in the open circuit, substantially as and for the purpose described.

"2. At a station employed in a wireless-telegraph system, an oscillation-receiving conductor, a variable inductance connected with said conductor; a wave-responsive device electrically connected with said conductor and in circuit with a condenser, substantially as and for the purpose described.

"3. At a station employed in a wireless-telegraph system, a signaling instrument comprising an induction-coil, the secondary circuit of which includes a condenser discharging through a means which automatically causes oscillations of the desired frequency, and the primary circuit of which includes a generator; means for varying the primary circuit; an open circuit electrically connected with the oscillation-producer aforesaid, and a variable inductance included in the open circuit, substantially as and for the purpose described.

"6. At a transmitting station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating conductor at one end and capacity at the other end, and whose primary is connected to a condenser-circuit discharging through a means which automatically causes oscillations of the desired frequency, and means for adjusting the oscillation period of each of the two circuits connected with the transformer to bring them into accord with each other, substantially as described.

"8. At a transmitting-station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating-conductor at one end and capacity at the other end, a variable inductance being included in said circuit, and whose primary is connected to a condenser-circuit discharging through a means which automatically causes oscillations of the desired frequency, substantially as described.

"10. A system of wireless telegraphy, in which the transmitting station and the receiving station each contains an oscillation transformer, one circuit of which is an open circuit and the other a closed circuit, the two circuits at each station being in electrical resonance with each other and in electrical resonance with the circuit at the other station, substantially as described.

[fol. 2816] "11. In apparatus for communicating electrical signals, the combination, with an oscillation transformer, at a transmitting station, of an induction coil; an electric circuit containing the secondary of said coil, a condenser and the primary coil of the oscillation transformer; a producer of electric waves of high frequency electrically connected with the secondary of the induction-

coil; a signaling instrument in circuit with the primary of the induction-coil; the secondary coil of the oscillation-transformer electrically connected, at one end to capacity and at the other end to an inductance, and an aerial conductor connected to the inductance, substantially as and for the purpose described.

"12. In apparatus for communicating electrical signals, the combination, with an oscillation-transformer, at a transmitting-station, of an induction-coil; an electric circuit containing the secondary of the said coil, a condenser and the primary coil of the oscillation-transformer; a producer of electric waves of high frequency connected with the secondary of the induction coil; a signaling instrument in circuit with the primary of the induction-coil; the secondary coil of the oscillation-transformer electrically connected, at one end to capacity and, at the other end, to a variable inductance, and an aerial conductor connected to the variable inductance, substantially as and for the purpose described.

"13. At a receiving station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a variable inductance being included in said circuit, a wave-responsive device electrically connected with the other windings of the oscillation-transformer, and a condenser in circuit with the wave-responsive device, substantially as described.

"14. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and means for adjusting the two transformer-circuits in electrical resonance with each other, substantially as described.

"16. At a receiving-station, employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at [2817] one end and capacity at the other end, an adjust-

able condenser in a shunt connected with the open circuit and around said transformer coil, a wave responsive device electrically connected with the other coil of the oscillation-transformer, and means for adjusting the two transformer-circuits in electrical resonance with each other, substantially as described.

"17. At a receiving station employed in a wireless telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a wave responsive device electrically connected with the other winding of the oscillation transformer, and means included in each of said transformer circuits, for adjusting said circuits in electrical resonance with each other, substantially as described.

"18. At a receiving-station employed in a wireless telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end, and capacity at the other end, a variable inductance being included in said open circuit, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and a variable inductance included in circuit with the wave responsive device, substantially as described.

"19. In a system of wireless telegraphy, the combination at a receiving-station, of an oscillation-transformer; an open circuit comprising, in part, an aerial conductor connected with one end of the primary coil of the oscillation transformer; a connection from the other end of said coil to capacity; a variable inductance in said open circuit; and electrical connections from the secondary coil of the oscillation-transformer to a receiving instrument, battery, condenser, wave responsive device and a variable inductance, substantially as and for the purpose described.

"20. In a system of wireless telegraphy, a transmitting-station containing an oscillation transformer, the primary of which is connected to a condenser-circuit discharging through a spark-gap which automatically causes electric waves of the desired frequency, the secondary of said transformer connected to an open circuit including a radiating-conductor, and with a capacity and a coil for charging the

condenser aforesaid; a receiving-station containing an oscillation-transformer, the primary of which is connected with an oscillation-receiving conductor and with a capacity, a wave-responsive device connected with the secondary of said transformer, and a receiving instrument connected [fol. 2818] with the wave-responsive device, all in combination with means for bringing the four transformer-circuits, two at each station, into electrical resonance with each other, substantially as described."

2. That the complainant, Marconi Wireless Telegraph Company of America, is the sole and exclusive owner of said Letters Patent.

3. That the said Guglielmo Marconi was the first, true, original and sole inventor of the inventions described in said Letters Patent and claimed in said claims 1, 2, 3, 6, 8, 10, 11, 12, 13, 14, 16, 17, 18, 19 and 20 of said Letters Patent No. 763,772.

4. That the defendant, National Electric Signaling Company, has infringed upon said claims 1, 2, 3, 6, 8, 10, 11, 12, 13, 14, 16, 17, 18, 19 and 20 of said Letters Patent No. 763,772, by manufacturing, selling and using, or causing to be manufactured, sold or used, apparatus containing, embodying or employing the inventions of said claims 1, 2, 3, 6, 8, 10, 11, 12, 13, 14, 16, 17, 18, 19 and 20 of said Letters Patent.

5. That the complainant do recover of the defendant the profits, gains and advantages which the defendant has derived, received, earned or made, or which it shall derive, receive, earn or make by reason of the aforesaid or any infringement of the said 1st, 2nd, 3rd, 6th, 8th, 10th, 11th, 12th, 13th, 14th, 16th, 17th, 18th, 19th and 20th claims of said Letters Patent No. 763,772, and that the complainant do recover of the defendant any and all damages which the complainant has sustained or shall sustain by reason of the aforesaid or any infringement of the said 1st, 2nd, [fol. 2819] 3rd, 6th, 8th, 10th, 11th, 12th, 13th, 14th, 16th, 17th, 18th, 19th and 20th claims of said Letters Patent No. 763,772; and it is hereby referred to Richards M. Cahoone, Esq., as a Master of this Court, to take and state an account of said gains, profits and advantages and to assess such damages and to report to the Court thereon with all con-

venient speed; and the said defendant, its directors, officers, receivers, agents and employees, are directed and required to attend before said Master from time to time as required, and to produce before him such apparatus, books, documents, vouchers, and papers, and to submit to such oral examination or otherwise as the said Master may require in connection with said accounting and the assessing of said damages.

6. That a perpetual injunction issue out of and under the seal of this Court directed to the said defendant, National Electric Signaling Company, its associates, directors, officers, receivers, attorneys, solicitors, clerks, servants, agents, workmen and employees, enjoining and restraining them and each of them from directly or indirectly making or causing to be made, using or causing to be used, selling or causing to be sold, renting or leasing to others to be used, or disposing of in any manner whatsoever, threatening to make, sell, lease or use, advertising or offering for sale, lease or use, contributing to the manufacture, sale or use [fol. 2820] in any manner whatsoever, of apparatus, devices or appliances containing, embodying or employing the inventions of said claims 1, 2, 3, 6, 8, 10, 11, 12, 13, 14, 16, 17, 18, 19 and 20 of said Letters Patent No. 763,772 or any material or substantial part thereof, or from infringing upon or violating or from contributing to the infringement or violation of said claims, or either or any of them, or any material or substantial part thereof, in any way whatsoever.

7. That the complainant do recover of the said defendant, National Electric Signaling Company, the costs and disbursements of this suit to be taxed, and that the question of increase of damages and all further questions be reserved until the coming in of the Master's report.

(sgd.) Van Vechten Veeder, United States Judge.

(Clerk's certificate attached.)

[fol. 2821] PLAINTIFF'S EXHIBIT 344

At a Stated Term of the United States District Court held in the Court Rooms in the Borough of Brooklyn, City of New York, on the 18th day of November 1914.

Present Hon. Van Vechten Veeder, U. S. Judge.

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA,
Plaintiff,

vs.

NATIONAL ELECTRIC SIGNALING COMPANY and SAMUEL M. KINTNER and HALSEY M. BARRETT, Receivers of Said Company, Defendants.

In Equity. D E 31 On Marconi Patent No. 763,772

This cause having come on to be further heard at this term of the Court, and a certified copy of the order entered in the United States Circuit Court of Appeals for the Second Circuit on November 18th, 1914, dismissing the defendants' appeal from the interlocutory decree entered herein on April 6, 1914, having been filed herein on November 18th, 1914, and it appearing that a settlement has been made between the parties hereto, it is upon consideration, the consent of both parties and the motion of Sheffield, Bentley & Betts, solicitors for the plaintiff,

Ordered, Adjudged and Decreed that the said order of the Circuit Court of Appeals be and the same hereby is made the order of this Court, and that the said interlocutory decree entered herein on April 6, 1914, and all the provisions [fol. 2822] thereof, except that directing the recovery by the plaintiff from the defendant of damages, profits, gains and advantages for the infringement of the Marconi patent in suit No. 763,772, and ordering an accounting and assessment thereof, be and hereby are affirmed and made final herein, with costs and disbursements to the plaintiff.

Van Vechten Veeder, U. S. Judge.

We hereby approve the foregoing decree as to form and consent to the entry thereof.

Sheffield, Bentley & Betts, Plaintiff's Solicitors.
Herbert G. Ogden, Defendants' Solicitor.

[fol. 2823] PLAINTIFF'S EXHIBIT 347

At a Stated Term of the United States District Court for the Southern District of New York, Borough of Manhattan, City of New York, on the 9th day of October, 1916.

Present Hon. Julius M. Mayer, U. S. D. J.

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA,

Plaintiff,

DEFOREST RADIO TELEPHONE & TELEGRAPH COMPANY and LEE DEFOREST, Defendants

In Equity No. 12-31. On Fleming aPtent No. 803,684

INTERLOCUTORY DECREE

This cause having come on to be heard at final hearing, upon the pleadings and proofs taken and filed on behalf of both parties herein, and counsel for the respective parties having been heard, and due consideration having been had, it is, upon motion of Sheffield & Betts, solicitors for the plaintiff,

Ordered, Adjudged and Decreed as follows:

1. That the plaintiff, the Marconi Wireless Telegraph Company of America, is the sole and exclusive owner of United States Letters Patent No. 803,684, to John Ambrose Fleming, dated November 7, 1905.

2. That said Letters Patent No. 803,684 to John Ambrose [fol. 2824] Fleming are good and valid in law as to the first and thirty-seventh claims thereof, which are as follows:

"1. The combination of a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for heating one of the conductors, and a circuit outside the vessel connecting the two conductors.

"37. At a receiving station in a system of wireless telegraphy employing electrical oscillations of high frequency, a detector comprising a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for heating one of the conductors, a circuit outside of the vessel connecting the two conductors, means for detecting a continuous current in the circuit, and means for impressing upon the circuit the received oscillations."

3. That the said John Ambrose Fleming was the first, true, original and sole inventor of the inventions described in said Letters Patent and claimed in said claims 1 and 37 of said Letters Patent No. 803,684.

4. That the defendant, DeForest Radio Telephone & Telegraph Company, has infringed upon said claims 1 and 37 of said Letters Patent No. 803,684, by manufacturing, selling and using, or causing to be manufactured, sold or used, apparatus containing, embodying or employing the inventions of said claims 1 and 37 of said Letters Patent.

5. That a perpetual injunction issue out of and under the seal of this Court, directed to the defendant DeForest Radio [fol. 2825] Telephone & Telegraph Company and its associates, officers, directors, attorneys, clerks, servants, agents, workmen and employees, enjoining and restraining them and each of them from directly or indirectly making or causing to be made, using or causing to be used, leasing or causing to be leased, selling or causing to be sold, advertising or offering for sale, use or lease, or causing to be advertised or offered for sale, use or lease, agreeing or contracting to sell or lease, or causing to be agreed or contracted for sale or lease, supplying or causing to be supplied, installing or causing to be installed, or threatening to make, use, lease, sell, supply or install, and threatening to offer or contract for sale, lease or supply, or disposing of in any manner, any devices, structures, appliances, instruments or wireless telegraph apparatus embodying or employing the said inventions and improvements or discoveries of the said 1st and 37th claims of said Letters Patent No. 803,684, or either of them, and from infringing upon or contributing to the infringement of said claims 1st and 37th of said Letters Patent, or either of them, in any way whatsoever.

6. That the defendant, DeForest Radio Telephone & Telegraph Company, is the sole and exclusive owner of the United States Letters Patent pleaded in the defendant's counterclaim, to Lee DeForest, as follows:

Nos. 824,637, dated June 26, 1906;
836,070, dated November 13, 1906;
837,901, dated December 4, 1906;
841,386, dated January 15, 1907;

[fol. 2826] Nos. 841,387, dated January 15, 1907;
867,876, dated October 8, 1907;
867,877, dated October 8, 1907;
867,878, dated October 8, 1907;
879,532, dated February 18, 1908, and
979,275, dated December 20, 1910.

7. That said Letters Patent No. 841,387 to Lee DeForest are good and valid in law as to the 4th and 6th claims thereof, which are as follows:

"4. In a device for amplifying electrical currents, an evacuated vessel, three electrodes sealed within said vessel, means for heating one of said electrodes, a local receiving-circuit including two of said electrodes, and means for passing the current to be amplified between one of the electrodes which is included in the receiving-circuit and the third electrode.

"6. In a device for amplifying electrical currents, an evacuated vessel, a heated electrode and two non-heated electrodes sealed within said vessel, the non-heated electrodes being unequally spaced with respect to said heated electrode, a local receiving-circuit including said heated electrode and that one of the non-heated electrodes which has the greater separation from the heated electrode, and means for passing the current to be amplified between the heated electrode and the other non-heated electrode."

8. That the said Lee DeForest was the first, true, original and sole inventor of the inventions described in said Letters Patent No. 841,387, and claimed in claims 4 and 6 thereof.

9. That said Letters Patent No. 879,532, dated February 18, 1908, are good and valid in law as to claims 2, 3, 6, 14, 18 and 21 thereof, which are as follows:

"2. An oscillation detector comprising an evacuated vessel, two electrodes inclosed within said vessel, means for heating one of said electrodes, and a conducting member inclosed within said vessel and interposed between said electrodes.

[fol. 2827] "3. An oscillation detector comprising an evacuated vessel, two electrodes inclosed within said vessel, means for heating one of said electrodes, and a grid shaped member of conducting material inclosed within said vessel and interposed between said electrodes.

"6. An oscillation detector comprising an evacuated vessel, two electrodes inclosed therein, means for heating one of said electrodes, a conducting member inclosed within said vessel and interposed between said electrodes, means for establishing a difference of electrical potential between said electrodes and means for preventing said conducting member from becoming electrically charged.

"14. An oscillation detector comprising an evacuated vessel, two electrodes, one of which is a filament, inclosed within said vessel, means for heating said filament, and a conducting member inclosed within said vessel and interposed between said electrodes.

"18. An oscillation detector comprising an evacuated vessel, two electrodes inclosed within said vessel, means for heating one of said electrodes, a grid of conducting material inclosed within said vessel and interposed between said electrodes, a local circuit including a source of electromotive force connecting said electrodes and a signal indicating device associated with said local circuit.

"21. An oscillation detector comprising an evacuated vessel, two electrodes inclosed therein, means for heating one of said electrodes, a conducting member inclosed within said vessel, a closed oscillation circuit, a circuit connecting one element of said oscillation circuit with one of said electrodes and said conducting member, a condenser in said circuit, a signal indicating device and a circuit connecting said device with the other of said electrodes and said conducting member."

10. That the said Lee DeForest was the first, true, original and sole inventor of the inventions described in said Letters Patent No. 879,532, and claimed in claims 2, 3, 6, 14, 18 and 21 thereof.

11. That a perpetual injunction issue out of and under the seal of this Court directed to the plaintiff, Marconi [fol. 2828] Wireless Telegraph Company of America, and its associates, officers, attorneys, clerks, servants, agents, workmen and employees, enjoining and restraining them, and each of them, from directly or indirectly making or causing to be made, using or causing to be used, leasing or causing to be leased, selling or causing to be sold, advertising or offering for sale, use or lease, or causing to be advertised or offered for sale, use or lease, agreeing or contract-

ing to sell or lease, or causing to be agreed or contracted for sale or lease, supplying or causing to be supplied, installing or causing to be installed, or threatening to make, use, lease, sell, supply or install, or threatening to offer or contract for sale, lease or supply, or disposing of in any manner, any devices, structures, appliances, instruments or wireless telegraph apparatus embodying or employing the said inventions and improvements or discoveries of said claims 4 and 6 of said Letters Patent No. 841,387, and claims 2, 3, 6, 14, 18 and 21 of said Letters Patent No. 879,532, or any of them, and from infringing upon or contributing to the infringement of said claims of said Letters Patent in any way whatsoever.

12. That the plaintiff, Marconi Wireless Telegraph Company of America, do recover of the defendant, DeForest Radio Telephone & Telegraph Company, the profits, gains and advantages which the defendant has derived, received, earned or made, or which it shall derive, receive, earn or make by reason of the aforesaid or any infringement of the [fol. 2829] 1st and 37th claims of said Fleming Patent No. 803,684; and that the plaintiff do recover of the defendant any and all damages the plaintiff has sustained or shall sustain by reason of the aforesaid infringement of the said 1st and 37th claims of said Fleming patent No. 803,684; and that the defendant, DeForest Radio Telephone & Telegraph Company, do recover of the plaintiff the profits, gains and advantages which the plaintiff has derived, received, earned or made, or shall derive, receive, earn or make by reason of the aforesaid or any infringement of the said 4th and 6th claims of United States Letters Patent No. 841,387 and claims 2, 3, 6, 14, 18 and 21 of United States Letters Patent No. 879,532; and that the defendant do recover of the plaintiff any and all damages which the defendant has suffered or shall sustain by reason of the aforesaid or any infringement of the 4th and 6th claims of said Letters Patent No. 841,387 and claims 2, 3, 6, 14, 18 and 21 of United States Letters Patent No. 879,532; and it is hereby referred to George C. Holt, Esq., as a Master of this Court, to take and state an account of said gains, profits, and damages, and to assess such damages and to report thereon to the Court with all convenient speed; and the said plaintiff and the said defendant and their directors, officers, agents and employees are directed and required to attend before said Master from

time to time as required and to produce before him such apparatus, books, documents and papers, and to submit to such oral examination or otherwise as the said Master may require in connection with said accounting and the assessing of said damages.

[fol. 2830] 13. That the plaintiff's bill of complaint as against the defendant Lee DeForest individually be dismissed.

14. That the defendant's counterclaim against the plaintiff upon Letters Patent No. 824,637, No. 836,070, No. 837,901, No. 841,386, No. 867,876, No. 867,877, No. 867,878, No. 979,275, and as to claim 5 of said Letters Patent No. 841,387, be dismissed.

15-a. That the plaintiff, Marconi Wireless Telegraph Company of America, do recover of the defendant, DeForest Radio Telephone & Telegraph Company, the costs and taxable disbursements incurred in defending defendants' counterclaim.

b. That the defendant, DeForest Radio Telephone & Telegraph Company, do recover of the plaintiff the costs and taxable disbursements, if any, in connection with the sustaining of claims 4 and 6 of United States Letters Patent No. 841,387 and claims 2, 3, 6, 14, 18 and 21 of United States Letters Patent No. 879,532.

c. That the defendant Lee DeForest do recover of the plaintiff the costs which he individually is entitled to recover as an individual defendant.

Julius M. Mayer, U. S. District Judge.

[Endorsed:] U. S. District Court, S. D. of N. Y. Filed Oct. 9, 1916.

[fol. 2831] PLAINTIFF'S EXHIBIT 348

UNITED STATES DISTRICT COURT, SOUTHERN DISTRICT OF NEW YORK

In Equity No. 12-31

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA,
Plaintiff,

vs.

DEFOREST RADIO TELEPHONE & TELEGRAPH COMPANY,
Defendant

And Now, To Wit, this 18th day of July, 1917, upon the return of the order of this Court dated January 22, 1917, and the motion of the plaintiff, requiring the defendant, De-Forest Radio Telephone & Telegraph Company, to show cause why the decree of this court, dated October 9, 1916, and the injunction issued in accordance therewith, restraining the defendant from infringing upon claims 1 and 37 of Fleming patent No. 803,684, do not cover and include certain devices heretofore manufactured and sold by the defendant; and upon consideration of the affidavit of Frank X. Waterman, verified January 18, 1917, filed in support of said order to show cause; and the affidavits of Lee DeForest and John Stone Stone, verified February 2, 1917, filed in opposition to said order to show cause; and the affidavits of Edwin H. Armstrong, Frank X. Waterman and Roy A. Weagant, verified April 18, 1917, filed in reply to said affidavits of DeForest and Stone and in further support of said order to show cause; and the affidavits of John Stone Stone and Robert F. Gowen, verified May 12, 1917, and of [fol. 2832] Charles V. Logwood and Walter A. Cohen, verified May 14, 1917, and of Lee DeForest, verified May 16, 1917, filed by the defendant in further opposition to the said order to show cause; and after hearing counsel for the respective parties, it is

Ordered, Adjudged and Decreed that, in addition to the devices or apparatus heretofore manufactured and sold by the defendant, and decreed to be an infringement of claims 1 and 37 of the Fleming patent in suit, that the devices or apparatus called by the defendant "amplifiers",

which have been manufactured and sold by the defendant separately, as well as the devices or apparatus which the defendant has manufactured and sold comprising "amplifiers" alone or in combination with other apparatus or instruments, are infringements of claims 1 and 37 of the Fleming patent in suit; and that any bulbs embodying claims 1 and 37 manufactured and sold by the defendant for use in such "amplifiers" or combination of "amplifiers" and other instruments or apparatus, are also an infringement of said claims 1 and 37 of the Fleming patent in suit, and that the injunction ordered to issue out of and under the seal of this Court by the interlocutory decree of October 9, 1916, shall cover and include each and all of such devices or pieces of apparatus, and that the defendant shall account to the plaintiff for all damages and profits which the plaintiff may be entitled to by reason of such infringing manufacture and sale, as provided for in the decree of October 9, 1916. [fol. 2833] And it is further Ordered, Adjudged and Decreed that the motion of the plaintiff with respect to the devices called by the defendant "oscillions," be and the same hereby is denied, without prejudice to the right of the plaintiff to renew said motion hereafter upon the filing of a new bill or a bill supplemental to the bill of complaint already filed. Future sales to U. S. Government are excepted from this order.

Julius Mayer, U. S. D. J.

Dated July 18, 1917.

[fol. 2834] PLAINTIFF'S EXHIBIT 349

At a stated term of the United States District Court for the Southern District of New York, held in the United States Court Rooms, in the Borough of Manhattan, City and State of New York, on the 9th day of July, 1919.

Present: Hon. Julius M. Mayer, U. S. D. J.

In Equity No. 12-31. On Fleming Patent No. 803,684

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA,
Plaintiff,

vs.

DEFOREST RADIO TELEPHONE AND TELEGRAPH COMPANY,
Defendant

This cause having come on to be further heard on the supplemental bill of complaint and answer and proofs taken

and filed on behalf of both parties herein and counsel for the respective parties having been heard and due consideration having been had, it is, upon motion of Sheffield & Betts, Solicitors for the Plaintiff,

Ordered, Adjudged and Decreed that in addition to the devices or apparatus heretofore manufactured and sold by the defendant and decreed to be an infringement of claim 1 of the Fleming patent No. 803,684, in suit, the devices or apparatus called by the defendant "oscillions" which have been manufactured and sold by the defendant separately, as well as the devices or apparatus which the defendant has manufactured and sold comprising "oscillions" alone or in combination with other apparatus or [fol. 2835] instruments are infringements of said claim 1 of the said Fleming patent in suit; and that any bulbs embodying said claim 1 manufactured and sold by the defendant for use in such "oscillions" or combination of "oscillions" and other instruments or apparatus, are also an infringement of said claim 1, of the said Fleming patent in suit; and that the injunction ordered to issue out of and under the seal of this Court by the Interlocutory Decree of October 9, 1916 and said Interlocutory Decree shall cover and include each and all of such devices or pieces of apparatus and that the defendant shall account to the plaintiff for all damages and profits to which the plaintiff may be entitled by reason of such infringing manufacture and sale as provided for in said Decree of October 9, 1916.

And It Is Further Ordered, Adjudged and Decreed that the plaintiff, Marconi Wireless Telegraph Company of America, do recover of the defendant, DeForest Radio Telephone and Telegraph Company, the costs and taxable disbursements in connection with said supplemental bill of complaint herein and the trial thereunder.

J. M. Mayer, U. S. District Judge.

It is hereby consented that the above order may be entered without further notice.

Sheffield & Betts, Plaintiff's Solicitors. Darby & Darby, Defendant's Solicitors.

[fol. 2836] PLAINTIFF'S EXHIBIT 363

House of Representatives

67th Congress, 1st Session

Report No. 173

Settlement of Damages for Infringements of Radio Patents

June 15, 1921.—Committed to the Committee of the Whole House on the state of the Union and ordered to be printed.

Mr. KAHN, from the Committee on Military Affairs, submitted the following Report. [To accompany H. R. 7111.]

The Committee on Military Affairs, to whom was referred the bill (H. R. 7111) authorizing the Secretary of War, the Attorney General, and the Secretary of the Navy jointly to make settlement of damages and compensation due by the United States for infringement of radio patents connected with the prosecution of the war, and for other purposes, having considered the same, report thereon with a recommendation that it do pass.

This bill was referred to the Committee on Military Affairs by the Speaker of the House in a communication signed, respectively, by the Secretary of War, the Attorney General, and the Secretary of the Navy, which reads as follows:

Departments of War, Justice, and Navy, *Washington, D. C., May 11, 1921.*

DEAR MR. GILLETT: We have the honor to invite attention to the situation that exists as a result of the use by the Government of patented inventions relating to radio communication and the development in that art.

Prior to the war with Germany the Government, principally the War and Navy Departments, found it necessary, because the validity of many patents relating to wireless telegraphy had not been judicially determined, to use wireless apparatus of various kinds without strict regard to the rights claimed by patentees, and during the war both departments used any and all apparatus, principles, and methods of known value without consideration of questions of infringement or proprietorship, giving where necessary

its warranty to contractors to protect them from litigation for infringement.

The development of this art has been very rapid and the patent situation with respect thereto is exceedingly complicated. There are many patents relating to the subject and a large number of claims for compensation for alleged use and infringement of patented inventions, among which there is much conflict, have been filed with the War and Navy Departments.

Realizing that the use by the Government had infringed the rights of many patentees while some of the claims possess little or no merit, and that a fair and reasonable determination of the whole matter would be difficult, long [fol. 2837] drawn out and expensive to the Government as well as to the claimants if an adjustment were not arrived at by a reasonable and business-like consideration of the interests of all parties concerned, a board designated "Interdepartmental Radio Board" was appointed by ourselves consisting of experts from the War Department, Department of Justice, and the Navy Department to consider all such claims, each with reference to its own merits and the merits of all the others. Such board has been considering the matter for nearly three years, giving all questions connected therewith careful, intelligent, and exhaustive consideration.

The claims presented to the board totaled many millions of dollars. Out of the 24 claims brought only 7 stated the amount of the compensation desired, and the total of those 7 was $14,800,000, the rest aggregating probably a much larger sum.

The board, giving due weight to matters of infringement, validity of patents, values of inventions, the circumstances of use by the Government, and the entire value of up-to-date wireless apparatus as the product of all inventions combined, has determined a sum of money that the Government should fairly and reasonably pay to the different patentees in proportion to the value of their respective inventions. Such sum will not exceed $2,500,000, which is only a small percentage of the aggregate sum claimed.

The owners of the various patents affected have been informed of the board's determination, and many or all of them have signified a willingness to accept the amounts allotted to them. The work of the board has been most pain-staking and careful, and its conclusions and determina-

tions reflect great credit upon its members. If settlement with the various patentees can be effected on the basis of the board's determination, a situation fraught with troublesome consequences would be disposed of to the great advantage of the Government and to the ultimate satisfaction of the claimants, and it is highly desirable, therefore, that provision be made for such settlements.

Therefore it is urgently recommended that the War, Justice, and Navy Departments be empowered to adjust and pay said claims on the basis of said board's determination.

Transmitted herewith is a draft of a provision that it is believed covers the matter adequately, and is suggested as an amendment to the act entitled "An act to provide relief in cases of contracts connected with the prosecution of the war, and for other purposes," approved February 2, 1919, commonly known as the Dent Act.

If at an early date payment could be tendered to all the claimants of the respective amounts found in their favor by said board, it is believed that all claimants having claims of substantial merit would accept settlement and release the Government, and it is earnestly requested that this matter be given favorable and prompt consideration by Congress.

Very sincerely, John W. Weeks, *Secretary of War.*
H. M. Daugherty, *Attorney General.* Edwin Denby, *Secretary of the Navy.*

Hon. Frederick H. Gillett, *Speaker of the House of Representatives.*

The testimony before the committee discloses the fact that during the World War it became necessary for the Government of the United States to seize radio telegraphic and telephonic appliances as a war emergency measure regardless of the rights of the patentees. The owners of these patents were given assurances that the Government would ultimately meet proper and just claims for the use of these patents.

The plan adopted and the work done during the past three years by the Departments of War, Justice, and Navy jointly reveals a most commendable and businesslike method of avoiding useless and expensive litigation and at the same time securing, on a very low basis to the Government, an adjustment of claims aggregating many millions of dollars.

The painstaking methods pursued in this instance by the

joint action of three Cabinet officers under the former administration and consummated and approved by the Secre-[fol. 2838] tary of War, the Attorney General, and Secretary of the Navy under the present administration furnish ample argument for the passage of this bill.

In the fall of 1918 the War and Navy Departments found themselves confronted with a large number of accrued and rapidly accumulating claims arising out of the necessary use by the Government of practically all the modern radio telegraphic and telephonic appliances without regard to the rights of patentees.

A large number of manufacturers were virtually ordered by the Government to furnish appliances which clearly infringed the patent rights of others, and at the same time gave assurance that the Government would assume and, at the close of the war, discharge such obligations as arose out of such infringements.

Foreseeing the intricate and expensive burden that would be imposed upon the Government if the various conflicting claims of various patentees on various instrumentalities were allowed to accumulate through a period of years, the Secretary of War, the Attorney General, and the Secretary of the Navy in the fall of 1918 appointed the "interdepartmental radio board" composed of the ablest experts in their respective departments to make a thorough investigation of all such claims then pending and likely to arise against the Government, and also to determine the relative rights of various patentees toward each other, with relation to patents on certain specific inventions, and furthermore to determine the comparative value of each patented instrument in cases where their simultaneous and joint use by the Government was found necessary. The creation of this board was also more formally verified by the precept of the three Cabinet officers on February 12, 1921. This board for more than two full years assiduously devoted itself to hearings and investigations and succeeded in reducing the claims aggregating approximately $30,000,000 to a settlement basis of $2,500,000, and beyond this all the principals to whom it finds the Government under legal obligation, have been induced to settle on this reduced basis if payment can be effected without delay.

The practical value to the Government of the plan adopted has been so pronounced that the British Government, after

studying it, has adopted it for settlement of claims of similar and other character.

During the progress of the investigation it developed that there are approximately 2,500 United States patents in this art, all of which were living during the period covered by the board. All of these have had to be considered in one way or another; if not directly as patents under which claims are made, then as to their bearing on patents under which claims were made. In addition, hundreds of foreign patents and hundreds of United States and foreign publications have been sought out and considered in relation to their effect on those patents presented in the claims.

The claimants did not know precisely just what the Government had used, and many of them brought claims under all patents, with the result that the board had to laboriously proceed through several hundred patents, pick out those under which it was evident there was no infringement; and then by hearings with claimants, long drawn out, eliminate the chaff.

The board finally came down to a real serious consideration of 149 patents. This consideration involved searches [fol. 2339] of the art, writing of long reports, receipt of briefs from claimants, hearings, more briefs, revised reports, and then an accounting on those patents considered good, which were 27 in number, with much discussion following as to the methods of accounting and the effect of decisions thereon.

Such a task has been stupendous, and has required a force of experts—expert to begin with, but which became more expert daily in its specific task as it gained knowledge from experience.

Consider the chaos that would have existed if such a task (the serious consideration of 149 patents of a difficult art) had been presented to a number of courts in different places and at different times; for a single patent could be the cause of half a dozen suits in order to reach the numerous contractors for the Government; and then, after the patents had been sustained, the long drawn out procedure of accounting in each case, each accounting duplicating in many respects accountings in other jurisdictions.

Under our judicial system, and with the extreme difficulty in presenting petent cases, it is probable that the task could not have been covered in the courts in 25 years in the same comprehensive but centralized method of the board.

The Secretary of War, the Attorney General, and the Secretary of the Navy urge these settlements without delay and request the necessary legislation.

[fol. 2840] PLAINTIFF'S EXHIBIT 364

UNITED STATES DISTRICT COURT, WESTERN DISTRICT OF WASHINGTON, NORTHERN DIVISION

No. 71. In Equity

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA,
Plaintiff,

vs.

KILBOURNE & CLARK MANUFACTURING COMPANY, Defendant

On Lodge Patent No. 609,154 and Marconi Patent No. 763,772

FINAL JUDGMENT

At a Regular Term of the United States District Court for the Western District of Washington, Northern Division, held in the Federal Building, in the City of Seattle, on the 16 day of July, 1917.

Honorable Jeremiah Neterer, United States District Judge, Presiding

This cause came on to be further heard at this term and was argued by counsel;

And thereupon, upon consideration thereof, it was Ordered, Adjudged and Decreed as follows:

1. That letters patent of the United States issued to Oliver J. Lodge on the 16th day of August, 1898, No. 609,154, during the term thereof, were good and valid in law, as to claims 1, 2 and 5 thereof.

2. That the plaintiff, Marconi Wireless Telegraph Company of America, was the sole and exclusive owner of said Letters Patent No. 609,154 during the term thereof.

3. That the said Oliver J. Lodge was the first, true, original and sole inventor of the inventions described in said [fol. 2841] letters patent and claimed in said claims 1, 2 and 5.

4. That the defendant, Kilbourne & Clark Manufacturing Company, during the term of said Letters Patent, and before its expiration, infringed upon said claims 1, 2 and 5 of said Letters Patent, by manufacturing and selling apparatus containing, embodying or employing the inventions of said claims 1, 2 and 5 of said Letters Patent No. 609,154, or material or substantial parts thereof

5. That the defendant has paid the plaintiff the sum of Four Thousand Dollars ($4000.00) in full of all claims for damages, gains and profits by reason of the aforesaid infringement of said claims 1, 2 and 5 of said Lodge Patent, including all claims against defendant's customers therefor, but exclusive of claims against the United States of America for apparatus infringing the said Lodge Patent manufactured or sold by the defendant herein for or to the United States of America, as per stipulation of the parties on file herein.

6. That the said patent having expired pending suit, no injunction shall issue restraining the said infringement.

7. That said Letters Patent of the United States issued to Guglielmo Marconi on June 28, 1904, No. 763,772, for apparatus for wireless telegraphy, are good and valid in law as to claims 1, 2, 3, 6, 8, 10, 11, 12, 13, 14, 16, 17, 18, 19 and 20, when properly construed in connection with the apparatus described in the specification of said patent, as more fully appears in the opinion herein filed.

8. That the plaintiff, Marconi Wireless Telegraph Company of America, is the sole and exclusive owner of said [fol. 2842] Letters Patent No. 763,772.

9. That the said Guglielmo Marconi was the first, true, original and sole inventor of the inventions described in said Letters Patent and claimed in the said claims 1, 2, 3, 6, 8, 10, 11, 12, 13, 14, 16, 17, 18, 19 and 20 thereof.

10. The manufacture and sale by the defendant of *of* its wireless apparatus known as the "Thompson Transmitter", the "Simpson Transmitter", and its Standard Receiver, or

either of them, as set forth, shown and described in the proofs herein, does not infringe upon the inventions described in said Letters Patent No. 763,772, and claimed in said claims 1, 2, 3, 6, 8, 10, 11, 12, 13, 14, 16, 17, 18, 19 and 20 thereof, or any of them.

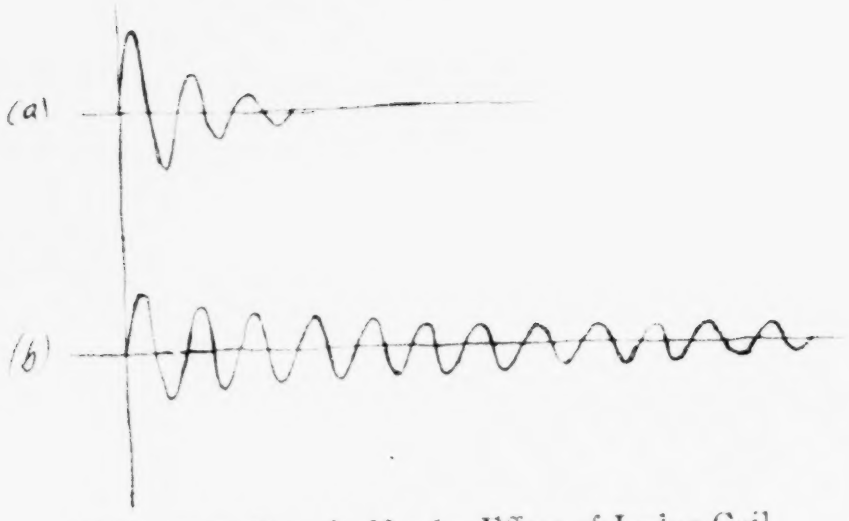
11. In view of the Act approved June 25, 1910, entitled "An Act to Provide Additional Protection for Owners of Patents of the United States and for Other Purposes", the Court has no jurisdiction to grant the prayer of the bill for an injunction and an accounting in respect to the wireless telegraph apparatus manufactured and sold by the defendant to the United States Government, a set of which was installed on the Steamship "Achilles", and the Court, therefore, makes no finding upon the question of whether said apparatus infringes the patent in issue.

12. That the prayer of the bill, so far as it seeks an injunction and an accounting in respect to defendant's said wireless telegraph apparatus installed on the Steamship "Achilles" as an infringement of each of the aforesaid claims of the said Lodge Patent No. 609,154 and Marconi [fols. 2843-2844] Patent No. 763,772, and so far as it relates to an injunction and an accounting in respect to the defendant's aforesaid "Thompson Transmitter", "Simpson Transmitter" and its Standard Receiver as infringements of each of the aforesaid claims of Marconi Patent No. 763,772, be and hereby is denied, and the bill of complaint, so far as it relates to such apparatus as infringements of said claims be and hereby is dismissed.

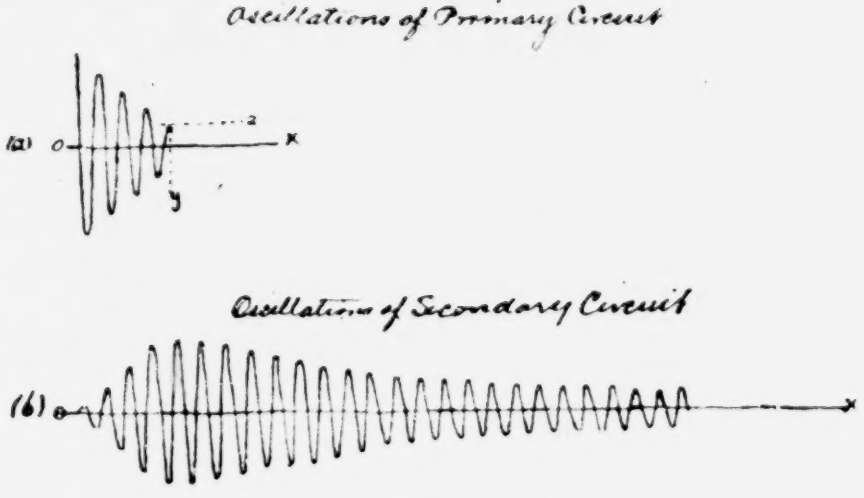
14. That no costs or disbursements heretofore incurred by either plaintiff or defendant in this proceeding be allowed or taxed in favor of either party hereto.

To paragraphs No. 10, 11, and 12 hereof, and each thereof, the plaintiff excepts, and said exceptions are hereby allowed.

Jeremiah Netterer, United States District Judge.

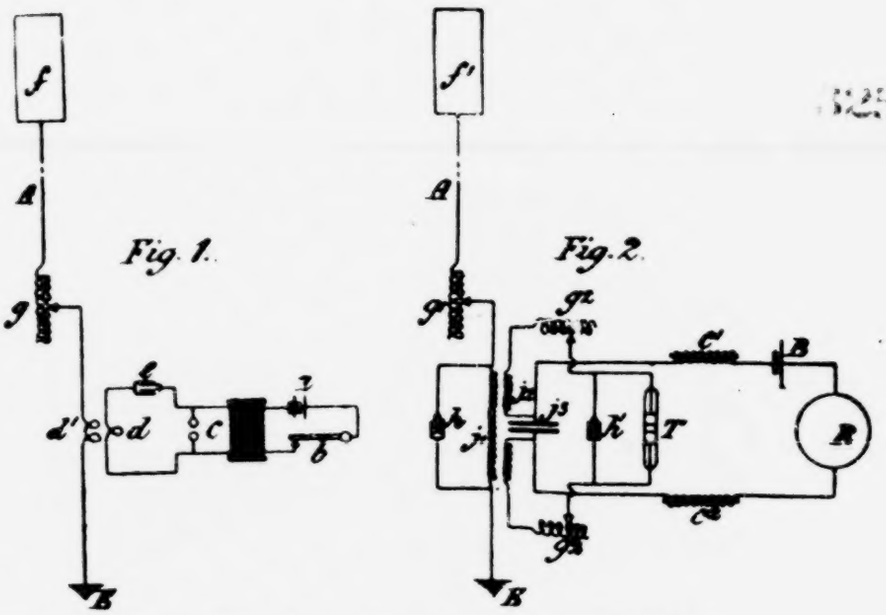


Waterman Sketch, No. 1—Effect of Lodge Coil

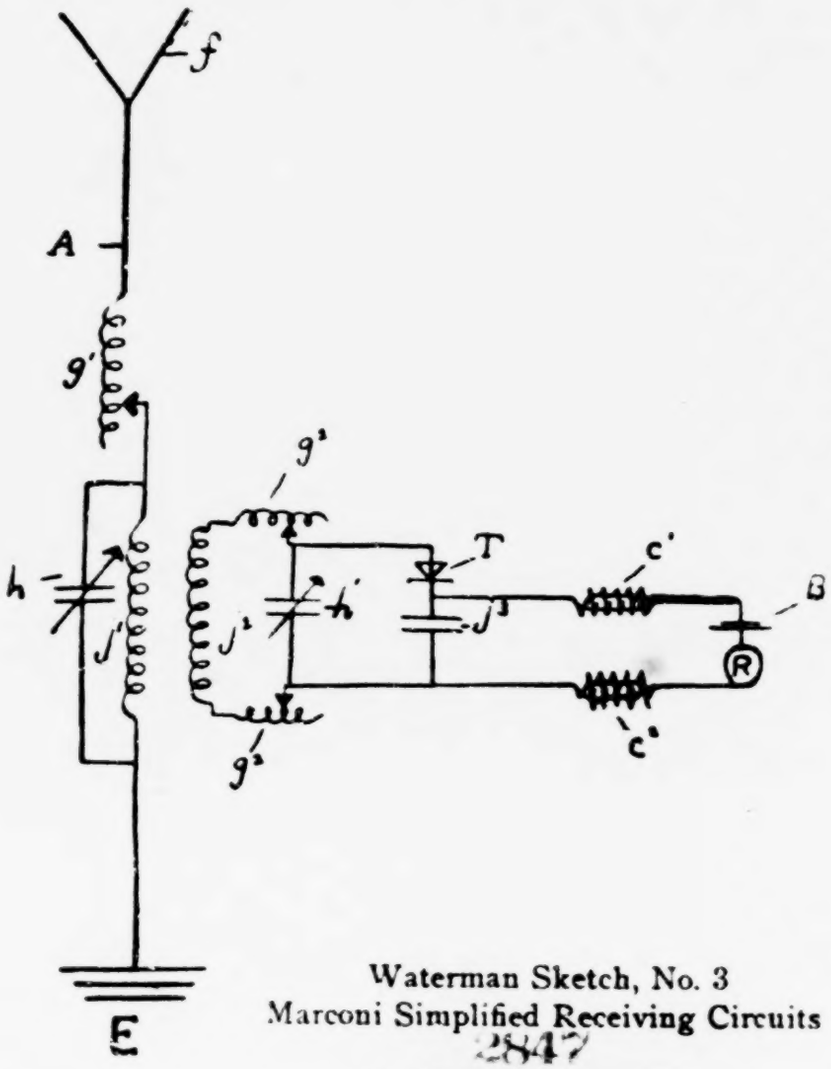


Waterman Sketch, No. 2

60
3259
410



Four Circuits or Tuning—Marconi Patent



Waterman Sketch, No. 3
Marconi Simplified Receiving Circuits

2847
FILED
MAR 14 1938
COURT OF CLAIMS
2848

Plaintiff's Ex. 410

12 Dec 410
Apr 17/32

Fig. 1a

Series

Fig. 2a

Fig. 2

Fig. 1

FILED
MAY 14 1938
COURT OF CLAIMS

PLAINTIFF'S EXHIBIT 413 - A A 3261

SE143 P-413A

U.S. NAVY RADIO RECEIVER

TYPE SE 143

Range 250 to 3100 metres

DESCRIPTION AND OPERATING INSTRUCTIONS

RADIO TEST SHOP
U. S. NAVY YARD
WASHINGTON, D.C.
May, 1918

Approved:

W. A. Eaton,
Lieut. (J.g.) U.S.N.
Radio Officer.

RY 46A 120A

DESCRIPTION AND DIRECTIONS FOR THE USE OF U.S. NAVY

SHORT WAVE RECEIVER

TYPE SE 143

This instrument is designed primarily for the reception of spark signals; secondarily for the reception of long, sustained waves, using an audion control box as a detector. A four pole, double throw switch in the receiver permits of the use of either crystal detector or audion, both of which may be permanently connected to the receiver.

The range of the primary of this receiver is 250 to 3100 meters. The range of the tuned secondary is 250 to 3800 meters. The primary may be increased from its normal range of 3100 meters to over 7000 meters on any antenna by connecting as shown in Fig. 1.

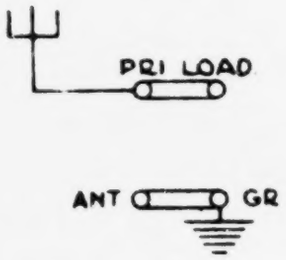


Fig. 1.

This places the primary variable condenser in parallel with the primary inductance. This combination is very efficient on waves longer than 3000 meters; on short waves, it is not as efficient as the series capacity.

The change over from shunt to series connection can be made quickly by using a double pole double throw switch as shown in Fig. 2.

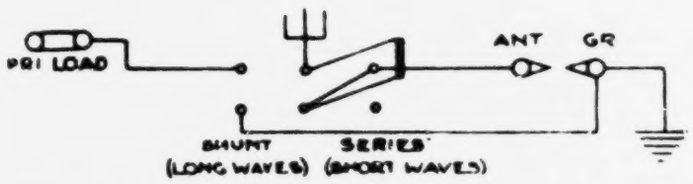


Fig. 2.

The receiver circuit, with detector switch on "AUDION", is shown schematically in Fig. 3.

DETAILED SPECIFICATIONS

ANTENNA CIRCUIT:

The antenna circuit of this receiver has a wave length range of 250 to 3100 meters when used with an antenna of 0.0008 mf. capacity. A greater range may be obtained by connecting the primary condenser in parallel with the primary inductance as previously described. The antenna circuit consists of a large, air dielectric, variable condenser, minimum capacity about 0.00008 mf. and maximum capacity 0.0045 mf.; a primary cylindrical loading coil, a primary coupling coil, inductance switches and coil cutouts.

The cylindrical loading coil consists of a micarta tube 5 inches outside diameter and 6.625 inches long, wound with a double bank winding of 212 turns of 3x16x38 Belden Litzendraht, and has an inductance of 3.8 millihenries.

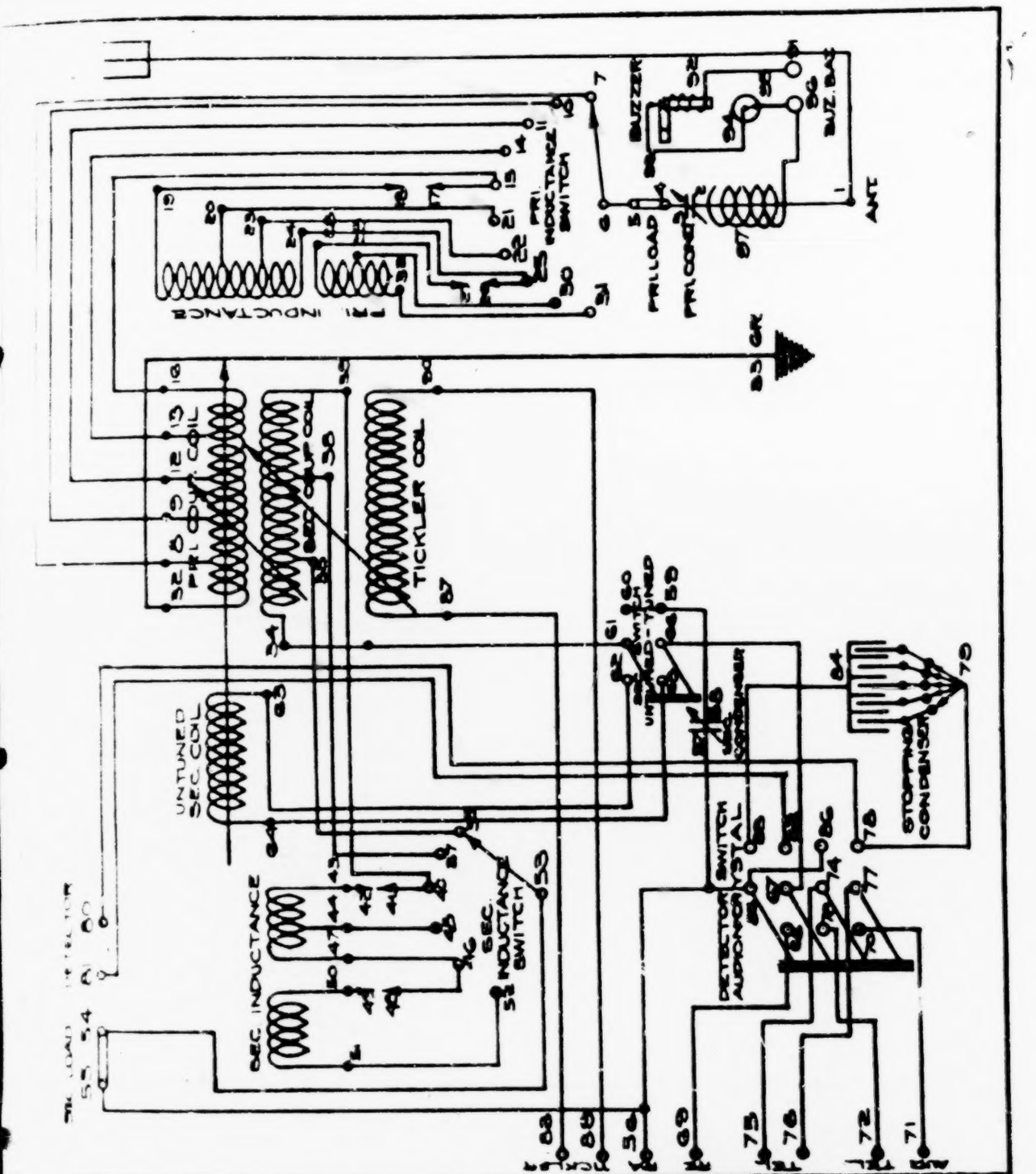
The primary coupling coil is 5 inches in outside diameter, 2 inches long, wound with a double bank winding of 47 turns of 3x16x38 Belden Litzendraht, and has an inductance of 0.42 millihenries.

The primary loading coil is wound in two sections; an air gap of 5/16 inch separating the first 94 turns from the remaining 118. This sectionalizing scheme is adopted to cut down both the distributed capacity and the natural period of the coil.

The primary condenser is of the balanced plate type. The fixed and movable plate systems are in two sections arranged 180 degrees from each other to balance the movable plate system mechanically. A knob marked FINE ADJUSTMENT is mounted on the receiver panel to the left and below the handle of the variable condenser. This knob permits of fine adjustment of the primary condenser through gears connected to the movable plates. A small sector, of 7 degrees, is cut from each end of the movable plates of the condenser. A sector, of 10 degrees, is cut from each end of the fixed plates of the condenser. This increases the ratio of maximum to minimum wave length of each coil, by reducing the end plate capacity to a minimum. The movable plate system carries a German silver dial on which the antenna wave lengths may be marked either in pencil or in India ink. An external loading coil may be inserted into the antenna circuit by connecting to the binding posts marked PRI. LOAD. COIL after removing the short circuiting link.

SECONDARY CIRCUIT:

The secondary circuit has a wave length range of from 250 to 6800 meters. There is an overlap of at least 35 per cent. on each of the steps of secondary coil.



ALTERATION TABLE		
REMARKS	DATE	INITIAL

DELINEATOR	[illegible]
TRACER	[illegible]
CHECKER	
[illegible]	[illegible]
APPROVAL	
EXPERT RADIO AIDES	
RADIO OFFICER	

MACHINERY DIVISION
U. S. NAVY YARD NEW YORK N.Y.
RADIO TELEGRAPH

SHORT WAVE RECEIVER
TYPE SE 143
WIRING DIAGRAM

SCALE — DATE 12/27/18

SHEET 13A

RY 46A 120

Pltff's Ex. 419

S E 950

ANALYSIS OF SWITCHING FOR SE RIES-SHUNT CONNECTIONS OF PRIMARY CONDENSER

Fig. 1

Cam as on Sheet 8 of Px.416-A. Switch arm on contact A

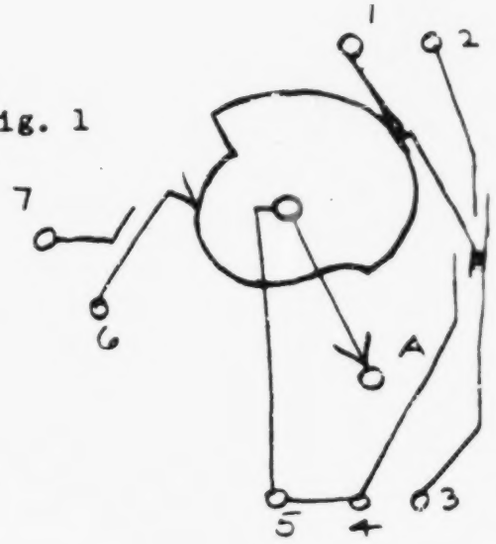
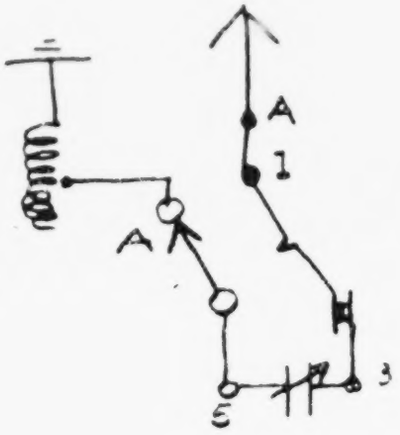


Fig. 1A
Schematic drawing of series connection.



Cam in extreme opposite position of that shown in PX 416-A. Switch arm on cortact 2 G

Fig. 2

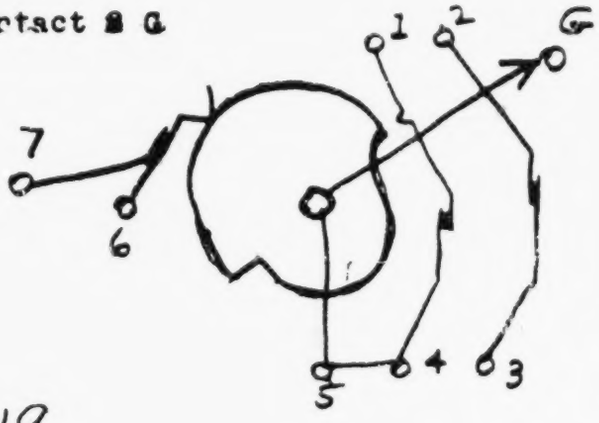
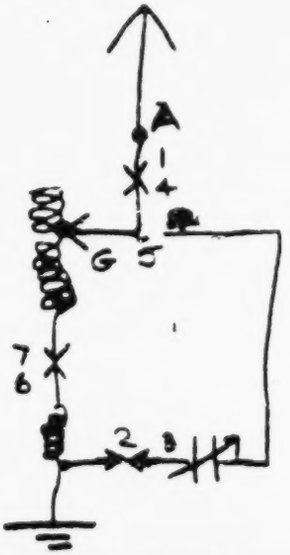


Fig. 2A



Schematic drawing of shunt connection

Pltf's 419
as ap 20/38

4-19-38
GHC

Obf E 420 ad apf 20/38

S E 1012

ANALYSIS OF SWITCHING FOR SERIES-SHUNT CONNECTION OF PRI. CONDENSER

Fig. 1

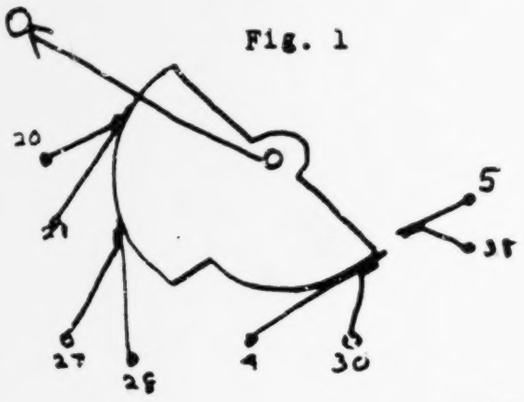


Fig. 1a

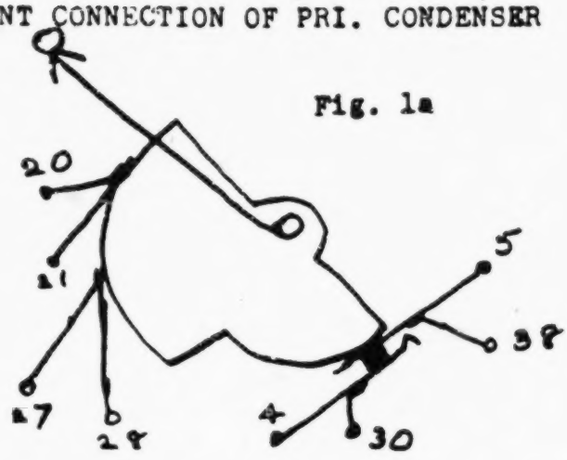


Fig. 2

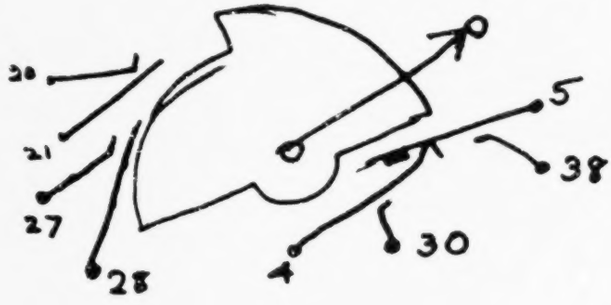


Fig.1b

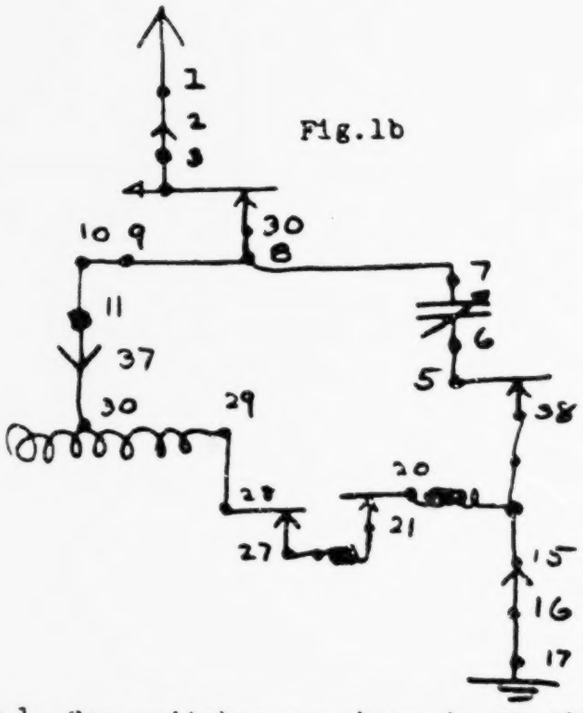


Fig. 2a

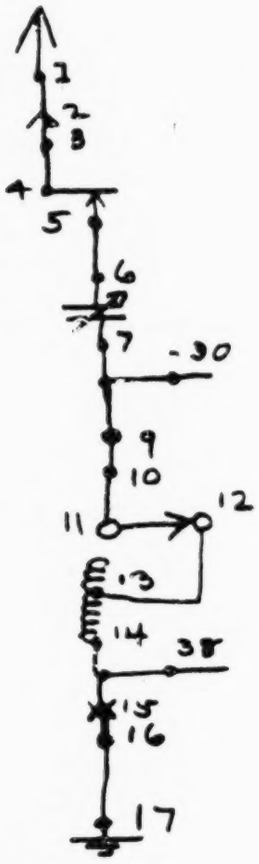
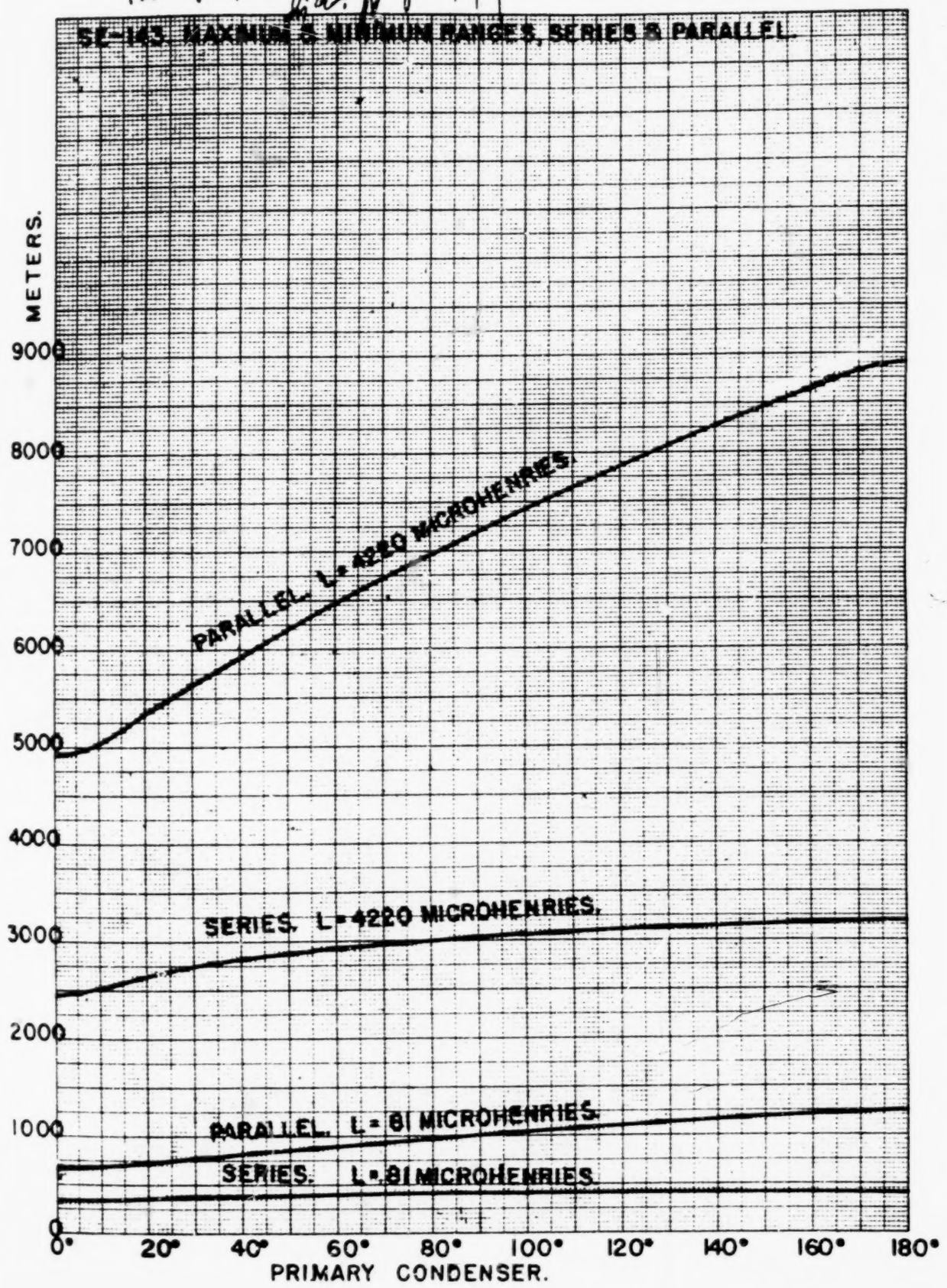


Fig.1. Cam switches as shown in PX 417. Inoperative.
Fig.1a. Cams shown correctly; long wave(shunt) position.
Fig.2 Cams shown correctly; short wave(series) position.
Fig.1b Circuit for shunt operation.
Fig.2a Circuit for series operation.

4-19-38
GHC

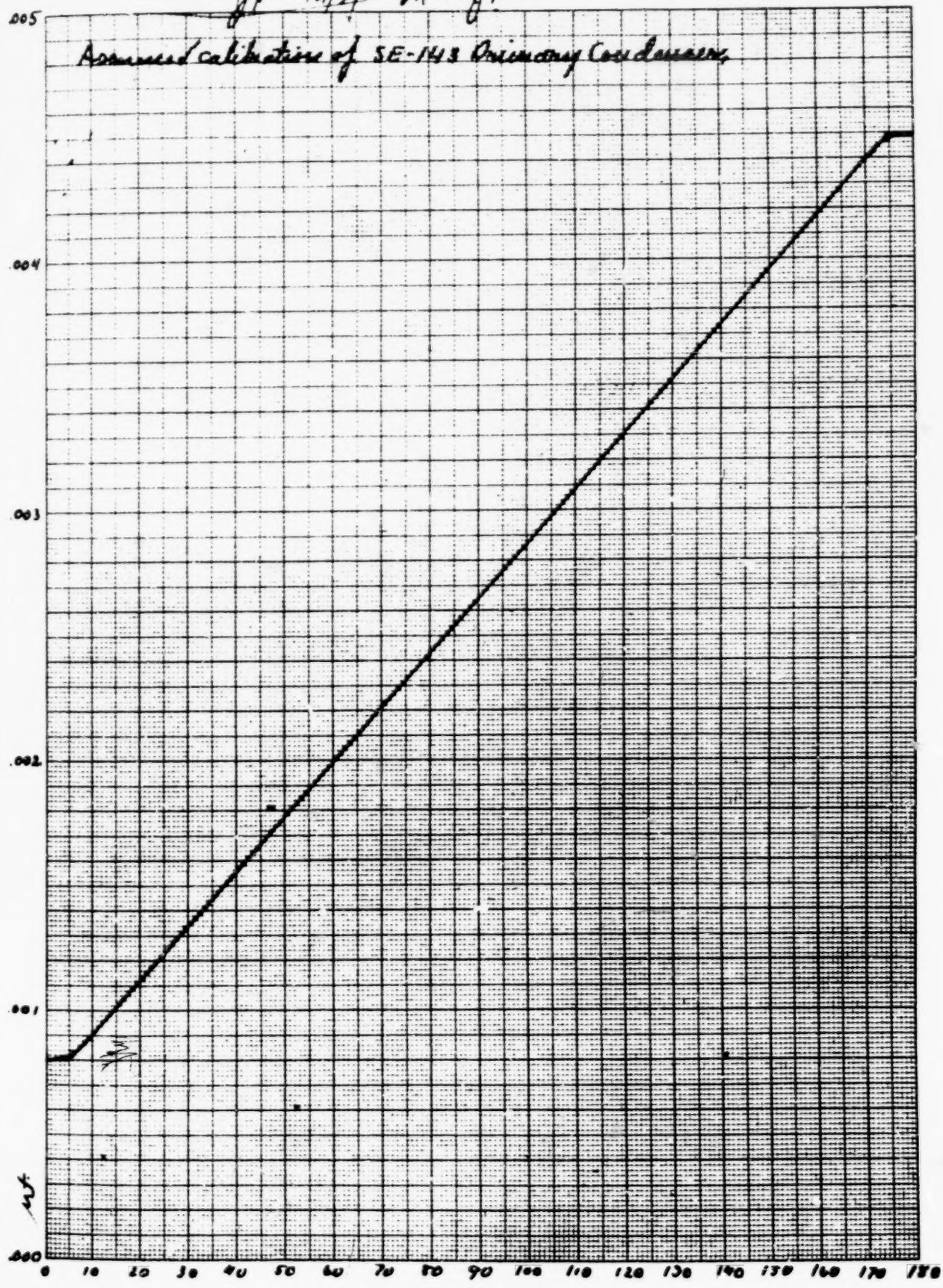
Plaintiff's Exhibit 440 for identification 3/1/39

Plaintiff's Exhibit 440



Plaintiffs Exhibit 441
ff 3/21/39 Dr Ex ff

Plaintiff's Exhibit 441



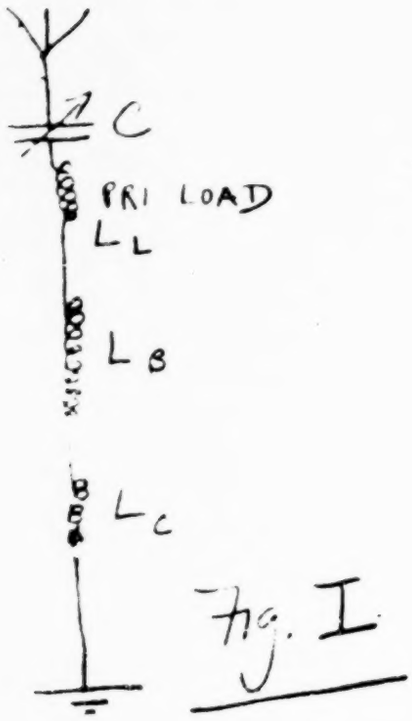


Fig. I

$$\frac{1}{C_e} = \frac{1}{C} + \frac{1}{C_A}$$

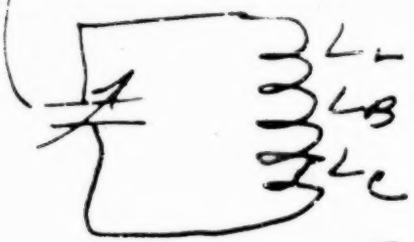


Fig. II

OFFICIAL
453
LAW REPORTER

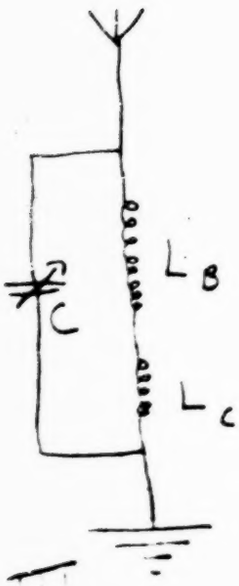


Fig III

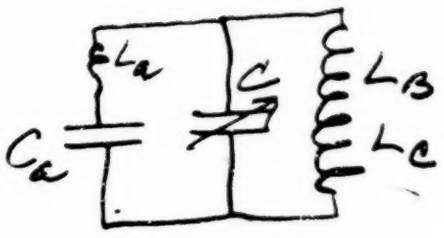


Fig. IV

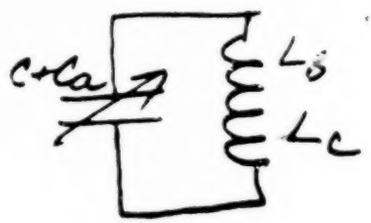
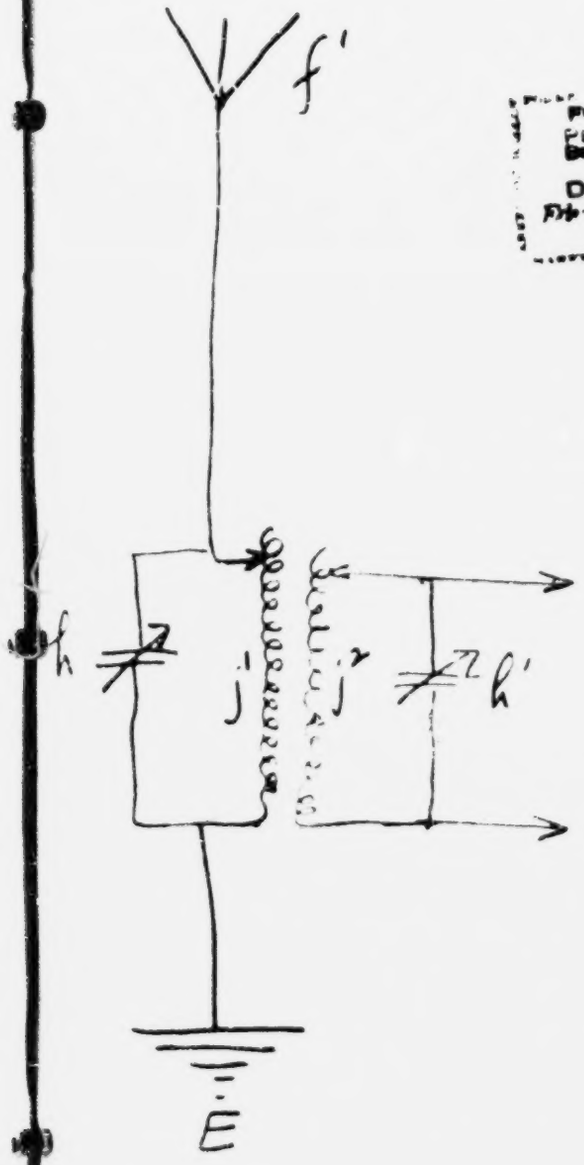


Fig. V

Pltff's Ex. 454



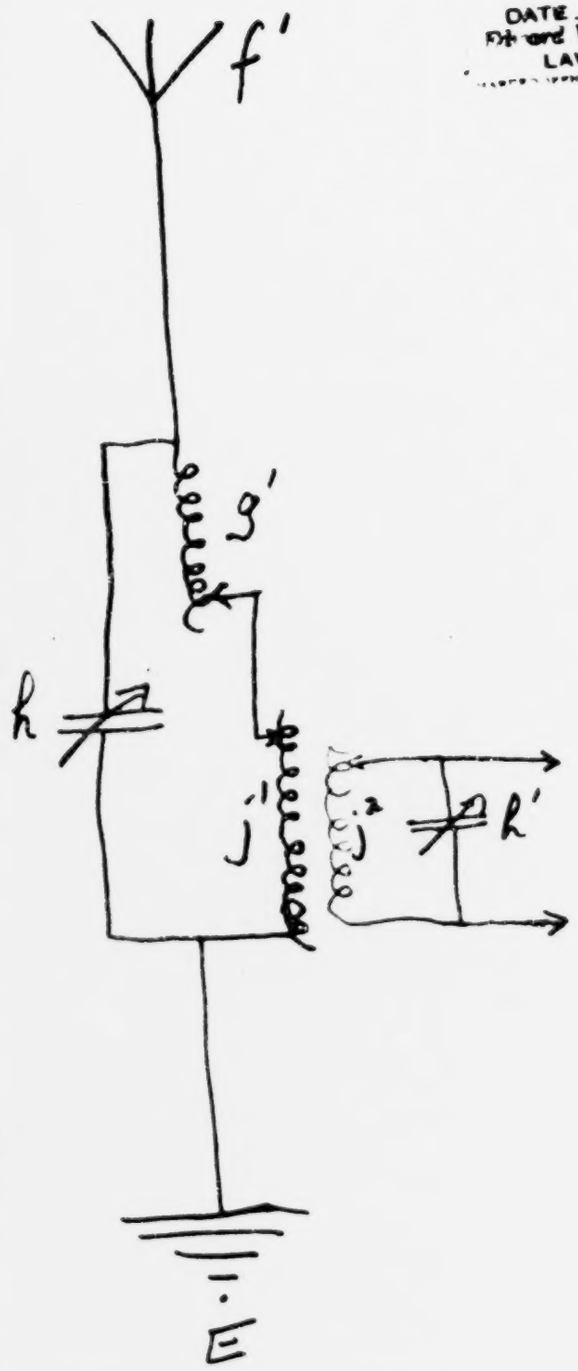
FOR IDENTIFICATION
PLAINTIFF NO. 454
DATE 2/18/37
Edward W. Cooper, C. S. R.
LAW REPORTER

EXHIBIT
PLAINTIFF NO. 454
DATE 2/19/37
Edward W. Cooper, C. S. R.
LAW REPORTER

Pltff's Ex. 455

IDENTIFICATION
PLAINTIFF NO. 455
DEFENDANT
DATE 3/18/39
Edward W. Cooper, C. S. R.
LAW REPORTER

EXHIBIT
PLAINTIFF NO. 455
DEFENDANT
DATE 3/19/39
Edward W. Cooper, C. S. R.
LAW REPORTER



NAR

Dec. 19 1912 — Transmitt + receive aerial

10:00 am wash. time

arc signals.

(Put in new secondary coil with less resistance than old one; this sec. is #111-5)

111

C_1 = 120° + 1 fx

L_1 = 2 coil

C_2 = 118° + 1/2 fx

L_2 = coil I.

cplg = 1

Shunt = 15w Ticker 150~

C_1 = 82° + 0

L_1 = 3 coil

C_2 = 116° + 1/2 fx

L_2 = coil I

K = 1.3

Shunt = 7w Ticker 150~

Transmitter

L_1 = 2.6 mh

L_1 = 3 coils

C_1 = 124° + 0

C_2 = 116° + 1/2 fx

coil I

1 50w ±

NAA at Key West

Dec. 20th 1912.

1 p.m — 3 p.m. Ticker out of adjustment — no wire available for contact. Rec'd some static from Key West.

5 p.m. arc signals

L_1 = 3 coils C_1 = 146° + 0 fx

L_2 = coil I C_2 = 105° + ½ fx

C_1 parallel to L_1

$K = 1$

shunt = 50Ω ticker, 150Ω fones

Dec. 21 1912.

First schedule rec'd, @ beginning ashore, was at 1:00 PM (890 miles)

1:00 PM — arc

L_1 = 3 coils C_1 (11) = 1:,2° + 0 fx

L_2 = coil I C_2 = 102° + ½ fx

$K = 1.5$

shunt = 40Ω Tired at 1.00 p.m.

Compensation was [illegible]

Better [illegible]

1:1 PM (640 miles)

3 coils C

coil I C

K = 1.5

shunt = 30Ω

[illegible] to [illegible]

[illegible] down to [illegible]

No [illegible] contact

[illegible]

3274

PLAINTIFF'S EXHIBIT 472

ROBISON'S MANUAL

OF

RADIO TELEGRAPHY

AND

TELEPHONY

FOR THE USE OF

NAVAL ELECTRICIANS

BY

CAPTAIN S. S. ROBISON, U. S. NAVY

REVISED BY

CAPTAIN D. W. TODD, U. S. NAVY
Director Naval Communications

AND

LIEUT. COMMANDER S. C. HOOPER, U. S. NAVY
In Charge of Radio Division, Bureau of Steam Engineering

4TH REVISED EDITION

[illegible]

1918

3275

Fig. 92 represents circuits of a receiving set complying with present specifications. In all such sets closed circuits are calibrated and curves drawn or a scale furnished showing wave lengths for all settings from 200

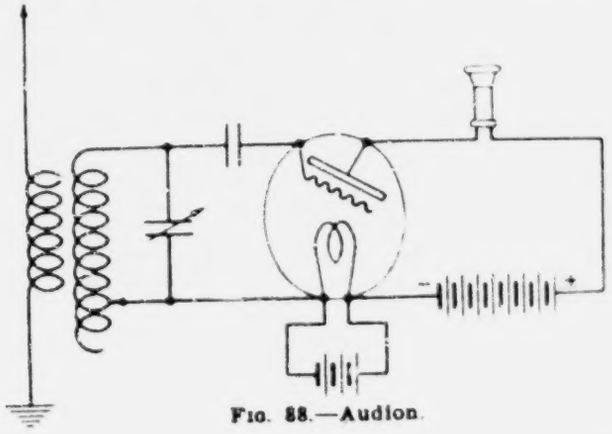


FIG. 88.—Audion.

to 4000 meters, and additional calibrated loading coils for very long waves are supplied.

With very loose coupling the wave length of received signals can thus be read directly.

200. Fig. 89 represents receiving circuits for continuous oscillations; it shows the receiving telephone connected across the terminals of a fixed condenser in series with the detector.

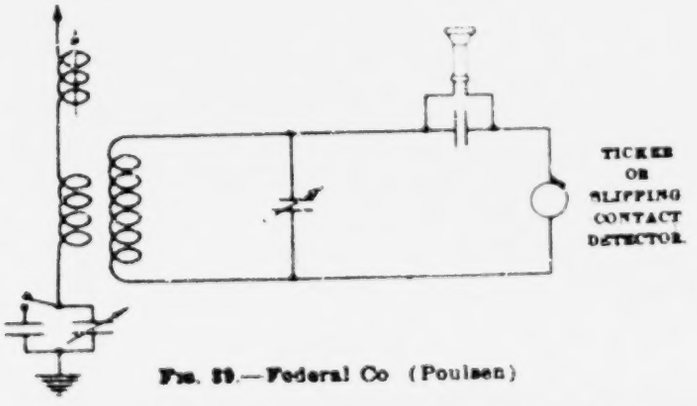


FIG. 89.—Federal Co (Poulsen)

In using undamped oscillations for wireless telegraphic purposes it must be remembered that the frequency of the oscillations themselves is too high to be heard in the telephone connected with the ordinary receiving circuit, and when the circuit at the sending station is closed all that would be heard is a slight click, so that there is no way of telling a

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as possible. With properly adjusted carbons, the instrument should operate an hour without attention and then requires only the careful cleaning and facing up of the carbons.

202. In spark sets we want the sending aerial to be a good radiator, but not so good that it will give a whip crack discharge. We want its oscillations to be persistent enough to require for their best reception a receiving aerial tuned to the period of the sender, and as a present standard we have set for the sender a damping considerably less than .2, so that it makes fifteen complete oscillations before the oscillating current falls to 1 of its original value. We want the receiving aerial to radiate as little

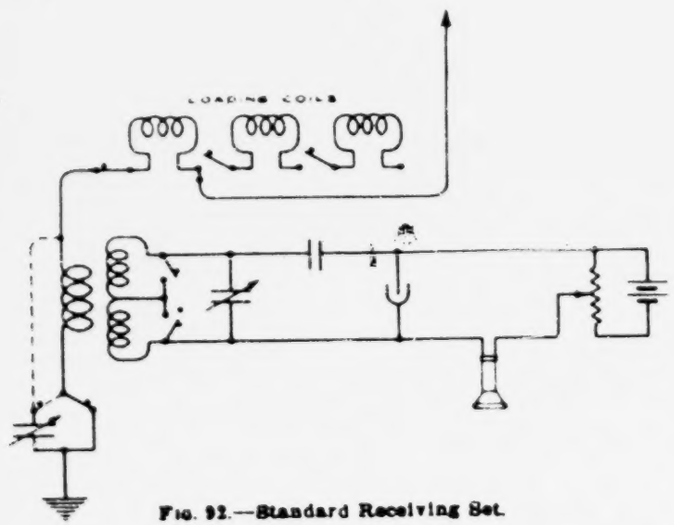

FIG. 92.—Standard Receiving Set.

as possible; but to so combine the energy of the fifteen waves that the highest maximum is produced in the aerial, and transferred to the closed receiving circuit.

If the sending aerial is coupled so as to send out waves of two lengths, there appears to be no question that the coupling of the receiving circuits should be such that, if they acted as senders, they would send out waves of these lengths, or so loosely coupled that their natural period is that of the arriving wave containing the most energy. If, in the case of very loosely coupled circuits or those supplied with quenched spark gaps, but one wave length is being radiated, receiving circuits should also be loosely coupled or should be coupled so that the transfer of energy from the open to the closed circuit and the damping of the latter (with the detector, however connected) is at such a rate that a maximum current in the closed circuit is reached at the instant the open circuit has come

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Acknowledgment.

25. NQM ..... Station which sent message.
26. ● ▬ ● ..... Received.
27. 5 ..... No. of message.
28. NAR ..... Receiving station.
29. SF ..... Receiving operator's sign.
30. ▬ ● ▬ ..... Go ahead.

Finished Signal.

31. ● ● ● ▬ ● ▬ ..... Finished.
32. NQM ..... Sending station.

RECEIVING.

249. In ordinary circumstances, while listening in, the set may be kept closely coupled, to broaden the tune; but the aerial circuit should be *stiff*, i. e., having a considerable amount of inductance (art. 231). The aerial circuit should be tuned with a variable condenser in series for short waves and in parallel (around inductance) for long waves (fig. 92).

When the calling station is well tuned in, loosen the coupling, if there is interference. This should be done gradually, *adjusting both the open (aerial) and closed circuits with each change of coupling*, until a point is reached where signals are readable through the disturbances. With fairly strong signals the coupling on a 1 P. 76 receiver should be not less than 16 on the coupling scale, and, at this point, for moderate wave lengths, the signal should not fall materially in intensity.

For further improvements in tuning, the closed circuit condenser should be made as large as possible and the closed circuit inductance correspondingly reduced.

The settings (for best coupling and of open and closed circuits) for all stations habitually communicated with should be recorded and posted for the use of the operator on watch.

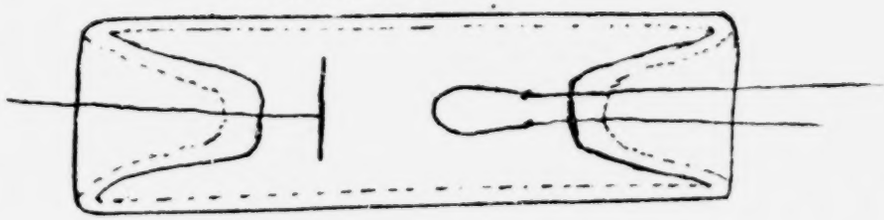
The practice of loosening coupling while receiving should be *made obligatory* on all operators. It not only cuts out existing interference, but prepares for any interference which may arise during reception. Owing to the change of effective self-induction, in both circuits, both require readjustment (retuning) with each change of coupling.

Two aerials in the same immediate vicinity as on board the same ship have an influence on each other so that if both are used for receiving at the same time, the tuning of either will affect the other and this effect may be observed between aerials on different ships if they are very close together.

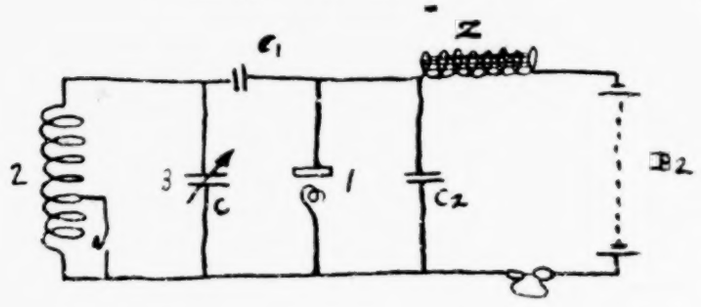
250. When two ships are close together, the one which is not doing the sending can generally assist in receiving faint signals. Regardless of opening of circuits, high power sending lessens the sensitiveness of the

2865–2866

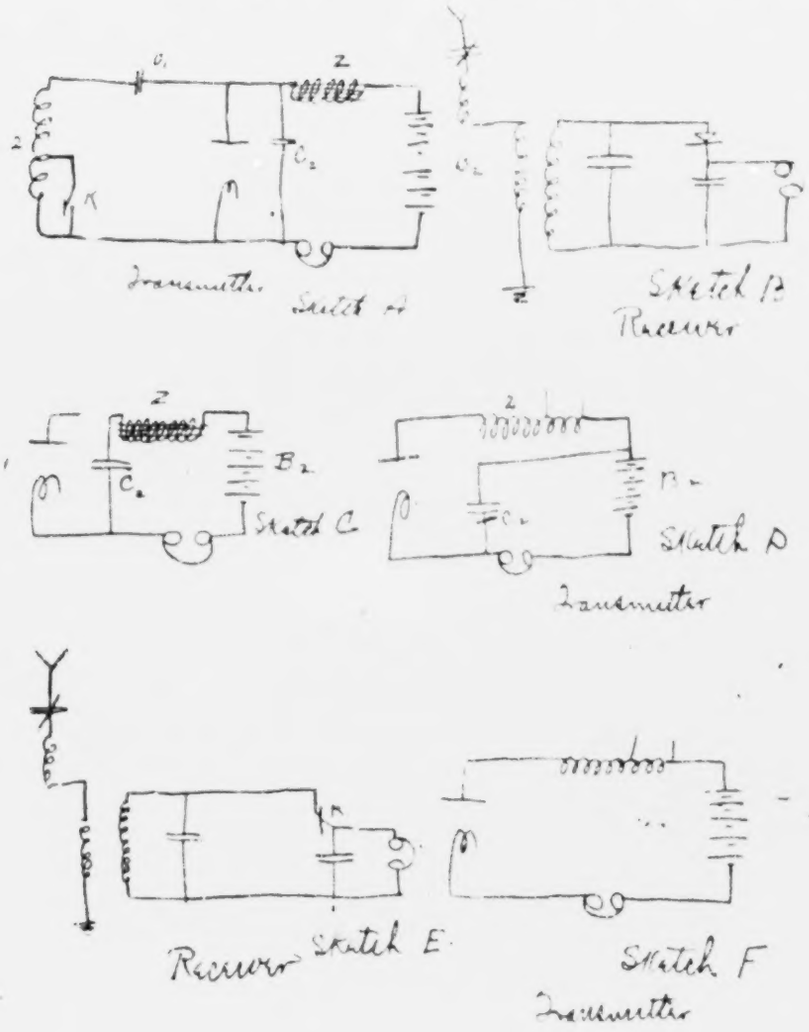
Defendant's Exhibit "A"

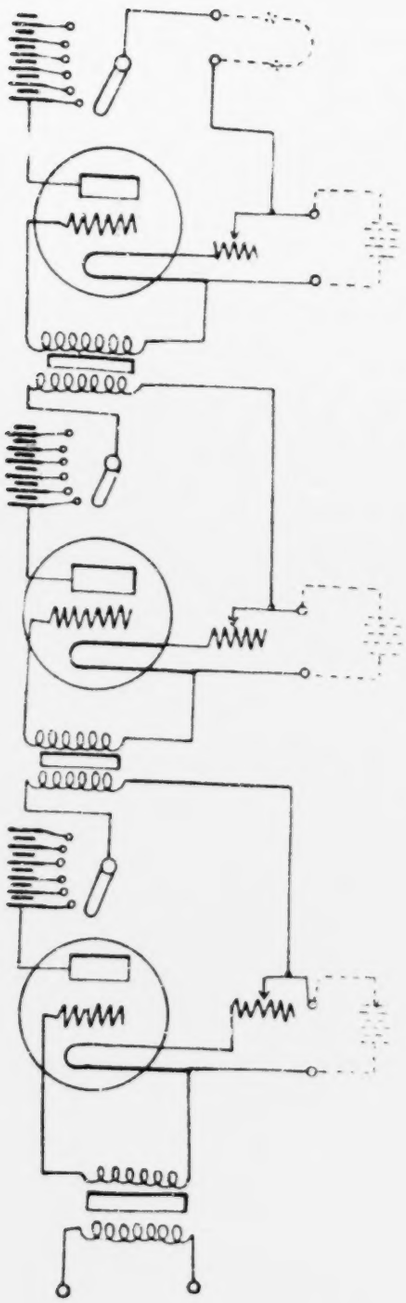


Defendant's Exhibit "B"
Fleming Two-Element Valve



Defendant's Exhibit "C"





Defendant's Exhibit "D"

DEFENDANT'S EXHIBIT I

MILLER DRAWING A

Fig 1

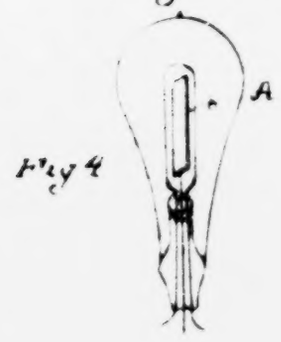
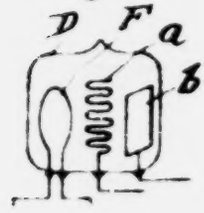
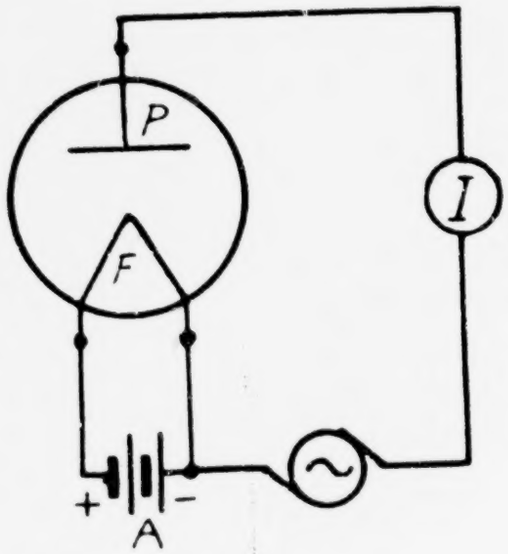


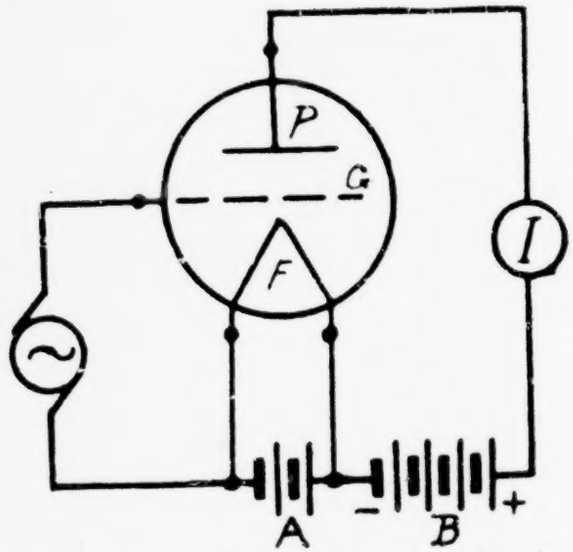
Fig 4

Fig. 2



MILLER DRAWING B





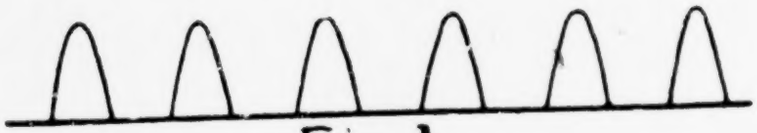


Fig 1

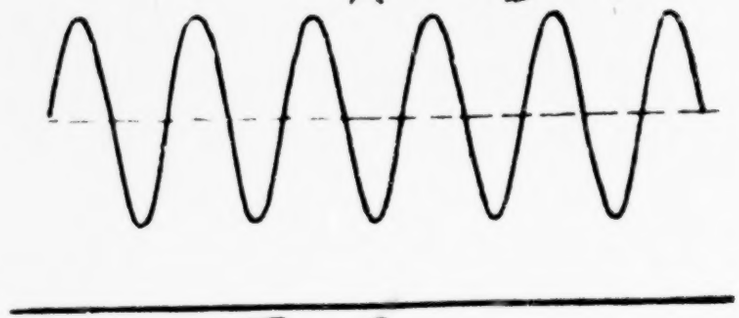


Fig. 2

2872

MILLER DRAWING C

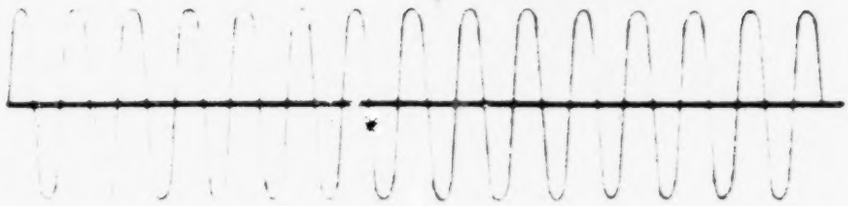


Fig. 1

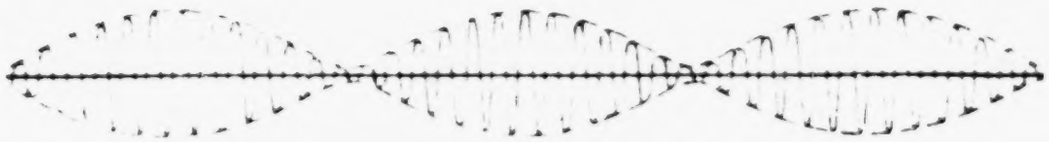


Fig. 2

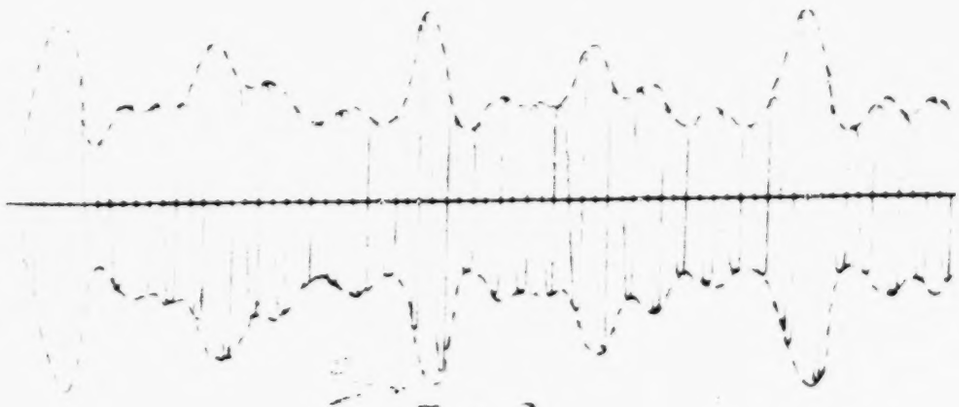


Fig. 3

Fig. 4

MILLER
DRAWING 1
D

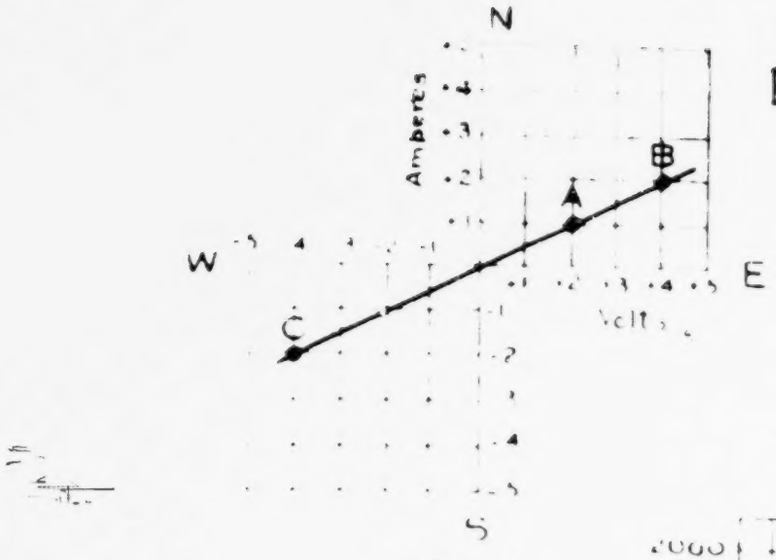


Fig. 1

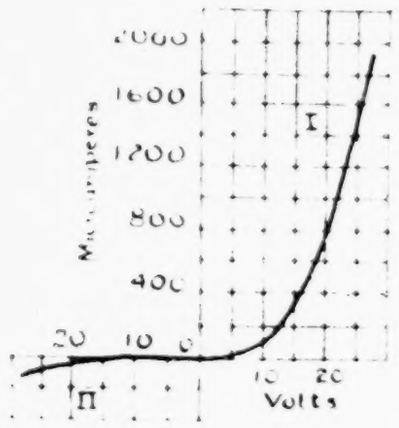


Fig 2

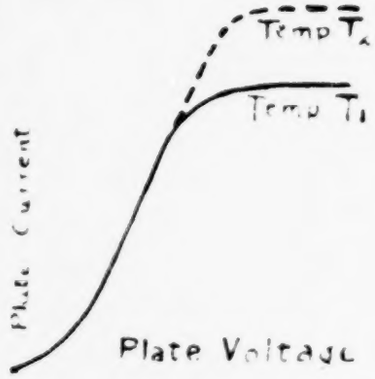


Fig 3

Characteristic curves of a two electrode tube for two different Temperatures

Fig. 4

Current voltage characteristic of the arc

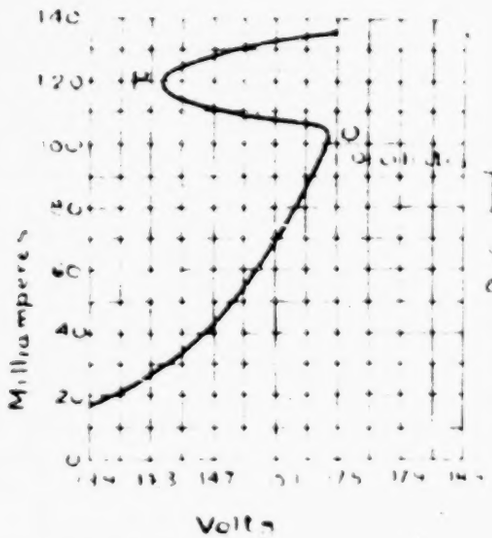


Fig 5

Sheet Drawing E

Fig 1

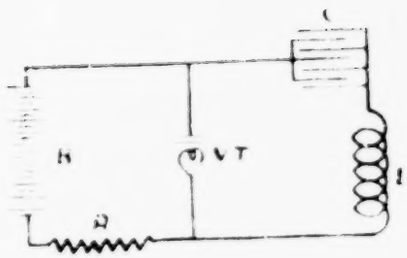


Fig 2

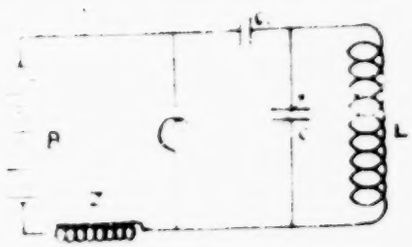


Fig 3

MILLER DRAWING F

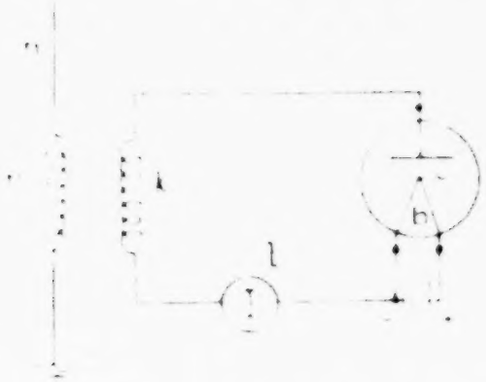


Fig 1

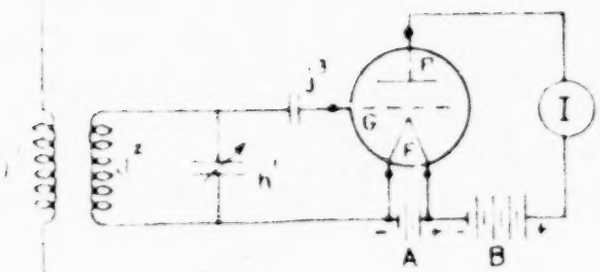


Fig. 2

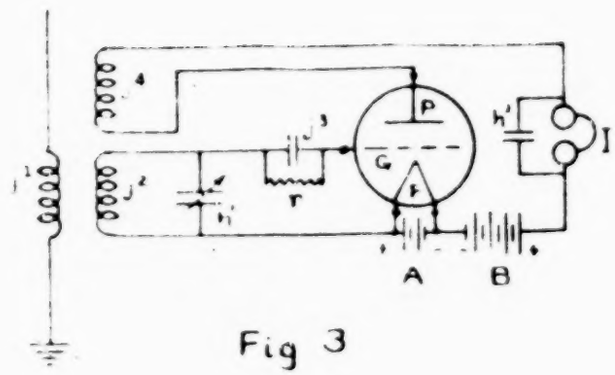


Fig 3

MILLER DRAWING

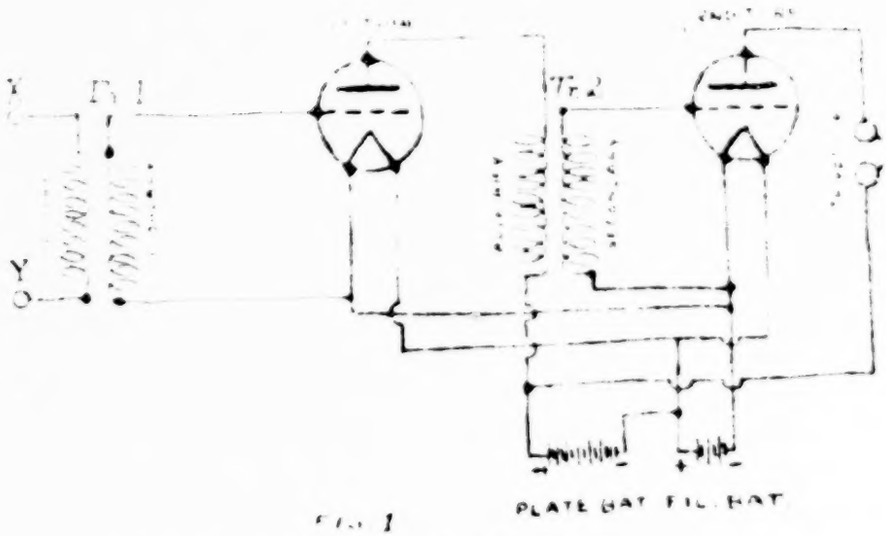


FIG. 1

FIG. 2.

MILLER DRAWING H

RADIO-AUDIO AMPLIFIER

MILLER DRAWING I

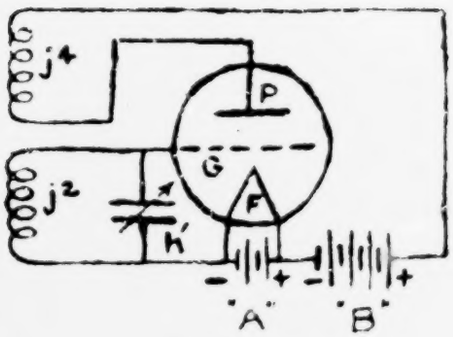


Fig. 1

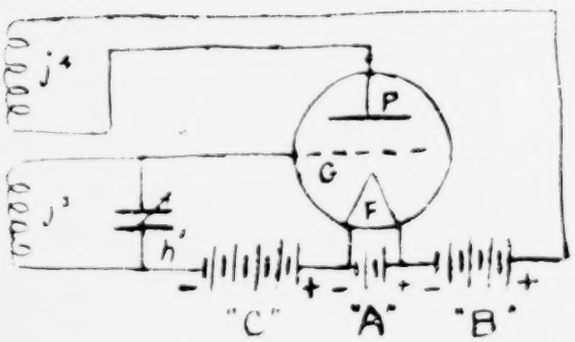


Fig. 2.

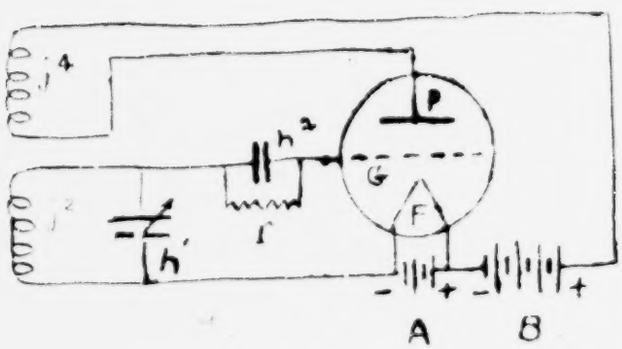


Fig 3.

MILLER DRAWING J

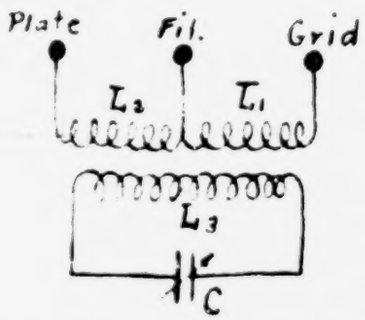


Fig. 1. Meissner

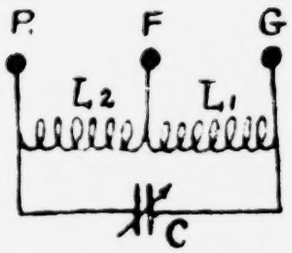


Fig 2. Hartley.

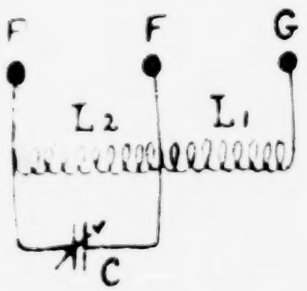


Fig. 3 Tuned Plate

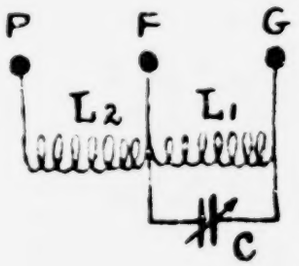


Fig. 4. Tuned Grid.

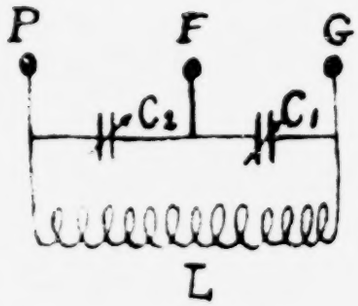


Fig. 5 Colpitts.

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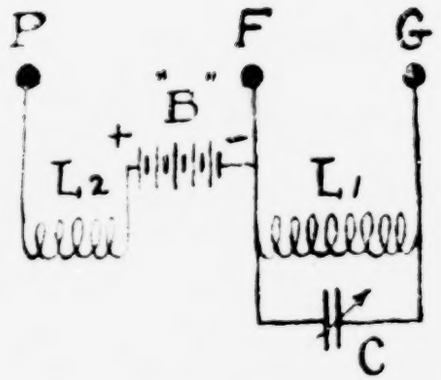

Fig. 1. Series "B" Battery.

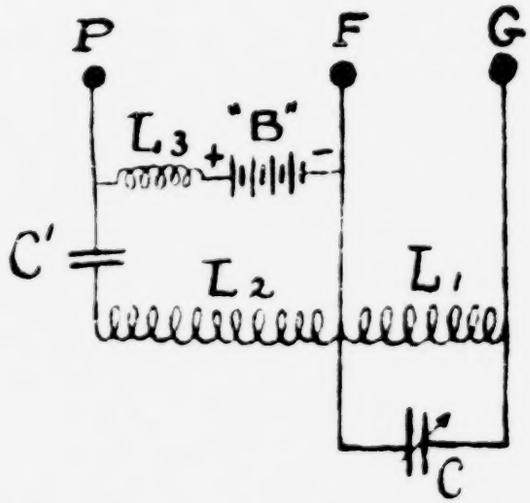

Fig. 2 Parallel "B" Battery.

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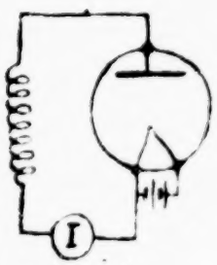

Fig 1

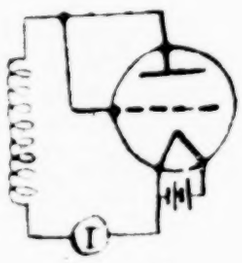

Fig 2

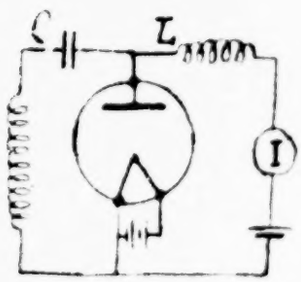

Fig. 3

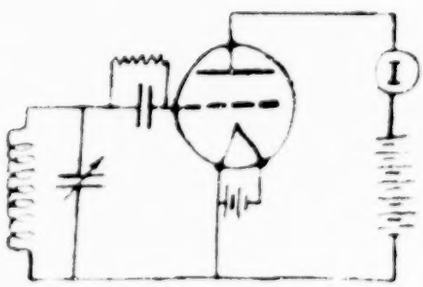

Fig. 4

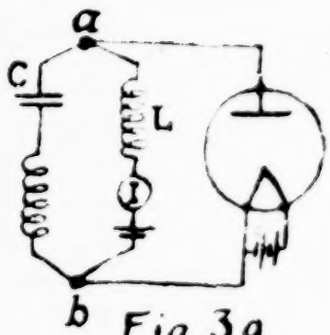

Fig. 3a

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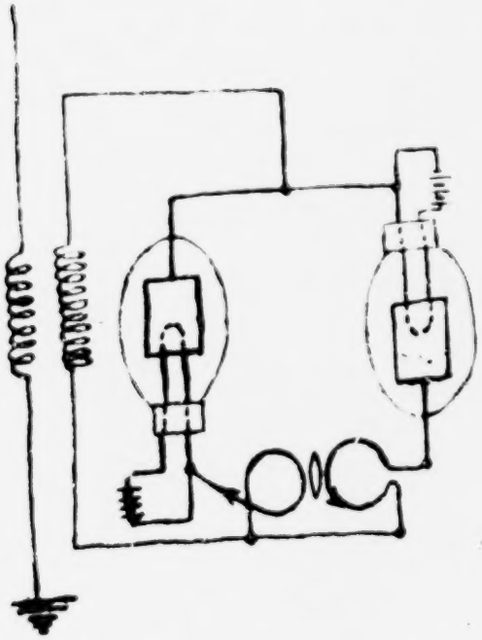
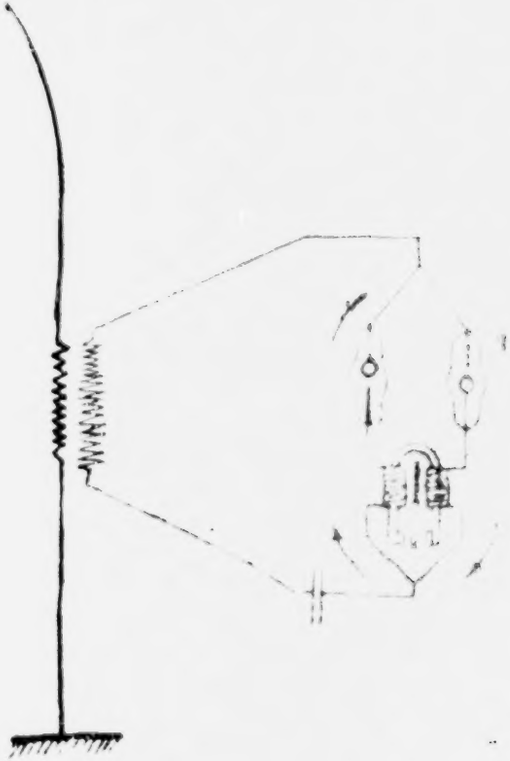


Fleming.



Valbreuze.

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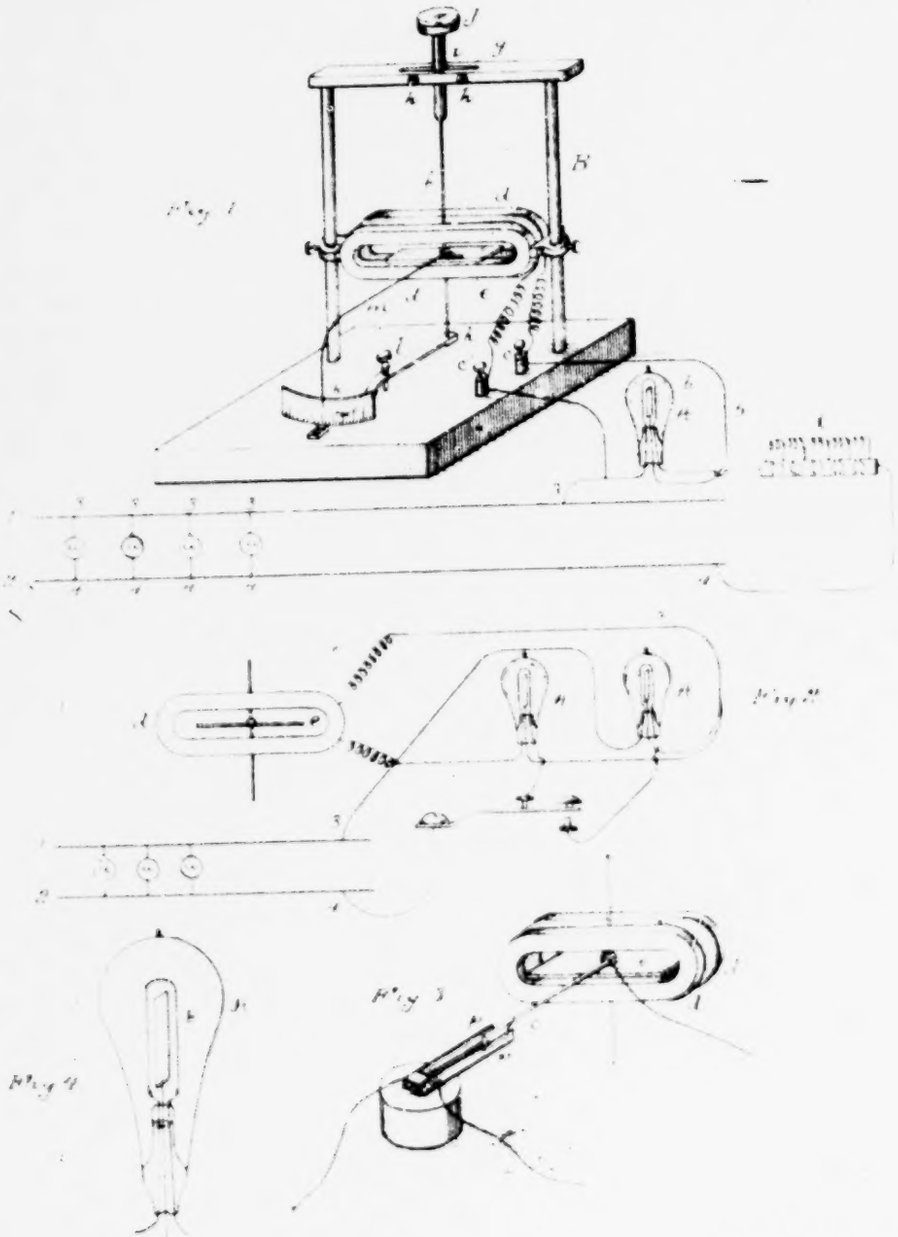
DEFENDANT'S EXHIBIT J

(No Model.)

T. A. EDISON.

ELECTRICAL INDICATOR.

No. 307,031. Patented Oct. 21, 1884.



ATTEST

2884-2885

32,937

UNITED STATES PATENT OFFICE.

THOMAS A. EDISON, OF MENLO PARK, NEW JERSEY.

ELECTRICAL INDICATOR.

SPECIFICATION forming part of Letters Patent No. 307,031, dated October 21, 1884.

Application filed November [illegible], 1884. (No model.)

To all whom it may concern:

Be it known that I, THOMAS A. EDISON, of Menlo Park, in the county of Middlesex and State of New Jersey, have invented a new and useful Improvement in Electrical Indicators, (Case No. 693,) of which the following is a specification.

The object of my invention is to produce an efficient apparatus for indicating variations of electro-motive force in an electric circuit, preferably for use in connection with systems of electrical distribution to show the changes in pressure in the various parts of the district. The apparatus is also capable of use in automatically regulating the electro motive force to correspond with such variations. I have discovered that if a conducting substance is interposed anywhere in the vacuous space within the globe of an incandescent electric lamp, and said conducting substance is connected outside of the lamp with one terminal, preferably the positive one, of the incandescent conductor, a portion of the current will, when the lamp is in operation, pass through the shunt-circuit thus formed, which shunt includes a portion of the vacuous space within the lamp. This current I have found to be proportional to the degree of incandescence of the conductor or candle-power of the lamp.

My invention consists in the utilization of this discovery for indicating or regulating variations in electro motive force, or for affecting electrical apparatus in any desired manner. By connecting a device for indicating current changes in the shunt-circuit, changes in the candle power of the lamp, and consequently in the electro motive force of the source of supply, are made apparent; or if, instead of an indicating device, the variations in electro motive force are made to affect circuit-controlling apparatus, automatic regulators or other electrical apparatus may be controlled thereby.

In applying my invention to a system of incandescent electric lighting I place a standard lamp having within its globe a piece of platinum, preferably a thin plate, though platinum wire may be used, placed preferably between the limbs of its carbon conductor, such platinum piece being in connection with the circuit whose electrical condition is to be observed, connecting said piece to a point similarly to those of the other lamps of the system, and making an additional connection from the positive terminal, preferably, of the lamp-circuit, to one terminal of a galvanometer or other indicator, and from the platinum piece through a wire sealed in the glass to the other terminal of the galvanometer or indicator. The galvanometer, if one is used, is provided with a torsional device for holding its needle at zero under a normal current, so that variations of a few volts from the normal deflect the needle to one direction or the other. If the electro motive force in the system, and consequently the candle-power of the lamps, increases, the indicating lamp varies with the rest, and the current from it to the galvanometer is increased, causing the deflection of the galvanometer needle; and conversely, a decrease in electro motive force in the system produces an opposite deflection. The galvanometer needle may be made to close circuit to electrically operated devices for accomplishing the automatic regulation of the generator supplying current to the system or for any other purpose.

My invention is illustrated in the annexed drawings.

Figure 1 is a diagram of the system and connections, with a view in perspective of the galvanometer; Fig. 2, a diagram of a modified arrangement; Fig. 3, a view showing the use of the galvanometer to close regulating or other circuits, and Fig. 4 a view of the indicating-lamp.

1 2 are main conductors of a system of electric lighting, and *a a* electric lamps connected across them in multiple arc circuits 3 4. A is a lamp similarly connected, and similar in every way to the other lamps, except that it has a piece of platinum, *b*, placed between the limbs of its incandescent conductor, while a wire, 5, attached to said platinum, is sealed in the glass of the globe with the wires 3 4. The wire 5 leads to the binding-post *c*, while a wire, 6, connected with the positive wire 3 of the lamp, leads to the binding-post *c'*. These binding-posts are the terminals of a galvanometer which consists of coils *d d* and a needle, *e*, carried by a torsion-wire, *f*. The parts are held in a frame, B. The upper cross-bar of the frame is split at *g*, the split being held to-

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gether by screws *h h*, and the torsion-wire is attached to the smooth stud *i*, which is held by friction in the split, its torsion being adjusted by turning the thumb-nut *j*. A spring, *k*, is attached to the other end of the torsion-wire, serving to keep said wire stiff, and the tension of the spring is adjusted by means of nut *l*. A pointer, *m*, extends from the needle to indicate its variations upon a scale, *n*. The torsion of the wire *f* is so adjusted as to hold the needle and the pointer centrally with a normal current—that is, when the lamps of the system are at their normal candle-power—and, as previously explained, any variations in the electro-motive force of the system causing changes in the candle-power of the lamps will produce deflections of the galvanometer-needle, which deflections will be indicated on the scale.

Instead of simply causing the variations to be indicated on the scale, a circuit-controlling arm, *o*, Fig. 3, may be carried by the needle, which may close circuit at contacts *p*, or in any other suitable manner to electrical devices for automatically regulating the electro-motive force of the system, to electrically-operated indicating devices, or to any electrically-operated apparatus.

For regulating a dynamo-electric machine, a mechanism such as shown in my Patent No. 287,524 may be used, the lamp A and galvanometer of the present apparatus being used in place of the pressure-magnet B of said patent, the working-magnets C C of said patent being located in the two circuits, closed by arm *o* of the present apparatus, which takes the place of the armature-lever of said pressure-magnet B. An adjustable resistance, C, may be placed in circuit with the lamp A, to maintain said circuit at the standard lamp-resistance.

In Fig. 2 a lamp, A', is shown placed in a shunt around the lamp A. The lamp A being constantly in use, lamp A' is occasionally placed in circuit instead, so by observing its candle-power it may be determined whether or not the resistance of the lamp A has changed.

What I claim is—

1. The combination of an incandescent electric lamp, a circuit including the vacuous space within the globe of said lamp, and electrical apparatus controlled by the current in such circuit, substantially as set forth.

2. The combination, with a system of electrical distribution, of an indicating or regulating apparatus therefor, comprising a standard lamp, a circuit including the vacuous space within the globe of said lamp, and electrical apparatus controlled by the current in such circuit, substantially as set forth.

3. The combination, with an incandescent electric lamp of a circuit having one terminal in the vacuous space within the globe of said lamp, and the other in connection without the lamp with one side of the lamp-circuit, substantially as set forth.

4. The combination, with an incandescent electric lamp, of a circuit having one terminal in the vacuous space within the globe of said lamp, and the other in connection without the lamp with the positive side of the lamp-circuit, substantially as set forth.

5. The combination, with an incandescent electric lamp, of a circuit having one terminal in the vacuous space within the globe of said lamp, and the other connected with one side of the lamp-circuit, and electrically controlled or operated apparatus in said circuit, substantially as set forth.

6. The combination, with an incandescent electric lamp, of a piece of conducting material placed in the vacuous space within its globe, and a conductor connected therewith and passing through and sealed in the glass of the lamp, substantially as set forth.

7. In a system of electrical distribution, the combination, with incandescent electric lamps connected in multiple arc, of a similar lamp similarly connected, a circuit having one terminal in the vacuous space within the globe of said lamp, and the other connected with one side of the lamp-circuit, and electrically-operated apparatus in said circuit, substantially as set forth.

8. The combination, with an incandescent electric lamp, of a piece of conducting material placed between the sides of the incandescent loop, and a conductor leading therefrom to the exterior of the lamp, substantially as set forth.

This specification signed and witnessed this 2d day of November, 1883.

THOS. A. EDISON.

Witnesses:
H. W. SEELY,
EDWARD H. PYATT.

DEFENDANT'S EXHIBIT K

No. 879,532. PATENTED FEB. 18, 1908

L. DE FOREST.

SPACE TELEGRAPHY.

APPLICATION FILED JAN. 29, 1907.

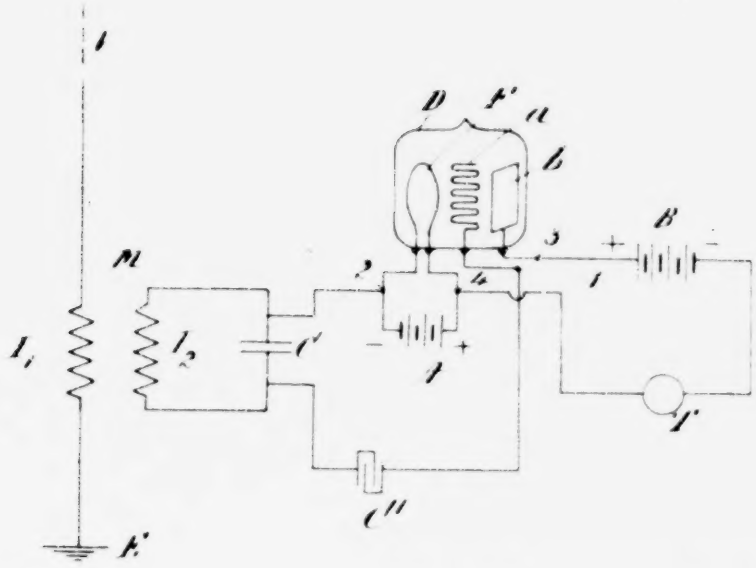

Fig. 1.

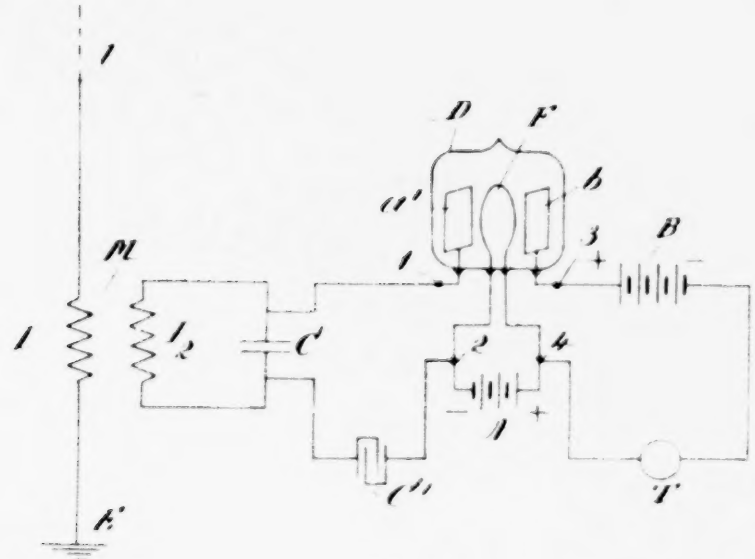

Fig. 2.

WITNESSES-

E. B. Tomlinson

Patrick J. Conroy

INVENTOR

Lee de Forest

by Geo. K. Woodworth.

Atty.

UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO DE FOREST RADIO TELEPHONE CO., A CORPORATION OF NEW YORK.

SPACE TELEGRAPHY.

No. 879,532. Specification of Letters Patent. Patented Feb. 18, 1908

Application filed January 29, 1907. Serial No. 354,662.

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented a new and useful Improvement in Space Telegraphy, of which the following is a specification.

My invention relates to wireless telegraph receivers or oscillation detectors of a type heretofore described in my prior Letters Patent Nos. 824,637, June 26, 1906 and 836,070, November 13, 1906.

The objects of my invention are to increase the sensitiveness of oscillation detectors comprising in their construction a gaseous medium by means of the structural features and circuit arrangements which are hereinafter more fully described.

My invention will be described with reference to the drawings which accompany and form a part of the present specification, although it is to be understood that many modifications may be made in the apparatus and systems herein described without departing from the principles of my invention.

In the drawings, Figure 1 represents in diagram a wireless telegraph receiving system comprising an oscillation detector constructed and connected in accordance with the present invention and Fig. 2 represents a space telegraph receiving system including a modified form of oscillation detector connected therein in a manner which constitutes one of the subjects matter of said invention.

V I, E is an elevated conductor system including the elevated conductor V, earth connection E, and primary I, of the transformer M, the secondary I, of which forms part of the tuned receiving circuit I, C. It will be understood of course that the aforesaid tuned receiving circuit may be associated with the elevated conductor system in any suitable manner.

D represents an evacuated vessel, preferably of glass, having sealed therein three conducting members, F, *a* and *b*, in Fig. 1 and F, *a'* and *b* in Fig. 2. The conducting member or electrode F is shown as consisting of a filament, preferably of metal, which is connected in series with the battery A or other source of electrical current of sufficient strength to heat said filament, preferably to incandescence. The conducting member *b*, which may be a plate of platinum, has one end brought out to the terminal 3. Interposed between the members F and *b* is a grid-shaped member *a*, which may be formed of platinum wire, and which has one end brought out to the terminal 1. The local receiving circuit, which includes the battery B, or other suitable source of electromotive force, and the signal indicating device T, which may be a telephone receiver, has its terminals connected to the plate *b* and filament F at the points 3 and 4 respectively. The means for conveying the oscillations to be detected to the oscillation-detector, are the conductors which connect the filament F and grid *a* to the tuned receiving circuit and, as shown, said conductors pass from the terminals 2 and 1 to the armatures of the condenser C.

I have determined experimentally that the presence of the conducting member *a*, which as before stated may be grid-shaped, increases the sensitiveness of the oscillation detector and, inasmuch as the explanation of this phenomenon is exceedingly complex and at best would be merely tentative, I do not deem it necessary herein to enter into a detailed statement of what I believe to be the probable explanation.

In associating an oscillation detector of the above mentioned type, said detector being now commonly known as the audion, with a closed tuned circuit, it will be noted by reference to Fig. 2, that the secondary I, closes a circuit containing a battery shown at B through the electrode *b*, conducting member *a'* and the conducting gaseous medium intervening between said electrode and member. Also by reference to Fig. 1, it will be seen that a similar closed circuit exists between said battery, and the electrode *b* and conducting member *a*. In order to close each of said circuits to the passage of direct current from the aforesaid battery therethrough, or to prevent the development of a difference of potential between the members *a* and *b*, or between *a'* and *b*, or to prevent the members *a* or *a'* from receiving an electrical charge from said battery, I insert the condenser C' in said otherwise mechanically closed circuit and find that the presence of said condenser produces a great increase in the sensitiveness of the oscillation detector as determined by the very marked increase in the sound produced in the telephone T

evacuated vessel, an electrode inclosed therein, means for heating said electrode, a second electrode inclosed within said vessel, a local circuit having its terminals electrically connected to said electrodes, said local circuit including a source of electromotive force and a signal indicating device, a grid of conducting material inclosed within said vessel and located between said electrodes, and means for conveying the oscillations to be detected to the heated electrode and grid.

14. An oscillation detector comprising an evacuated vessel, two electrodes, one of which is a filament, inclosed within said vessel, means for heating said filament, and a conducting member inclosed within said vessel and interposed between said electrodes.

15. An oscillation detector comprising an evacuated vessel, two electrodes inclosed within said vessel, means for heating one of said electrodes, a grid of conducting material inclosed within said vessel and interposed between said electrodes, a local circuit connecting said electrodes, and a source of electromotive force and signal indicating device in said local circuit.

16. An oscillation detector comprising an evacuated vessel, two electrodes, one of which is a filament, inclosed within said vessel, means for heating said filament, and a grid of conducting material inclosed within said vessel and interposed between said electrodes.

17. An oscillation detector comprising an evacuated vessel, two electrodes inclosed within said vessel, means for heating one of said electrodes, a conducting member inclosed within said vessel and interposed between said electrodes, and a local circuit including a source of electromotive force connecting said electrodes.

18. An oscillation detector comprising an evacuated vessel, two electrodes inclosed within said vessel, means for heating one of said electrodes, a grid of conducting material inclosed within said vessel and interposed between said electrodes, a local circuit including a source of electromotive force connecting said electrodes and a signal indicating device associated with said local circuit.

19. An oscillation detector comprising an evacuated vessel, two electrodes, one of which is a filament, inclosed within said vessel, means for heating said filament, a grid of conducting material inclosed within said vessel and interposed between said electrodes and a local circuit including a source of electromotive force connecting said electrodes.

20. An oscillation detector comprising an evacuated vessel, two electrodes inclosed therein, means for heating one of said electrodes, a conducting member inclosed within said vessel, a closed oscillation circuit, a circuit connecting one element of said oscillation circuit with one of said electrodes and said conducting member, and a condenser in said circuit.

21. An oscillation detector comprising an evacuated vessel, two electrodes inclosed therein, means for heating one of said electrodes, a conducting member inclosed within said vessel, a closed oscillation circuit, a circuit connecting one element of said oscillation circuit with one of said electrodes and said conducting member, a condenser in said circuit, a signal indicating device and a circuit connecting said device with the other of said electrodes and said conducting member.

In testimony whereof, I have hereunto subscribed my name this 21st day of Dec 1906.

LEE DE FOREST

Witnesses:
THOMAS L. GALLAGHER,
HANS W. GOETZE.

[fol. 2892] DEFENDANT'S EXHIBIT L

The Thermionic Vacuum Tube and its Applications

By H. J. Van Der Bijl, M.A., Ph.D., M.Am.I.E.E.,M.I.R.E., Mem. Am. Phys. Soc., Scientific & Technical Adviser, Dept. of Mines & Industries, Union of South Africa, Late Research Physicist, American Tel. & Tel. Co. and Western Electric Co., New York. First Edition. McGraw-Hill Book Company, Inc., New York, 239 West 39th Street, London: 6 & 8 Bouverie St., E.C. 4, 1920

If we are concerned only with electrodes that can be heated by passing a current through them we can adopt the practice that lamp manufacturers have been following for the last twenty or thirty years, viz., passing a current through the electrodes to raise them to a higher temperature than they attain during operation, and by baking the bulbs in ovens to as high a temperature as the glass can stand. But thermionic devices of the most commonly employed types also contain electrodes (anode and grid) which cannot be heated by passing a current through them. These electrodes can be heated during evacuation by electron bombardment; that is, by passing a thermionic current from cathode to anode through the tube. The amount of this current and the voltages applied should be higher than the values used when the tube is subsequently put in operation. Although these tubes operate under the condition that gas has no influence on the discharge, the operation of the tube will always be better understood if the effects of small traces of gases are known. These effects are therefore discussed in Chapter V.

The thermionic valve (by this we mean a two-electrode thermionic tube) is still used at the present time as a rectifier of alternating current, and as such it is a valuable instrument, and is capable of performing useful functions. Its operation and some of its uses are discussed in Chapter VI.

As a detector of electromagnetic waves, the valve has no commercial value. The device which is used for detecting [fol. 2893] purposes is the three-electrode tube which in addition to the anode and hot cathode, also contains a grid to control the flow of electrons from cathode to anode. The grid was inserted by de Forest in 1907, who called the device the "Audion" and it is the insertion of the grid which has

made the thermionic tube of such great value. Since the flow of electrons from filament to anode or plate can be varied by applying potential variations to the grid, the circuit in which this tube is used consists of two branches: the output circuit connecting the filament to the plate through a current or power indicating device and the input circuit connecting the filament to the grid through the secondary of a transformer or other means of supplying potential variations to the grid.

The audion was first used as a radio detector but was subsequently found to be capable of performing a number of other important functions. In fact, the insertion of the grid into the valve resulted in a device of tremendous potentialities—one that can justly be placed in the same category with such fundamental devices as the steam engine, the dynamo and the telephone.

Since a mere variation in the potential of the grid produces a variation in the plate current, it could reasonably be expected that more power would be developed in the output circuit than the power expended in the input circuit, and this has actually been found to be the case. The operation of the tube as an amplifier is simpler than its operation as a detector. I have therefore found it best first to discuss the manner in which the tube operates as an amplifier, reserving its operation as detector for discussion in a later chapter. Chapter VII not only describes the amplifier and the manner in which it operates, and the circuits that can be used, but also discusses the characteristics of the three-electrode tube.

Since the power in the output circuit of the audion tube is greater than the power expended in the input, it is possible to increase the degree of amplification by feeding back part of the energy in the output to the input. If the proportion of the energy thus returned to the input circuit is large enough and the phase relations of the currents in the output and input circuits are right, the tube can be made to produce sustained oscillations. What is usually done is to connect the tube in an oscillation circuit having the desired capacity and inductance, and then couple the output circuit to the input in such a way that current variations in the output circuit cause potential variations to be impressed on the grid. There are a great variety of circuits whereby this can be accomplished. To make a three-electrode tube produce sustained oscillations is an extremely simple matter,

but to make it operate in the most efficient way as an oscillation generator requires a knowledge of the various factors that influence its operation as such. These matters are discussed in Chapter VIII.

When the tube is used as an amplifier or oscillation generator it is desirable that the characteristic representing the relation between the plate current and the potential of the plate or grid be as nearly linear as possible. On account of the negative space charge of the electrons in the space [fol. 2894] between filament and anode the characteristic is not linear, but convex towards the axis of voltage. When the applied voltage becomes sufficiently high to attract the electrons over to the plate as fast as they are emitted from the filament, the characteristic curve becomes concave towards the voltage axis and finally becomes nearly horizontal, thus giving the saturation current. In order to obtain the best operation of the tube as an amplifier, it is necessary to straighten out the characteristic of the plate circuit. Means whereby this can be done are discussed in Chapter VII. The curvature of the characteristic causes the shape of the current wave in the output to be distorted, and is therefore a very undesirable feature of the audion as an amplifier. On the other hand, the fact that the characteristic is curved simply increases the number of uses to which the audion can be put. Its ability to detect electromagnetic waves lies in the curvature of its characteristic. This also makes it possible to use the tube for modulating high frequency waves for the purpose of radio or carrier telephony and telegraphy. The processes involved in detection and modulation are identical, and these are therefore treated together in Chapter IX.

In Chapter X are described a few miscellaneous applications of the thermionic tube. This list is intended to exemplify the manner of applying the principles of the tube and does not make any pretense at being complete. It is believed that the number of such applications is destined to increase considerably and that the tube will become of increasing importance not only in engineering practice, but also in university and college laboratories.

A large number of names have been used to designate the three-electrode type of thermionic tube, such as audion, pliotron, triode, thermionic valve, etc.—an impressive array of names which certainly attests the importance of this device. To forestall any possible confusion in the mind of

the uni-tiated reader I may say that these names all apply to one and the same thing, namely the audion or three-electrode tube discussed in the following pages.

The major portion of the development of the audion has taken place in the past eight years, but while the number of applications of the tube increases almost daily, we must frankly admit that as far as the tube itself is concerned, it was developed to a full grown and powerful instrument as early as 1914. The rapid development of this device, both in the United States and Europe and the popularity it has gained, are due to a number of factors that have concurred to place it in the foreground. One obvious reason of course, is its ability to perform such a large number

. . . . . .

Referring now to Fig. 12, it is seen that there is a definite frequency ν_0 of the light at which the voltage necessary to drive the electrons back becomes zero. This means that for frequencies lower than this value no electrons escape at all. Putting $V=0$ in equation (21) we get:

$$\nu_0=\frac{\epsilon}{h}\Phi \qquad (22)$$

[fol. 2895] This limiting frequency, commonly referred to as the *photo-electric long wave length limit* is a fundamental property of solids and, is equal to a constant multiplied by the electron affinity—the same constant that plays such an important part in the emission of electrons from hot filaments in the thermionic vacuum tube.

The quantities h and ϵ are universal constants, that is, their values are independent of the matter under investigation and the conditions of the experiments. Their values are $h=6.55\times10^{-27}$ erg. sec., and $\epsilon=4.77\times10^{-10}$ E.S. units.

22. *Control of Space Current by Means of an Auxiliary or Third Electrode.*—A convenient and what has proved to be a very valuable means of varying a space current is obtained by placing a third electrode in the neighborhood of the cathode and applying potential variations to it. This scheme was used by de Forest to control the electron discharge in his audion detector in 1907.[1] He later gave the

[1] Lee de Forest, U. S. Patent No. 841387, 1907.

auxiliary electrode the form of a wire gauze or grid placed in the path of the discharge between cathode and anode.[2] About the same time von Baeyer[3] also used an auxiliary electrode to control a thermionic current from a hot filament. In von Baeyer's arrangement the anode was a cylinder and the cathode a wire placed along its axis. The third electrode was a wire gauze bent into the form of a cylinder and placed between cathode and anode. A similar scheme was also used by Lenard[4] in 1902 in connection with photo-electric experiments. It is hardly necessary to say that the insertion of the grid has made the audion a device of immense practical importance and enabled it to perform functions that would otherwise have been impossible.

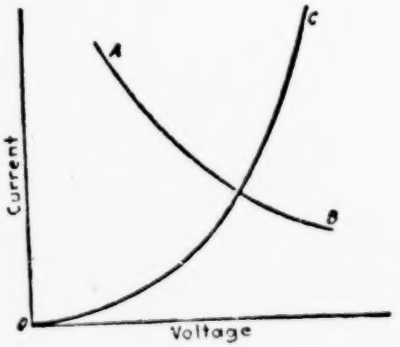

FIG. 34

tic"; that is, its relation between current and voltage is given by a curve such as AB (Fig. 34). The gas-free device, on the other hand, has a characteristic similar to OC. The difference between tubes containing these characteristics becomes apparent when we consider the corresponding a-c. resistances. The a-c. resistance for small current or voltage variations at any definite voltage is given by the reciprocal of the slope of the characteristic at a point corresponding to that voltage. Since the slope of the curve AB is negative, the arc has a negative resistance, while the resistance of a gas-free tube is positive.

It is the negative resistance of the arc which enables it to produce sustained oscillations. It will be shown in Chapter VIII that a device containing only two electrodes can only produce sustained oscillations if it has a negative resistance or a falling characteristic. The principle involved in the production of sustained oscillations by the audion or three-[fol. 2896] electrode thermionic tube is entirely different

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[2] Lee de Forest, U. S. Patent No. 879532, 1908.

[3] O. von Baeyer, Verh. d. D. Phys. Ges., Vol. 7, p. 109, 1908.

[4] P. Lenard, Ann. d. Phys., Vol. 8, p. 149, 1902.

and depends on the controlling action of the grid on the electron flow from filament to anode.

* * * * * * *

radio detector. The circuit in which Marconi used this device as a radio detector is shown in Fig. 39.

45. *Valve Detector with Auxiliary Anode Battery.*—By our present standard of measurement the two-electrode tube is a very inefficient detector. It can be, and has been used more efficiently by operating on a chosen point of the current-voltage characteristic, thus making it fall in the class of rectifiers given by condition (4) instead of that represented by condition (3). This can be done by inserting a local battery in the circuit as shown in Fig. 40.[5]

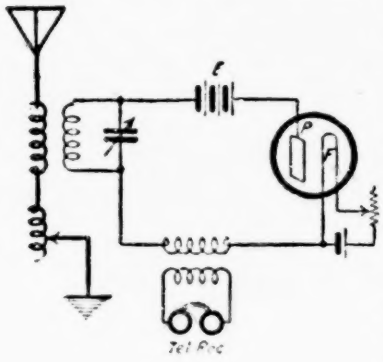

FIG. 40

The operation of the device when used this way can be understood from the following: By the insertion of the battery E there is established in the circuit FPE a constant direct current which has a finite value even when no oscillations are impressed from the antenna. The current through the device can therefore be represented by a function of the form

$$I_{(+i)} = f(E + e \sin pt), \qquad (5)$$

where E is the local source of direct voltage, I the direct current due to E and i the superposed a-c. due to e. This can be expanded into a powerseries.

$$f(E + e \sin pt) = f(E) + f'(E)\, e \sin pt + f''(E) \cdot \frac{e^2 \sin^2 pt}{2} + \cdots + f^{(n)}(E) \frac{e^n \sin^n pt}{n} \cdots$$

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[5] See Lee de Forest, Proc. A. I. E. E., Vol. 25 p. 719, 1906, and J. A. Fleming, Proc. Roy. Inst., Great Britain, June, 1919, p. 677.

Chapter VIII—The Vacuum Tube as an Oscillation Generator

79. *Introductory.*—Since the three-electrode tube can operate as an amplifier, the energy in the output circuit is greater than that in the input circuit. Hence, if part of the energy in the output be returned to the input, there will — a further amplification of energy resulting in an increased output. If the amplified energy gets back to the input in sufficient amount, and if the phase relations of the output and input currents are right, there will be a constant re-amplification and feeding back of energy from the output to the input, and the device will then produce sustained oscillations without it being necessary to supply potential variations to the grid by external means. In other words, the device will then operate as an oscillation generator. [fol. 2897] The frequency of the oscillations will be determined by the constants of the circuit, while their intensity will depend on the amount of energy fed back to the input, the shape of the characteristic curve, and the rate at which power is dissipated. There is a variety of circuit arrangements whereby this can be done. These circuits can all be divided into three main groups in which part of the energy in the output is returned to the input: (1) by resistance coupling, such as is explained, for example, in connection with Fig. 145, page 259; (2) inductive coupling; (3) capacitative coupling between output and input.

In the present chapter we shall briefly discuss the conditions that must be satisfied in order to use the three-element tube to produce oscillations of a definite frequency and amplitude. A large amount of work has been done on this phase of the subject, and no attempt will be made here to enter into a full discussion of these investigations. It is believed rather that an explanation of the fundamental principles that govern the production of sustained oscillations with the three-electrode tube, and an indication

* * * * * * *

From this we see that in order to obtain sustained oscillations from a device having only two electrodes, it is necessary that the device shall have a negative resistance. Examples of negative resistances have already been given in the previous pages. Thus an arc may have a negative resistance, its characteristic being of the form shown by the

curve AB in Fig. 34. The resistance is given by the slope of the characteristic and this is a negative quantity for a characteristic of the kind shown. Fig. 16, page 48, shows another characteristic which over a region ABC has a negative slope and is obtained as the result of the emission of electrons from metals under the impact of electrons. Such characteristics as these are sometimes referred to as "falling characteristics."

The thermionic valve does not show a falling characteristic like the curve AB of Fig. 34, when it is sufficiently well evacuated to prevent the effects of ionization by collision from appreciably influencing the discharge. The characteristics of thermionic valves are those given and discussed in the previous chapters and it will be seen that for such devices the resistance is always positive. It is, therefore, impossible to obtain sustained oscillations from a well-evacuated thermionic valve containing only two electrodes. If such a device contains an appreciable amount of gas during the operation, the characteristic becomes unsteady and sometimes, especially at the higher voltages, exhibits regions over which the slope is negative, and when operated over that region it is, of course, possible to obtain sustained oscillations. The condition which makes this possible in a two-electrode device is unfortunately due to the cause which makes such a device unsatisfactory; namely, the presence of too much gas in the device, thus causing unsteadiness of the discharge and making reproducibility practically impossible. If a controlling electrode or grid be added to the two electrodes of a valve, the operation becomes different and we now have a device which can produce sus- [fol. 2898] tained oscillations with facility while at the same time satisfying all the conditions that are necessary to secure satisfactory operation in every respect, namely, freedom of gas with consequent steadiness and reproducibility of results, and comparatively long life.

82. *Condition for Oscillation for Three-Electrode Tube.*— Let us now consider a circuit like that shown in Fig. 152. This is one of a large number of possible oscillation circuits. It is

DEFENDANT'S EXHIBIT M

Proceedings of Physical Society of London, Vol. XXII, September 1910

XXV. On ~~an~~ Oscillation Detector actuated solely by Resistance-temperature Variations. By W. H. Eccles, D.Sc.[1]

In a recent communication to the Physical Society[2] the properties of a type of iron-oxide coherer were discussed. The paper described experiments on coherers made by dipping a slightly oxidised iron wire into clean mercury, or by pressing a fine iron wire against a thinly oxidized iron plate, and the results were discussed mathematically. It was shown that in the case of the iron point and oxidized plate the whole of the experiments could be explained qualitatively on the assumption that the only electrical phenomena at play were the Joule effect and the resistance-temperature changes in the small mass of oxide between the metal electrodes. The hypothesis that was put forward must be summarized here. Let z be the resistance of that part of the detector where the current flow is so constricted that the Joule effect produces rise of temperature, and r the resistance of the remainder of the circuit. The resistance z is usually localized at the contact of the conductors that form the detector, and it varies with the temperature of the minute mass of matter at the contact; let a be the coefficient of decrease of resistance with rise of temperature. The resistance r includes that of the bulk of the substances forming the detector, the leads and the telephone; it is supposed constant. Let c be the current when the electromotive force applied to the detector is e. Assume that the rate of loss of heat from the warmed contact is $m\theta$, where θ is the temperature of the contact above that of the surroundings. Then it was shown that in the steady state

$$e=\left(\frac{\rho_0}{1+q\alpha\theta^2}+r\right)c, \qquad (1)$$

[1] Read May 27, 1910.

[2] W. H. Eccles, "On Coherers," Phil. Mag. June 1910; Proc. Phys. Soc. vol. xxii. 1910.

where ρ_0 is the resistance of the contact when cold and q is a constant. If the curve $\epsilon = \rho_0 c / (1 + q\alpha c^2)$ be plotted with c as abscissæ and ϵ as ordinates, it is seen to rise from the origin of coordinates with an increasing gradient till at a definite value of c it becomes vertical. Then as c increases, the curve bends towards the axis of c and approaches it asymptotically. Along this latter part of the curve, increasing current is associated with decreasing elec- [fol. 2899] tromotive force—an unstable state of affairs. Any conductor possessing a negative temperature-coefficient of resistance exhibits these properties. In such conductors an increase of current produces, in accordance with Joule's law, an increase of temperature, and consequently, a diminution of the resistance. The curve shows that after a certain stage is passed the diminution of the resistance which accompanies increasing current is great enough to lead to a catastrophe. Stability can, however, be obtained by introducing into the circuit of the variable resistance ρ a sufficiently large constant resistance r. The phenomenon resembles that of the electric arc. The unstable portion of the above curve corresponds, in fact, to the "falling characteristic" of the arc.

If the resistance r is large the ϵ, c curve has a positive gradient throughout, and the gradient has a maximum at some value of ϵ. Near this point the contact is found to work best as a detector of oscillations. The hypothesis put forward by the author supposes that a train of oscillations, by yielding its energy as heat to the contact, raises the temperature there and disturbs the existing equilibrium of current and voltage. The dissipation of a train of oscillations is accomplished in a time of the order of a fifty-thousandth of a second; the ensuing fluctuation of the current causes the sound in the telephone. In the paper cited, the energy w given to the telephone circuit was shown to be connected with the energy W delivered by the train of waves by the equation

$$w = m(W - a), \qquad (2)$$

where m and a are constants for any fixed value of the current. This theoretical conclusion agreed well with the experiments on an iron oxide coherer. The object of the present paper is to show that the above hypothesis holds good for a very different type of detector. All the well-known forms of "contact" detector consist of a contact between two substances that stand well apart in the thermo-

electric series, and the thermoelectric force plays a very important part in their operation. They are usually classed as "rectifying detectors" to distinguish them from such detectors as the coherers. In seeking a "rectifying detector" that would illustrate the above hypothesis, substances that stand far apart in the thermoelectric series must be avoided, for such substances would introduce Peltier effects that would tend to mask the resistance-temperature phenomena we wish to isolate. Even in the iron : iron-oxide : iron coherer it is possible that thermoelectric forces arise owing to unequal heating of the two iron to iron-oxide junctions. It occurred to me, therefore, to construct a detector out of one substance only. Accordingly a search was made for a substance possessing high, but not too high, resistivity, with large negative temperature-coefficient. Several such substances were found among the native crystalline oxides and sulphides. Most of these are allotropic, and must on that account be avoided. Fortunately galena, the native sulphide of lead, has fairly high resistivity, a very large negative resistance coefficient, and crys- [fol. 2900] tallizes in the cubic system. A galena-galena detector was therefore constructed. Two pieces of galena cut from the same crystal were embedded in solder, mounted in a clamp, and brought into gentle contact. It was put into a wireless telegraph receiving set and was found to yield excellent signals when a current of proper magnitude was passed through it.

A few preliminary experiments showed that it was not easy to find two pieces of galena, which when placed together and submitted to positive and negative voltages in turn, exhibited perfect symmetry. The symmetry is always small, and is probably due to the rise of thermoelectric forces at the contact when it becomes heated by the steady current, and these forces are probably caused by slight variations in the chemical composition of the galena from point to point in the crystal. When a contact that gives symmetrical voltage-current curves is found, it constitutes a detector that operates only when a current is passing through it. The efficiency of the detector is the same for each direction of the current, and appears to be practically independent of the shape of the galena surfaces at the contact.

The experiments now to be described were made on selected galena-galena combinations in precisely the same

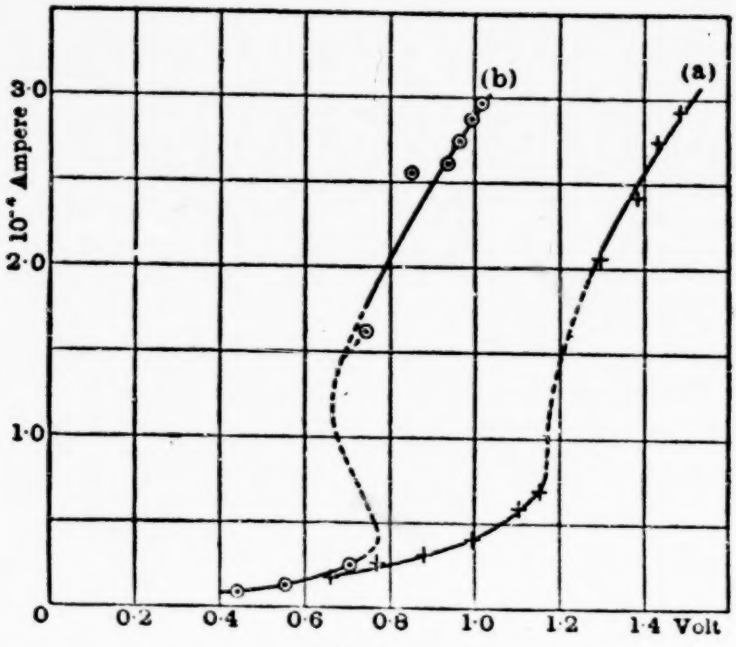


FIG. 1

way as the earlier experiments on the iron-oxide detectors. The diagram of the apparatus employed is shown in fig. 1 of the previous paper (Phil. Mag. June 1910, p. 872, & Proc. Phys. Soc. vol. xxii; p. 293). The mutual inductance between L and L′ was 2500 cm. in obtaining the results described below.

[fol. 2901] The detector was placed at D and submitted to an electro-motive force from P_2, which was varied in steps from zero to about one volt positive or negative. At each step an observation was made of the steady current through the detector, and of the intensity of the sound produced in the telephone by electrical oscillations of amplitude fixed by the position of the jockey on P_1. The steady current observation was made by means of a shunted galvanometer kept connected in series with the telephone. The intensity of the sound was

DEFENDANT'S EXHIBIT N

Wireless Telegraphy with Special Reference to the Quenched-Spark System

By Bernard Leggett, A. M. I. E. E., late Wireless Technical Staff, Messrs. Siemens Bros. and Co., Ltd., Late Officer in Charge of Trench Wireless, 1st Corps, B. E. F. London, Chapman & Hall, Ltd., 11 Henrietta St., W. C. 2, 1921

increase of the e. m. f. causes the passage of a current. Such increase may be due to a signal received upon an aerial and the passage of the current of the external e. m. f. is rendered audible by the telephone.

For good working the negative electrode should be a point of about .002 sq. mm. surface. These detectors are extremely sensitive, but require accessory regulating apparatus and attention, and are now largely replaced by contact detectors.

4. *Contact detectors.*—These are the detectors most used at the present day. They consist essentially of contact points between a suitable metal and crystal such as molybdenite or galena. Such a contact has the property of allowing oscillatory currents to pass in one direction and not the other, so rendering them aperiodic. The passage of these aperiodic currents may be heard by connecting a small condenser in circuit and shunting it with a telephone wound to the correct high resistance.

These detectors are the most sensitive for ordinary working, cannot be greatly damaged, are always ready for use, and require no auxiliary apparatus. They are therefore very widely used.

The action of Crystal Detectors.—Very many hypotheses have been put forward to explain the action of contact detectors, the chief views being that the phenomena depends on thermo-electric properties, photo-chemical properties, electrolysis in solids, electro-static attraction, etc.

The balance of evidence would seem to be that their action depends on electro-thermal phenomena. Such phenomena depends on:

1. The variation of resistance with temperature.

2. The Peltier effect, which may be expressed as the causation of an increase or decrease of temperature, when

an electrical current passes across a junction of two *different* metals. Conversely a current is generated when such junction undergoes a variation in temperature (made use of in the thermo-couple).

[fol. 2902] 3. The Thomson effect, which produces an electrical e. m. f. between different parts of the same metal at different temperatures.

Any or all of these phenomena appear to cause rectification of the oscillatory currents of wireless telegraphy. The elaborate consideration of these effects is primarily a matter of pure physics, and for further information the reader must be referred to Starling's Electricity and Magnetism."

The application of such phenomena to wireless reception is Boltzmann in 1890, would appear to be the first to apply gaseous tubes to wireless purposes, i. e. to detect Hertzian oscillations.

Zehnder, in 1892, improved Boltzmann's arrangement producing his "trigger-tube" (Fig. 72 (1)), in which a local circuit (F.E.G.) was so adjusted that its potential was just insufficient to break down the resistance of a gaseous tube. Complete breakdown resulted when a small additional potential was supplied by an Hertzian oscillator, represented by ABCD. The apparatus was used purely to detect the presence of oscillations, but was undoubtedly also an intensifying arrangement.

Whilst it was not thermionic, i. e. it did not utilise electrons given off from a heated filament, it is undoubted more allied to the present-day amplifier in its method of operation than the later two-electrode tube of Fleming.

In 1884, Edison, at the Philadelphia Exhibition, had exhibited an apparatus consisting of a plate between the limbs of the filament of an incandescent lamp (Fig. 72 (2)). He showed that if a galvanometer was connected between the plate and the negative end of the filament no current was shown, whereas when the plate and the positive end of the filament were connected, a current was obtained.

Since electrons had not yet been shown to exist no reason could be given for this effect, called the Edison effect, but which had also been independently shown in high vacua, by Elster and Geitel.

Fleming, in 1904, utilised the Edison effect, and Elster and Geitel's apparatus in a modified form, to produce a

wireless detector, rectification being brought about owing to the unidirectional conduction already mentioned. Fleming's arrangement is shown in Fig. 72 (3), and is in effect a reversal of the relative position of plate and filament in Edison's apparatus.

The Fleming valve was purely and simply a rectifier or detector. In no way was it an intensifying device, it did not use a very high vacuum, as is the case in the modern valves of Langmuir and Meissner, and was not a means of generating oscillations like these later valves.

Whilst Fleming must be credited as being the first to apply thermionic phenomenon to wireless detection, the claim that he is alone the originator of the present-day thermionic valve is rather exaggerated, since the intensifying properties of the present-day valve are far more important than its detecting properties, and as an intensifying arrangement, the Zehnder "trigger-tube" is more akin to the modern valve in principle.

[fol. 2903] As a detector the Fleming valve was fairly sensitive, but from the author's own personal experience, a result also noticed by Stanley, it was not so sensitive as a crystal detector. As well as being more sensitive, the crystal detector has the advantage of not requiring any heating battery, with consequent adjustment and maintenance troubles.

The next step in the development was due to de Forest who was the first to use the modern three-electrode valve for wireless work in his "Audion" patent of 1907. This arrangement (Fig. 72 (4)) is essentially the modern valve. It had a vertical filament, a zig-zag grid and a plate, and was certainly a great advance.

As far as the author can ascertain, and certainly from his patent specification, this valve did not, like some of his later ones, use an oxide coated filament. It was a vacuum tube but not of exceeding high vacua. De Forest would appear to have intended his device as a detector only, and did not recognise its possibilities as an intensifier, which it must undoubtedly have been.

Much controversy and litigation occurred over the patent aspects of the audion, Fleming claiming that it infringed his two-electrode valve, although he himself states "the Audion differs from the author's oscillation valve in having a grid and a plate sealed into the bulb, in place of a single metal cylinder surrounding the filament."

The result of this American litigation was that, whereas de Forest was prevented from using his valve, since it infringed Fleming's patent, on the other hand the Marconi Company, who were interested in Fleming's action, were equally prevented in using de Forest's three-electrode valve, which according to de Forest ("Electrician," p. 26, 1916) was their intention.

De Forest's letter referred to above should certainly be read before forming any opinion as to the relative value of claims regarding the origin of the valve. It certainly illustrates how patent litigation can retard scientific progress.

The whole situation regarding this controversy is best summed up in Mr. Justice Sargeant's words at the Chancery Division, on Fleming's application for extension of his 1904 patent: "I should hesitate to describe a three-electrode valve or de Forest valve as being a mere improvement in view of the great independent invention displayed in that device. I do not think that the valve would ever have come into being but for the previous invention of the 1904 Fleming valve, though it is of course obvious and admitted by the Petition, that where the de Forest

* * * * * * *

It will be most convenient to deal with each class of generator separately, before dealing with purely telephonic questions.

Arc-generators

In 1899 Mr. W. Duddell found that if a direct-current electric arc, such as that of an arc-lamp, is shunted by a circuit containing capacity C and inductance L (Fig. 180), [fols. 2904-2905] oscillations of a frequency, approximately

$$\frac{1}{2\pi\sqrt{LC}},$$ occur in the shunt circuit.

The production of these oscillations is as follows:

On closing the shunt circuit, the flow into the condenser causes a drop in the flow of current into the arc. Consequently the temperature falls, and the resistance of the arc increases, becoming a greater fraction of the resistance of the main circuit. The resistance of the main circuit and the difference of potential between the arc carbons rises with a further production of flow into the condenser. Eventually

the accumulation of charge in the condenser raises the difference of potential between its plates to that between the carbons. This results in stopping the flow into the con-

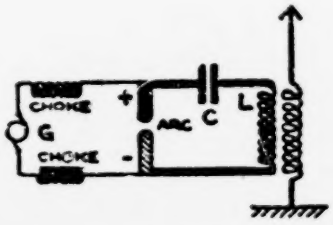


FIG. 180.—Duddell arc.

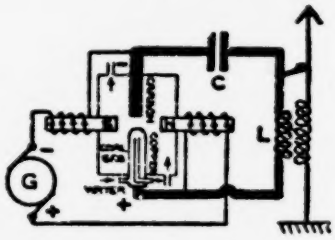


FIG. 181.—Poulsen arc.

denser, and the arc regains its original condition. When the current via the arc has risen to its original value, its resistance falls, and in consequence the potential across the arc falls. The condenser then begins to discharge across the arc, so reversing the previous condition.

The inductance in the shunt circuit gives this circuit inertia so that the current having started, the circuit is always carried past the stable condition and oscillations occur. The existence of the oscillation depends upon the fact that the resistance of the arc varies with the current in such a manner that the potential difference between the carbons diminishes with increasing current, and the arc behaves as though it had a negative resistance.

133120

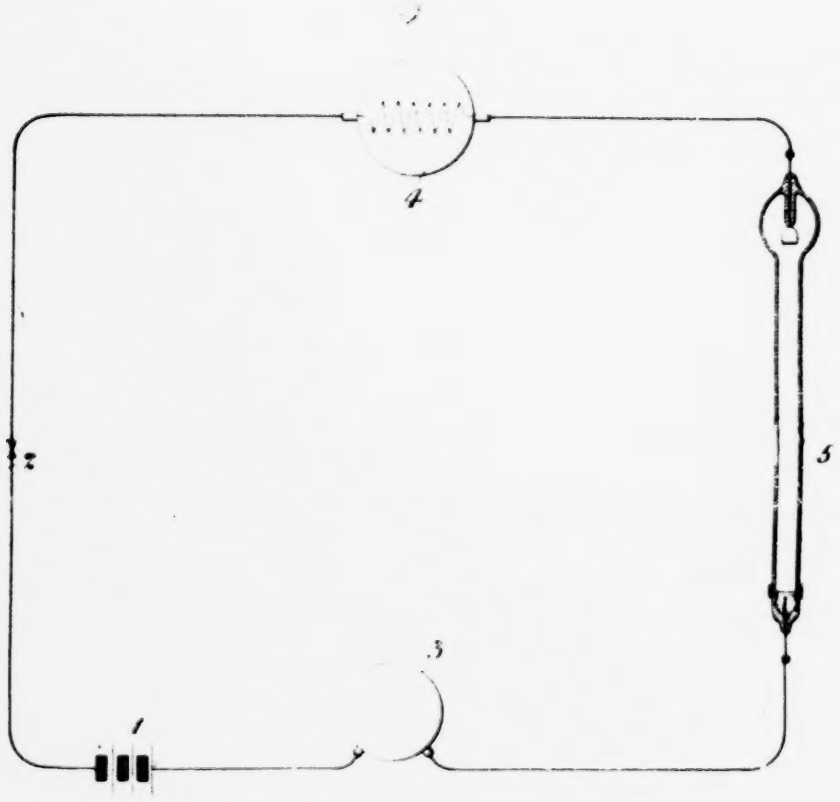
Defendant's Exhibit O

No. 781,001. PATENTED JAN. 31, 1905.

P. C. HEWITT.

MEANS FOR AMPLIFYING ELECTRICAL VARIATIONS.

APPLICATION FILED MAY 16, 1902.



Witnesses
Elizabeth H. Sleeper

Inventor
Peter Cooper Hewitt
By his Attorney
Charles A. Terry

2906-2907

33321

No. 781,001. Patented January 31, 1905.

UNITED STATES PATENT OFFICE.

PETER COOPER HEWITT, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO COOPER HEWITT ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

MEANS FOR AMPLIFYING ELECTRICAL VARIATIONS.

SPECIFICATION forming part of Letters Patent No. 781,001, dated January 31, 1905.

Application filed May 16, 1902. Serial No. 107,804.

To all whom it may concern:

Be it known that I, PETER COOPER HEWITT, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Means for Amplifying Electrical Variations, of which the following is a specification.

In certain patents granted to me September 17, 1901, attention is called to the fact that the resistance of an inclosed vapor or gas carrying current in an electric circuit varies inversely with the current carried by the vapor. Accordingly if a varying potential be applied to an apparatus of the general character described in the patents referred to a variation of current will take place in the inclosed gas or vapor, and this variation of current will affect the entire circuit in which the apparatus is included, and if the circuit is so arranged that the gas or vapor apparatus shall represent a considerable portion of the total resistance of the circuit the variations of current thus caused in the conducting gas or vapor will cause comparatively large variations in the entire circuit.

It is customary to operate electric circuits for various purposes by causing variations of potential in the circuit, such variations being utilized to influence appropriate receiving apparatus. In the present invention I avail myself of the peculiar features of electrical resistance in a gas or vapor conductor to vary or magnify the effects produced by potential variations in a circuit. By virtue of the described characteristics of gas or vapor conductors it is possible, for instance, to translate variations of potential in a circuit into variations of current or quantity, and inasmuch as the conducting gas or vapor responds practically instantaneously to the applied variations of potential, currents of any practical rapidity or frequency can be made to undergo the described transformation and produce their effects upon a suitable receiving apparatus. As the practical result of an increase of applied potential is an increased flow of current, the original electrical impulses in the circuit may produce magnified effects as compared with those which the same impulses would produce if applied directly to the receivers.

The drawing herewith is a diagram of a typical circuit embodying my invention.

In the drawing, 1 is a suitable source of current supplying a circuit 2. Included in the circuit are a transmitting or potential-changing apparatus 3 and a receiving apparatus 4. The transmitting apparatus may be a telegraph-relay, a telephone-transmitter, or any other device adapted to vary the potential of the current in the circuit 2. The receiving apparatus 4 may be any suitable receiver adapted to respond to variations of current in the line.

A circuit made up as described is common enough in the electrical arts. The improvement forming the subject of the present application consists in causing the described circuit to be affected by the peculiar action of an inclosed gas or vapor apparatus, (shown at 5.) This apparatus may be such an apparatus as described in my patents above referred to as a "gas" or "vapor" electric lamp, or it may be an apparatus generally similar to such a lamp, but having no light-giving quality by reason of being specially adapted to the purposes of this invention without regard to the matter of light. For this purpose the device may be made with a comparatively short gas or vapor path and having such cross-section that with the current normally traversing it the vapor or gas may become but faintly luminous. The resistance of the circuit outside the device 5 is practically constant except for the slight variations introduced through the instrumentality of the potential-changing apparatus 3. As the resistance of the device 5 varies substantially inversely with the quantity of the current flowing, or, to put it another way, requires a definite voltage to pass a definite current therethrough, any diminution, for instance, of the potential applied to its terminals by reason of an increase of resistance on the part of the device 3 will result in not only the diminution of flow of current due to the

2908

increased resistance of the device 3, but also to an additional diminution due to the change brought about in the device 5 by the decreased current resulting from the decreased potential at the terminals of the device 5. Likewise an increase of potential at the terminals of the device 5, due to a change of resistance in the outside circuit, will cause an increase of current-flow therethrough greatly in excess of the change due to the change of resistance in the other portions of the circuit. In other words, the changes of resistance in other portions of the circuit than the device 5 bring about such variations of conditions in the device 5 as to augment the variations of current-flow through the entire circuit. It should be borne in mind, however, that the resistance of the other portions of the circuit than the device 5 serves in a measure as a balancing resistance for the device 5; otherwise a decrease of resistance in the external circuit might result in a continuing unchecked decrease of the total resistance of the circuit including the device 5. The device 5 itself, however, has in a measure a self-corrective tendency within certain limits, due to internal variations of resistance resulting from changes in its temperature. The temperature of the device 5 must be taken into consideration when measuring the device for ohmic resistance, as its ohmic resistance varies with the temperature which is brought about by variations in the flow of current and also by the surrounding conditions. The method of controlling these is set forth in the patents hereinbefore referred to. The variations in the amount of current through which the device 5 may be made to operate may be made quite wide by constructing it with the required heat-radiating capacity. It will now be understood that the receiving apparatus 4 will be affected by a comparatively large current and will respond with greater certainty and effectiveness than it otherwise would. The same amplification of the effects of potential changes in the circuit takes place whatever be the degree of potential increase or variation.

When the resistance of the element 5 is made a considerable portion of the total resistance of the circuit, the effect of the changes of resistance in the element named will be very marked, especially when the source of supply is great.

By reason of the gaseous condition of the conducting medium employed the gas or vapor apparatus responds instantly to potential changes in the current without essential loss of energy. In this respect it differs from other materials or substances, because in such other materials or substances work has to be done in the process of reducing the resistance whereby a loss of energy is caused and the time element becomes a considerable factor, while in my apparatus the amount of material so affected is so small that the energy required to produce the result may be practically neglected.

Means for starting the flow of current through the apparatus are set forth in the patents hereinbefore referred to.

I claim as my invention

1. The combination in an electric circuit, of a source of potential variation, a receiving apparatus adapted to translate the variations caused by the source, and an inclosed gas or vapor conducting medium.

2. The combination in an electric circuit, of a source of potential variations, a receiver adapted to respond to changes of current in the circuit, and a quickly-responding inclosed gas or vapor conducting medium whose resistance decreases with increments of temperature.

Signed at New York, in the county of New York and State of New York, this 9th day of May, A. D. 1902.

PETER COOPER HEWITT.

Witnesses:

WM. H. CAPEL.

GEORGE H. STOCKBRIDGE.

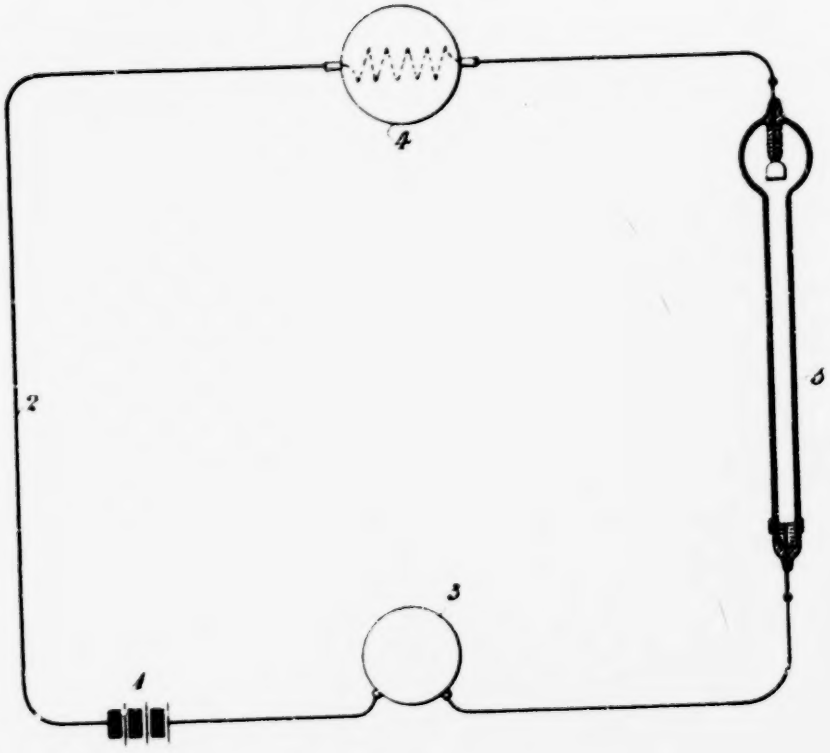
DEFENDANT'S EXHIBIT P

No. 781,002. PATENTED JAN. 31, 1905.

P. C. HEWITT.

METHOD OF AMPLIFYING ELECTRICAL VARIATIONS.

APPLICATION FILED MAY 16, 1902.



Witnesses
Frank L. Otis
Geo. H. Strong

Inventor
Peter Cooper Hewitt
By his Attorney
Charles A. Terry

No. 781,009. Patented January 31, 1905.

UNITED STATES PATENT OFFICE.

PETER COOPER HEWITT, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO COOPER HEWITT ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

METHOD OF AMPLIFYING ELECTRICAL VARIATIONS.

SPECIFICATION forming part of Letters Patent No. 781,009, dated January 31, 1905.

Application filed May 16, 1903. Serial No. 157,805.

To all whom it may concern:

Be it known that I, PETER COOPER HEWITT, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Methods of Amplifying Electrical Variations, of which the following is a specification.

In certain patents granted to me September 17, 1901, notably in the patents numbered 682,695, 682,696, and 682,697, attention is called to the fact that the resistance of an inclosed vapor or gas carrying current in an electric circuit varies inversely with the current carried by the vapor. Accordingly if a varying potential be applied to an apparatus of the general character described in the patents referred to a variation of current will take place in the inclosed gas or vapor, and this variation of current will affect the entire circuit in which the apparatus is included, and if the circuit is so arranged that the gas or vapor apparatus shall represent a considerable portion of the total resistance of the circuit the variations of current thus caused in the conducting gas or vapor will cause comparatively large variations in the entire circuit.

It is customary to operate electric circuits for various purposes by causing variations of potential in the circuit, such variations being utilized to influence appropriate receiving apparatus. In the present invention I avail myself of the peculiar features of electrical resistance of a gas or vapor conductor to vary or magnify the effects produced by potential variations in a circuit.

By virtue of the described characteristics of gas or vapor conductors it is impossible, for instance, to translate variations of potential in a circuit into variations of current or quantity, and inasmuch as the conducting gas or vapor responds practically instantaneously to the applied variations of potential currents of any practical rapidity or frequency can be made to undergo the described transformation and produce their effects upon a suitable receiving apparatus. As the practical result of an increase of applied potential is an increased flow of current, the original electrical impulses in the circuit may produce magnified effects as compared with those which the same impulses would produce if applied directly to the receivers.

The drawing herewith is a diagram of a typical circuit embodying my invention.

In the drawing, 1 is a suitable source of current supplying a circuit 2. Included in the circuit are a transmitting or potential changing apparatus 3 and a receiving apparatus 4. The transmitting apparatus may be a telegraph-relay, a telephone-transmitter, or any other device adapted to vary the potential of the current in the circuit 2. The receiving apparatus 4 may be any suitable receiver adapted to respond to variations of current in the line.

A circuit made up as described is common enough in the electrical arts.

The improvement forming the subject of the present application consists in causing the described circuit to be affected by the peculiar action of an inclosed gas or vapor apparatus, (shown at 5.) This apparatus may be such an apparatus as described in my patents above referred to as a "gas" or "vapor" electric lamp, or it may be an apparatus generally similar to such a lamp, but having no light-giving quality by reason of being specially adapted to the purposes of this invention without regard to the matter of light. For this purpose the device may be made with a comparatively short gas or vapor path and having such cross-section that with the current normally traversing it the vapor or gas may become but faintly luminous. The resistance of the circuit outside the device 5 is practically constant except for the slight variations introduced through the instrumentality of the potential-changing apparatus 3. As the resistance of the device 5 varies substantially inversely with the quantity of the current flowing, or, to put it another way, requires a definite voltage to pass a definite current therethrough, any diminution, for instance, of the potential applied to its terminals by reason of an increase of resistance on the part of the de-

vice 3 will result in not only the diminution of flow of current due to the increased resistance of the device 3, but also to an additional diminution due to the change brought about in the device 5 by the decreased current resulting from the decreased potential at the terminals of the device 5. Likewise an increase of potential at the terminals of the device 5 due to a change of resistance in the outside circuit will cause an increase of current-flow therethrough greatly in excess of the change due to the change of resistance in the other portions of the circuit. In other words, the changes of resistance in other portions of the circuit than the device 5 bring about such variations of conditions in the device 5 as to augment the variations of current-flow through the entire circuit. It should be borne in mind, however, that the resistance of the other portions of the circuit than the device 5 serves in a measure as a balancing resistance for the device 5. Otherwise a decrease of resistance in the external circuit might result in a continuing unchecked decrease of the total resistance of the circuit including the device 5. The device 5 itself, however, has in a measure a self-corrective tendency within certain limits due to internal variations of resistance resulting from changes in its temperature. The temperature of the device 5 must be taken into consideration when measuring the device for ohmic resistance, as its ohmic resistance varies with the temperature which is brought about by variations in the flow of current and also by the surrounding conditions. The method of controlling these is set forth in the patents hereinbefore referred to. The variations in the amount of current through which the device 5 may be made to operate may be made quite wide by constructing it with the required heat-radiating capacity.

It will now be understood that the receiving apparatus 4 will be affected by a comparatively large current and will respond with greater certainty and effectiveness than it otherwise would.

The same amplification of the effects of potential changes in the circuit takes place whatever be the degree of potential increase or variation.

When the resistance of the element 5 is made a considerable portion of the total resistance of the circuit, the effect of the changes of resistance in the element named will be very marked, especially when the source of supply is great.

By reason of the gaseous condition of the conducting medium employed the gas or vapor apparatus responds instantly to potential changes in the current without essential loss of energy. In this respect it differs from other materials or substances, because in such other materials or substances work has to be done in the process of reducing the resistance, whereby a loss of energy is caused and the time element becomes a considerable factor, while in my apparatus the amount of material so affected is so small that the energy required to produce the result may be practically neglected.

Means for starting the flow of current through the apparatus are set forth in the patents hereinbefore referred to.

I claim as my invention—

1. The method of amplifying potential variations caused in an electric circuit, which consists in applying the said variations to a quickly-responding medium in the circuit, thereby causing a change in current-flow through such medium, and by such change of current-flow producing in such medium a change of specific resistance resulting in a still further change in current-flow through the circuit.

2. The method of amplifying energy variations caused in an electric circuit of which an inclosed gas or vapor forms part, and of translating the effects of such amplified variations, which consists in affecting the conducting gas or vapor by variations of current, transforming such variations of current into variations of resistance, and applying such currents to a suitable translating device.

3. The method of amplifying energy variations caused in an electric circuit including an inclosed conducting gas or vapor and electrodes therefor, which consists in affecting the conducting gas or vapor by variations of current, and thereby transforming such variations into corresponding amplified variations of current.

Signed at New York, in the county of New York and State of New York, this 9th day of May, A. D. 1902.

PETER COOPER HEWITT.

Witnesses:

WM. H. CAPEL,

GEORGE H. STOCKBRIDGE.

The Principles Underlying Radio Communication

Radio Pamphlet No. 40, December 19, 1918, Signal Corps, U. S. Army. Washington, Government Printing Office, 1919

to be used for large distances. In this factor, λ enters in such a way as to make the received current less when the wave length is short than when it is long. Hence, in general, we conclude that to get the greatest possible received current, we should use short waves for short distances and long waves for long distances.

It may be seen from the formulae that, for simple antennae, the received current (for a given wave length, sending current, receiver resistance, and distance apart) is greater, the greater the heights of the antennae. In the case of closed-coil aerials under the same conditions, the received current is greater the larger the areas and the number of turns of the coils. For the dimensions actually used, antennae are much more effective radiators and receivers than closed coils. In order to secure the same radiation or received current with a closed coil as with an antenna, other conditions being the same, its dimensions must be made nearly as great as the antenna height. However, it is often possible to put more current into a transmitting coil than into the corresponding antenna, and also the resistance of a receiving coil is usually smaller than that of the corresponding receiving antenna. Hence the closed coil can be a smaller structure than the antenna.

The closed coil has some other advantages. For a given power input in the transmitter, the closed coil aerial is not at quite such a disadvantage with the ordinary antenna as the formulae show, because a larger fraction of the radiation is sent out in the direction desired. As a receiver, the closed coil has the very great advantage that the direction of the waves it receives can be determined. These points are discussed further in the next chapter.

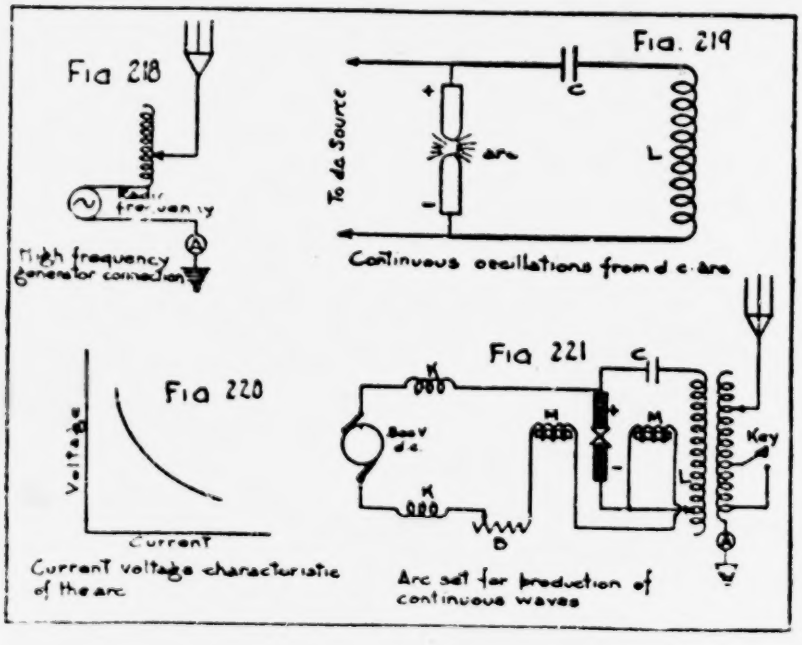
E. Device for Radiating and Receiving Waves

137. *Description of the Antenna.*—The antenna is used in radio communication for two purposes, (1) to radiate elec-

tric waves, and (2) to receive or detect electric waves which come to it. An antenna consists essentially of one or more wires, suspended at some elevation above the earth. When electric waves reach an antenna, they set up an alternating emf. between the wires and the ground, and the longer and higher the wires, the greater the emf. produced. As a result of this emf., an alternating current will flow in the antenna wires. The energy of the current is absorbed from the passing wave, just as some of the energy of a water wave is used up in causing vibrations in a slender reed which stands in its way.

. . . . . .

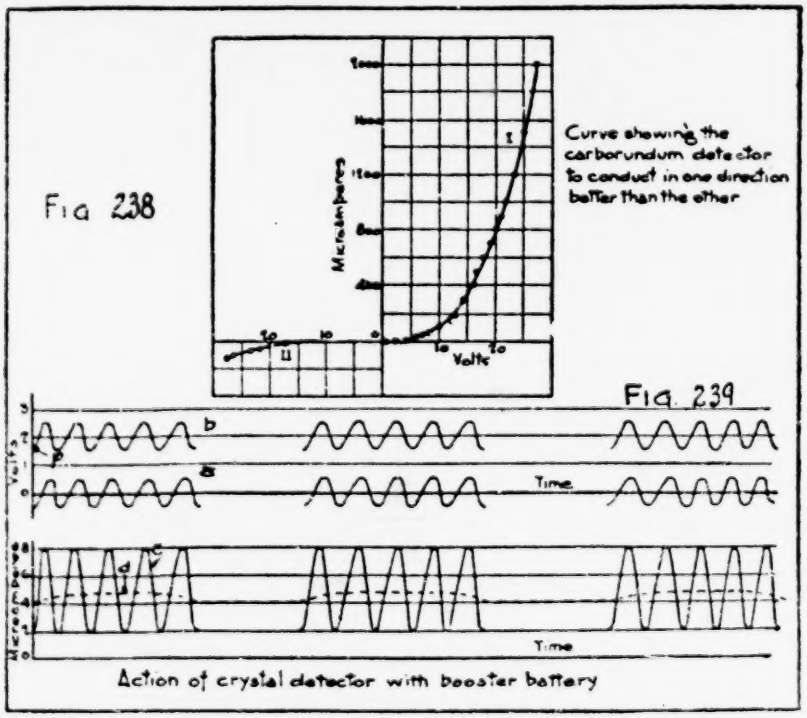
[fol. 2915] frequency can be used. See Section 95. This is connected directly or inductively to the antenna and ground. See Fig. 218. This constitutes the simplest possible connection for producing continuous waves. However, to obtain a wave length as short as 1500 meters, the frequency of the alternating current must be as high as 200,000 cycles per second. The generator speed required to produce this frequency is so high that a special type of construction is needed for such a machine. It is also necessary to have apparatus for keeping the speed constant, so that the wave



length will not change (since $f\lambda_m = 300{,}000{,}000$). This method is not available for generating very short waves; for these, the oscillating vacuum tube is used. See Section 198.

174. *Arc Sets.*—A much used method for producing undamped waves of rather great wave length is by means of a d. c. arc operated on about 500 volts. It has been discovered that an electric arc between proper electrodes shunted by an inductance coil and a condenser will produce undamped oscillations through the shunt circuit. The connection is shown in Fig. 219. The operation is as follows.

[fol. 2916] Fig. 238 shows a current-voltage characteristic curve for carborundum in contact with a metal. The current flows much more readily in one direction than in the other under equal but opposite emfs. For example, under a constant impressed emf. of 10 volts in one direction a current of 100 microamp. is obtained, while with the voltage reversed the current is only 1 microamp. This illustrates the property of "unilateral conductivity," or rectification. Furthermore, as regards the second property, when the



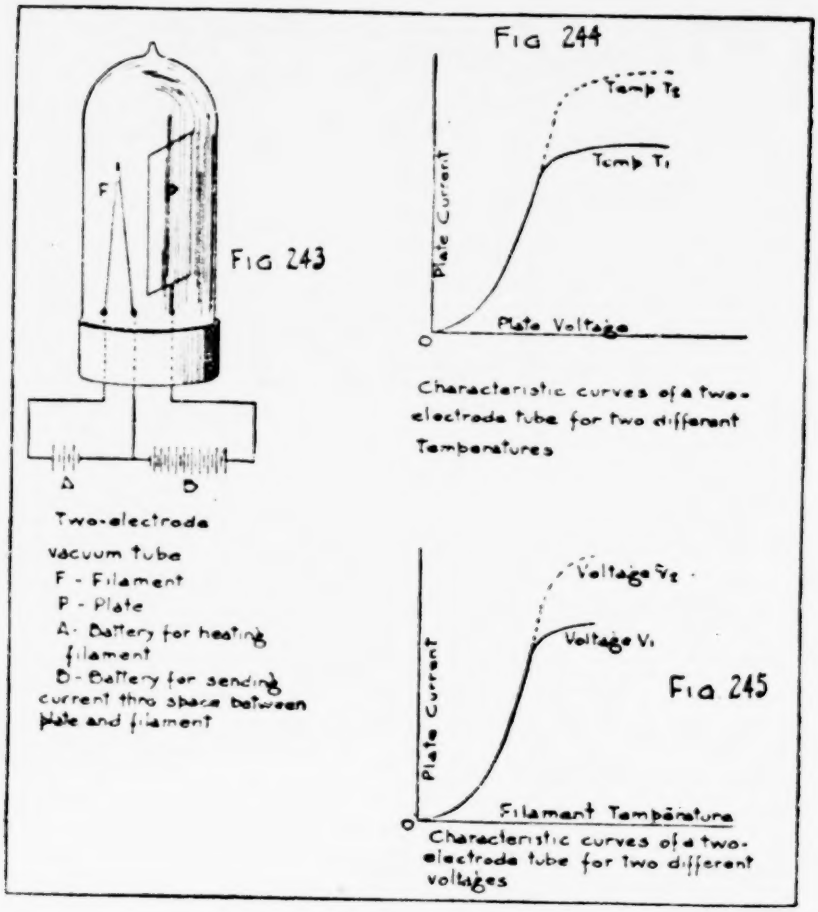
voltage is applied in the direction giving the larger current, the conductivity (ratio of current to voltage) increases as

the voltage increases. This is shown by the right hand portion of the figure. The characteristic curve of any ordinary metallic conductor would be a straight line.

Booster Battery.—In order to make use of the second property namely the bending of the current-voltage characteristic, a local or "booster" battery is inserted in series with the crystal. Using the battery makes the crystal operate at a voltage which corresponds with the sharpest bend of the curve, so that a slight increase of volt-

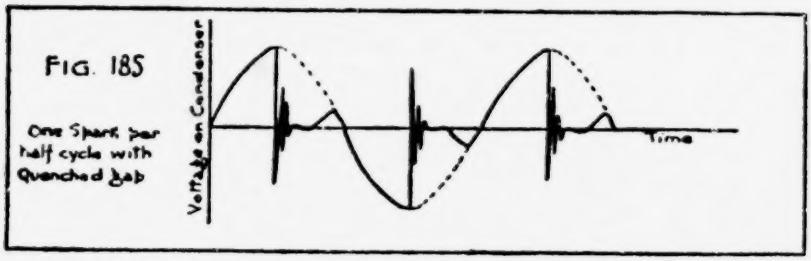
[fol. 2917] the vacuum is very complete. If there is more than the merest trace of gas remaining in the tube, the operation is more complicated, and a larger current will usually flow with the same applied voltage. This happens in the following manner.

In a rarefied gas, some of the electrons present are constituent parts of atoms and some are free. These free



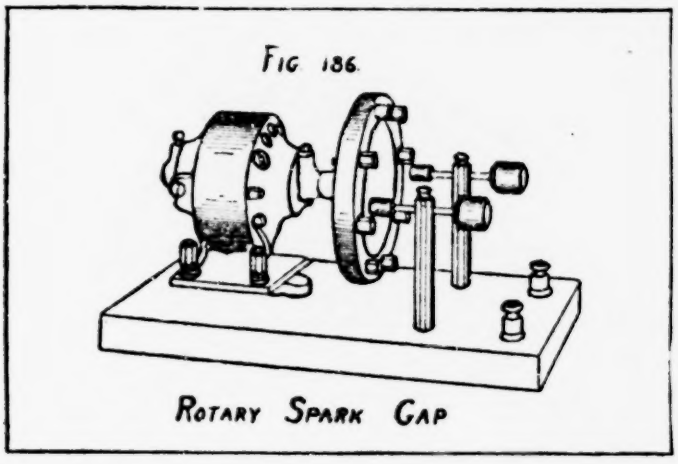
electrons move about with great velocity, and if one of them strikes an atom, it may dislodge another electron from the atom. Under the action of the emf. between plate and filament the newly freed electron will acquire velocity in one direction (that of the colliding electron) and the——

[fol. 2918] This regular occurrence of the discharges gives smooth and efficient operation, and a pure musical tone. The synchronizing is made possible by attaching the rotating element of the spark gap to the shaft of the generator



which charges the condenser. A rotary gap not so timed is called "non-synchronous."

Attempts to produce a high pitch from a 60-cycle source by a synchronous gap giving, say, exactly 6 sparks per half cycle, have not given satisfaction, because the applied voltage is not the same at the time of the different sparks, and



while the note is of high pitch, it is not musical. It has been found better to use a non-synchronous gap in such a case, producing a large number of sparks per second and letting them occur wherever they may happen——

[fol. 2919] DEFENDANT'S EXHIBIT T

Principles Underlying Radio Communication, 1922

175. *The Characteristics of the Direct-Current Electric Arc.*—If between two pieces of conducting material, such as two carbon rods, separated in air by a short distance, there is applied a considerable d.c. voltage, an arc will be formed between the carbon electrodes and will continue if a sufficient voltage is maintained. The voltage required to maintain the arc will be much less than that required to start the arc cold, and, in fact, an arc is not usually started with the electrodes separated. If we study the behavior of such an arc and measure the current corresponding to various d.c. voltages maintained at the terminals of an arc already formed, we will obtain a curve for voltage plotted against current like that shown in Fig. 223. This curve shows that as the applied voltage is increased the current through the arc decreases. The corresponding characteristic curve of an ordinary ohmic resistance would be a straight line sloping upward to the right from the origin. This behavior of the arc, exactly opposite to what occurs when the voltage applied to an ordinary conductor is increased, is described by saying that the arc has a "falling characteristic," or that it is a variable resistance, which increases as the applied voltage increases. It is this "falling characteristic" of the arc that makes possible its use as a generator of undamped oscillations.

When the arc is used to generate undamped oscillations the current which flows at any instant between the arc electrodes is the resultant of the steady current supplied by the d.c. generator and the current in the condenser shunt circuit, as described in the next section. In the first two cases described in the next section, which can properly be considered to be arc discharges, the current between the electrodes always flows in the same direction, but may vary in magnitude.

The statement is sometimes made that an arc is a "negative resistance"; this statement can not be considered correct. The current in an arc passes from the electrode of higher voltage to

[fol. 2920] The production of this effect is, however, subject to certain conditions. The arc A must be formed by the electromotive force of a secondary battery or other steady generator, and a resistance, R (see Fig. 81), must be placed in series with it. The inductive resistance L placed a shunt to the arc must be a low resistance—generally speaking, something less than 1 ohm. The condenser C employed should be one suitable for high potential, as although the impressed electromotive force on it is only 50 volts, the action of resonance (see Chap. III) creates a potential difference between its plates, which at moments rises to several hundred volts, and hence a thin paper condenser may break down.

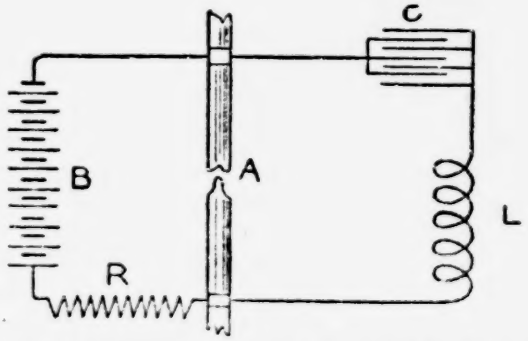


Fig. 81.—Arrangements for producing Duddell's Musical Arc. B, battery; R, resistance; A, carbon arc; C, condenser; L, inductance.

One explanation put forward as an explanation of this effect on its discovery was that it essentially depends upon the existence of a *negative resistance* in the arc, and that the frequency which can be obtained is limited by the arc itself. We shall present the outlines of this theory first, as proposed by Mr. Duddell and supported by some others.

Suppose a small instantaneous change dV, is made in the potential difference of the electrodes, whether carbon or metal, between which the arc is formed, and let the corresponding small change in the current through the arc be denoted by dA. Also let the resistance of the inductance in series with the condenser be represented by r. The theory advocated by Mr. Duddell is that the conditions for the production of high frequency alternating currents

. . . . . .

It has been shown by the author that even then the oscillations are not quite continuous.[1] The oscillating arc tends to break up into a series of intermittent discharges, and it is somewhat difficult to obtain absolutely unbroken undamped oscillations. Some interesting investigations were carried out in the author's laboratory in 1907 by Mr. W. L. Upson, on the characteristic curves of electric arcs between various electrodes and in different gases.[2] These experiments showed that for an arc taken between a carbon (negative) and a water cooled copper (positive) electrode the characteristic curve is much steeper at and about the same arc current, than for the carbon-carbon arc in air (see Fig. 86). Hence it is clear that one element in Poulsen's discovery is [fol. 2921] the effect of hydrogen or hydrocarbon vapour in steepening the characteristic curve of the direct current arc. The reason for this has not yet been fully explained.

Poulsen immediately applied the above method for producing undamped electric oscillations in radiotelegraphy, with the cooperation of P. O. Pedersen.[3]

[1] See J. A. Fleming, "On the Poulsen Arc as a Means of generating Undamped Oscillations," *Phil. Mag.*, August, 1907; also *Proc. Phys. Soc., Lond.*, vol. 20, 1907; also "Recent Advances in Electric Wave Telegraphy," a discourse at the Royal Institution. See *The Electrician*, May 31, June 7, 14, 21, 1907.

[2] See W. L. Upson, "Observations on the Electric Arc," *Proc. Phys. Soc., Lond.*, vol. 20, 1907, or *Phil. Mag.*, July, 1907. Also J. A. Fleming, "Some Observations on the Poulsen Arc as a Means of obtaining Continuous Electric Oscillations," *Phil. Mag.*, August, 1907, series vi. vol. 14, p. 254.

[3] See V. Poulsen, "A Method for producing Undamped Electric Oscillations and its Employment in Wireless Telegraphy," *The Electrician*, vol. 58, p. 166, 1906. In this article a number of diagrams are given showing the type of receiving circuit used.

We shall return again, in Chap. VIII. on radiotelegraphic stations, to the consideration of the practical use of Poulsen's discovery and apparatus in wireless telegraphy and telephony.

Meanwhile the reader's attention may be drawn to one or two other points in connection with the production of electric oscillations by the arc.

Much light has been thrown on the nature of the phenomenon by the careful researches of Professor H. Th. Simon.[4] He has studied by means of the oscillograph and Braun vacuum tube, the form of

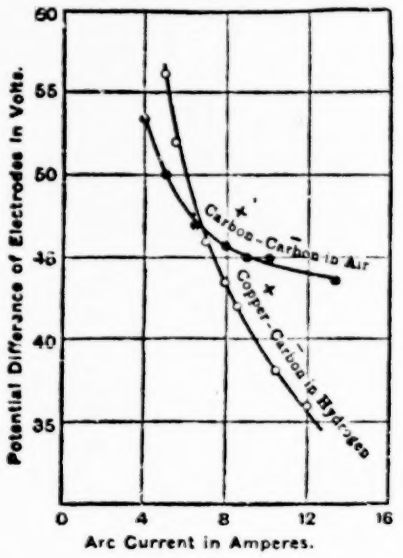


FIG. 86. Diagram showing Results of Upson's Experiments on Characteristic Curves of Arcs

DEFENDANT'S EXHIBIT V

Wireless Telegraphy and Telephony

A Handbook of Formulae, Data and Information. By W. H. Eccles, D.Sc., A.R.C.S., M.I.E.E., Professor of Applied Physics and Electrical Engineering at the City and Guilds of London Technical College, Finsbury. Honorary Secretary of the Physical Society of London and of the British Association Committee for Radiotelegraphic Investigations. Second Edition, Revised and Enlarged, 1918

(a) The maximum value of the oscillatory current may be so much less than the steady current that the arc is not extinguished. This is the case of the musical arc first described fully by Duddell.

(b) The discharge current from the condenser may be so large as to extinguish the arc at an instant near the maximum of the oscillatory current. This includes the usual case of the Poulsen arc.

[4] See H. T. Simon, "The Dynamics and Hysteresis of the Electric Arc," *Phys. Zeitschrift*, vol. 6, p. 297, 1905, or *Science Abstracts*, vol. 8A, *abs.* 1465; also "Theory of the Singing Arc," *Phys. Zeitschrift*, vol. 7, p. 433, 1906, or *Science Abstracts*, vol. 9A, *abs.* 1423.

(c) The oscillatory current may, after extinguishing the arc, kindle it in the direction opposite to the steady current. [fol. 2922] This is exemplified by the quenched spark with the "ordinary" spark as an extreme case. They have been discussed in the preceding pages.

Case *a.—Condenser Current Less than Arc Current.*— The first type of arc generator, which gives nearly pure sine oscillations of feeble intensity, has had no application. The greatest rates of conversion of direct current energy into oscillatory energy are reached within acoustic limits of frequency.

The ability of an arc to sustain oscillations in a shunt circuit depends on the fact that in the circumstances in which it is used, an increase of current through the arc involves a decrease of the voltage at its terminals, and vice versa. The curve connecting i and e with values of i as abscissae is called the "characteristic" curve of the arc; it has a negative gradient. Suppose the condenser-inductance circuit applied suddenly as shunt to an arc supplied with a constant current i_0. The condenser begins to charge, robs the arc of current, the arc voltage therefore rises, and the condenser charges still further. A limit to the voltage is reached when the condenser current stops increasing, for then the steady current through the arc starts increasing, the voltage falls and the condenser begins to discharge more or less in the time of oscillation determined by L and C. The condenser discharge current now adds to the steady current through the arc, makes the arc terminal voltage lower than the normal, and encourages the motion of the electricity, which goes on till the condenser is fully charged in sign opposite to the last occasion. The process plainly goes on indefinitely. The arc thus acts somewhat like the slide valve of a single-acting steam engine, since it automatically admits electricity at a pressure above normal into the capacity and withdraws it at a lower pressure than normal, work being done on each occasion. In Fig. 130 let PN represent the normal voltage, ON the corresponding current, of an arc with a falling characteristic. Then QM represents the condenser current and QN the voltage of the condenser terminals at a certain instant during the

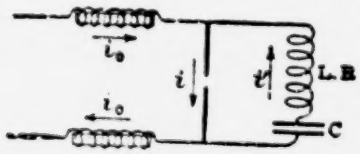


Fig. 129.

oscillatory charging, and M′ refers to an instant during discharge. Assuming that the oscillations follow a sine law, and that they are of the natural period of the circuit, then since v and i are in phase the work done per second in the shunt-circuit is $\frac{1}{2}IV$ where I is the amplitude of the current, V of the voltage, of the shunt-circuit. This work may be regarded as all spent in a resistance R in the circuit, or partly in a coupled circuit, and thus

$$\tfrac{1}{2}IV = \tfrac{1}{2}RI^2$$
$$R = V/I.$$

that is,

[fol. 2923] If R exceeds this value the oscillation will not be sustained. Thus, the average negative gradient, which is V/I, or QQ′÷(MQ+Q′M′), must not be less than R. For infinitesimal oscillations this may be written

$$R < -\frac{dv}{di},$$

which is sometimes called Kaufmann's condition.

H. T. Simon first made clear that the characteristic curve of Fig. 130 is not followed exactly during rapid oscillations: during reduction of current a lower curve during augmentation of current a higher curve, is followed. (See Case *b*.) Being a time effect, this has no analogy with hysteresis, though sometimes given that name in error. This "dynamic characteristic" for *a* type oscillations is indicated in Fig. 131.

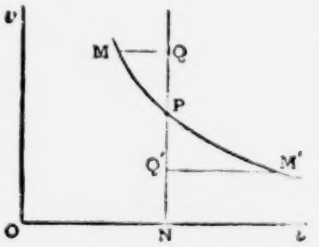


Fig. 130.

W. Duddell has given the following details of a musical arc: Carbons solid, Conradty, 9 mm. diameter, arc length 1·5 mm., arc current 3·5A, steadying resistance 42Ω, shunt inductance 5·3mH, resistance of inductance and leads 0·41Ω capacity of condenser 1·1 to 5·4μ F, R.M.S. current through condenser 3A when capacity is 5·4μ F, voltage of battery 50V.

Case *b*.—*Condenser and Arc Currents Nearly Equal.*—The second type of arc generator, the Poulsen arc, gives very energetic oscillations at frequencies up to two or three millions per second, and is used in the Poulsen system of wireless telegraphy (see "Systems"). In order to make the

FIG. 131.—Dynamic characteristic of arc oscillations.

characteristic steep and allow of the use of high voltages, it is advantageous to form the arc between carbon and copper electrodes, with the copper as the positive pole, in an atmosphere of hydrogenous vapour (Fig. 132). The desired periodic extinction of the arc is assisted by strongly cooling the electrodes and by forming it in a strong perpendicular magnetic field, but is governed largely by the relative magnitudes of condenser and inductance. Kiebitz states that when the inductance is too small (the product LC being of assigned value) the arc is very sensitive to changes in the supply of voltage, the frequency of the oscillations varies

. . . . . .

Although a great many investigators have attempted to give the rationale of the Poulsen arc, it was not until very recently that even an approximate understanding of its operation was attained. P. O. Pedersen points out that many early investigations are vitiated by the fact that the arc as set up in laboratories for investigation has usually been working under conditions different from those of the [fol. 2924] Poulsen arc as used in practice. He calls the practical size of arc the "normal Poulsen arc." Such an arc is one with at least 10 to 15 amperes direct current, and with, for example a value $\sqrt{L/C} = 50$ ohms at wave length 1,000 m. In the normal arc the arc is extinguished and ignited every period of the oscillation, and the ratio of the effective oscillatory current to the steady feeding current is $1/\sqrt{2} = 0.707$. Such an arc gives maximum efficiency of conversion when the voltage across it is the least possible, and for this a definite gap and a definite magnitude of field are required, whose values depend on the constants of the circuits. The arc will maintain oscillations for adjustments of gap slightly different from the optimum and great latitude in magnetic field is possible if the normal condition has not to be maintained. According to Barkhausen, the connection between current and voltage at the arc during oscillation is as follows: The arc burns for the greater part of the oscillation at a steady voltage, while the current rises and falls when the voltage reaches a very low value the arc expires suddenly, and the voltage falls to a low negative value in common with the condenser it then rises, while the current

is still zero, to a high value, perhaps tenfold the burning value, and the arc is ignited; immediately the current is established the voltage falls to the burning value and remains practically steady while the current rises and falls in the oscillation. Barkhausen's view is that the high ignition voltage is the essential element in the efficient working of the Poulsen arc, and that the hydrogenous atmosphere and the magnetic field operate by enhancing the ignition voltage. Pedersen's experiments contradict this view as regards the normal Poulsen arc, through supporting it to some extent if the gap is much too long for normal. In the normal arc, in fact, the ignition voltage is not very high, and the efficiency of the normal arc is brought about almost entirely by the high value of the voltage rise that occurs at the *extinction* of the arc, which was disregarded by Barkhausen. This rise of voltage at extinction has been shown previously to exist in the case of the musical arc by A. Blondel using his oscillograph, and it is now shown to be of paramount importance in the radiofrequency arc by Pedersen's oscillograms obtained with Gehrcke's cathode glow oscillograph. It is, no doubt, the consequence of the negative gradient of the arc characteristic.

With the correct arc gap and the correct strength of magnetic field, the oscillogram of the current through the arc is an almost complete sine-wave with small sections cut away from the troughs near the maximum negative point, and the voltage rises and falls sharply at the extinction, and also at the ignition, point without becoming negative at any time. The arc is struck on or near the edges of the electrodes, is driven outwards by the magnetic field, is extinguished at the extreme position and ignites afresh at the edges, the process being repeated with great regularity in each

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[fol. 2925] DEFENDANT'S EXHIBIT W

The Radio Review, 1919

Discussion on Thermionic Values. W. H. Eccles, "The Three-Electrode Thermionic Vacuum Tube and the Revolution in Wireless Telegraphy"

During the war dark hints reached the civilian that a revolution was taking place in wireless telegraphy, the

principal agent in which was reported to be an instrument called a "valve", a "lamp", or a "tube." This instrument seemed to have risen suddenly into a predominant position among all the apparatus of the wireless experimenter and operator, and appeared to be of use in every corner of his outfit. The complete name of the instrument is the three-electrode thermionic vacuum tube. It must be emphasised that it is the three-electrode valve, and not the valve with two electrodes, that has been responsible for the overthrowing of the old methods and apparatus. That it has been a veritable revolution can be seen by comparing the common practice in wireless telegraphy of 1914 with that of 1919. In 1914 practically all the most powerful transmitting stations in the world generated waves by sparks, and signals were received at nearly all stations by means of crystal detectors or magnetic detectors. The spark method of generating waves involved the use of very large antennæ for spanning great distances; and at receiving stations which wished to listen to stations

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DEFENDANT'S EXHIBIT X

Journal of the Institution of Electrical Engineers, including original communications on telegraphy and electrical science

Published under the supervision of the editing committee and edited by W. G. McMillan, secretary. Vol XXX. 1900-01. London: E. and F. N. Spon, Limited, 125, Strand, W.C. New York: Spon and Chamberlain, 12, Cortlandt Street. 1901

On rapid variations in the current through the direct-current arc

By W. Duddell, Wh. Sc., Associate

It may be thought by some that the title of this paper is rather contradictory in that there should not be any variation in the current through a direct-current arc. I will therefore explain at once that I simply use the term "direct-current" as implying that the current is supplied by cells or by a direct-current dynamo, and not as implying that the

current is necessarily constant in value. It may also be as well to state that by *Arc* I do *not* mean *Arc Lamp*, as all the effects to be described are quite apart from those produced by regulating mechanisms.

The effect of varying the current through the direct-current arc very slowly, so slowly in fact that the carbons have time to burn into shape corresponding to each value of the [fol. 2926] current, has been investigated by many experimenters, but it is to Mrs. Ayrton [1] that the honour belongs of giving a complete investigation of all that occurs when any of the variables in the direct-current arc are changed in any way. The other extreme, namely, very sudden changes in the current, has also been investigated by Mrs. Ayrton,[2] thus leaving a gap in the experimental evidence as to what occurs between very slow variations and isolated sudden changes in the current.

The present paper is an attempt partly to fill this gap by giving an account of what occurs when the current is periodically varied more or less rapidly over a range which is very small compared with the mean value of the direct current.

The current through a direct-current arc supplied with power from any circuit may vary either owing to changes taking place in the circuit, such as variations in E.M.F. or resistance, or owing to effects in the arc itself, such as hissing, humming. Although any variation in the current naturally entails a corresponding change in the arc itself, it will, I think, be found convenient to classify the observed effects according to whether the primary cause of the variation is in the arc or in the circuit which supplies it.

Part I

Cause of the Variation of the Current in the Circuit Supplying the Arc

The effects of varying the current may be divided under four heads, viz., the effect on the P.D. between the terminals of the arc, on the light emitted, on the shape of the craters, and on the vapour column. These will be considered in order. I shall assume in all cases in Part I. that the ampli-

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[1] *The Electrician*, vols. xxxiv., xxxv., and xxxvi.

[2] *The Electrician*, 1895, vol. xxxiv., pp. 471, 541.

tude of variation of the current from the mean is small, generally much less than 10 per cent, and that the arc experimented on is neither hissing nor humming.

Effect on the Potential Difference Produced by Variations of the Current

If the current varies very slowly, then the relation between the P.D. current and length is that given by Mrs. Ayrton's curves. Directly the rate of variation is increased so that the carbons have not time to burn into shape, corresponding with the instantaneous values of the current, the relation will be changed, and it is conceivable that *if* the rate of variation were high enough and the amplitude small enough, the conditions of the arc would in no way be changed, so that the ratio of the change in P.D. to the corresponding change in current, would be a constant and equal to the true resistance of the arc. I shall show later that this assumption, which is the basis of several experiments on the resistance of the arc, notably those by Messrs. Frith and Rodgers,[2] requires a much higher rate of variation of current than they employed.

[fol. 2927] One of Mrs. Ayrton's curves, contained in a letter by Prof. Ayrton to *The Electrician*,[3] illustrates very well how the connection between the P.D. and current depends on the rate of variation of the latter. This curve shows that the *first* effect of *suddenly increasing the current* through a cored-solid arc[4] is to cause a *transient rise in the P.D.* between the terminals; the effect of a *slow increase of current* being, as is well known, to produce a *decrease in the P.D.* This first transient rise in the P.D. which was obtained with a cored-solid arc, was also, I believe, obtained with a cored arc, but I am unaware of its having been observed for a solid arc.

Thinking that this might be due, as pointed out by Prof. Ayrton, to the extreme quickness of the phenomenon when

[2] *Proceedings of the Physical Society*, 1896, vol. xiv, p. 307.

[3] *The Electrician*, 1896, vol. xxxvii, p. 321.

[4] "Solid", "solid-cored", and "cored" are mean, respectively are between two solid carbons, between one solid and cored, and between two cored carbons; the top or + electrode being always placed first.

both carbons were solid, I tried to record the transient rise in P.D. for the solid arc by means of an oscillograph, the sudden increase of the current being obtained by discharging a condenser through the arc. This experiment was successful, and a transient rise in P.D. was observed, *the P.D. and current increasing together, but only for about* 1/5000 *second*. At the end of this very short time the P.D. decreased with an increase of current in the ordinary way.

If it can be assumed that during this first 1/5000 second the conditions of the arc are not changed, then the solid arc has a positive resistance, contrary to the results obtained by Messrs. Frith and Rodgers, and it is at any rate evident that, had the frequency of their superimposed alternating current between 5,000 ~ per sec. instead of 250 ~ per sec., the sign of the resistance as obtained by them would have changed, though I do not say that even at that frequency its true value would have been obtained. In any method for measuring the resistance of the solid arc which depends on the change in the P.D. produced by a change of current, these changes must, therefore, take place in less than 1/5000 sec. in order not to allow the arc conditions to change; results to be described later indicate a still shorter time.

I will not, however, pursue this subject any further, as it would unduly extend the length of this paper to include a description of a complete series of experiments on the resistance of the arc which I have recently completed.

Effect on the Light Emitted Produced by Variations of the Current

It is well known that the light of the arc varies when the current is changed, though how small and rapid the variation in current may be and yet produce a perceptible change in the light does not seem to have been investigated. Professor Fleming and Mr. Petavel [6] and Mr. Burnie [7] have determined the instantaneous values of the light and current in the case of alternate-current arcs, and have found that [fol. 2928] the variation in light roughly follows the variation of the current; the maximum luminous intensity occurring about 1/1000 sec. later than the maximum current.

[6] *Proceedings of the Physical Society*, 1896, vol. xiv, p. 115.

[7] *The Electrician*, 1897, vol. xxxix, p. 846.

Herr Görges[5] has also noticed that the variations in the current due to the teeth on the armature of a dynamo produced an appreciable variation in the light at the rate of 300 per second.

In order to test how rapid and how small a variation of the current from the mean could be detected in the light of the direct-current arc, I arranged an arc so that its image as seen through a central slit parallel to the carbons was projected on to a rapidly falling photographic plate, the instantaneous value of the current being recorded simultaneously on the same plate by means of an oscillograph. The small quick variations of the current through the arc were produced by passing the oscillatory discharge of a condenser in series with a self-induction through it, so that the arc current consisted of a large constant part on which was superimposed a small ripple which died away after a few oscillations.

By this method I find that in an 8 ampere solid arc a *distinct variation is produced in the light emitted by both the + crater and the vapour column when the amplitude of the variation of the current from the mean is only 3 per cent. and the frequency of these superimposed variations is as large as 1300 ~ per sec.* At this frequency the variation in light became indistinguishable when the amplitude of the variation of the direct current was reduced to 2 per cent.

Owing to the difficulty in estimating the points of maximum density in the band on the plate which represents the light emitted in consequence of the smallness of the variation of the current and therefore of the light, I was unable to be certain whether the maximum light lags behind the maximum current; but if it does, the lag is very slight, not exceeding 1/10000 sec. for an 8 ampere solid arc.

It must be remembered that the above variations of light are those of the actinic rays which affect the photographic plate; the visual rays will probably vary in a similar manner, though possibly not to the same extent.

Effect on the Craters Produced by Variations of the Current

Mrs. Ayrton tells me that she noticed that the variations in the current used by Messrs. Frith and Rodgers, who superimposed an alternating current of 0.5 to 1.0 ampere

[5] *Elektrotechnische Zeitschrift*, 1895, vol. xvi, p. 548.

R.M.S. value, at frequency of 100 ~ per sec. on a 10-ampere direct-current arc, so altered the shape of the ends of the carbons that she could easily distinguish them from normal carbons formed without any variations in the current. I find that if the superimposed alternating current be reduced to 0.1 ampere under the same conditions, the ends of the carbons appear unaffected.

[fol. 2929] Effect on the Vapour Column Produced by Variations of the Current

Sounds

Corresponding with each value of the current through the arc there is probably a definite cross-section of the vapour column, so that if the current varies rapidly through an arc of fixed length, the volume of the vapour will also vary and sound-waves will be given out. This, I believe, is the generally accepted explanation of the humming of the alternate-current arc.

In the case of the direct-current arc, sounds are also emitted even when the variations in the current are very slight. For example, the variation of current caused by the commutator segments of a direct-current dynamo passing under the brushes can be heard in the arc. This variation of the current caused by the commutator segments, even when in good condition, was found by Messrs. Frith and Rodgers[9] in the case of a 5 k.w. two-pole machine to vary between 2.5 and 9 per cent. of the mean current according to the position of the brushes.

Another striking example of how sensitive the arc is to small variations in the current is furnished by the fact that a Wehnelt interrupter, working an induction coil on the direct-current street mains, will cause any arc supplied by the same mains to give out the same noise as the interrupter itself, even when a considerable distance intervenes between the place where the arc is connected with the mains, and where the interrupter and coil are joined on, as observed by Herr Simon,[10] Mrs. Ayrton, and Mr. Jervis Smith.[11]

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[9] *Proceedings of the Physical Society*, 1896, vol. xiv., p. 307.

[10] *Annalen der Physik und der Chemie*, 1898, vol. lxiv., p. 233.

[11] *The Electrician*, 1899, vol. xliv., p. 16.

It must be clearly understood that the arcs here referred to are normal silent arcs; that is, if they were supplied with a really steady current they would have been practically silent.[12]

In order to determine what variation in the current was necessary to cause the arc to emit a clearly audible note, the current from a high-frequency alternator, kindly lent by Sir D. Salomons, was superimposed on the direct current by the method shown in Fig. 1. The current from the alternator passes through a condenser F, a dynamometer D, and the arc in series; and it is practically prevented from flowing through the cells which supply the arc by the self-induction L. The direct current is prevented from flowing through the alternator by the condenser F.

It was found by this means that a 10-ampere direct current, solid or cored arc, length 3 to 5 mm., would produce a distinct note even if as small a R.M.S. current as 1 1000 ampere, as measured by D, was superimposed on the direct current for frequencies of the added current from a few hundred up to 8,000 ~ per second. Thus a *variation of the* [fol. 2930] *order of 1 part in 10,000 from the mean current will alter the vapour column sufficiently to produce sound-waves.*

Further experiments with another alternator and R.M.S. superimposed currents of 1 20 to 1 10 ampere on a 10-

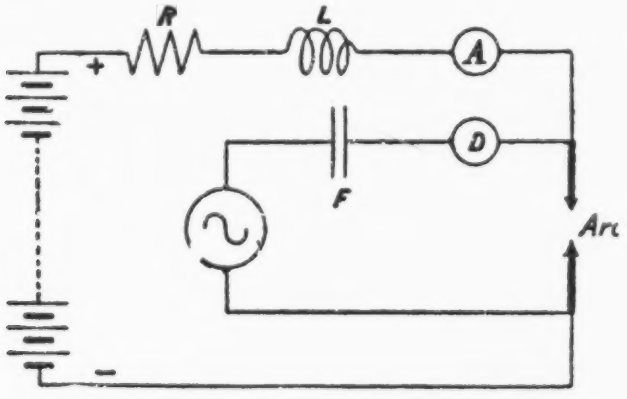

Fig. 1.

[12] Absolute silence is almost impossible, as the least want of homogeneity, or impurity in the electrodes, causes small spits and sounds.

ampere solid arc, proved that the sounds only became inaudible at frequencies approaching 30,000 ~ per second.

At these frequencies I am uncertain whether the arc had really ceased to give a note, as the ear fails to detect sounds of so high a pitch.

This sensibility of the arc for very small changes in its current explains the fact that not only can rapid variations

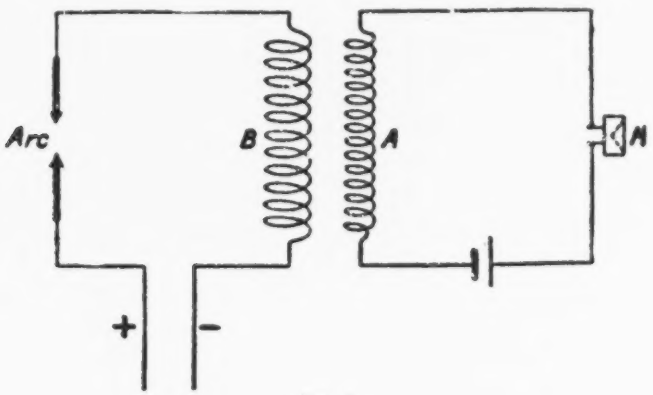

FIG. 2.

of current in any circuit supplied from the same generator as the arc be heard in the arc, but also variations of current which occur in a totally independent circuit supplied by a separate generator can be detected in the arc due to mutual induction between the two circuits.

Arc as a Telephone Receiver

The fact that the arc is sensitive to such small variations in the current and over such a wide range of frequency, at once suggests that the direct-current arc might be used as [fol. 2931] a telephone receiver. This suggestion, which was made in a leader of *The Electrician* in 1899, had already been carried out by H. Simon [13] in 1898.

The method used by H. Simon for superimposing a microphone current on the main arc current is shown in Fig. 2, in which A and B are two coils having mutual induction, and M the microphone. The current through A varies when M is spoken into and induces E.M.F.'s in B, which vary the current through the arc in such a way that it reproduces sounds and even speech distinctly.

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[13] *Annalen der Physik und der Chemie*, 1898, vol. lxiv., p. 233.

The variation of the current through the arc obtained by this method is not as large as it might be, as the E.M.F.'s induced in B have to send currents round the whole arc circuit, including any steadying resistances, and also through the self-induction in the armature, if a dynamo is used, instead of only through the arc where the varying currents are actually required. I have obtained a better result by replacing the alternator of Fig. 1 with a microphone and mutual induction as shown in Fig. 3. A and B are the two coils of a mutual induction, F a condenser of about two or three microfarads, and L a high self-induction, the object of the self-induction being to prevent the microphone currents flowing around the cells instead of through the arc.

With this arrangement and suitable arc conditions, to be explained later, *the arc will speak sufficiently loudly and clearly to be heard at a distance of 10 to 12 feet in a quiet room.* [Experiment.][14] The sound-waves given out by the arc are, therefore, of such an intensity that when the energy is spread over a spherical surface of 20 feet diameter, the ear placed at any point can hear speech distinctly. It seems probable that if all the energy available could be collected

[14] Note (*added February 1st, 1901*).—As I have had several inquiries from experimenters wishing to repeat this experiment, I append some data of the apparatus actually used at the meeting.

The microphone M was supplied by the National Telephone Company and intended for long distance transmission, two accumulators being used in series with it. The mutual induction A : B consisted of a solenoid 30 cms. long wound with about 1,200 turns of No. 18 D.S.C. wire in six sections having an iron wire core about 15 mm. diameter. Diameter of solenoid over winding = 54 mm. For the experiments 3 sections = 600 turns were used for A, and two sections = 400 turns for B.

Resistance of A = 1.52, of B = 1.53 ohms. Mutual induction 25.3×10^{-3} henrys. Cored carbons were used in the arc, the other data being those given above.

If a suitable mutual induction A:B is not available a self-induction may be used, by connecting the leads from the microphone and cells to the terminals of B instead of those of A, B being now simply a coil having high self-induction and low resistance.

and concentrated on the ear, very powerful sound-sensations might be produced.

The loudness of the sounds given out by the arc is increased by lengthening the arc, as this increases the volume of the vapour column which emits the sounds. It would also seem as if increasing the main current which increases the cross-section of the arc should also be beneficial, but experimentally I have not found any appreciable gain. The best results have generally been obtained with a current of 10 to 12 amperes, carbons 11 to 13 mm., and an arc length of 20 to 30 mm.

To obtain these long lengths with ease, it is necessary to use cored carbons or some other means of introducing foreign bodies, such as salts of potassium and sodium, into the arc, for there is not much doubt that the stability of the arc [fol. 2932] between ordinary cored carbons is due to the presence of potassium silicate in the core.[15] (See also Appendix I.) These salts may be introduced either by soaking the carbons in their solutions, or by using them as cores.

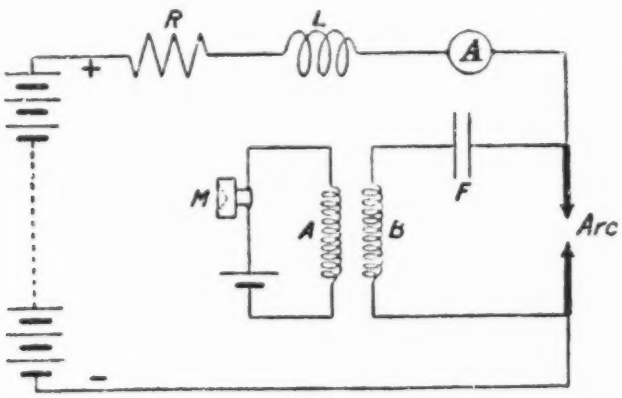

Fig. 3.

Mr. Jervis Smith has recommended the insulator glass as a core, which I find works well.

Arc as a Telephone Transmitter

Before leaving the subject of the use of the arc as a telephone, it will be convenient to consider its use as a telephone

[15] See Duddell and Marchant, *Proceedings of the Institution of electrical Engineers*, 1899, vol. xxviii., p. 66; Blondel, *International Congress of Electricity*, Paris 1900.

transmitter, though this subject strictly belongs to Part II. of this paper.

H. Simon found that if he replaced his microphone in Fig. 2 by a telephone receiver, *any sounds made near the arc were heard in the receiver*. In this case, as before, I find it preferable to modify his method by connecting the receiver in series with a condenser between the terminals of the arc, as in Fig. 4.

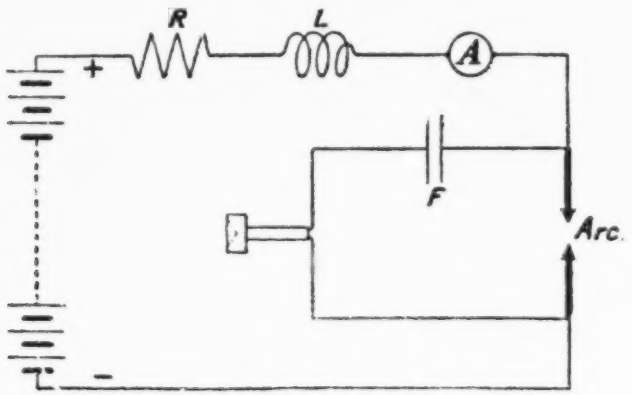

FIG. 4.

A sound-wave striking the arc may affect it in two ways, either by vibrating the arc as a whole and varying its length, [fol. 2933] or the waves of condensation and rarefaction may alter the cross-section of the arc: both of these effects will tend to alter the apparent resistance of the arc, and hence vary the current through it.

The sounds obtained in the telephone receiver when using the direct-current arc as a transmitter are not generally very satisfactory, as, besides not being very loud, they are obscured by the extraneous sounds due to the small spits and hisses which occur in the arc each time the air gets to the + crater due to any slight defect in the carbons. If a common pair of carbons be used containing cracks and impurities, the noise in the receiver is sometimes unbearable, although there is no outside source of disturbance of the current through the circuit.

In all experiments on the arc as a telephone transmitter or receiver, it is essential that the current generator should be free from rapid variations, or extraneous sounds will be produced. If a dynamo has to be used, then the variations of the current produced by the commutator segments may be minimised by inserting a large self-induction in

series with the arc, as in Figs. 1, 3, and 4. This self-induction serves the double purpose of keeping extraneous variations of the current out of the arc, and of preventing the variations we desire to observe from being dissipated in the source of supply.

Thus we see that *the direct-current arc is not only extremely sensitive to small variations in its current of almost any frequency, but also that it is affected by such small changes of outside conditions as sound-waves produce.* Whether this sensibility can be turned to useful account in telegraphy or telephony remains for future experiment to decide.

Part II

Current Caused to Vary by the Arc

Humming

Mr. Trotter [16] discovered that the direct-current humming arc rotates, including a coma-like appearance at the + crater, and he also found that the current through the arc varied periodically, the frequency of these variations being the same as the pitch of the humming sound produced, and as the speed of rotation of the arc.

In order further to investigate the connection between the variation of the light P.D. and the current, I have recorded the P.D. and current by means of an oscillograph, the humming arc experimented on being used as the source of light to illuminate the oscillograph mirrors. The arc was so inclined that only the light from the + crater and a small part of the vapour column reached the mirrors. So that the density at any point of the lines represents the photographic intensity of the light emitted at that instant in the direction of the mirrors by the + crater and part of the vapour column, and the distance of the point from this zero line measures the P.D. or the current as the case may be.[17]

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[16] *The Electrician*, 1894, vol. xxxiii., p. 298.

[17] In Figs. 5, 6, and 7, the centre line is not the zero-line, but represents 20 amperes and 40 volts.

(Here follows 1 photolithograph, side folio 2934)

HUMMING ARC.

CARBONS: + 11 and − 9 mm. Solid "Apostle." Mean P.D. = 50·5 volts. Mean Current = 15·2 amperes.

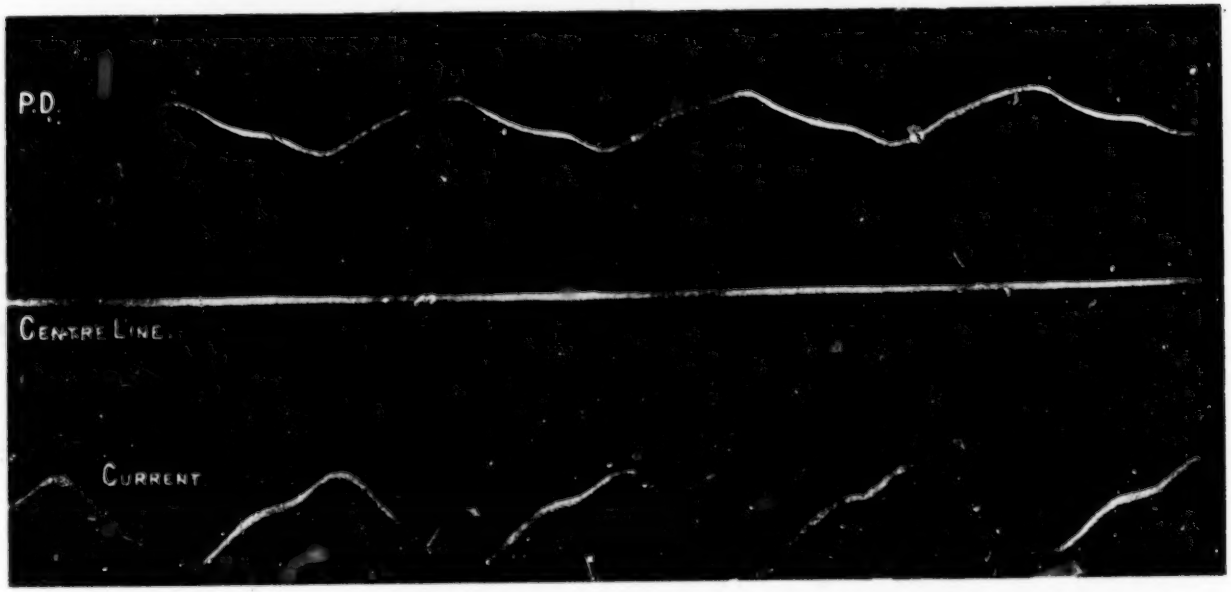

FIG. 5.

Scales.—1 mm. = 0·5 volt = 0.186 ampere = $\frac{1}{2400}$ second. Centre Line = 40 volts = 20 amperes.

2934

[fol. 2935] A typical example of the variations observed in the humming arc is given in Fig. 5, from which it will be seen that the P.D. current and light emitted in a fixed direction vary in a regular periodic manner with the same frequency.

The variation of the current, which is about 6 per cent. from the mean, is not sufficient to account for the large variation in the light emitted in the direction of the mirrors. This periodic variation of the light is most probably due to the fact that the arc rotates so that the + crater alternately either supplies light to the oscillograph mirrors, or is prevented from doing so by being on the other side of the + carbon. The periodic time of the variations of the light will, of course, be unaffected by a change in the position from which the arc is observed, but the times at which the light maxima occur relatively to the times at which the current is a maximum will depend on this position.

Thus besides the rotation of the humming arc and the variation of the current observed by Mr. Trotter, I find that the light and P.D. vary with the same frequency, so that in the humming arc the frequencies of the rotation of the arc, and of the variations in the P.D. current, and light emitted in a given direction, are identical with the pitch of the note given out.

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Musical Arc

A direct-current arc of suitable length and current, between solid carbons, will give out a musical note if it be shunted with a condenser in series with a self-induction, as

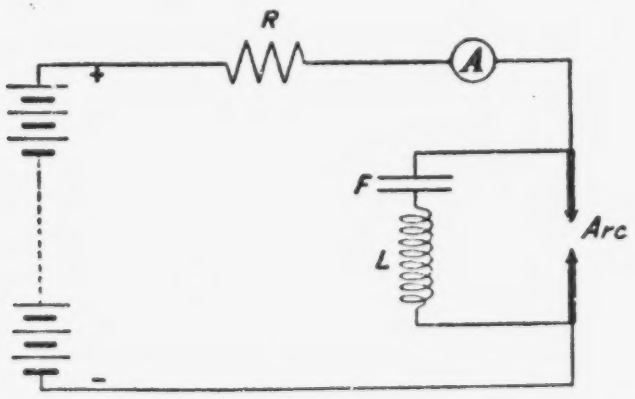

FIG. 9.

in Fig. 9, even though the source of supply of the current be perfectly constant and the arc be protected as far as possible from any outside cause of disturbance. [Experiment.]

[fol. 2936] I find that the musical note is produced by oscillatory currents flowing in the circuit composed of the condenser F, the self-induction L, and the arc, Fig. 9, and its pitch is determined by the periodic time of this circuit—that is, on the relation between the capacity, self-induction, and effective resistance of the circuit. Neglecting the resistance, which it will be shown later must be small, the periodic time of the circuit $\tau = 2\pi\sqrt{LF}$, and this has been found, by judging the pitch of the note by ear, to be approximately correct, so that for lecture purposes Kelvin's law can by this means be easily demonstrated. (See Appendix III.)

It must be remembered that although we have an alternate current through the condenser and self-induction, the source of supply is not an alternating one, and that *it is the arc itself which is acting as a converter and transforming a part of the direct current into alternating, the frequency of which can be varied between very wide limits by altering the self-induction and capacity.* The upper limit I find to be about 10,000 ~ per second, and the lower limit, if such exists, is well below 500 ~ per second.

It has long been known that a train of oscillations of almost any frequency can be obtained on discharging a condenser through a suitable inductive resistance, but of course these oscillations have a rapidly decreasing amplitude; and the means of supplying energy to such a circuit so as to maintain *the amplitude of the swings constant*, other than by means of a varying source of power having the same periodic time as the circuit, has been wanting. It is, therefore, necessary to inquire under what conditions it is possible for the arc to cause the source of direct current to supply the energy necessary to maintain the oscillations in the condenser circuit when once they have been started.

If the resistance in the main circuit in series with the arc is large, and if δV be a small instantaneous change in the P.D. between the terminals of the arc, δA the corresponding small change in the current through it, and r the resistance of the condenser circuit, not including the condenser; then, during the time this small change lasts, sufficient energy may be supplied to the condenser circuit to

make up for the energy dissipated there, in ohmic losses, if the following conditions are fulfilled (see Appendix II.):—

$$1.\ \frac{\delta V}{\delta A},\ \text{negative.}$$

$$2.\ \frac{\delta V}{\delta A},\ \text{numerically greater than } r.$$

The question is, can the arc fulfill these two conditions? Messrs. Frith and Rodgers[18] have experimentally deter-
[fol. 2937] mined the value of $\frac{\delta V}{\delta A}$, which they call the resist-
ance of the arc, for various arcs, and they found that while $\frac{\delta V}{\delta A}$ was always + when *both* carbons were cored, it was, on the contrary, always — when *both* carbons were solid; and that it was as small as −2 ohms for a 4-ampere solid arc. Now the resistance of the condenser circuit, r, external to the condenser, can easily be made less than 2 ohms, so that the arc can fulfill both the necessary conditions.

I will now describe some observations on the musical arc which tend to confirm the above conclusions.

Arcs between solid carbons for which $\frac{\delta V}{\delta A}$ is always negative *work well*, while those between *cored* carbons for which $\frac{\delta V}{\delta A}$ is positive I find *will not work* under any conditions.

[Experiment.]

The largest negative value of $\frac{\delta V}{\delta A}$ given by Messrs. Frith and Rodgers is 2 ohms for a 4-ampere solid arc, and it is probable that it did not exceed 2.5 ohms. for the smaller cur-

[18] *Proceedings of the Physical Society*, 1896, vol. xiv., p. 307.

rents, viz., 3 to 3.5 amperes, which I used. According to the above conditions, 2.5 ohms should be the limiting resistance of the condenser circuit; by experiment it was found that when the resistance of this circuit was increased to 2.4 ohms the oscillations stopped and could not be restarted. [Experiment.]

It is evident that besides the resistance there are other causes, such as hysteresis, which tend to dissipate the energy in the condenser circuit and stop the arc giving its note. The hysteresis in an iron-wire core introduced into the self-induction will instantly stop the note. [Experiment.] Any complete circuit such as a ring of wire placed near the self-induction has the same effect. [Experiment.]

On several occasions before the importance of these causes of the dissipation of the energy were realised, considerable trouble was experienced in tracing the reason of the arc failing to give its note. As examples, in one case it was traced to an ammeter and in another to the tinfoil in the condenser which were acting as short-circuited secondaries to the self-induction coil, which had been placed too near them. [Experiment.]

The relation between the self-induction, capacity, and frequency can be very easily demonstrated by playing a tune on the arc by varying either the capacity or the self-induction by means of a keyboard. [Experiment.] (See Appendix III.) [fol 2938] Another method of varying the self-induction is by separating or bringing closer together the turns of the coil, as if playing on a concertina, the relative positions of the turns determining the self-induction and the pitch of the note. The musical arc can be used as a means of comparing self-inductions or capacities by comparing the pitch of the notes produced.

The "enclosed arc" will work equally as well as the open arc, though the note given out is not so audible owing to the globe; but it can easily be made so by taking advantage of some of the telephoning effects mentioned in Part I.

The alternating current through the condenser circuit may be as large as from 3 to 5 amperes R.M.S. value, and the direct current in the main circuit also varies considerably depending on the amount of resistance in the circuit. This condenser current is sufficient to show experiments with alternating currents which do not require much power, and is very convenient in many cases for lecture purposes as the frequency, and any changes in it, are at once evident

from the pitch of the note given out by the arc. Magnetic space telegraphy can easily be demonstrated on a small scale by using the self-induction coil as the transmitting circuit. [Experiment.] Several arcs can be used in series when more power is required in the condenser circuit than can be obtained from one arc alone.

* * * * * * *

The President

The PRESIDENT: It is quite evident we have not time for much discussion, and I am sorry to say the discussion on this paper cannot be adjourned. I think, however, we ought to call upon Professor Ayrton to say how it bears upon that negative resistance of his which was so much maligned some time ago.

Professor Ayrton

Professor W. E. AYRTON: The paper which we have just heard read has given me exquisite pleasure: not because I have any claim to be its author, although I felt as pleased while I heard it read as if I had been the writer; nor is it merely because I feel convinced that these experiments of to-night will assist in the development of the electrical industry of to-morrow: it is rather because it so rejoices the hearts alike of professional men—yea, and of professors—to find a student who so resembles a solid carbon arc that he is ever on the alert to catch at and magnify any hint which may come from Nature or man. From Mr. Duddell's papers of two years ago, and of to-night, we learn much; among other things this second one has taught us [fol. 2939] how valuable was that research made some five years ago by Messrs. Frith and Rodgers. For what did that investigation really show us? It brought out an absolutely new fact. Supposing this is an alternating-current circuit (Fig. A), the alternator running at a given frequency and supplied with a given exciting current, the alternating current in the circuit being measured by an accurately graduated alternate-current ammeter, and that this is a wholly separate circuit—a direct-current circuit supplied by accumulators—and sending a direct current through a solid carbon arc. Then what they showed was this, that if you make a break in this alternate circuit and insert the solid carbon arc (Fig. B) without making any

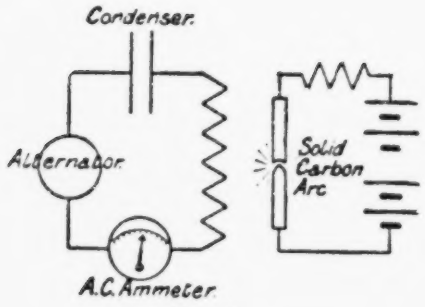

FIG. A.

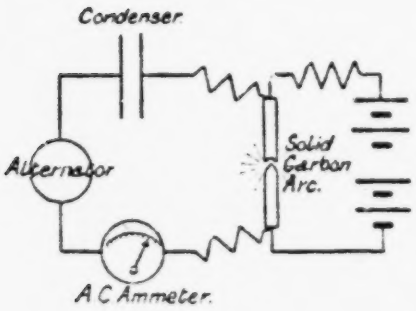

FIG. B.

change in the resistance, speed, or excitation of the alternator, etc., you increase the alternate current, not merely the current when flowing in one direction—for the condenser stops any direct current—but you increase the current in *both* directions; that is, the alternate-current ammeter reads higher after the arc has been inserted than it did before, and higher than it will if the arc be short-circuited. Now that investigation was undertaken by these gentlemen because certain theoretical considerations led me to suggest that if the method that had been employed by various experimenters to measure the resistance of the arc—a method employed without comment or adverse criticism as long as a positive answer was obtained—was applied in a certain case to an arc a negative answer for the resistance of the arc would be found: that the method, in fact, which up to that period had been used successfully to give the resistance of the arc, and which had always given a positive value, I pointed out would give under certain conditions, a negative answer. Certain preliminary experiments having been made by Mr. Mather which confirmed my idea, a long investigation was carried out by Messrs. Frith and Rodgers. And they found that whenever the arc was formed between *solid* carbons, the ratio of an instantaneous change of P.D. to the corresponding instantaneous change of current was *negative*, whereas if the carbons were *both cored* it was always *positive*.

[fol. 2946] A howl of indignant criticism followed. Had Messrs. Frith and Rodgers and I lived in the Middle Ages we should undoubtedly have been burned in the solid carbon arc. But there were three distinguished investigators

who had the insight, who had the courage, not to be drawn into this net of conventional antagonism, and these were Professor Gray, then of Bangor, now Lord Kelvin's successor at Glasgow, Mr. Oliver Heaviside, and last but by no means least, the Chairman of your Dublin local section, Professor Fitzgerald, to whom we, like so many experimenters, are indebted for the many suggestions which he has made. And I, even I, ventured to suggest that progress would be more expedited, I thought, if the critics, instead of merely cavilling at the anatomy of the sugar figure on the cake, would cut it open, and see whether there were really any plums inside. It has remained, however, for Mr. Duddell to be the real Jack Horner to put in his thumb and pull out the plum, and modestly leave you and me to finish the rhyme and add "what a good boy he is."

I do not propose this evening to consider whether or not what Messrs. Frith and Rodgers measured was the true resistance of the arc, because opportunity, I hope, we shall soon have of going fully into the subject; but in justice to Messrs. Frith and Rodgers, and in virtue of the far-reaching principle that they really brought to light, I desire to emphasise what they really obtained. Mr. Duddell has taught us what was the real significance of their work. Our lost friend Professor Hopkinson, following Mr. Wilde, proved several years ago that two alternators could not be run in series. Thus, for example, if an alternator with a certain exciting current supplied to it, and driven with a steam engine, or an electric motor, or whatever it might be, were coupled mechanically to another similar alternator, driven by an independent steam engine, and speed were got up so that the two machines were going exactly in step and then were joined in series with some outside circuit, he proved to us that the moment this mechanical coupling was severed the two alternators would get out of step. So, as is well known, two alternators cannot run in series. And he might have added—if there had been the slightest necessity for him to do so—that if two alternators cannot continue running in series even if they have been started with the same frequency and exactly in step, still more impossible must it be for one alternator, driven by its own steam engine, to run in series with another independently driven when the frequency of the second is being altered within

wide limits. Nevertheless, gentlemen, that is exactly what the arc does. For in Fig. B we have one alternator running in series, with a second alternator, viz., the solid carbon arc, supplying alternating current to the circuit—because the arc transforms direct-current energy into alternate-current energy—and does it in such a way that whether the frequency of this alternator be as Messrs. Frith and Rodgers found, seven periods per second, or 70, or 170, or 250, which was the highest limit which could be obtained in my laboratory at that time, and whatever the current [fol. 2941] might be within the limits they tried, this gallant little alternator—the solid carbon arc—helps the other, and supplies current sufficiently in phase as to make the alternate current greater when it, the arc, is inserted than when it is taken away or short-circuited.

Mr. Duddell has not only pointed out the importance of that result, the novelty of that result, but he has pointed out something even further. He has shown us that an ordinary so-called perfectly silent arc supplied with current from accumulators is, if the carbons be solid, like the mouthpiece of a flageolet or flute, not blown. The application of a shunt to that arc, consisting of a capacity in series with a self induction, performs two operations. It starts vibrations in the arc, just as blowing a flute gives rise to vibrations of many different rates. Just as one of those rates of vibration is picked out and reinforced in the case of a flute or flageolet by the form of the resonance chamber dependent on the position of your fingers or keys, so in this musical arc the particular one of the many vibrations that is probably started which is picked out and reinforced depends on the capacity of the condenser and the value of the self-induction which is in series with it.

Already he has shown you a practical result that has followed from this. I do not mean merely those illustrations which he has given of magnetic space telegraphy, and by means of which he has shown how it has become possible to easily and experimentally demonstrate that the E. M. F. of the current induced in the distant secondary coil is proportional to the frequency of the alternating current in the primary, which will be of marked value to teachers; but beyond that he has shown us how to much improve a well-known instrument. The other day he demonstrated in my laboratory that, adding to the ordinary circuit of that very

induction-coil, joined up as usual, his little motor so as to put the condenser across the break *just after* the break was made, a spark was obtained from five to seven times as long as was obtained with the coil in the ordinary way. Even if you try to make the comparison absolutely fair, and try to arrange the very best conditions in each case for the old method and for the new method, you still find a great advantage. Let somebody take, for example, an induction coil and arrange the battery-circuit, contact-breaker, etc., in the old way as well as he can, and let Mr. Duddell use the same induction-coil, battery, condenser, etc., and deal with it as well as he can, then the spark produced in the latter case will be from $2\frac{1}{2}$ to 3 times as long as in the former.

There is one other point which has come out in connection with these experiments of a rather different kind. Some ten or more years ago a paper was read by Dr. Sumpner and myself before the Royal Society, pointing out what was then new, that in the case of an alternating-current arc, if we used solid carbons, the true power given to the arc, that is the power measured by some accurate method, was considerably less in some cases than the current meas- [fols. 2942-2943] ured by a good current ammeter multiplied by the pressure measured by an alternate-current voltmeter. Subsequently to that, in making experiments I was pretty convinced that under certain circumstances a direct-current arc behaved in the same way. I was pretty certain, in the case of a direct-current arc, especially when solid carbons were used and the arc was hissing, that the power-factor was no longer unity, but not sufficiently sure of the fact to publish it, especially in view of the way in which that other paper which I have just referred to was received at the Royal Society, and the scepticism which was raised when Dr. Sumpner and I pointed out how far from unity we found the power-factor was with certain alternate-current arcs. But now I am sure, from results of experiments which have been recently made in my laboratory, that with an arc supplied with accumulators, a so-called steady direct-current arc, if the carbons be solid and there is hissing, the power-factor may be several per cent. different from unity—that is, the true power as measured by a true instrument, for example a good wattmeter, may be several per cent. less than the product of the voltmeter reading into the ammeter reading.

When I read this paper of Mr. Duddell's, I thought he had proved that a solid carbon direct-current arc was the most sympathetic soul I had ever met, but you have convinced us that that is not quite the case for you have shown Mr. Duddell this evening that the sympathy of his arc is even exceeded by the sympathy of his audience.

[fol. 2944] DEFENDANT'S EXHIBIT Z

United States of America,
Navy Department,
Washington, July 7, 1923.

I hereby certify that the annexed Blueprint copy of "Bellini-Tosi Direction Finder Tests", prepared by Mr. George H. Clark, while on duty at the Radio Test Shop, Navy Yard, Washington, D. C., in the year 1915, is a correct copy of the original now on file in the Radio Test Shop, Navy Yard, Washington, D. C.

F. H. Brumby, *Captain, U. S. Navy, Acting Commandant.*

Office of the Secretary.

I hereby certify that F. H. Brumby, Captain, U. S. Navy, who signed the foregoing certificate, was at the time of signing Acting Commandant, Navy Yard, Washington, D. C., and that full faith and credit should be given his certification as such.

In testimony whereof, I have hereunto set my hand and caused the Seal of the Navy Department to be affixed this fifteenth day of July, one thousand nine hundred and twenty-three.

(Seal.) T. Roosevelt, *Secretary of the Navy.*

Bellini-Tosi Direction Finder Tests

Radio Test Shop, U. S. Navy Yard, Washington, D. C.

Radio Laboratory,
Navy Yard, Washington, D. C.,
10-5-15.

Test of Bellini-Tosi Direction Finder

Enclosures:

Photos: RW69P92 to RW69P100 inclusive (9 photos)

Prints: RW50A106A t
RW66A101A RW69A92B
RW69A56A to RW69A100A inclusive. (45 prints)
RW69A102A and 103A

[fol. 2945] 1. *Description of Apparatus.* — The apparatus consists essentially of the following parts:

a. Two special antennas.
b. One direction-finder system.
c. One receiver with detector and accessories.
d. One angle-bisector.
e. One tester.

(a) The antenna system consists of two triangular, insulated, ungrounded antennas of equal size, the plane of one being exactly at right angles to the plane of the other. RW69A96A shows a typical aerial on land, and RW69A94A shows the method of installation on shipboard. Since by far the greatest use of the device is on shipboard, the names assigned to the aerials correspond to the location of the aerial with reference to the ship. One aerial is called the "Port forward-starboard aft" aerial, the other the "Port aft-starboard forward" aerial. Similarly, the horizontal leads from the lower ends of the sloping antenna wires to the receiving apparatus are known by the quarter of the ship in which they lie, as "Port forward", "starboard aft", etc. As shown in the drawing, the planes of the aerials lie at an angle of forty-five degrees with the fore and aft plane of the ship; this is done in order to obtain as great a length of base line as possible. Other things being equal, the dis-

tance-efficiency of the direction-finder increases with increase in base line.

When installed on shipboard, the triangular aerials are usually suspended by their top corners thru insulators from a triatic or other fore and aft stay, or from a sprit, gaff, or bracket on one of the masts. Connecting wires are led to the instruments from the centres of the horizontal base lines of the triangular aerials, which are split by an insulator at their point of intersection. The range of the installation suffers to some extent if these connecting wires are very long, so that it is desirable to keep the distance between the instruments and the centre of the aerial system as short as practicable.

(b) The direction finder system consists of two coils of wire of equal size, crossing each other at right angles in vertical planes. In the middle of each coil of wire is inserted a variable condenser of the sliding plate type; this location being for reasons of symmetry. Inside the crossed coils a third coil, called the "exploring coil" is mounted on a vertical spindle, so that its angular position with reference to the fixed coils can be varied. On this spindle is mounted the indicating handle from which the direction is finally read. RW69P92 shows the exterior of the Direction-Finder, and RW69P95 the interior. The connections of the primary coil system are shown in print RW69A92A; the dimensions and value of the primary coil system in RW69A83A; the mechanical details of the sliding plate condenser in RW69A82A; and the calibration of this latter in RW69A81A.

Each aerial passes thru a double pole switch, which, when opened, completely disconnects the aerial from its associated coil system. Safety spark gaps serve to take care of any high potential developed in the aerial due to the local transmitter or other causes.

[fol. 2946] The inductance of one side of one of the primary coils is 0.0046 m. h., and the total inductance of the two halves of one coil is 0.018 m. h.

The series primary condenser has a maximum value of 0.0014 mfd. The fixed plates are provided with an adjusting screw, so that the absolute value of capacity at any given setting may be varied within certain limits. The series condensers of both aerials are varied simultaneously, hence if there should be a slight dissimilarity in the constants of

the two aerials both would not be exactly in resonance if both condensers had exactly the same value. Hence by the adjusting screw any difference in antenna constants can be offset once for all by a variation in the value of the series condenser associated with the antenna, the other series condenser remaining unchanged.

The pick-up coil which rotates inside the primary cage is shown as coil L'_2 in RW69A77A. Its inductance is 0.155 m. h. at 1,000 meters.

(c) The receiver system is shown in photos RW69P93, 94, 96, 97, and 98. The wiring is shown in print RW69A92A.

The intermediate circuit which acts to transfer energy from the primary squirrel-cage coil system to the detector system consists of two coils and a variable condenser, all three being in parallel with each other. The variable condenser is of the Marconi ebonite-plate type, and has a maximum capacity of 0.011 mfd. This is very much greater than is required to reach the wave lengths intended when used with the associated coil system. An air-dielectric variable condenser would be far preferable. The calibration of this Marconi condenser is shown in RW69A78A. The constants of the intermediate circuit inductances and of the detector circuit inductance and the coupling between these circuits is shown in RW69A77A. This coupling is variable by a handle projecting from the receiver box, and marked "Intensifier handle". The choice of term is not ideal.

The detector circuit consists of a cylindrical inductance of value 0.60 m. h. at 1,000 meters, and a sliding tubular condenser, this latter being known as a "billi" condenser. The term is given on account of the mythological value of capacity supposed to be available with this condenser, i. e., one billionth of a farad. As a matter of measurement, the condenser varies from 0.000016 mfd. to 0.00024 mfd. The construction of the condenser is shown in RW69A80A, and the calibration in RW69A79A. This condenser is also known as the "jigger" condenser.

Two detectors were supplied with the set, (1), carborundum, and (2), Fleming valve.

The general diagram and also RW50A106A show the diagram of connections for the valve. A series resistance Rh, varies the filament current and hence the brilliancy of the filament. A potentiometer RH, varies the potential

on the enveloping plate. These resistances are in series with each other, hence a variation in the series resistance (to vary the filament brilliancy) requires a readjustment of the potentiometer. A six-volt storage battery is used for current supply. This battery with its associated charg- [fol. 2947] ing and connecting plug, and also voltmeter, is shown in RW69P98.

When using the crystal detector, the potentiometer alone is in use. The series resistance is in circuit, but is no longer a factor in adjustment.

A simple two-way switch serves to connect valve or crystal.

(d) In obtaining the direction of a sending station, as explained in the next paragraph, greater accuracy is obtained by noting the position on each side of the maximum at which signals die off to a certain equal value. The direction-indication is then the mean of these two angles on either side of the maximum. For rapid determination of this mean angle an angle-bisector is supplied with the apparatus. See photo RW69P100. If the two outer arms be set at angles corresponding to the reading of the direction finder each side of the maximum position, the middle arm automatically indicates the mean of these two angles.

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2. *Operation of Direction Finder.*—Each aerial loop forms a directional aerial, which receives best when its plane is in the direction of the sending station. If the plane of the aerial is at right angles to the direction of the sending station, equal and opposite currents are set up in each side of the loop, and the net result is zero. When the plane is in the direction of the sending station, currents of different phase are set up in the two sides of the loop, the phase difference depending on the relation between the wave length and the length of the base line of the aerial. Hence a resultant current flows thru the system. When the plane of the aerial is intermediate between the positions described above, the induced current varies as the cosine of the angle between the plane of the aerial loop and the direction of the sending station.

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3. *Experiments With the Direction Finder.*—Tests made between May and September, 1914.

f. *Sending station.*

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g. *Receiving aerials.*—A number of aerials were rigged up for use with the Direction Finder, utilizing for this purpose the main and topmasts of the wooden mast then existant at the Navy Yard.

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h. *Effect of removing direction finder to station 90° distant.*

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i. *Effect of main flat-top aerial on direction indication.*

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j. Plot of current in each aerial and resultant current in direction-finder.

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[fol. 2948] k. Effect of coupling between intermediate and detector circuits on direction-indication.

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l. Effect on direction-indication of detuning both aerial circuits equally (by series condenser).

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m. Effect on direction-indication of detuning one aerial circuit, the other remaining at resonance.

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n. Effect on direction indication of error in bearing of one side of one aerial.

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o. Determination of direction of distant lightning disturbances the Direction Finder.

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p. Comparison of aerials with (1) base line 180', and (2) 300'.

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q. Tests of various primary circuits.

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r. Test of relative sensitiveness of detectors. Method of test: Signals sent at constant power from portable set at War College. Shunts taken on receiving telephone. One side of another telephone in series, unshunted, as permanent choke. Wireless Specialty adjustable telephones, D. C. resistance 1000 ohms.

Carborundum detector as supplied with Direction Finder 80 audibility.

Fleming valve as supplied with Direction Finder 160 audibility.

Galena crystal and copper wire contact (From Wireless Specialty receiver) 400 audibility.

After the first few tests on the Direction Finder, the galena detector was used for all tests.

s. Tests of direction:

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t. Sensitiveness of direction finder apparatus as a whole.

. . . . . .

u. Reactance curves of aerial systems.

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v. Recommendations:

1. Replace secondary condenser (Marconi type, with ebonite dielectric) by standard air condenser. Present condenser is much too large for the wave lengths normally used with the apparatus, is liable to get out of order, and has serious internal losses.

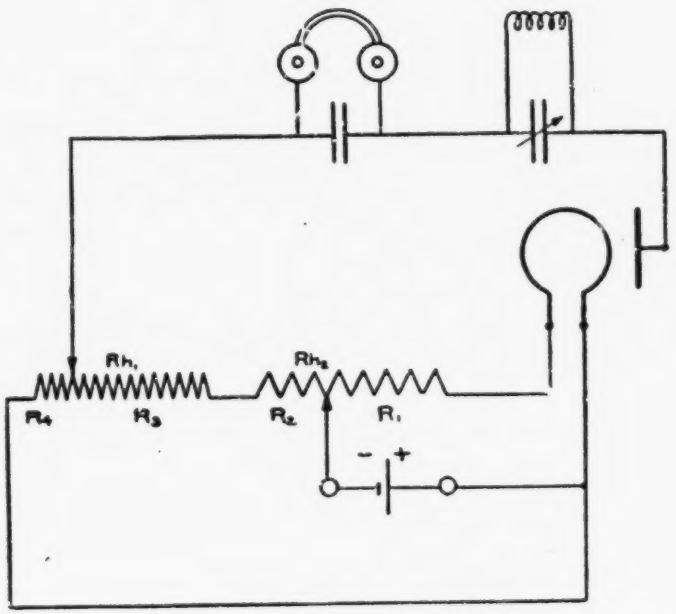
2. Replace carborundum detector and Fleming valve by more sensitive crystal detector (as galena or silicon-arsenic) and Deforest audion amplifier. Possibly it would be sufficient to supply binding posts for this, and use the detectors available at the station of use.

[fol. 2949] 3. Tests should be begun to devise a method of direction finding which, as this one, is independent of the movement of the ship, (i. e. does not require orientation of the ship to determine direction), but which has a much greater range. The limited range of the Bellini-Tosi ap-

paratus, even on land where an antenna of considerable size can be erected, is a severe disadvantage to the system.

Approved.

A. L. Winary, Commander, U. S. Navy, Engineer Officer.



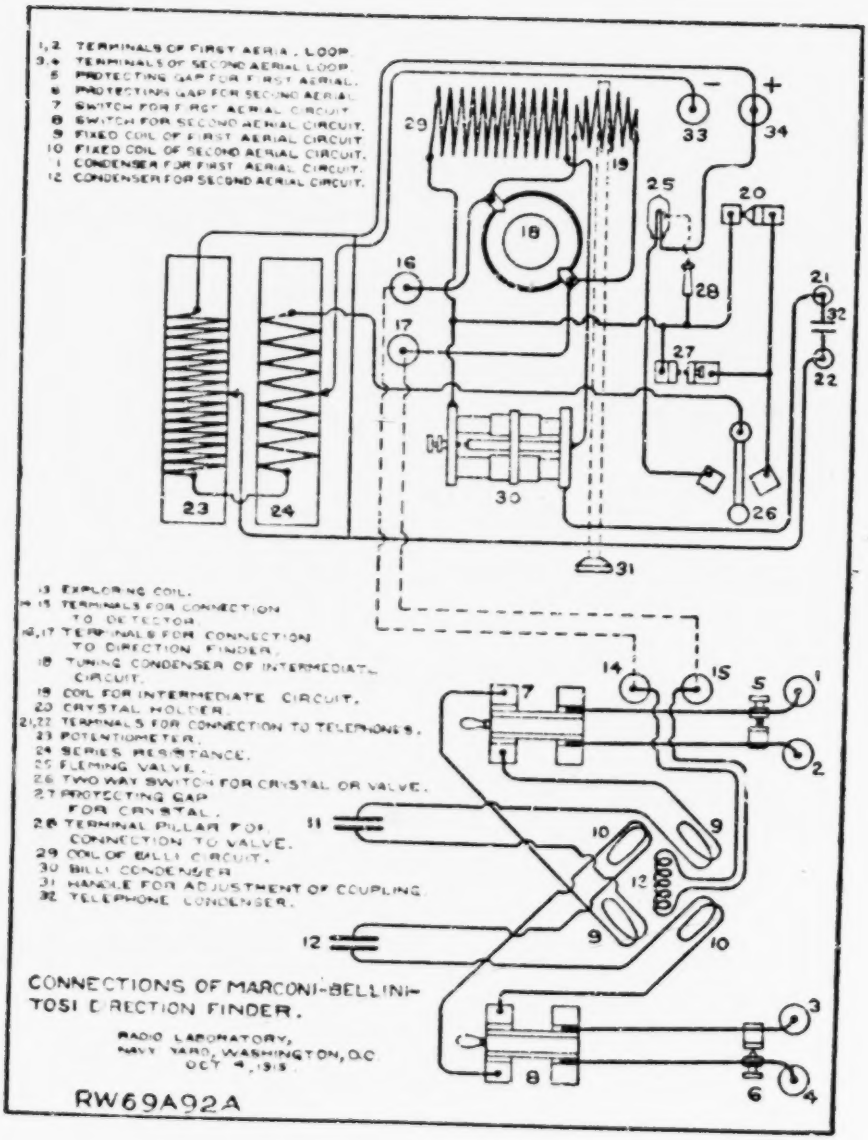
MARCONI DIRECTION FINDER
CONNECTIONS FOR
FLEMING VALVE.

NAVY YARD,
WASHINGTON.
10-1-15.

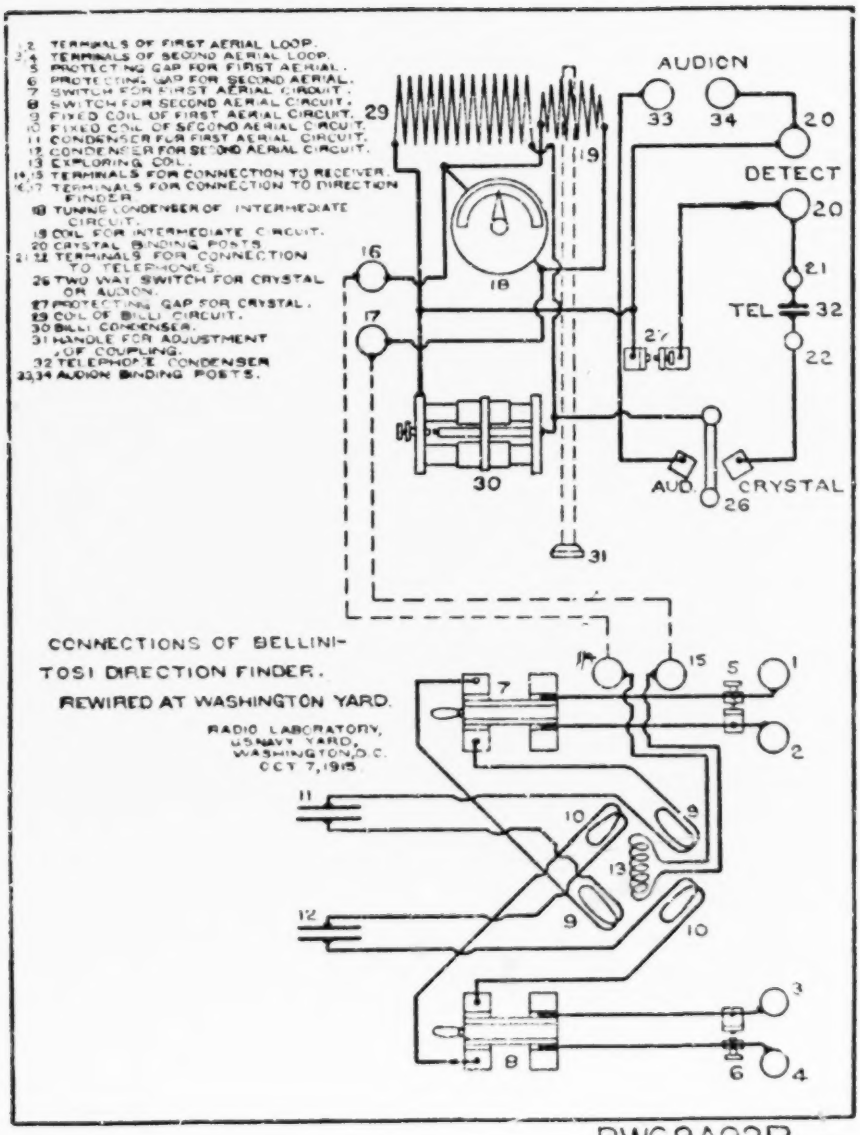
From RW69A92A
of 12-27-14.

RW50A106A

[Vol. 2956]


1,2 TERMINALS OF FIRST AERIAL LOOP
3,4 TERMINALS OF SECOND AERIAL LOOP
5 PROTECTING GAP FOR FIRST AERIAL.
6 PROTECTING GAP FOR SECOND AERIAL.
7 SWITCH FOR FIRST AERIAL CIRCUIT.
8 SWITCH FOR SECOND AERIAL CIRCUIT.
9 FIXED COIL OF FIRST AERIAL CIRCUIT.
10 FIXED COIL OF SECOND AERIAL CIRCUIT.
11 CONDENSER FOR FIRST AERIAL CIRCUIT.
12 CONDENSER FOR SECOND AERIAL CIRCUIT.
13 EXPLORING COIL.
14,15 TERMINALS FOR CONNECTION TO DETECTOR.
16,17 TERMINALS FOR CONNECTION TO DIRECTION FINDER.
18 TUNING CONDENSER OF INTERMEDIATE CIRCUIT.
19 COIL FOR INTERMEDIATE CIRCUIT.
20 CRYSTAL HOLDER.
21,22 TERMINALS FOR CONNECTION TO TELEPHONES.
23 POTENTIOMETER.
24 SERIES RESISTANCE.
25 FLEMING VALVE.
26 TWO WAY SWITCH FOR CRYSTAL OR VALVE.
27 PROTECTING GAP FOR CRYSTAL.
28 TERMINAL PILLAR FOR CONNECTION TO VALVE.
29 COIL OF BELLI CIRCUIT.
30 BELLI CONDENSER.
31 HANDLE FOR ADJUSTMENT OF COUPLING.
32 TELEPHONE CONDENSER.
CONNECTIONS OF MARCONI-BELLINI-TOSI DIRECTION FINDER.
RADIO LABORATORY,
NAVY YARD, WASHINGTON, D.C.
OCT 4, 1915
RW69A92A

[fol. 2951]



DEFENDANT'S EXHIBIT A-1

Manual of Wireless Telegraphy (Radio)

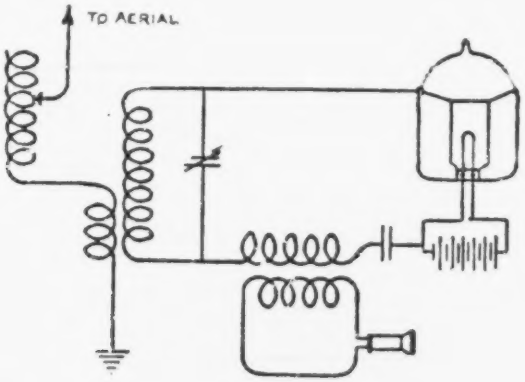
For the use of Naval Electricians by Commander S. S. Robison, U. S. Navy, 3d Revised Edition. Annapolis, Md., the United States Naval Institute, 1915

U. S. Naval Wireless Telegraph Station, Sitka, Alaska.

199. The variable inductance of fig. 83 is hinged so that the coupling can be varied by a combined movement of

separation and rotation with reference to the fixed inductance (fig. 100).

[fol. 2952] In fig. 86 the coupling is varied by sliding the closed circuit inductance on a graduated bar parallel to its axis (fig. 101a).



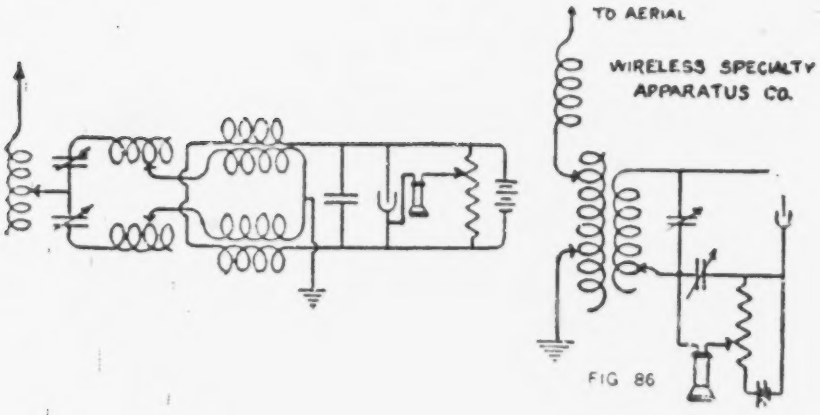


FIG 86

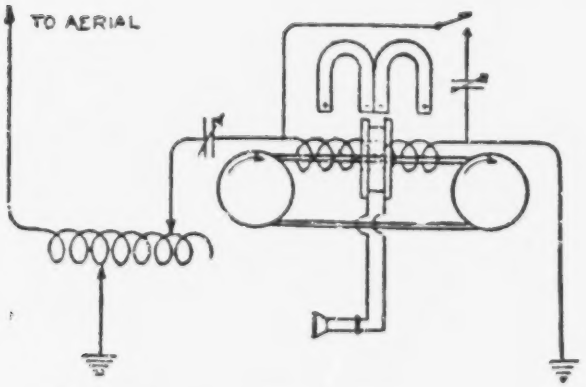


FIG. 87.—Magnetic Detector—Marconi.

Figs. 84 and 88 represent the valve and audion receiving circuits. In fig. 84, the valve detector is shown as shunted [fol. 2953] around a tuned, closed circuit. The audion shown in fig. 88 has tuned connections like the valve detector, but has a local battery in the telephone circuit.

Fig. 92 represents circuits of a receiving set complying with present specifications. In all such sets closed circuits are calibrated and curves drawn or a scale furnished show-

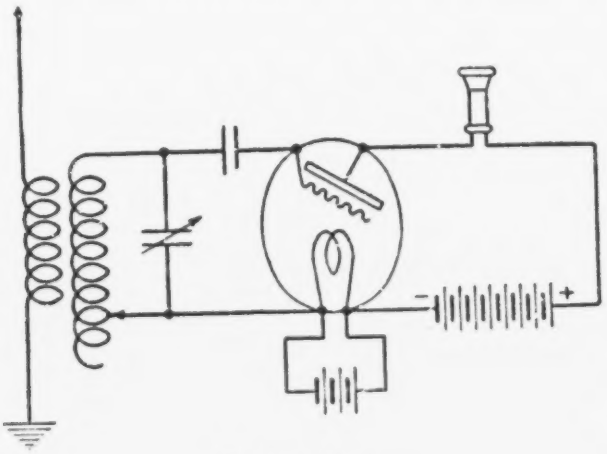


Fig. 88.—Audion.

ing wave lengths for all settings from 200 to 4000 meters, and additional calibrated loading coils for very long waves are supplied.

With very loose coupling the wave length of received signals can thus be read directly.

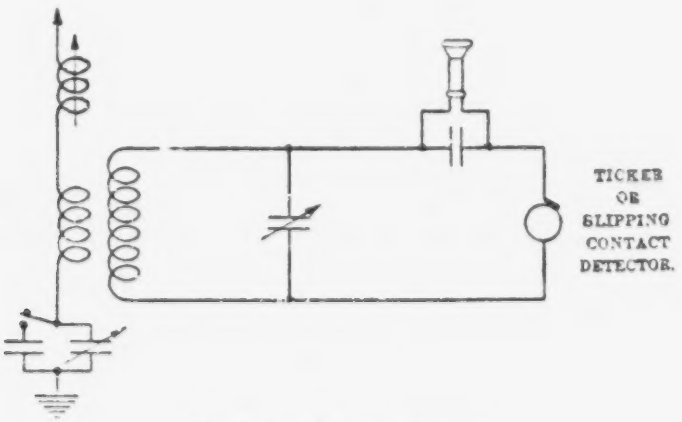


Fig. 89.—Federal Co. (Poulsen).

200. Fig. 89 represents receiving circuits for continuous oscillations; it shows the receiving telephone connected across the terminals of a fixed condenser in series with the detector.

In using undamped oscillations for wireless telegraphic purposes it must be remembered that the frequency of the oscillations themselves is too high to be heard in the telephone connected with the ordinary receiving circuit, and when the circuit at the sending station is closed all that would be heard is a slight click, so that there is no way of [Feb. 2954] telling a

. . . . . .

being wound in a spiral groove on an ebonite cylinder. A sliding contact, on a rod parallel to the cylinder, works in the groove and is pressed against the wire by a spring. By revolving the cylinder an infinite number of adjustments can be obtained.

Earlier Fessenden sets (figs. 79 and 82), have double roller inductances, by turning which, the wire can be reeled from one roller to another as desired. On one roller the turns are insulated from each other and on the other they are short circuited so that any desired length can be retained in the circuit.

None of the above types of variable inductances can be readily mounted so as to vary the mutual induction between them by any definite amount. They are suitable for loading but not suitable for loose coupling.

For this reason the preferred types of receiving circuits are made up of fixed inductances (or those varied by plug or dial stops), mounted so that they can either be coiled apart or one coil revolved so as to change its plane and hence the mutual induction with reference to the other or others. The variometer type, mounted like variable condensers, are now being manufactured. Their self induction can be varied quickly and conveniently and close adjustment of period (tuning) made with them or with the variable condensers, but the entire coil is always in circuit.

Each section of an inductance not in circuit should be opened at both ends, i.e., entirely disconnected, and if its natural period is large it should be mounted so that the inductive effect of active parts on it is a minimum. This applies especially to loading coils for long wave lengths. (Fig. 92.)

All inductances are wound on hard rubber, porcelain or glass and so as to have a minimum high frequency resistance. The decrement of the entire circuit must not exceed .3.

From the formula for damping $d=\frac{R}{2nL}$ it can readily be seen that a very pronounced natural period—a stiff circuit—can not be obtained unless the self-induction is large compared with the total resistance (including the radiation resistance.)

205. *Detectors.*—There is but one type of detector now in general use, viz., the *Crystal* or rectifying detector. The *electrolytic* is used only as a standard for comparison. Coherers and microphones are practically obsolete, and comparatively few of the magnetic and audion, or valve detectors, have been installed, but the use of audions and ultra-audions is increasing. Unlike coherer detectors, all types of crystal, magnetic, electrolytic and audion detectors are self-restoring. Generally speaking all should be put on open circuit while sending, to preserve them from injury due to induced potentials and currents.

The ordinary detector serves as well for receiving the continuous modified oscillations of *wireless telephony* as for the groups of oscillations in ordinary wireless *telegraphy*.

[fol. 2955] 206. *The electrolytic detector.*—It consists of a fine platinum wire just touching an electrolyte made either of a 20% solution of nitric or sulphuric acid or an alkali. Of these the nitric acid solution is preferred. The other electrode is also of platinum. The containing cup (fig. 79) is made quite small so that the cohesive power of the electrolyte will prevent splashing in a sea way. The electrolytic detector must have the fine wire terminal connected to the positive pole of the local battery (fig. 79), otherwise the device is not operative.

Dr. Austin states that the higher the frequency, the finer the wire should be, and that the depth of immersion does not matter if the detector is not directly in series in the closed circuit.

When a current flows through the electrolyte, the latter is decomposed (the action being called electrolysis) liberating oxygen at the anode and hydrogen at the cathode. The accumulation of these non-conducting gases on the electrodes

interferes with the passage of the current, which soon ceases to flow and the cell is then said to be *polarized*.

The fine wire anode is then insulated by the oxygen, which forms the dielectric of a small condenser, of which one conducting surface is the electrolyte and the other the wire point.

The critical potential of the detector is just below that necessary to break down this insulating layer of oxygen and is determined by increasing the potential at the detector terminals by means of the potentiometer until a bubbling or hissing sound is heard in the receiving telephone; then resistance is cut in until this sound just ceases.

When electric oscillations are impressed on this condenser, the polarization layer breaks down and permits a pulse of direct current from the battery to pass through the cell and *telephone*. As soon as the oscillations cease the polarization is restored.

Except when they are very strong, the loudness of the sounds produced in the telephone is an exact measure of the energy of the oscillations passing through the cell.

This constancy of action of the electrolytic cell is utilized as a means of comparing the sensitiveness of detectors, the standard being the sensitiveness of an unjacketed platinum wire electrode .0002 in diameter in a solution of 20% nitric acid.[1]

Glass jacketed electrodes formed by sealing the wire in glass (the two having the same coefficient of heat expansion) have been used, but are less reliable and in general less sensitive and are no longer supplied. Some of these glass points were made hook shaped, the hook pointing upward to facilitate depolarizing but no increase in sensitiveness was noted on this account.

With the Shoemaker receiving sets was furnished what was called a primary cell detector. The electrolyte used was a 20% solution of sulphuric acid and the other electrode was a zinc rod amalgamated with *mercury*, which in the acid solution gave a difference of about .7 volt between zinc [fol. 2956] and platinum. No local battery was required (fig. 82). At times this detector compared favorably with

[1] Dr. Austin has invented a "detector tester" which affords a means of direct comparison between detectors operating under the same conditions.

the one just described, but was in general more irregular and less sensitive in its action.

In all electrolytic detectors very strong signals or static discharges produce actual sparking or an explosive action in the electrolyte, which destroys the platinum point and an operator must be constantly on the lookout to protect his point from burning out. The best results in electrolytic detectors have been obtained with a distance between electrodes of approximately $\frac{1}{4}$ inch.

207. *Rectifying detectors.*—There are certain substances which when brought together in not too close contact, have the property of producing a direct current when an alternating current or electrical oscillations are sent through them. The cause of this action is not yet known. Among these substances are carbon in contact with steel, tellurium with aluminum or galena, silicon with any of the ordinary metals, and certain crystals.

The first of the crystal detectors to be supplied was General Dunwoody's carborundum crystal detector.

Since rectifying detectors permit the passage of current in but one direction, they produce pulses of direct current. These pulses, if strong enough, can be heard in a telephone so that local batteries are not required, although a slight increase of sensitiveness is noted in some detectors with an E.M.F. across the terminals of the detector of about 0.2 volt.

Rectifying detectors are connected in receiving circuits in the same manner as the electrolytic.

Their sensitiveness for general use is practically equal to the electrolytic and their simplicity makes them the more suitable. They are in general less sensitive to injury from static discharges, strong signals, or induced currents from sending, than the electrolytic, but, like coherers, different crystals of the same material vary widely in sensitiveness and sensitive spots in any crystal have to be found by trial and when found are not constant. They are thus not as capable of quick readjustment as the electrolytic, but their other advantages are such as to be conclusive as regards their use.

The carborundum detector when first introduced, was simply held between two points or wrapped with copper wire for one connection, with a needle, knife edge, or more blunt piece of metal for the other. It was later found that embedding a large part of the crystal in a conductor such

as solder or a mercury paste, and thus limiting the rectification to one contact only, produced much better results and carborundum crystals have been found equal in sensitiveness to other crystals now generally utilized.

Pickard's silicon detector followed the carborundum and is still in use but it has been largely superseded by the Perikon & Pyron, supplied with the receiving set illustrated in fig. 86. The Perikon detector consists of two crystals, chalcopyrites and zincite. A number of zincite crystals are held in a conducting disc, a crystal of chalcopyrites is mounted [fol. 2957] so that it can be brought into contact with any part of any of the zincite crystals at will, and the pressure between the two *regulated*. In the adjustment for maximum intensity of signals, the exact degree of pressure and the most favorable points of contact are of importance. These can only be ascertained by trial and test with the testing buzzer.

The sensitiveness of the Perikon may be approximately doubled by connecting a battery across its terminals so as to give approximately 0.2 volt. The positive pole must be connected to the single crystal.

The Pyron consists of a crystal of iron pyrites in contact with a metal point like the silicon. This is very satisfactory for strong signals and constant in its action. The iron pyrites is more sensitive when the pressure of the metal point is adjustable. The *area* of contact is also a determining factor of sensitiveness; comparatively fine points will discover sensitive places on irregular crystals, which blunt points will not.

The Perikon is more sensitive and must be protected against strong signals. The *zincite* is the crystal injured by strong signals. It should not be subjected to heavy pressures or grinding from the chalcopyrite. When deadened the zincite crystals can be made operative by scrubbing them with a bristle brush wet with carbon bisulphide, then with soap and water and then rinsing with fresh water and drying. In damp weather or in tropical climates this detector is improved by spreading a drop of paraffin oil over the surface of the crystals. This comment applies to the silicon also.

Galena, cerusite (a form of galena), and iron pyrites are all giving satisfactory use by mounting so as to have contact all over one surface and a very fine, flexible wire point just touching *the other* surface.

208. *Vacuum tube detectors.*—The two forms which have been used are known as the valve and the audion, illustrated in figs. 84 and 88. The valve was discovered by Fleming, and is sometimes called the Fleming valve. It is a rectifier, permitting the passage of current in one direction only. It consists of a special incandescent lamp (see fig. 84), operated by a 12-volt storage battery and having a small sheet or cylinder of metal held in the bulb near the filament. Lamp filaments when glowing emit negative electricity, which carries away part of the filament and causes the darkening of the bulb seen on old carbon lamps. The vacuum thus becomes a conductor in one direction only. It is not found to be a very sensitive one.

The audion (fig. 88) has a metal grid interposed between the metal plate and the lamp filament. In the valve, the metal plate is connected to the receiving circuit, but in the audion, the grid is connected to the receiving circuit, while the plate is connected to the telephone. In the valve, the variations of current in the receiving circuit produce differences of potential between the filament and the plate. In the audion, these differences of potential are between the filament and the grid: or, as it is perhaps better to say, the grid is charged by the received oscillating currents. In [fol. 2958] addition to this difference, the audion has a local battery with its positive pole connected to the metal plate, and its negative pole to the lamp filament. This battery, as well as the battery supplying the lamp, has a variable voltage. The battery voltage and lamp voltage must both be adjusted to secure the greatest sensitiveness of this detector; but this adjustment is permanent for any given conditions. The charge on the grid, produced by the incoming signals, interferes with the flow of negative electricity between the filament and the plate. This flow of negative electricity, when the heat from the filament and the local

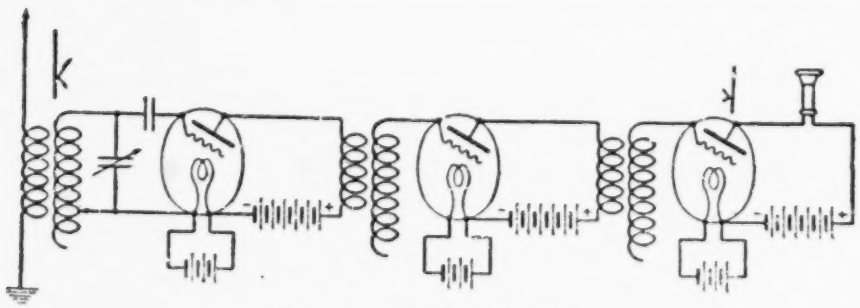


FIG. 88A.—Amplifying Audion.

battery voltage are properly adjusted, produces a current through the audion of the order of a milliampere. This current flows through the receiving telephone and variations in it, produced by the varying charge on the grid, are what make the signals heard in the telephone.

The audion has the further advantage over the valve, in that the telephone can be replaced by the primary of a transformer, the secondary of which is connected to another audion, with the result of amplifying the signals produced. (See fig. 88a.) Audion bulbs have tantalum lamp filaments, and plate and grid are usually double, one on each side of the filament. The plate and grid are of nickel. The audion can also be used as a heterodyne (art. 201). When connected for receiving continuous oscillations it is called "the ultra-audion."

We see, therefore, that the audion is suitable for use with arc, as well as spark sets, and also as an amplifier: thus combining within itself the qualities of all other detectors.

209. *Magnetic detectors.*— The operation of magnetic detectors depends on the fact that when iron is being magnetized its magnetization is somewhat delayed in time behind the impressed magnetizing force, and when in this condition the iron is very sensitive to any change in the magnetizing force, a very small increase of which will produce a momentarily large increase in the strength of the magnetic field.

Many patents have been issued for various forms of magnetic detectors, the best known and the most largely used of which is Marconi's, patented in England in 1902. It is not [fol. 2959] injured by strong sending, but is not as efficient as the crystal detector, the electrolytic nor the audion.

In its present form it consists of a flexible band of silk-covered iron wires, moved by clockwork around two pulleys which support it. A glass tube, through which the band passes, has a primary winding of insulated wire in series with the aerial and a secondary winding forming a closed circuit through a telephone. Close to the secondary windings are placed similar poles of two horse-shoe magnets, which magnetize the iron band slowly moving under them. Electric oscillations in the primary winding, produced by passing electric waves, produce momentary changes in the magnetization of the iron band under the magnets, and

these changes induce oscillating currents in the secondary winding which produce sounds in the telephone.

An elementary diagram of this magnetic detector is shown in fig. 87. It requires no local battery, and, not being subject to burnouts except from very large currents, it is a very convenient instrument, but is not as sensitive as those previously described, especially for short wave lengths. There are other methods of connecting this detector than that shown in fig. 87, but since comparatively few magnetic detectors are in use they are not shown here.

Defendant's Exhibit B 1

Robinson's Manual of Radio Telegraphy and Telephony, 1918

205. *Detectors.*—There are two types of detectors now in general use, viz., the *Audion*, and the *Crystal* or rectifying detector. The *electrolytic* is used only as a standard for comparison. Coherers and microphones are practically obsolete, and comparatively few of the magnetic detectors have been installed, but the use of audions and ultra audions is increasing. Unlike coherer detectors, all types of crystal, magnetic, electrolytic and audion detectors are self-restoring. Generally speaking all should be put on open circuit while sending, to preserve them from injury due to induced potentials and currents.

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206. *The Electrolytic Detector.*—it consists of a fine platinum wire just touching an electrolyte made either of a 20% solution of nitric or sulphuric acid or an alkali. Of these the nitric acid solution is preferred. The other electrode is also of platinum. The containing cup (fig. 79) is made quite small so that the cohesive power of the electrolyte will prevent splashing in a sea way. The electrolytic detector must have the fine wire terminal connected to the positive pole of the local battery (fig. 79), otherwise the device is not operative.

[fol. 2960] DEFENDANT'S EXHIBIT C 1

Wireless Telegraphy and Telephony

An Outline for Electrical Engineers and Others by

L. B. Turner, M.A., M.I.E.E., Fellow of King's College, Cambridge; recently of the Signals Experimental Establishment, Woolwich (Royal Engineers), and of the Engineer-in-Chief's Office, Post Office; Member of the Imperial Wireless Telegraphy committee 1919-20. Cambridge, at the University Press, 1921

example, the triode[1] produced by H. J. Round of the Marconi Company, shown at C in Plate XVII, would generally give wonderful results in expert hands; but it had to be carefully nursed, and its vacuum was actually controlled by the operator from time to time by warming more or less the pellet of asbestos sealed in a pocket in the tube, and visible in the photograph. In other tubes, a mercury amalgam was introduced for a similar purpose.

6. *Introduction of third electrode.*—We pass now to the effect on the space charge of introducing into it, or near it, a third electrode, maintained at a higher potential so as more or less to neutralise the charge. The tube then becomes a three-electrode tube, and is called a "triode." The third electrode is usually in the form of a perforated plate, or a wire grid, placed between cathode and anode, and is commonly called the "grid."[2] The introduction of the grid was the work of L. de Forest in 1907, and although the rationale of the triode does not appear to have been fully understood at the time, and its uses have only recently been developed, this addition to the Fleming Valve marks the conversion of the thermionic tube from a mild convenience into the potent and indispensable instrument it is to-day.

The reader will be helped to some physical picture of the action of the grid by studying the diagrams in Fig. 58. Here

[1] The fact that this is a triode and not a diode is irrelevant in this connection.

[2] "Control electrode" (grid) and "repeat electrode" (anode) are good descriptive terms, used by Eccles. Most commonly, the electrodes are referred to as filament (or cathode), grid, and anode (or plate).

C, G and A are sections of the cathode, grid and anode, which may be regarded for simplicity as portions of large plane surfaces perpendicular to the paper. The diagrams are intended to show the lines of electric force in the space between anode and cathode which would act upon the electrons if any were present, urging them to move in the direction against the arrow-head (since the electron is a *negative* charge). The presence of the electrons modifies the field in a manner not easy to portray, but by first considering the field in their absence we can obtain some insight into the action of the grid. To arrive at the electron currents, which are stated on the right of the diagrams, we have to picture a cloud of electrons congregated near the cathode, repelling freshly evaporated electrons.

[fol. 2961] DEFENDANT'S EXHIBIT D-1

Guide to the Study of the Ionic Valve

Showing its Development and Application to Wireless Telegraphy and Telephony, by William D. Owen, Associate Member of the Institute of Electrical Engineers, Head of the Department of Wireless Telegraphy, Rutherford College, Newcastle, 1919

IV. *The "Audion" or Three-Electrode Valve.*—The two electrode valve is now obsolete except in a modified form called the "Kenotron," to which reference is made later on. It was abandoned in favour of carborundum, which is more sensitive and requires less auxiliary apparatus. By the introduction of a third electrode into the valve between filament and plate, Dr. Lee de Forest, of New York, made use of an entirely new principle. The additional electrode must be such as to have capacity with respect to the filament and, in spite of its position, must allow electrons to pass to the plate. Incidentally it might be mentioned that the capacity effect between the *plate* and the third electrode is made use of in some circuits.

DEFENDANT'S EXHIBIT E-1

Proceedings of Physical Society of London, 1914

This shows the "Perikon" or zincite-chalcopyrite detector to be the most sensitive of those tested when used as a simple rectifier. The table also gives the maximum meas-

ured values of the sensitiveness for the various detectors tested when used with boosting voltage.

Table showing the relative sensitiveness of various detectors

Detector	Maximum sensitiveness when used as simple rectifiers	Maximum measured sensitiveness with boosting voltage
Marconi magnetic, assumed as unity		
Molybdenite-copper point	2 15	2 15
Graphite-steel point	1 26	
Carborundum, one end set in solder	0 50	0 60
Carborundum, not set in solder	0 325	1 0
Galena-plumbago	8 35	[1]12 6
Zincite-copper point	6 6	
Zincite-brass point	3 43	
Chalcopyrite-copper point	0	
Chalcopyrite-brass point	0	
"Perikon" (zincite-chalcopyrite)	10 5	12 1
Bornite-copper point	1 0	
Bornite-carbon point	0	
Zincite-bornite	7 4	7 4
Fleming carbon-filament valve (No. 12)		1 0
Fleming 12-volt metal-filament valve		1 0
Fleming 15½-volt metal-filament valve (No. 33)		12 0
Tellurium-aluminum	..	0 9
Electrolytic (German make)		1 0
Electrolytic-nitric acid		4 0

[1] NOTE.—It the *general shape* of the sensitiveness curve for the galena detector may be assumed to remain the same for very light contact as for firmer contact (with which the above measurements were taken), the maximum *estimated* sensitiveness for this detector with very light contact is *of the order of 60 to 70*, as compared with the magnetic detector.

[fol. 2962] Since the exact values of the current, voltage, &c., obtained in these tests for the various detectors will necessarily differ with different crystals, tables giving the results of the measurements are not given, but sample curves are included to show the general form of these results, as the *general shapes* of the curves will probably remain the same for the same substances.

DEFENDANT'S EXHIBIT F-1

Department of Commerce and Labor. Bulletin of the Bureau of Standards, Vol. 6, No. 4, S. W. Stratton, Director. Issued November, 1910. The Comparative Sensitiveness of Some Common Detectors of Electric Oscillations. Louis W. Austin, 527. Washington, Government Printing Office, 1910.

The Comparative Sensitiveness of Some Common Detectors of Electric Oscillations

By Louis W. Austin

Although probably many comparisons of the sensitiveness of detectors have been made in the laboratories of the wireless companies, very little quantitative information on this subject has been made public. For this reason the experiments here described have been carried out. On account of the difficulties and the amount of time involved in the testing of detectors in wireless stations, methods have been developed during the last three years whereby these tests can be made in the laboratory more expeditiously and accurately than is possible in the regular stations. The difficulties usually encountered in laboratory tests of this kind are due mainly to the direct effect of the source of the oscillations on the receiving circuits and detector; but by using properly designed exciting circuits in connection with a buzzer as a source of oscillations these difficulties have been removed. As it is also possible in this way to produce oscillations of any required degree of damping as well as of any required wave length, all of the problems of wireless telegraphy can be successfully investigated in the laboratory except those which have to do with the properties of different types of antennae and the passage of the waves from station to station. In the following paper some experimental comparisons of the sensitiveness of wireless detectors are described.

Symbols

D = Galvanometer deflection } In general proportional to energy in detector.
A = Telephone audibility }
I = Oscillatory current. "
c = Direct current.
R = Direct current resistance.
R' = High frequency resistance.
$L_1 L_2$, etc. = Inductances.
$C_1 C_2$, etc. = Tuning condensers.
K = Large fixed condenser 0.04–0.1 mf.

[fol. 2963]

M_{34} = Mutual inductance between coils 3 and 4.
d_{12} = Distance between coils 1 and 2.
δ_1 = Logarithmic decrement in circuit I.
λ = Wave length.

Method of Experiment

The exciting circuit[1] in all the experiments is shown in Fig. 1. Here B is a buzzer run by two storage cells with considerable resistance in series. The oscillatory circuit consists of a variable air condenser C_1 having a maximum capacity of 0.005 microfarads, and for moderate wave lengths an inductance L_1 of 0.062 millihenries. These are connected directly across the contact of the buzzer.

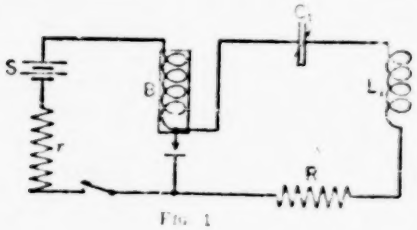

Fig. 1

The action of the circuit is as follows: When the buzzer contact is broken, the condenser C_1 is charged and this charge is retained until the contact is again closed, when the condenser discharges through the contact, producing oscillations in the circuit L_1C_1. As these oscillations take place in a closed metallic circuit, they are very feebly damped unless extra resistance is introduced at R.

All buzzers are not equally suited to producing oscillations by this method. In some, considerable adjustment of the contact is required before sharp tuning is obtained. The buzzer used in these experiments was of the 1905 United States Signal Corps type, and gave very satisfactory results with wave lengths varying between 350 and 2000 meters. With some care in adjustment the wave length could be pushed up beyond 3000. For telephonic reception of signals

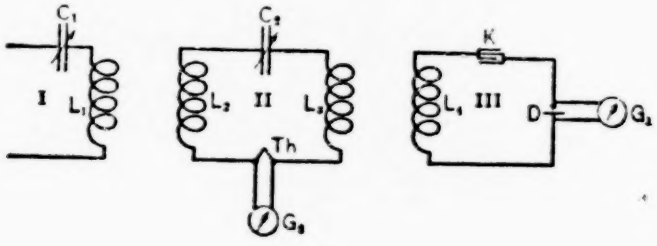

Fig. 2

[1] Other forms of buzzer circuit such as are used in several well-known types of wave meters were also tried, but with the buzzer used they gave less powerful oscillations than the one here shown.

it was usually found necessary to cut down the intensity of oscillations from the buzzer, and this was done by placing an incandescent lamp across the buzzer contact.

The chalcopyrite-zincite rectifier known as the perikon detector [2] was used as a standard for the comparison of the various detectors. As its sensitiveness varies somewhat from time to time, it was standardized before each experiment in the following manner, the circuits being shown in [fol. 2964] Fig. 2. Here *I* is the buzzer circuit, *II* a circuit containing a thermoelement of known sensitiveness, and *III* the circuit consisting of the perikon *D*, its coupling inductance L_3, and a suitable stopping condenser *K* of about 0.04 microfarad. With a given loose coupling between L_2 and L_3 the relation was noted between the reading of the galvanometer attached to the thermoelement and that attached to the perikon,[3] the condition of wave length and damping being kept constant. This relation gives at once the relative sensitiveness of the perikon. It was found better to take account of the variations in sensitiveness observed rather than to readjust each time to the same sensitiveness.

Table I shows the admirable proportionality between the deflections of the perikon detector and the square of the oscillatory current as measured by the thermoelement.

TABLE I.—*Comparison of tellurium-constantan thermoelement and Perikon rectifier.*
(See Fig. 2)

Thermoelement, Circuit II D	Perikon, Circuit III D	Ratio
2·3	25	10·9
5·3	54	10·2
9·7	100	10·3
19·8	198	10·0
31·2	330	10·6
41·3	480	10·9
51·7	540	10·4

L_2=0.03 mh. ν=900 $\sim$
L_3=0.425 ε_I=0.16
L_4=0.420 ε_{II}=0.13
M_{34}=0.025

Circuit III untuned.

[2] The perikon was a new one which had been little used and was of normal sensitiveness.

[3] The resistance in the perikon galvanometer circuit must be equal to that to be used in the experiment.

Two general methods have been used for measuring the sensitiveness for telephonic reception of radiotelegraphic receivers: First, the shunted telephone method in which

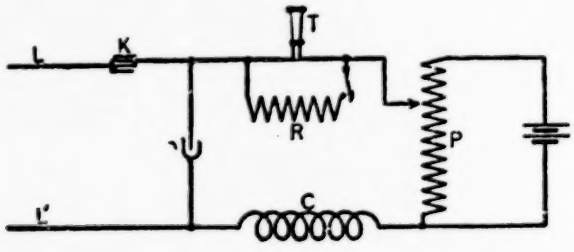

FIG. 3.

the relative loudness of response to the same signal in two different receivers can be compared, and, second, the variable coupling method by means of which the least audible signals for the different receivers can be compared.

[fol. 2965] A form of circuit for the shunted telephone method in the case of the electrolytic detector is shown in Fig. 3. Here L and L' are wires leading to the oscillatory circuit, K a stopping condenser of 0.04 microfarads capacity, T the telephones, R a variable resistance in shunt across the telephones, and C a choke coil to prevent the oscillations from running around through R instead of passing through the detector when the shunt R is closed. Two 60-ohm telephones form a suitable choke. Whatever choke coil is used it is necessary to test it by placing it across L L'. If the choke is perfect, no oscillations will pass through it, and when it is placed across L L' no change in the loudness of the signals will be observed.

The measurement of the intensity of signals is made as follows: After the receiving circuit and detector are adjusted to give maximum loudness in the telephone the shunt resistance R is closed and the resistance regulated until the signal just becomes audible. The value of the current pulses c in the telephone, which are proportional to the energy of the incoming waves in the detector, is expressed by the following well-known formula, where r is the value of the shunt, and t is the resistance of the telephones, and c' the least current audible in the telephones:

$$c = \frac{r+t}{r} c'$$

The audibility, $A = \frac{c}{c'} = \frac{r+t}{r}$

The signal is often expressed in terms of *A* as being so many times audibility. With care a series of measurements of intensity may be made to agree among themselves to within about 10 per cent.

In the variable coupling method for comparing the least audible signals in two detectors, the deflections of the galvanometer connected to the perikon are observed for a number of different degrees of coupling between the inductances L_1 and L_2. (See Fig. 2.) From these a curve is plotted which gives the variation of the received energy as determined by the distance between the coils. The coupling, for which the signals just become audible in the telephones of the detectors being compared, is then observed and the relative energy taken from the curve.

Fig. 2 shows the general plan of the circuits used in the comparison of the detectors. *I* is the exciting circuit adjusted to send out wave trains having a wave length group frequency and damping similar to those occurring in wireless practice. *II* is a circuit whose constants were made to correspond to a receiving antenna of moderate size. *III* is an untuned circuit containing a detector connected to a galvanometer or to a pair of head telephones, as the circumstances of the work required. The electrolytic, perikon, and audion were used in circuit *III*, each being so coupled to circuit *II* as to give maximum effect. The magnetic detector was placed in circuit *II*, as it is generally used in the antenna. The Fleming vacuum valve detector was coupled to *II* by its own fixed coupling coils.

[fol 2966] TABLE II. Electrolytic and Perikon detectors, shunted telephone method

	Relative sensitiveness	
	Strong signals	Weak signals
Electrolytic [1]	2.5	2.4
Perikon Electrolytic [1]	1.1	1.3
Perikon (0.2 volt)		
Electrolytic [2]	2.3	2.5
Perikon Electrolytic [2]	1.3	1.3
Perikon (0.2 volt)		
Telephone Resistance, 2100 Ohms		
Electrolytic [2]		2.7
Perikon Electrolytic [2]		1.1
Perikon (0.2 volt)		

[1] Wollaston wire 0.0012 mm diam.
[2] Wollaston wire 0.0003 mm diam.

Telephone Resistance, 813 Ohms.

Inductances, decrements, and wave length as in Table I. M_{12} adjusted for maximum sensitiveness.

The Electrolytic Detector

Comparison was made of the sensitiveness of the electrolytic detector and the perikon, using a wave length of approximately 900 meters and a decrement of the waves given out by the exciter circuit, amounting to 0.16. The values of the inductances and capacities of the circuits were so chosen that they simulated the conditions of commercial work.

In Table II are given the ratio of sensitiveness for both strong and weak signals. The perikon was used without external EMF and also with about 0.2 of a volt applied in the direction of the rectification. Comparison was made by the shunted telephone method, the same telephones being used for both detectors. In one set of experiments the telephones used were of 2100 ohms and in another of 813 ohms. The relative sensitiveness of the two detectors was little affected by this change, showing that their effective resistances must be about the same. It is seen that without external EMF the perikon is less than half as sensitive as the electrolytic, but that when the 0.2 volt is applied the difference is very small. The electrolytic used in the experiment was of the free-wire type and two positive Wollaston wires were used during the test, one 0.003 and one 0.0012 mm in diameter. This was done because it has been frequently stated that the finer wire was more sensitive to weak signals. No marked difference between the two, however, could be detected. This shows that it is only necessary for sensitiveness, that the capacity reactance for the given frequency should be large, and that beyond a certain limiting diameter there is no object in reducing the size of the positive wire.

Table III shows the relation between galvanometer deflections with the thermoelement in circuit *II* and the intensity of signals in the electrolytic in circuit *III* as meas- [fol. 2967] ured by the shunted telephone method.[1] This shows that the responses of the electrolytic as indicated by

[1] A comparison was also made of the sensitiveness of the perikon without external EMF and the electrolytic at the Washington Navy-Yard wireless station using incoming signals from a distant station. The results agreed within a few per cent with those found in the laboratory.

the telephone are proportional to the square of the oscillatory current.[5]

TABLE III. Electrolytic, received energy, and audibility of signals

Thermoelement in circuit II D	Electrolytic in circuit III	Ratio
3 3	12	36
5 6	22 4	40
3 4	140	41
6 3	256	40
8 0	324	41
17 0	645	38

Inductances, decrements, and wave length as in table I. $M_{23}=0.025$.

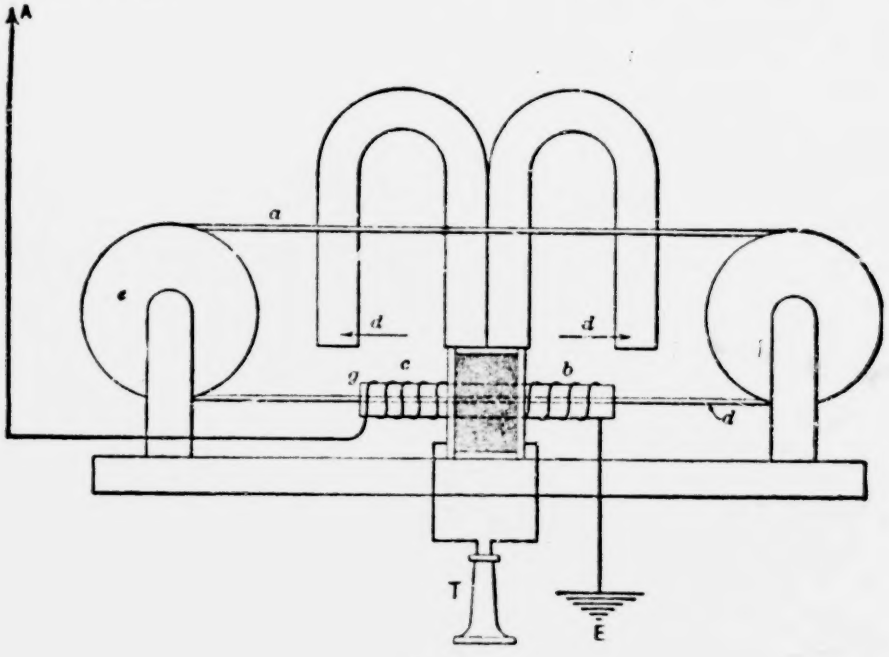

FIG. 4.

The Magnetic Detector. (Fig. 4)

The circuits for the comparison of the magnetic and perikon detectors are shown in fig. 2. The magnetic detector was connected directly in circuit *II* since it is usually used in the antenna. The magnetic detector used was of the ordinary commercial type, the D.C. resistance of the oscillatory coil being 9.7 ohms and the telephone coil 120 ohms. The

[5] Very strong signals, i.e., more than about 300 times audibility, sometimes give irregular results.

[fol. 2968] telephones furnished with the magnetic detector and used in the experiments had a resistance of 168 ohms. The telephones used with the perikon were of 1,200 ohms resistance and medium sensitiveness. For the comparison of sensitiveness the variable coupling method was used, the coupling L_1 and L_2 being changed until the signals became inaudible. When the readings on the magnetic were being taken the circuit containing the perikon was removed, then for the perikon readings the magnetic was cut out and the coupling L_1 L_3 regulated for maximum strength of signals. The relative strength of signals for the different degrees of coupling between L_1 and L_2 was determined by means of the deflection of a galvanometer attached to the perikon. Such a series of readings is shown in table IV.

TABLE IV.—Relative energy in circuit II for different distances d_{12} between L_1 and L_2 (see fig. 2)

d_{12}	Perikon D
10 cm	100
12	245
14	172
16	115
18	75
20	54
24	30
28	14
32	8
38	3

$\lambda = 2000$ m

$\delta_1 = 0.16$

With waves from the buzzer circuit having a damping of 0.16 and a wave length of about 2000 meters, it was found that the magnetic detector required 2.1 times as much energy to produce an audible sound as the perikon used without external LMF.

Further experiments showed that by putting a 0.05 microfarad condenser in series with the telephone of the magnetic, thus tuning it roughly to the rate of the buzzer, the loudness of signals could be increased so that there was very little difference between it and the perikon.

TABLE V.—Magnetic and Perikon Detectors, Weak Signals.

λ	Ratio of sensitiveness: Magnetic/Perikon
350 m	0.22
900	0.9
2000	1.0
3000	1.5

Comparisons were also made at a wave length of 350 meters and at 2000 and 3000 meters. At 3000 meters the magnetic with tuned telephone was approximately one and [fol. 2969] one-half times as sensitive as the perikon. At 2000 there was very little difference, while at 350 meters the perikon was nearly five times as sensitive as the magnetic.

In order to explain these differences in relative sensitiveness, the logarithmic decrement of the circuit containing the magnetic was determined for different frequencies. For the purpose the circuits were those shown in Fig. 2, the magnetic detector being in its place in circuit *II* and the perikon with its galvanometer in the untuned circuit *III*, very loosely coupled to *II*, so that no appreciable energy was taken up by it. The buzzer exciter circuit was adjusted so as to give feebly damped oscillations having a decrement of about 0.02. The decrement of circuit *II* was determined from the well-known formula

$$\delta_I + \delta_{II} = \pi \frac{C_m - C}{C_m} \sqrt{\frac{I^2}{I_m^2 - I^2}}$$

where C_m represents the reading of the condenser in circuit *II* for resonance and C any other reading slightly removed from resonance. I_m then represents the value of the oscillatory current for resonance and I that for the setting of the condenser at C. This formula becomes much more convenient in practice if we choose I^2 so that it is just one-half I_m^2, for then the expression under the radical reduces to unity. As the deflection of the galvanometer connected to the perikon is proportional to I^2, our expression becomes

$$\delta_I + \delta_{II} = \pi \frac{C_m - C}{C_m}$$

where the change from C_m to C, either an increase or a decrease, is just sufficient to reduce the deflection of the galvanometer to one-half. The mean of several determinations of $C_m - C$ gives as accurate values for the decrement as can be obtained from a curve plotted in the usual manner and calculated according to the complete formula. In damping experiments it is necessary that all the couplings be made so loose that any further loosening will not decrease the value of the damping.

TABLE VI.—Effective resistance of magnetic detector at different wave lengths

λ	R'
350 m	110 ohms
900	32
3000	10

TABLE VII.—Received energy and audibility of signals in magnetic detector

Perikon D	Magnetic A
300 mm	120
80	53
55	40
20.5	16.5
7.5	10
2.0	2

[fol. 2970] δ' having been previously measured, the effective resistance R' of the circuit containing the magnetic detector was calculated from the formula

$$R' = 2\pi L \delta_{II}$$

where δ_{II} is the decrement, ν the frequency, and L the inductance of the circuit. After subtracting the known ohmic high frequency resistance of the circuit, the other losses due to the detector for the different frequencies are shown in Table VI. This table would indicate that the amount of iron and the number of turns of the oscillatory circuit of the magnetic detector should be varied according to the frequency for which it is to be used.

In Table VII is shown the relation between loudness of signal as determined by the shunted telephone method in the magnetic and the oscillatory energy passing through it as determined by the deflections of the perikon galvanometer. It is seen that the loudness of signal in the telephone attached to the magnetic is not proportional to the square of the oscillatory current, but corresponds more nearly to the 1.4 power.

The Fleming Vacuum Valve Detector. (Fig. 5)

The vacuum valve detector furnished for the test was constructed with fixed coupling coils inclosed in its case, so that it was found impossible to test it fairly at any except very short wave lengths without taking it completely to pieces.

The circuits were arranged as shown in Fig. 2, the vacuum valve being coupled by its own coils to circuit *II*. Signals were taken alternately on the perikon, adjusted for maximum strength of signal, and on the vacuum detector, one

detector circuit being removed when the other was in action. At a wave length of 350 meters and with a decrement of the incoming signals of 0.16, the ratio of sensitiveness of the perikon to that of the vacuum detector, as determined by the variable coupling method, was almost exactly two to one. For a wave length of 900 meters the perikon appeared to be at least ten times as sensitive as the vacuum valve. As there is no reason to believe that the vacuum detector would change its sensitiveness with frequency, this difference is almost certainly due to insufficient coupling.[6] [fol. 2971] In Table VIII is given the relation between oscillatory energy in the main circuit and the audibility of signals in the telephone of the vacuum detector, as determined by the shunted telephone method. The audibility is seen to be proportional to the energy. The telephones furnished with the vacuum detector had a resistance of 8300 ohms and were connected by means of a step-in transformer to the detector circuit.

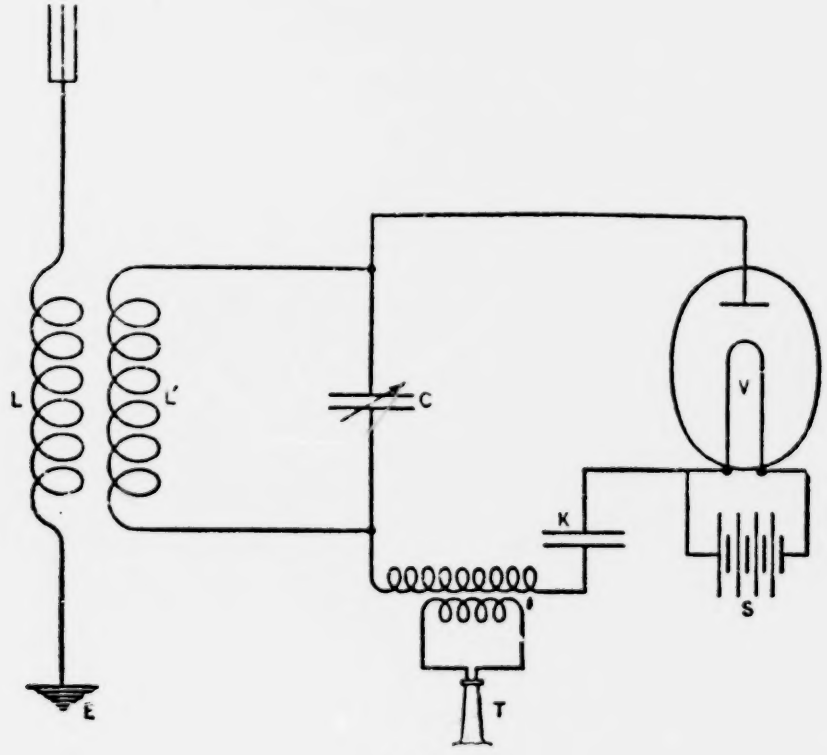

Fig. 5.

[6] This shows the disadvantage of constructing receiving apparatus with fixed coupling.

TABLE VIII.—*Received energy and audibility of signals in Fleming vacuum detector.*

Perikon	Vacuum detector
D	A
43	38
23	20
10	9
5	5

The Audion. (Fig. 6)

The De Forest form of vacuum detector, called by him the audion, is shown diagrammatically in Fig. 6. Here V is an exhausted glass bulb containing a tantalum filament F, heated by three storage cells S, a metal plate P and a metal grid G between the filament and the plate. The filament and plate are connected externally through a battery B

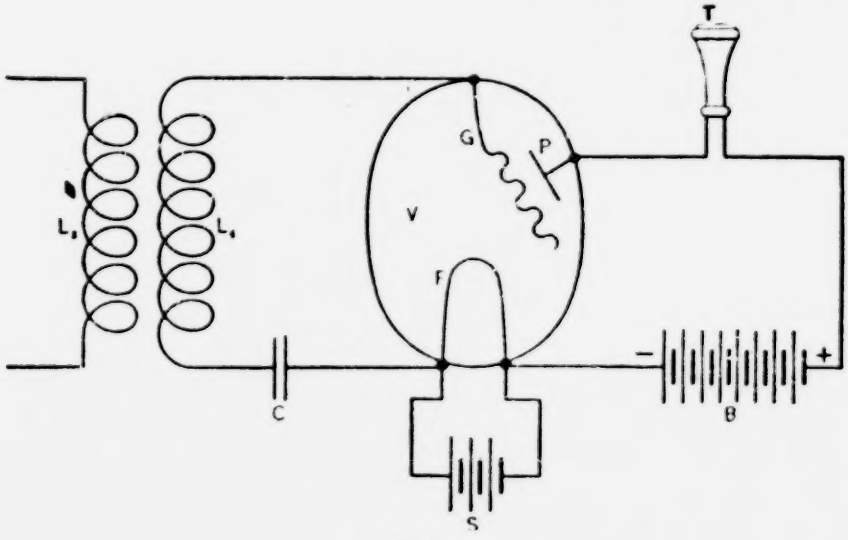

Fig. 6

[fol. 2972] of 36 small cells, any number of which can be thrown into the circuit, and a pair of head telephones of about 1200 ohms resistance. The filament and grid are connected through a small fixed condenser C and an inductance L_2 which is coupled to the oscillatory circuit.

The action of the detector appears to be as follows: The heated filament F is charged negatively by the battery B and a steady stream of negative electrons flows from the hot filament to the cold plate producing a direct current through the telephone. When an oscillatory electromotive force is impressed on the circuit $F\ L_2\ G$, the negative current can flow from F to G inside the bulb and not in the reverse direction, just as in the Fleming detector. The grid G thus

becomes negatively charged and as it lies between F and P the direct current through the telephone is decreased as may be shown by placing a galvanometer in the telephone circuit.

The sensitiveness of the audion was compared with that of the electrolytic already described by the varying coupling method. (See Fig. 2.) Here L_3 and L_4 were the primary and secondary of a Wireless Specialty Apparatus Company tuner, the secondary condenser of the tuner being detached. The detectors were introduced alternately in circuit *III* and their most favorable conditions of coupling were determined separately. The audion, having a higher resistance, required a stronger coupling. The same telephones (1200 ohms) were used for both detectors, previous tests having shown that they were suited to each. High-resistance telephones up to 8000 ohms were tried with the audion, but were found to be less satisfactory than the ones used. This is remarkable, as with the Fleming vacuum detector 8000-ohm telephones are used and even then the current is stepped down through a transformer.

[fol. 2973] Below are given the data of the experiment:

λ=900 m., δ_3=0.3, L_1=0.062, L_2=0.03, L_3=0.705, L_4=0.92 m. h. (electrolytic). L_4=2.3 (audion).

Electrolytic coupling L_3 L_4=7 cm on coupling scale[7] of tuner; audion coupling =2 cm. Distance between coils L_3 L_4 for least audible signal, 20.5 cm (electrolytic); 23 cm (audion).

Ratio of energy sensitiveness $\frac{\text{audion}}{\text{electrolytic}}$ 1.5. Some of the bulbs were slightly more sensitive than this when first tried, but the sensibility decreased with use.

The law governing the relations between the intensity of the oscillations and the loudness of response in the telephone, as determined by the shunted telephone method, seems to depend on the impressed direct electromotive force from the battery B and also on the temperature of the filament F, as would be expected from the known form of the current voltage curve in the case of the passage of electricity from a hot to a cold body through a gas. For most adjustments the response of the telephone is apparently nearly proportional to the square of the oscillatory current.

[7] The numbers on the scale represent the distance the two coils are drawn apart from the position of maximum mutual inductance.

In addition to the above detectors, a very large number of other types have been tested in the laboratory, among which are the tellurium, silicon, and carbon already described,* and also many crystal detectors. These detectors are all of the rectifying type and are remarkable in that when properly adjusted and used with telephones of proper resistance, and in some cases with small EMF in the direction of the rectification, they all give practically the same sensibility as the perikon. The usefulness of several of these is, however, limited by the difficulty of adjustment and a lack of constancy. In most of these detectors the loudness of the signal increases nearly in proportion to the square of the oscillating current, although in some of them the increase in loudness is less rapid.

United States Naval Wireless Telegraphic Laboratory, March 1, 1910.

Defendant's Exhibit G-1

Practical Wireless Telegraphy, by Bucher, 1918

Like the carborundum detector, the Fleming valve has a rising characteristic and when an E. M. F. is applied to the space between the plate and the filament the current may be adjusted to the critical point on the characteristic curve so that the addition of a slight antenna voltage causes a large increase of the local battery current flowing through the head telephones.

A satisfactory diagram appears in Fig. 162 wherein a potentiometer P-1 is shunted across the filament battery and a portion of the current flows through the head telephones and the detector. With this arrangement of circuits advantage is taken of the particular voltampere characteristic of the valve and a relay action due to a local [fol. 2974] source of energy is obtained. For the maximum strength of signals with this circuit it is necessary to adjust the position of the sliding contact on the potentiometer as well as the incandescence of the filament, until the desired results are obtained.

The diagram, Fig. 162, shows the fundamental circuit of the widely used *Marconi-Fleming valve receiver*. The *open circuit* comprises:

* This Bulletin, Vol. 5, No. 1, p. 153; 1908.

(1) The aerial tuning inductance L-1,
(2) The short wave condenser C-1,
(3) The primary winding L-2,
(4) The shunt impedance R-1,
(5) The change-over switch S-1, S-2, S-3.

The *intermediate circuit* comprises:

(1) The winding L-3 in inductive relation to L-2,
(2) The winding L-4 in inductive relation to L-5,
(3) The variable condenser C-2.

The *secondary circuit* comprises:

(1) The secondary winding L-5,
(2) The billi condenser C-3,
(3) The Fleming valve F, P,
(4) The battery B (or four volts generally),
(5) The 10 ohm rheostat R,
(6) The 400 ohm potentiometer P-1,
(7) The fixed condenser C-4,
(8) The head telephone P-2.

Inductances L-2, L-3, L-4, L-5, L-6 are of fixed value, but L-1 is variable through the medium of a multi-point switch.

When the D. T. three blade switch S-1 is thrown to the right, primary winding L-2 is connected in series with the *aerial circuit* which brings the *intermediate circuit* into use, but the switch, thrown in the opposite direction, disconnects L-2 and connects L-6 in series with the aerial. L-6 being wound tightly about the turns of L-5, the open and closed circuits are closely coupled. *This increases the damping of the receiving system* and makes the set responsive to waves of different length at one set

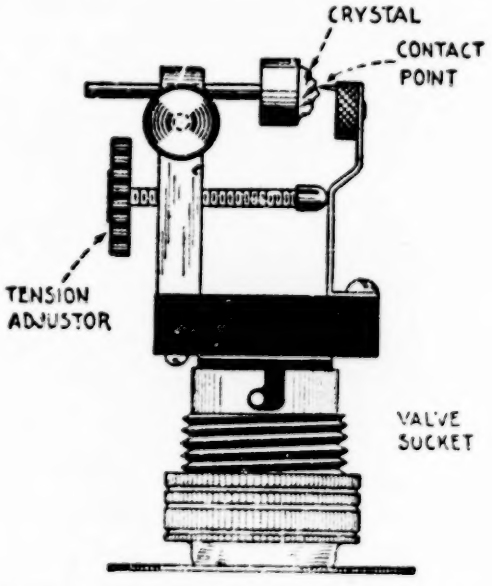

FIG. 163.—Carborundum Crystal Holder to Fit Fleming Valve Socket.

of adjustments, but, of course, does not give the strength of signals that can be obtained by resonant adjustments.

The position of the switch corresponding to "*close coupling*" is marked "Stdbi," an abbreviation for the word [fol. 2975] "standby." The switch is placed in this position when a particular receiving station awaits a call from one of several sending stations which are not exactly tuned to the same wave length.

In the opposite position, the changeover switch is marked "*tune*" and with the circuits of this connection, sharp resonant adjustments can be obtained. The wave length of the *intermediate circuit* is increased or decreased by the variable condenser C-2 only and similarly the wave length

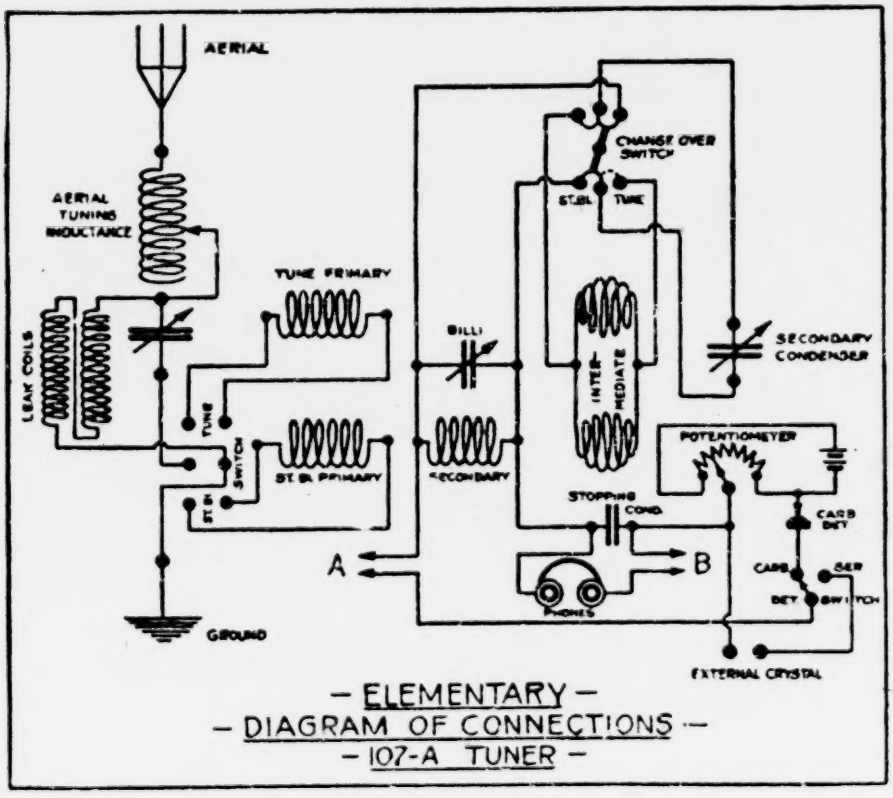

FIG. 164.—Complete Circuits of Type 107a Tuner (American Marconi Company).

of the secondary or detector circuit, by the condenser C-3.

The coupling between the inductances of the intermediate circuit and inductively related coils is varied simultaneously by means of a shaft (and knob) upon which both coils, L-3 and L-4, are mounted.

The impedance coil R-1 prevents the accumulation of high voltages upon the dielectric of the variable condenser, which may be punctured in case the windings of the tuner should come in direct contact with the high voltage wires of the transmitting apparatus.

The American Marconi Company has developed a crystal holder to fit in the Fleming valve socket as shown in Fig. [fol. 2976] 163. The circuit for the crystal detector is practically identical with that of the oscillation valve with the exception that the lighting battery is connected to the potentiometer instead of to the lamp filament.

The vaive tuner was original- designed to be responsive to waves varying between 300 and 1,650 meters in length, but the circuit has been modified to respond to waves up to 2,500 meters, as in Fig. 164.

136. *Marconi Type 107-a Tuner.* (*American Marconi Company*).—The various connections and arrangements of circuits of the Marconi type 107-a tuner are shown in Figs. 165-a, 165-b and 165-c. The principal change over the ordinary valve circuit lies in the special six point double throw switch (marked "*change-over switch*") which disconnects the condenser of large capacity (.01 microfarads) across the *intermediate circuit* and places it in shunt to the secondary winding and the *billi-condenser* (see Fig. 165-a). With the increased capacity of this condenser in shunt, the secondary circuit will respond to a wider range of wave

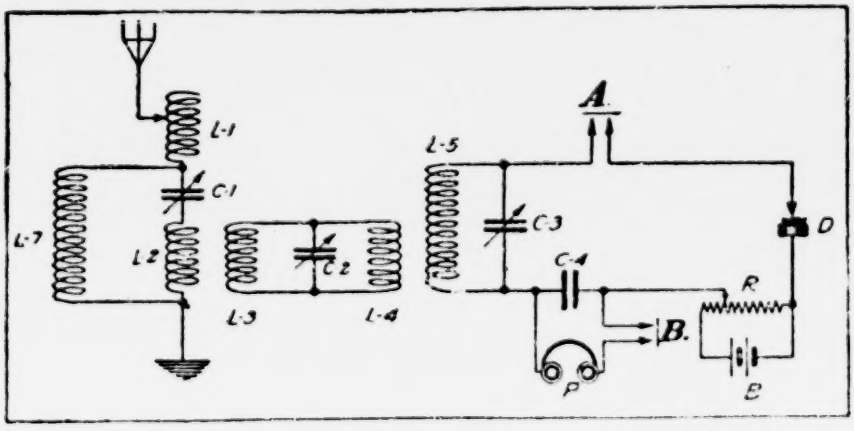

Fig. 165a.—"Standby" Long Wave Adjustment of Marconi Type 107a Tuner.

lengths than the original design of the tuner would permit.

For the reception of wave lengths exceeding 1,500 meters,

the D.P.D.T. switch is thrown to the "*standby*" position and the intermediate circuit cut out. For wave lengths below 1,000 meters either the "*standby*" or "*tune*" circuits can be employed at the discretion of the operator.

It is to be noted, although the 107-a tuner is designed for the carborundum detector, an extra set of posts is provided for an additional crystal such as *crusite*. When the latter detector is employed, the potentiometer is out of the circuit. Observance next should be made of the binding posts from which wires are connected to the receiver circuits and to the contacts of an aerial change-over switch. The latter, when open, protect the detector and head telephones from the induced potentials of the local transmitter. [fol. 2977] In the diagram, Fig. 165-b, L-1 is the aerial tuning inductance, the value of which is altered by means of a multi point switch mounted on the left hand front of the tuner.

C-1 is the short wave variable condenser connected in series with the aerial system. In the full scale position it short circuits itself and is thus cut out of the antenna circuit. This condenser is mounted on the left hand side on the top of the tuner.

L-2 is the primary winding of the receiving tuner and has a fixed value of inductance (not variable).

. . . . . .

The complete circuit for this connection is indicated in Fig. 165a. Note carefully that the intermediate circuit is *not* employed. It is important to note also that the type

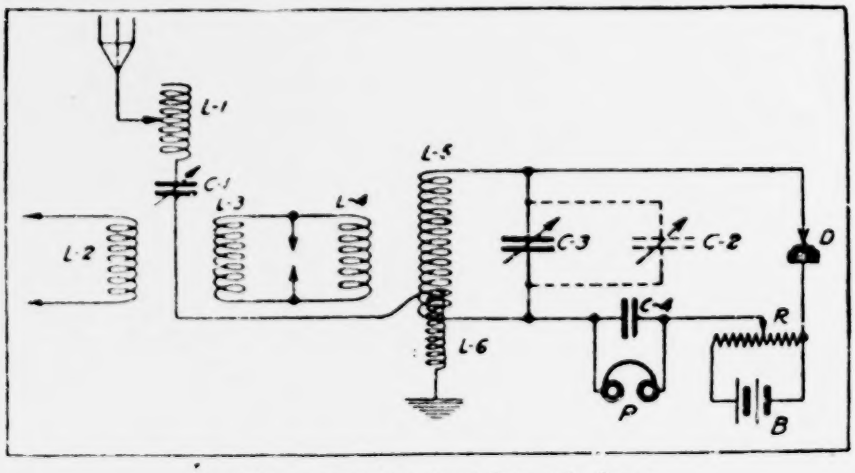

Fig. 165b. "Tune" Circuits of Type 107a Tuner

107-a tuner is fitted with four binding posts (at the rear) from which connections extend to the type S aerial changeover switch. When the antenna switch is placed in the transmitting position, the circuits of the 107-a tuner are interrupted at the points A and B (Fig. 165b), thus breaking the circuit to the detector and the head telephones. The contacts at this switch must have careful inspection from time to time, for, unless they close properly, the apparatus positively will not function.

Should these contacts be broken, a permanent jumper should be placed across the binding posts to keep the circuit closed.

Type 107-a tuner should be used with the type S or type I aerial changeover switches only.

The complete circuits for the tuner are shown in detail in Fig. 165a and with the foregoing explanation, the functions of the various elements should be clear without further instruction.

(c) *General Instructions.*—For "*stand-by*" *tuning or broad adjustment* at wave lengths up to 1,000 meters (see Fig. 165c), place the double throw knife switch to the left.

Set the condenser switch on "tune." Set the coupling knob at zero. Carefully adjust the billi condenser. Con- [tol. 2978] nect in a few points of the aerial tuning inductance. Vary the capacity of the short wave condenser.

For long wave lengths (in excess of 1,000 meters) place the condenser switch on "stand-by long wave" position. Vary carefully the capacity of the intermediate condenser. Add inductance at the aerial tuning inductance.

For *sharp tuning on the shorter wave lengths* (below 1,000 meters), place the double throw knife switch to the "tune" position. Place the condenser switch on the "tune" position. Set the coupling knob at from 70° to 90°. Adjust carefully the intermediate condenser. Add two or three points of inductance at the aerial tuning inductance. Follow this by variation of the capacity of the short wave condenser. In this position, all the variable elements of the complete tuner are in use.

137. *Marconi Magnetic Detector and the Multiple Tuner Circuits (English Marconi Company).*—The magnetic detector shown diagrammatically in Fig. 167 is an oscillation

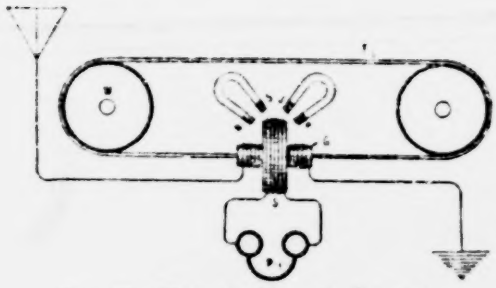

Fig. 167. Marconi's Magnetic Detector

detector of unvarying stability. A description of the detector and an explanation of its functioning follow:

A continuous *band* made up of a group of fine *iron wires* revolves on the *ebony grooved wheels* W which are turned by clockwork in the base of the instrument. The band passes through the *glass tube* G, which has a small single layer of fine wire comprising 6 to 10 turns through which the radio frequent oscillations flow. Directly over this winding is placed the *small bobbin of wire* S which has approximately the resistance of the head telephones P-1. Two *horse-shoe permanent magnets* with like poles adjacent are mounted immediately above the tube and near to it. Some argument exists concerning the action of this detector during the reception of signals but it is sufficient to say that when the iron band passes underneath the two permanent magnets it undergoes a cyclic change in magnetism and is extremely sensitive to an impressed external magnetic field such as that generated by a radio frequent current flowing through the winding G.

When electrical oscillations induced in a receiver aerial by a distant transmitter pass through the winding P, one complete group of oscillations sets up an alternating magnetic field which causes a single movement or a change in the position of the flux in the iron band. The bobbin S being in the path of the flux, it is acted upon inductively, a current being induced in the windings which flows through the head telephone creating a single sound for each group of incoming oscillations. The note of the transmitter is faithfully reproduced, because each group of oscillations radiated by [fol. 2979] the transmitter has a cumulative effect on the change of flux in the iron band, which causes a single movement of the telephone diaphragm. Although the magnet detector lacks the sensitiveness of the crystal

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It has frequently been observed that the magnetic detector gives better response to 500 cycle transmitters when the iron band revolves at a speed about twice that used in receiving from 60 cycle transmitters. Normally the band travels at a very low speed—a few feet per minute.

* * * * * * *

138. *The Marconi Type 106 Receiving Tuner. (American Marconi Company).*—A receiving set of particular excellence combining mechanical and electrical features of merit is the type 106 tuner of the American Marconi Company. This set is of the panel type, the necessary controlling switches being mounted on the front of the board as shown in photograph 170, the coupler, variable condensers, potentiometer, etc., being mounted on the rear as in photograph 171. The *coupling* between the primary and secondary windings is varied by means of a special *rack and pinion adjustment* which is in turn controlled by a knob on the front of the panel with a scale marked from zero to 10 (marked "coupling").

The switch marked "*transformer secondary*" and the control handle marked "*secondary condenser*" control the inductance and capacity of the secondary circuit. The wave length adjustment of the circuit can be increased by turning the switch or the knob of the condenser counter clockwise. Different values of inductance and capacity can be employed in this circuit while holding the same wave length. This changes the damping of the circuit and proper proportioning (of inductance and capacity) may give increased strength of signals during the reception of signals from certain stations.

The control handle marked "*potentiometer*" varies the flow of current through the detector crystal. Close adjustment of the potentiometer is necessary when the incoming signals are comparatively weak. The switch marked "*battery*" turns the local battery current on and off.

The terminals marked "*battery*" connect to four dry cells in a separate box and the terminals marked "*telephones*" are the binding posts for connection to 2,000 ohm receivers.

As the transmitter operates at approximately the wave length to which the secondary circuit of the receiver is adjusted, it produces exceedingly strong signals which are liable to impair the sensitive condition of the crystal. To obviate this, connections are made with the antenna switch so that when the antenna switch is in the transmitting position the terminals of the detector and the secondary condenser are short-circuited. Care should be taken to see that the antenna switch, with which this receiver is to be used, is so constructed as to perform the above operations. If [fol. 2980] this is done, the transmitter has very little or no effect on the sensitiveness of the crystal and it will, therefore, be in a sensitive condition for receiving immediately after transmission. (See diagrams, Figs. 201, 202 and 203.) In addition to paragraph 130 the student should read the general instructions in paragraph 156a.

139 *Marconi Receiving Tuner Type 101 (American Marconi Company).*—The type 101 receiver consists of an inductively coupled transformer with two solid rectifier detectors and the necessary accessory apparatus mounted on a hard rubber panel and enclosed in a mahogany case. The front elevation of this set is shown in photograph, Fig. 173, the rear elevation in Fig. 174, and a fundamental diagram in Fig. 175.

The aerial is connected to the binding post "antenna" and the earth connection is made to the binding post marked "ground." The circuit between these two points is adjusted to resonance with the incoming signal by variation of the two transformer primary switches, the primary loading coil switch, the primary condenser, and the primary condenser switch which is marked "out" "series" and "shunt." The purpose of this switch is to connect the primary condenser in series or in parallel to the aerial or to disconnect the condenser entirely.

* * * * * * *

Placing the primary condenser switch in the "Shunt" position increases the wave length of the aerial circuit corresponding to any given setting of the inductance switches. This may be done at any time instead of increasing the inductance. Generally speaking, the method of varying inductance is preferable and gives a louder response, but in

exceptional cases the reverse is true and in any particular case a trial of the two methods can be made to find out which is the better. The best secondary setting for maximum response to any particular wave length is that of maximum inductance and minimum capacity, but the greatest selectivity will be obtained with smaller inductance and greater capacity.

When the carborundum detector is in use it will be necessary to adjust the potentiometer to a point which gives the greatest sensitiveness.

It should be noted that when using the Cerusite detector during the reception of very weak signals the potentiometer should always be in zero position, but for signals of moderate intensity it does not matter particularly what position this may happen to be in. In order that the operator may be able to measure approximately the wave length of the incoming signals, calibrations of the secondary are given with each tuner, it being understood that these are correct only when the secondary is coupled very loosely to the primary.

With the 101 receiver are supplied adjustable head telephones which are tuned to the group frequency of the transmitter. Also the electrical circuit through the telephones and the stopping condenser is tuned to the same group frequency.

[fol. 2981] It is advisable occasionally to insert a piece of paper between the spark points of the antenna and ground binding posts and telephone binding posts to make sure they are not short-circuited.

140. *The Marconi Universal Receiving Set (English Marconi Company).*—The complete circuits of the Universal Crystal Receiver are indicated in the diagram, Fig. 176, and a photograph of the finished instrument in Fig. 177, the tuner having been designed for wave lengths between 300 and 3,000 meters. The circuits are applicable to all types of crystal rectifiers, particularly those of carborundum, zincite, bornite, etc.

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The usual aerial tuning inductance is represented at L 1, the short wave condenser at C 1, and the primary winding of the *tuning transformer* at L 2. L 2 has three tappings,

which are varied by means of the switch. The secondary circuit of the receiving tuner is divided into three units, the following range of wave lengths being obtained with each: L-5 has the correct values for all wave lengths up to 600 meters; L-4 for waves between 600 and 1,600 meters, and L-3 for waves between 1,000 and 3,000 meters. The necessary change of inductance is obtained by the wave length changing switch D, which completely disconnects the unused turns from the circuit.

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154. *The Marconi Balanced Crystal Receiver (English Marconi Company).*—No apparatus or circuit has so far been devised to completely eliminate the interference of static discharges. However, communication can be effected by the circuits of the Marconi balanced crystal receiver when with ordinary circuits it would not be possible. In fact, the balanced crystal tuner often reduces the interference from this source to a marked degree.

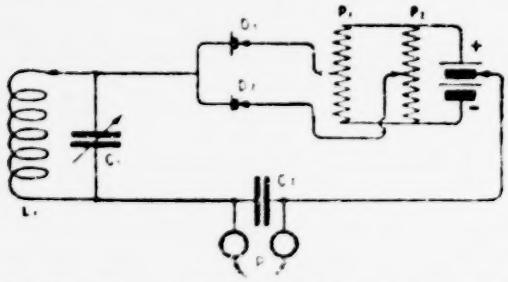

Fig. 198.—Circuits of Marconi's Balanced Crystal Receiver. (English Marconi Company.)

The complete circuits of the balanced crystal receiver are shown in the diagram, Fig. 198, where the secondary winding of the receiving tuner is represented by the coil L-1, the secondary condenser at C-1, the opposed crystals at D-1 and D-2, the potentiometer at P-1 and P-2, the battery at B and the telephones at P.

To carry out the fundamental principle of this receiver, crystals D-1 and D-2 must have like volt-ampere characteristics, and, accordingly, crystals are especially selected for the purpose.

Briefly, the action of this circuit can be described as follows: If crystals D-1 and D-2 are adjusted to the same degree of sensitiveness their currents will act equally and oppositely upon the telephone P, and no signals will result. If, however, D-2, let us say, is adjusted to a high degree of [fol. 2982] sensitiveness and D-1 to a lesser degree, signals will be received.

Under these conditions, if an extra severe discharge of static excites the aerial circuit, almost equal effects are

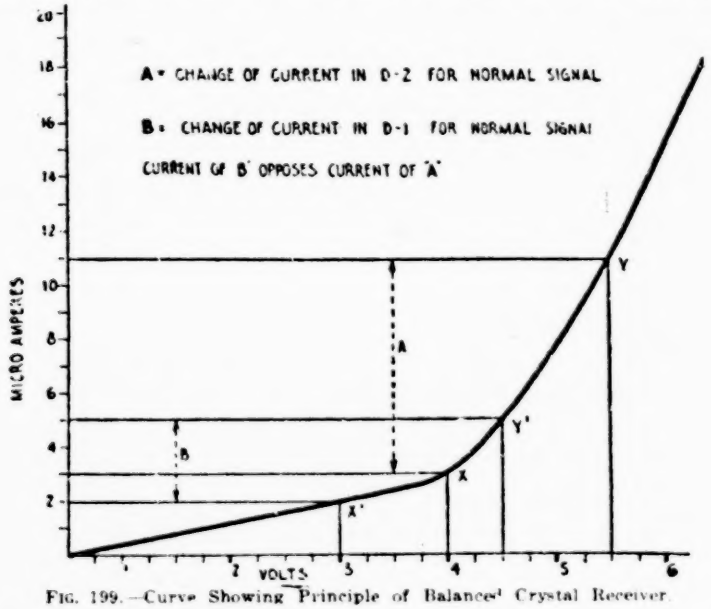

FIG. 199.—Curve Showing Principle of Balanced Crystal Receiver.

produced in the head telephone P by both crystals, and the crashing sounds ordinarily experienced are partially eliminated.

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steel bar F closes the circuit to the primary winding of the power transformer through the contacts 11 and 12. In the opposite position the bar separates the spring contacts M, M' 200–a, which disconnects the transmitting oscillation transformer from the aerial during the period of reception, preventing the incoming oscillations leaking to earth. *The various circuits closed by the discs mounted on the hard rubber rod place the detector and head telephone on short circuit during the period of transmission. They may also be employed to start and stop a motor blower or an automatic motor starter.* The type I switch is supplied with Marconi transmitting sets up to 5 K.W. capacity.

For the use of operators in the Marconi service, the circuit diagrams, Figs. 201, 202, and 203, are published, showing the connections in Fig. 201 of the type I antenna switch to the external binding posts of the type 106 receiving tuner, and in Fig. 202 the connections of the type S, H, aerial changeover switch to the external binding posts of the type 106 tuner. The diagram, Fig. 203, shows the connections

of the type I antenna switch to the external binding posts of the type 107-a receiving tuner.

[fol. 2983] In the diagram, Fig. 201, binding posts 2, 4, and 5 of the type I antenna switch short circuit the crystal detector and the head telephones during transmission. Binding post No. 1 connects to aerial binding post No. 1 of the type 106 tuner. Contacts 11 and 12 close the circuit to the primary winding of the transformer. The binding posts 6, 7, 8, and 9 of the type 106 tuner are connected to the four binding posts of the battery box as shown.

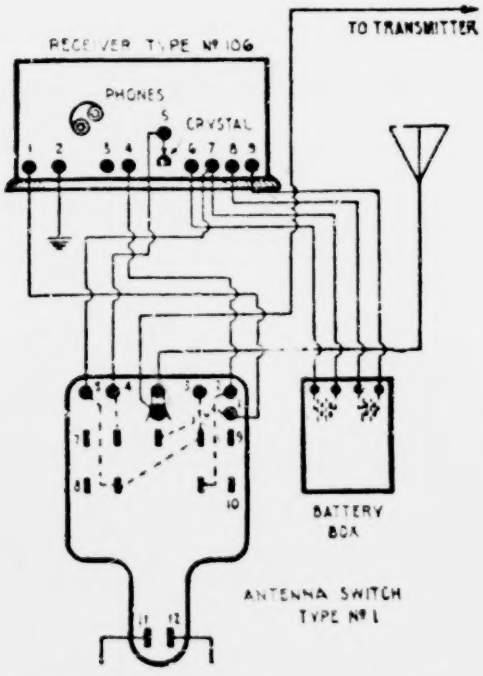

Fig. 201. Type I Switch Connected to Type 106 Receiving Tuner.

In the diagram, Fig. 202, posts 1, 2, 4 and 5 of the type S. H. antenna switch lead to contacts which place the head telephone and detector of the type 106 tuner on short circuit. Binding posts 11 and 12 close the circuit to the primary winding of the transformer.

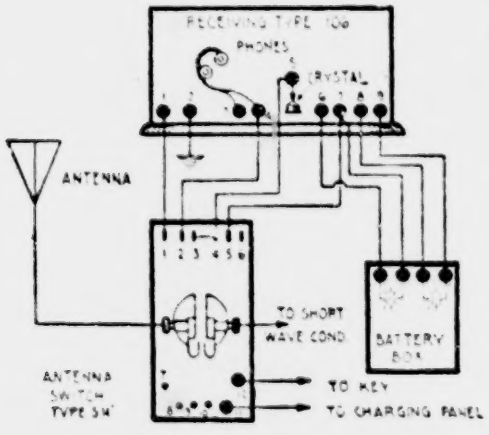

Fig. 202. Type S. H. Switch Connected to Type 106 Receiving Tuner.

In the diagram, Fig. 203, posts 2, 4, and 5 of the type I switch lead to contacts which short circuit the receiving detector and the receiving telephones. These diagrams should be carefully studied and in event that the wiring is taken down, the connections shown should be carefully duplicated.

156. *Type 112 Receiving Tuner.*—This receiving tuner was primarily de-

signed for use with the special ¼ K.W. cargo type transmitter developed by the Marconi Company and fundamentally is similar to the type 101 and type 106 tuner, but the construction is considerably simplified. A front view is shown in Fig. 203-a and a side view in Fig. 203-b.

As will be seen in the wiring diagram, Fig. 203-c, the circuits are similar to those shown in Fig. 153-b, the potentiometer, battery, and head phones being shunted.

[fol. 2984] DEFENDANT'S EXHIBIT H-1

Proceedings of Institute of Radio Engineers, August 1916

The receiver used with these sets is of the coupled circuit type and is known as the type "106" receiver. There are two circuits in this receiver, the one circuit known as the open or antenna circuit, and the other as the closed tuned circuit. These two circuits are coupled inductively and means are provided for varying the inductive relation of the two circuits. The primary circuit consists of the antenna, a loading coil, a primary coil, a series condenser, and a ground connection, all being connected in series. By means of a switch any amount of the loading coil in the primary can be thrown into circuit at will. This enables the operator to adjust readily this circuit to the received signals. In case the wave length of the received signal is shorter than the natural period of the antenna, the series condenser is thrown in the circuit which brings this circuit to the desired period. The secondary circuit consists of a secondary coil or inductance which is movable with respect to the primary. This coil is in series with a variable condenser. A switch is provided which permits any amount of the secondary to be thrown in the circuit. The variable condenser permits the variation of the capacity of this circuit so that it may be adjusted for resonance with the primary circuit. By having both the inductance and capacity of this circuit variable, the ratio of capacity to inductance can be varied while keeping the period of the circuit constant. This enables the operator to obtain the best adjustment for operating the detector. The detector used in this receiver is of the crystal type. A battery and potentiometer are provided so that a crystal can be operated either with or without battery as desired. The detector circuit consists of the potentiometer, a stopping condenser and the telephones. The

potentiometer and stopping condenser are connected in series with each other and in shunt to the variable condenser. The telephones are connected in shunt with the stopping condenser. A test circuit is provided which enables the operator to excite the antenna circuit at will so that he can adjust the detector for maximum sensitiveness. These circuits are all shown in Figure 4. A careful consideration of this drawing will enable the reader to understand fully the complete circuits of both transmitter and receiver.

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PROCEEDINGS

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families are also comparatively few. The families so contributing are, however, among the most important and widely distributed in the vegetable kingdom; as also are some of the plants they contribute. As prominent examples may be mentioned, the *Gramineæ*, affording the cereal grains, a large proportion of the mixed herbage of grass-land, and other products; also the *Leguminosæ*, yielding pulse crops, many useful herbage plants, and numerous other products. As we have said, there does not seem to be an unsolved problem as to the sources of the nitrogen of other of our agricultural plants than those of the leguminous family. Obviously, however, it would be unsafe to generalise in regard to individual families as a whole, from results relating to a limited number of examples supplied by their agricultural representatives alone. Still, there is nothing in the evidence at present at command, to point to the supposition that there is any fundamental difference in the source of the nitrogen of different members of the same family, such as is clearly indicated between the representatives of the leguminous, and of the other families, supplying staple agricultural products. On the other hand, existing evidence does not afford any means of judging whether or not similar, or allied agencies to those now under consideration, or even quite different ones, may come into play in the nitrogen assimilation of the members of other families which contribute such a vast variety of vegetation to the earth's surface.

We have pleasure in stating that the conduct of the investigation has largely devolved upon Dr. N. H. J. Miller. He has been almost wholly responsible for the analytical work, as well as for the photographing, by which a permanent record, not only of the above-ground growth, but of the root-development of the experimental plants has been secured. It should be added, that Mr. J. J. Willis has materially assisted in the observation and noting on growth; also in the separation of the roots, mounting them for observation and for photographing, and in noting upon them.

II. "On Electric Discharge between Electrodes at different Temperatures in Air and in High Vacua." By J. A. FLEMING, M.A., D.Sc., Professor of Electrical Engineering in University College, London. Communicated by Professor G. C. FOSTER, F.R.S. Received December 16, 1889.

(Preliminary Notice.)

It has been known for some time that if a platinum plate or wire is sealed through the glass bulb of an ordinary carbon filament incandescent lamp, this metallic plate being quite out of contact with

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the carbon conductor, a sensitive galvanometer connected between this insulated metal plate enclosed in the vacuum and the external *positive* electrode of the lamp indicates a current of some milliampères passing through it when the lamp is set in action, but the same instrument when connected between the *negative* electrode of the lamp and the insulated metal plate indicates no sensible current. This phenomenon in carbon incandescence lamps was first observed by Mr. Edison, in 1884, and further examined by Mr. W. H. Preece, in 1885.* The primary object of the experiments described in this paper was the further examination of this effect, but the inquiry has extended itself beyond this range and embraced some general phenomena of electric discharge between electrodes at unequal temperatures, and in particular has revealed some curious effects in the behaviour of an electric arc taken between carbon poles towards a third insulated carbon or metal poles.

The first series of experiments had reference to the nature of the effect observed in the incandescence lamps having an insulated wire or plate placed in the vacuum.

If a platinum wire is sealed through the glass bulb of an ordinary carbon filament lamp and carries at its extremity a metal plate, so placed as to stand up between the legs of the carbon horseshoe without touching either of them, then when the lamp is actuated by a continuous current it is found that :—

(1.) This insulated metal plate is brought down instantly to the potential of the base of the negative leg of the carbon, and no sensible potential difference exists between the insulated metal plate and the negative electrode of the lamps, whether the test be made by a galvanometer, by an electrostatic voltmeter, or by a condenser.

(2.) The potential difference of the plate and the positive electrode of the lamp is exactly the same as the working potential difference of the lamp electrodes, provided this is measured electrostatically, *i.e.*, by a condenser, or by an electrostatic voltmeter taking no current.

* See 'Roy. Soc. Proc.,' vol. 38, 1885, p. 219. "On a Peculiar Behaviour of Glow Lamps when raised to High Incandescence."—In this paper Mr. Preece describes a very careful series of observations carried out with Edison incandescence lamps, and which cover the same ground as a portion of the experiments here described. The results given in (4), (7), and (11) confirm the facts which were first ascertained by him. He also arrived at the general conclusion that the phenomena so observed are due to an electric convection by matter projected from the incandescent carbon. By carrying up the working electromotive force of the lamp to a point productive of very high incandescence, he was able to measure the resulting current through a galvanometer connected between the positive lamp electrode and the middle plate corresponding to every degree of incandescence, and showed that, whilst increasing up to a certain point, the galvanometer current fell off rapidly soon after a certain critical temperature was reached, which corresponded to the appearance of a blue light or haze in the glass receiver.—[Jan. 14th, 1890.]

but if measured by a galvanometer the potential difference of the plate and the positive electrodes of the lamp is something less than that of the working lamp electrodes.

(3.) This absolute equality of potential between the negative electrode of the lamp and the insulated plate only exists when the carbon filament is in a state of vivid incandescence, and when the insulated plate is not more than an inch or so from the base of the negative leg. When the lamp is at intermediate stages of incandescence, or the plate is considerably removed from the base of the negative leg, then the plate is not brought down quite to the same potential as the negative electrode.

(4.) A galvanometer connected between the insulated plate and the *positive* electrode of the lamp shows a current increasing from zero to four or five milliampères, as the carbon is raised to its state of commercial incandescence. There is not any current greater than 0·0001 of a milliampère between the plate and *negative* electrode when the lamp has a good vacuum.

(5.) If the lamp has a bad vacuum this inequality is destroyed, and a sensitive galvanometer shows a current flowing through it when connected between the middle plate and either the positive *or* negative electrode.

(6.) When the lamp is actuated by an *alternating* current a *continuous* current is found flowing through a galvanometer, connected between the insulated plate and *either* terminal of the lamp. The direction of the current through the galvanometer is such as to show that negative electricity is flowing from the plate through the galvanometer to the lamp terminal. This is also the case in (4); but, if the lamp has a bad vacuum, then negative electricity flows *from* the plate through the galvanometer *to* the positive terminal of the lamp, and negative electricity flows *to* the plate through the galvanometer from the negative terminal of the lamp.

(7.) The same effects exist on a reduced scale when the incandescent conductor is a platinum wire instead of carbon filament. The platinum wire has to be brought up very near to its point of fusion, in order to detect the effect, but it is found that a current flows between the positive electrode of a platinum wire lamp and a platinum plate placed in the vacuum near to the negative end of that wire.

(8.) The material of which the plate is made is without influence. Platinum, aluminium, and carbon have been indifferently employed.

(9.) The active agent in producing this effect is the *negative* leg of the carbon. If the negative leg of the carbon is covered up by enclosing it in a glass tube this procedure entirely, or nearly entirely, prevents the production of a current in a galvanometer connected between the middle plate and the positive terminal of the lamp.

(10.) It is a matter of indifference whether a glass or metal tube is

employed to cover up the negative leg of the carbon; in any case this shielding destroys the effect.

(11.) If, instead of shielding the negative leg of the carbon, a mica screen is interposed between the negative leg and that side of the middle plate which faces it, then the current produced in a galvanometer connected between the positive terminal of the lamp and the middle plate is much reduced. Hardly any effect under the same circumstances is produced when the mica screen is interposed on that side of the metal plate which faces the positive leg of the carbon.

(12.) The position of the metal plate has a great influence on the magnitude of the current traversing a galvanometer connected between the metal plate and the positive terminal of the lamp. The current is greatest when the insulated metal plate is as near as possible to the base of the negative leg of the carbon, and greatest of all when it is formed into a cylinder which embraces without touching the base of the negative leg.

The current becomes very small when the insulated metal plate is removed to 4 or 5 inches from the negative leg, and becomes practically zero when the metal plate is at the end of a tube forming part of the bulb, which tube has a bend at right angles in it. Copious experiments have been made with metal plates in all kinds of positions.

(13.) The galvanometer current is greatly influenced by the surface of the metal plate, being greatly reduced when the surface of the plate is made small, or when the plate is set edgeways to the negative leg, so as to present a very small apparent surface when seen from the negative leg. In a lamp having the usual commercial vacuum, the effect is extremely small when the insulated metal plate is placed at a distance of 18 inches from the negative leg, but even then it is just sensible to a very sensitive galvanometer.

(14.) If a charged condenser has one plate connected to the insulated metal plate, and the other plate connected to any point of the circuit of the incandescent filament, this condenser is instantly discharged if the positively charged side of the condenser is connected to the insulated plate, and the negative side to the hot filament. If, however, the negative leg of the carbon horseshoe is shielded by a glass tube, this discharging power is much reduced, or altogether removed.

(15.) If the middle plate consists of a separate carbon loop, which can itself be made incandescent by a separate insulated battery, then, when this middle carbon is rendered incandescent and employed as the metal plate in the above experiment, the condenser is discharged when the negatively charged side of it is connected to the hot middle carbon, the positively charged side of it being in connexion with the principal carbon horseshoe.

(16.) If this last form of lamp is employed as in (4) the subsidiary carbon loop being used as a middle plate, and a galvanometer being connected between it and either the positive or negative main terminal of the lamp, then when the subsidiary carbon loop is cold, we get a current through the galvanometer only when it is in connexion with the positive main terminal of the lamp, but when the subsidiary carbon is made incandescent by a separate insulated battery, we get a current through the galvanometer when it is connected either to the positive *or* to the negative terminal of the lamp. In the first case the current through the galvanometer is a negative current, flowing from the middle carbon to the positive main terminal, and in the second case it is a negative current, from the negative main terminal to the middle subsidiary hot carbon.

(17.) If a lamp having a metal middle plate held between the legs of the carbon loop has a galvanometer connected between the negative main terminal of the lamp and this middle plate, we find that when the carbon is incandescent there is no sensible current flowing through the galvanometer. The vacuous space between the middle plate and the hot negative leg of the carbon possesses, however, a curious unilateral conductivity. If a single Clark cell is inserted in series with the galvanometer, we find that this cell can send a current deflecting the galvanometer when its negative pole is in connexion with the negative main terminal of the lamp, but if its positive pole is in connexion with the negative terminal of the lamp, then no current flows. The cell is thus able to force a current through the vacuous space when the direction of the cell is such as to cause negative electricity to flow across the vacuous space from the hot carbon to the cooler metal plate, but not in the reverse direction.

(18.) If a vacuum tube is constructed, having at each end horseshoe carbon filaments sealed into it, and which can each be made separately incandescent by an insulated battery, we find that such a vacuum tube, though requiring an electromotive force of many thousands of volts to force a current through it when the carbon loops are used as electrodes and are *cold*, will yet pass the current from a single Clark cell when the carbon loop which forms the negative electrode is rendered incandescent. It is thus found that a high vacuum terminated electrically by unequally heated carbon electrodes possesses an unilateral conductivity, and that electric discharge takes place freely through it under an electromotive force of a few volts when the *negative* electrode is made highly incandescent.

(19.) These experimental results above described led the writer to investigate, in the same manner, the electric arc between carbon poles taken in air. If an electric arc is formed, in the usual way, between carbon poles, and a third insulated carbon pole is allowed to dip into or touch the electric arc, or, better still, has the electric arc projected

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against it by a magnet, it is found that this third or insulated pole is brought down almost to the potential of the negative carbon of the arc, and that a galvanometer connected between the third insulated carbon and the negative carbon of the arc indicates no current, but that if joined up between the positive carbon and the middle carbon a strong current of about an ampère or so is found to be passing. If an electric bell or an incandescent lamp is joined up between the third carbon and the *negative* carbon of the arc, they do not work; but if the bell or the lamp is joined between the *positive* carbon of the arc and the third carbon, they are set in action by a strong current passing through them. These effects are produced, although the third carbon (which is best held at right angles to the other two forming the arc) is half or three quarters of an inch away from the positive and negative carbon, the sole condition being that the flame of the arc must touch or be projected by a magnet so as to touch this third carbon. We have, therefore, similar phenomena in the case of the arc and incandescence lamps.

(20.) When the electric arc is being projected against the third carbon, and has brought it down to the same potential, a galvanometer joined in between the two carbons shows no current; but this space between the negative carbon of the arc and the third carbon possesses a unilateral conductivity, and will pass the current from a small battery of secondary cells one way, but not the other. The secondary battery when joined in series with the galvanometer sends a current, if its negative pole is in connexion with the negative carbon of the arc, and its positive pole, through the galvanometer, with the third carbon; but if the secondary battery is reversed in position it sends no current. Negative electricity can pass along the flame-like projection of the arc *from* the hot negative carbon *to* the cooler third carbon, but not in an opposite direction.

(21.) If the arc is projected by means of a magnet for a long time against the third insulated carbon, it *craters* it out in the same fashion as the crater of the positive carbon, and the tip of this third carbon, where it has received the flame-like blast of the arc, is converted into graphite.

The same effects are observed if an iron rod is used as a third pole, and in this case the end is converted into *steel*, and rendered so hard as to be scarcely touched by the file when it has been quenched in water.

In seeking for an hypothesis to connect together these observed facts, the one which suggests itself as most in accordance with the facts is as follows:—

In the case of a carbon incandescence lamp when at vivid incandescence, carbon particles are being projected from all parts of the filament, but chiefly from the negative half of the loop. These carbon

molecules carry *negative* charges of electricity, and when they impinge upon a metal plate placed in the vacuum they can discharge themselves if this plate is positively electrified, either by being in metallic connexion with the positive electrode of the lamp or with a separate positively charged body. When the plate is simply insulated the stream of negatively charged carbon molecules brings down this insulated plate to the potential of the base of the negative leg, or to the potential of that part of the carbon conductor from which it is receiving projected molecules. These carbon molecules projected from an incandescent conductor can carry negative charges, but either cannot be positively charged, or else lose a positive charge almost instantly when projected off from the conductor.

In the case of the electric arc we must suppose that the negative carbon is projecting off a torrent of negatively electrified carbon molecules, and these, impinging against the positive carbon, wear out a crater in it by a sand-blast-like action.

The higher temperature of the positive carbon in a continuous current arc is thus explained as due to the impact of the carbon molecules projected from the negative carbon.

If the electric arc is diverted against a third insulated lateral carbon, the carbon blast from the negative carbon wears out a crater in it and brings it down to the same potential as itself. The actions going on in an electric arc may be considered to be somewhat as follows:—When the carbons are first put together, the resistance at the point of contact renders the extremities incandescent. When thus incandescent and separated, the electrification of each carbon is sufficient to begin the projection of molecules from both positive and negative carbons, probably most largely from the latter. The impact of the molecular stream from the negative pole raises the temperature of the positive carbon, and this again by radiation raises the temperature of the negative carbon end. The electromotive force is thus able to keep up a projection of negatively charged carbon molecules from the end of the negative carbon, which molecules are loosened from the mass by heat, and then move away by electric repulsion from the surface in virtue of the electric charge which they retain. It would seem as if a hot carbon molecule cannot retain a positive charge, and hence the potential difference between a third insulated carbon and the positive carbon of the arc is nearly the same as the potential difference of the positive and negative carbons of the arc. The rise of potential along the arc takes place very suddenly just in the neighbourhood of the crater of the positive carbon.

It has often been suggested that the electric arc contains a counter-electromotive force. It is questionable whether such experiments as those of Edlund ('Phil. Mag.,' vol. 36, 1868, p. 352) are entirely conclusive on this point.

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It has been shown by other experimenters* that for arcs of varying length, but the same current, beyond a certain small initial length, the potential difference necessary to maintain the arc is proportional to the length of the arc plus a constant. This might thus be interpreted to mean that a certain proportion of the working electromotive force of the arc was employed in detaching the carbon molecules from the mass of the poles, and that the excess alone is represented by the current produced in an arc of definite length.

In the case of the incandescence lamps the hypothesis of the projection of negatively charged carbon molecules from the incandescent conductor, to which the name of *molecular electrocection* may be given, will suffice to explain all the various different effects produced by varying the surface, position, and distance of the metal plate against which they impinge, and also the nullifying effect of shielding this plate from the negative leg of the carbon.

That this molecular discharge goes on chiefly from the negative leg is additionally proved by the greater erosion which takes place in the deposit of carbon on the negative leg when the carbon is uniform and traversed by a continuous current.

The hypothesis that a carbon molecule detached from an incandescent carbon surface in a high vacuum can only convey away a negative charge, reconciles also the above described observed effects in which a negative discharge can be made *out* of a hot surface of carbon more easily than a positive discharge. When an electromotive force is applied to two metallic terminals or electrodes sealed into a good vacuum, it is well known that a certain initial electromotive force has to be applied before any electric current begins to flow through the gas at all. It seems conclusively proved by Mr. Crookes's researches that the nature of an electric discharge through a high vacuum consists in a torrent of electrified particles proceeding from the negative electrode. If this is the case the initial electromotive force required to begin a discharge through such rarefied gas would naturally be reduced by heating the negative electrode, so as to favour and assist the detachment of the charged molecules of that electrode. The effect of heating the negative electrode in facilitating discharge through vacuous spaces has previously been described by W. Hittorf ('Annalen der Physik und Chemie,' vol. 21, 1884, p. 90—139), and it is abundantly confirmed by the above experiments. We may say that a vacuous space bounded by two electrodes—one incandescent, and the other cold—possesses a unilateral conductivity for electric discharge when these electrodes are within a distance of the mean free path of projection of the mole-

* See Professors Ayrton and Perry, 'Proceedings of the Physical Society,' vol. 5, p. 201.

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cules which the impressed electromotive force can detach and send off from the hot negative electrode.

This unilateral conductivity of vacuous spaces having unequally heated electrodes has been examined by MM. Elster and Geitel (see 'Wiedemann's Annalen,' vol. 38, 1889, p. 40), and also by Goldstein ('Wied. Ann.,' vol. 24, 1885, p. 83), who in experiments of various kinds have demonstrated that when an electric discharge across a vacuous space takes place from a carbon conductor to another electrode, the discharge takes place at lower electromotive force when the carbon conductor is the negative electrode and is rendered incandescent.

III. "A Milk Dentition in *Oryzoropus*." By OLDFIELD THOMAS, Natural History Museum. Communicated by Dr. A. GÜNTHER, F.R.S. Received December 12, 1889.

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[fol. 2995] DEFENDANT'S EXHIBIT J-1

Proceedings of Royal Institution of Great Britain, 1890-1892.

Weekly Evening Meeting, Friday, February 14, 1890. William Crookes, Esq., F.R.S. Vice President, in the Chair Professor J. A. Fleming, M.A. D.Sc. M.R.I. Problems in the Physics of an Electric Lamp

More than eighty years ago Sir Humphry Davy provided the terminal wires of his great battery of 2000 pairs of plates with rods of carbon, and, bringing their extremities in contact, obtained for the first time, a brilliant display of the electric arc.[1] The years that have fled away since that time have seen all the marvelous developments of electro magnetic engineering, have placed in our possession the electric glow-lamp, and brought the art of electrical illumination to a condition in which it progresses each year with giant strides. In addition to the importance attaching to their ever-increasing industrial use, there are many questions of purely scientific interest which present themselves to our minds when we proceed to examine the actions [fol. 2996] that take place when a carbon conductor is rendered incandescent in a high vacuum, or when an electric arc is formed between two carbon poles. It is to a very few of these physical problems that I desire to direct your attention to-night, but more especially to one which is particularly interesting from the bearing which it has on the general nature of electric discharge.

We know as a very familiar fact that if we attempt to raise the temperature of a carbon conductor enclosed in a vacuum beyond a certain limit, not far removed from the melting point of platinum, the carbon begins to volatilise

[1] Sir Humphry Davy laid a request before the managers of the Royal Institution on July 11th, 1808, that they would set on foot a subscription for the purchase of a large galvanic battery. The result of this suggestion was that a galvanic battery of 2,000 pairs of copper and zinc plates were set up in the Royal Institution, and one of the earliest experiments performed with it was the production of the electric arc between carbon poles, on a large scale. It is probable, however, that Davy had produced the light on a small scale some six years before and, according to Quetelet, Curtet observed the arc between carbon points in 1802. See Dr. Paris' "Life of Sir H. Davy."

with great rapidity. If an electric glow-lamp has passed through its carbon more than a certain strength of current, the glass bulb speedily becomes darkened by a deposit of this volatilised carbon condensed upon it; and experience shows us that we cannot raise the temperature of that carbon beyond a definite point without causing this waste of the conductor to become very rapid. In the highly rarefied atmosphere within the bulb of a glow lamp, the carbon, when at its normal incandescence, must be considered to be projecting off molecules of carbon in all directions, partly in virtue of purely thermal actions, but probably also in consequence of certain electrical effects to be presently discussed. This scattering of the material of the carbon conductor takes place with disadvantageous rapidity from an industrial point of view at and beyond a certain temperature,[2] but it exists as well at much lower temperatures than that which is found to determine the practical limit of durability. A curious appearance is found in many incandescent lamps which have been "over-run," which shows us that this projection of carbon molecules from the hot conductor is not, perhaps, best described by calling it a vaporisation of its substance, but that the surface molecules are shot off in straight lines, and that they reach the glass envelope without being hindered to any great extent by the molecules of the residual air.

If an electric current is passed through an otherwise uniform carbon conductor, which possesses at any one place a specific resistance higher than that of the remaining portion, the current, in accordance with a well-known law, there develops a higher temperature, and the molecular scattering at that spot may in consequence be greatly exaggerated. It may be that the detrition of the conductor at that locality will be so great as to cut it through after a very short time. When the carbon has the form of a simple horseshoe loop, and when this molecular scattering takes place from some point in the middle of one branch, the molecular projection makes itself evident by producing a

[2] When the rate of expenditure of energy in the carbon conductor is raised until it reaches a value of about 500 watts, or 360 foot pounds per second per square inch of radiative surface, a limit of useful temperature has been reached for economical working, under the usual present conditions of steam-engine-driven dynamos and modern glow-lamps.

"molecular shadow" of the other leg upon the interior of the glass. I will project upon the screen an image of the carbon horseshoe loop taken from an old glow-lamp, and you will be able to see that the filament has been cut through at one place. At that position some minute congenital defect caused the carbon to have a higher resistance, the temperature at that point when it was in use became ex- [fol. 2997] cessive, and an intensified molecular scattering took place from that locality. On examining the glass bulb from which it was taken, we find that the glass has been everywhere darkened by a deposit of the scattered carbon except along one narrow line (*see* Fig. 1), and that line is in the plane of the carbon loop and on the side opposite to the point of rupture of the filament.[3]

I may illustrate to you by a very simple experiment the way in which that "shadow" has been formed. Here is a ∩-shaped rod: this shall represent the carbon conductor in the lamp: this sheet of cardboard placed behind it, the side of the glass receiver. I have affixed a little spray-producer to one side of the loop, and from that point blow out a spray of inky water. Consider the ink spray to represent the carbon atoms shot off from the overheated spot. We see that the cardboard is bespattered on all points except along one line where it is sheltered by the opposite side of the loop. We have thus produced a "spray shadow" on the board (Fig. 2). The existence of these molecular shadows in incandescent lamps leads us therefore to recognise that the carbon atoms must be shot off in straight lines, or else obviously no such sharp shadow could thus be formed. This phenomenon confirms in a very beautiful manner the deductions of the Kinetic theory of gases. I may remind you that at the ordinary temperature and pressure the mean free path of a molecule of air is deducted to be about four one-millionths of an inch. This is the average distance which such a gaseous molecule moves over before meeting with a collision against a neighbour which changes [fol. 2998] the direction of its path. Let the air be rarefied, as in these bulbs, to something like a millionth of the ordinary atmospheric pressure, and the mean free path is increased to several inches. The space within the bulb though from one point of view densely populated with

[3] The writer desires to express his indebtedness to the Editor of the "Electrician" for the loan of the blocks illustrating this abstract.

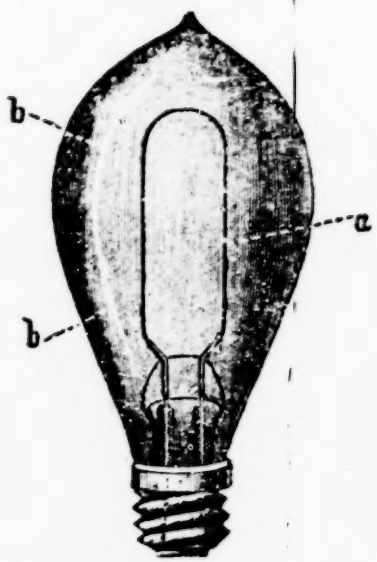


FIG. 1. Glow-lamp, having the glass bulb blackened by deposit of carbon, showing the molecular scattering which has taken place from the point *a* on the filament, and the shadow in line of no deposit produced at *b*.

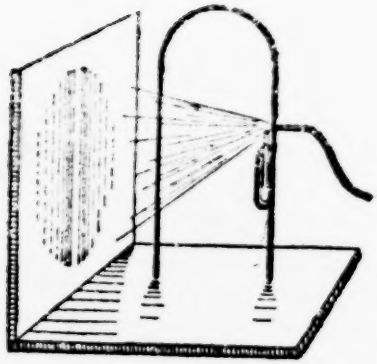


FIG. 2. "Spray shadow" of a rod thrown on cardboard screen to illustrate formation of molecular shadow in glow lamps.

molecules of residual air—is yet, as a fact, in such a condition of rarefaction that a carbon molecule projected from the conductor can move over a distance of three or four inches on an average without meeting with interference by collision with another molecule, and the facts revealed to us by these shadows show that this must be the case. I have also at hand some Edison lamps in which these "molecular shadows" are finely shown, but in these cases the deposit on the interior of the bulb is not carbon but copper, because the molecular scattering has here taken place by excessive temperature developed at the copper clamps by which the carbon filament is attached to the platinum wires. The theory, however, is the same. The deposit of copper shows a fine green colour by transmitted light in the thinner portions. One curious lamp also before me had by an accident an aluminium plate volatilised within the bulb. The glass receiver has in consequence been covered with a mirror-like deposit of aluminium, which on the thinner portions shows a fine blue colour by transmitted light, and a silvery lustre by reflected light. This lamp also shows a fine "molecular shadow."

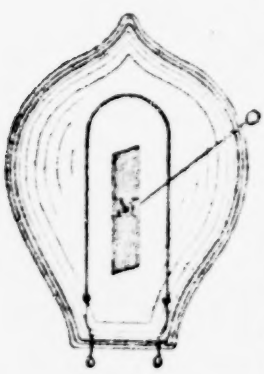
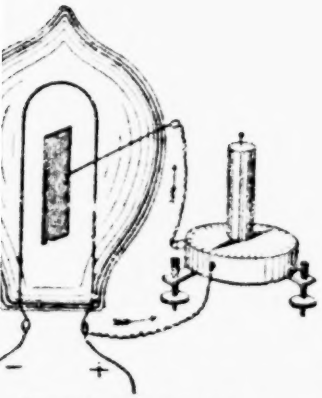


FIG. 3. Glow-lamp having insulated metal middle plate M sealed into bulb to exhibit Edison effect.

These facts prepare us to accept the view that when a glow-lamp is in operation the highly rarefied residual air in the interior of the bulb is being traversed in all directions by multitudinous carbon atoms projected off from the incandescent carbon conductor. I now wish to pass in review before you some facts which indicate that these carbon atoms carry with them electric charges, and that they are charged, if at all, with *negative electricity*. I may preface all by saying that much of what I have to show you will be seen to be closely related to the phenomena studied by Mr. Crookes in his splendid and classical researches on radiant matter. Our starting-point for this purpose is a discovery made by Mr. Edison in 1884, and which received careful examination at the hands of Mr. Preece in the following year,[1] and by myself more recently. Here is the initial experiment. A glow-lamp having the usual horse-shaped carbon (*see* Fig. 3) has a metal plate held on a platinum shoe wire sealed through the glass bulb. This plate is so fixed out it stands up between the two sides of the carbon arch without touching either of them. We shall illuminate the lamp by continuous current of electricity, and for brevity's sake speak of that half of the loop of carbon on the side by which the current enters it as the positive leg, [fol. 2999] and the other half of the loop as the negative leg. The diagram in Fig. 4 shows the position of the plate with respect to the carbon loop. There is a distance of half an inch, or in some cases many inches, between either leg of the carbon and this middle plate. Setting the lamp in action, I connect a sensitive galvanometer between the middle plate and the *negative terminal* of the lamp, and you see that there is no currents passing through the instrument. If, however, I connect the terminals of my galvanometer to the middle plate and to the *positive electrode* of the lamp, we find a current of some milliamperes is passing through it. The diagrams in Fig. 5 show the mode of connection of the galvanometer in the two cases. This effect, which is often spoken of as the "Edison effect," clearly indicates that an insulated plate so placed in the vacuum of a lamp in action is brought down to the same potential or electrical

[1] Mr. Preece's interesting paper on this subject is published in the "Proceedings" of the Royal Society for 1885, p. 219. See also "The Electrician," April 4th, 1885, p. 426.



Sensitive galvanometer connected
een the middle plate and positive
ode of a glow-lamp, showing cur-
flowing through it when the lamp
action ("Edison effect").

FIG. 5.—Mode of connection of galvanometer G to middle plate M and carbon horseshoe shaped conductor C in the experiment of the "Edison effect."

as the negative electrode of the carbon loop. On
ning the direction of the current through the galva-
er we find that it is equivalent to a flow of negative
icity taking place through it *from* the middle plate *to*
sitive electrode of the lamp. A consideration of this
hows us that there must be some way by which nega-
lectricity gets across the vacuous space from the nega-
g of the carbon to the metal plate, whilst at the same
negative charge cannot pass from the metal plate
to the positive leg. Before I pass away from this
experiment, I should like to call your attention to a
s effect at the moment when the lamp is extinguished.
ecting the galvanometer as at first, between the middle
nd the negative electrode of the lamp, we notice that
h made highly sensitive the galvanometer indicates
rent flowing through it whilst the lamp is in action.
ing off the current from the lamp produces, as you
violent kick or deflection of the galvanometer, indi-
a sudden rush of current through it.

ndeavoring to ascertain further facts about this effect
the experiments which early suggested itself was one
1000] directed to determine the relative effects of
nt portions of the carbon conductor. Here is a lamp
ig. 6) in which one leg of the carbon horseshoe has
nclosed in a glass tube of the size of a quill, which
s one-half of the carbon. The bulb contains, as be-
n insulated middle plate. If we pass the actuating
t through this lamp in such a direction that the
d or sheathed leg is the *positive* leg, we find the

effect existing as before. A galvanometer connected between the plate and positive terminal of the lamp yields a strong current, whilst if connected between the negative terminal and the middle plate there is no current at all. Let us, however, reverse the current through the lamp so that the shielded or enclosed leg is now the negative one, and the galvanometer is able to detect no current, whether connected in one way or the other. We establish, therefore, the conclusion that it is the negative leg of the carbon loop which is the active agent in the production of this "Edison effect," and that if it is enclosed in a tube of either glass or metal, no current is found flowing in a galvanometer connected between the positive terminal of the lamp and this middle collecting plate.

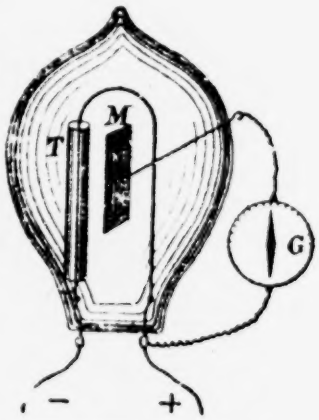


FIG. 6.—Glow-lamp having negative leg of carbon enclosed in glass tube *T*, the "Edison effect" thereby being annulled or greatly diminished.

Another experiment which confirms this view is as follows:—This lamp (see Fig. 7) has a middle plate, which is provided with a little mica flap or shutter on one side of it. When the lamp is held upright the mica shield falls over and covers one side of the plate, but when it is held in a horizontal position the mica shield falls away from the front of the plate and exposes it. Using this lamp as before we find that when the positive leg of the carbon loop is opposite to the shielded face of the plate, we get the "Edison effect" as before in any position of the lamp. Reversing the lamp current and making that same leg the *negative* one, we find that when the lamp is so held the metal plate is shielded by the interposition of the mica, and the galvanometer current is very much less than when the shield is shaken on one side and the plate exposed fully to the negative leg.

At this stage it will perhaps be most convenient to outline briefly the beginnings of a theory proposed to reconcile these facts, and leave you to judge how far the subsequent experiments confirm this hypothesis. The theory very briefly is as follows: From all parts of the incandescent carbon loop, but chiefly from the negative leg, carbon molecules are being projected which carry with them, or are charged with, negative electricity. I will in a few moments make a suggestion to you which may point to a possible

hypothesis on the manner in which the molecules acquire this negative charge. Supposing this, however, to be the case, and that the bulb is filled with these negatively-charged molecules, what would be the result of introducing [fol. 3001] into their midst a conductor such as this middle metal plate which is charged positively? Obviously, they would all be attracted to it and discharge against it. Suppose the positive charge of this conductor to be continually renewed, and the negatively-charged molecules continually supplied, which conditions can be obtained by connecting the middle plate to the positive electrode of the lamp, the obvious result will be to produce a current of electricity flowing through the wire or galvanometer, by means of which this middle plate is connected to the positive electrode of the lamp. If, however, the middle plate is connected to the negative electrode of the lamp, the negatively charged molecules can give up no charge to it, and produce no current in the interpolated galvanometer. We see that on this assumption the effect must necessarily be diminished by any arrangement which prevents these negatively charged molecules from being shot off the negative leg or from striking against the middle plate. Another obvious corollary from this theory is that the "Edison effect" should be annihilated if there a metal collecting plate is placed at a distance from the negative leg much greater than the mean free path of the molecules.

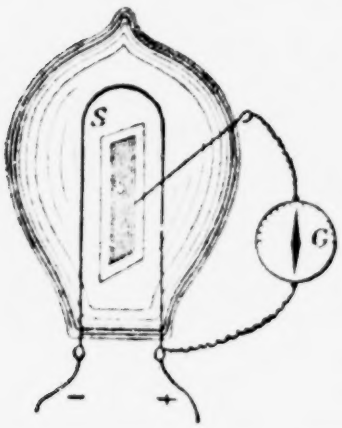


FIG. 7.—Glow-lamp having mica shield S interposable between middle plate M and negative leg of carbon, thereby diminishing the "Edison effect."

Here are some experiments which confirm this deduction. In this bulb (Fig. 8) the metal collecting plate, which is to be con-

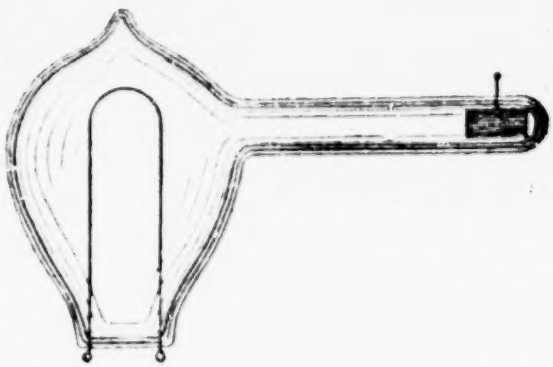


FIG. 8.—Collecting plate placed at end of a tube [illegible] length, opening out of the bulb [illegible]

nected through the galvanometer with the positive terminal of the lamp, is placed at the end of a long tube opening out of and forming part of the bulb. We find the "Edison effect" is entirely absent, and that the galvanometer current is zero. We have, as it were, placed our target at such a distance that the longest range molecular bullets cannot hit it, or, at least, but very very few of them do so. Here again is a lamp in which the plate is placed at the extremity of a tube opening out of the bulb, but bent at right angles (Fig. 9). We find in this case, as first discovered by Mr. Preece, that there is no "Edison effect." Our molecular marksman cannot shoot round a corner. None of the negatively-charged molecules can reach the plate, although that plate is placed at a distance not greater than [fol. 3002] would suffice to produce the effect if the bend were straightened out. Following out our hypothesis into its consequences would lead us to conclude that the material of which the plate is made is without influence on the result, and this is found to be the case. Many of the foregoing facts were established by Mr. Preece as far back as 1885, and I have myself abundantly confirmed his results.

We should expect also to find that the larger we make our plate, and the nearer we bring it to the negative leg of the carbon, the greater will be the current produced in a circuit connecting this plate to the positive terminal of the lamp. I have before me a lamp with a large plate placed very near the negative leg of the carbon of a lamp, and we find that we can collect enough current from these molecular charges to work a telegraph relay and ring an electric bell. The current which is now working this relay is made up of the charges collected by the plate from the negatively-charged carbon molecules which are projected against it from the negative leg, across the highly perfect vacuum. I have tried experiments with lamps in which the collecting plate is placed in all kinds of positions, and has various forms, some of which are here, and are represented in the diagrams before you; but the result may all be summed up by saying that the greatest effects are pro-

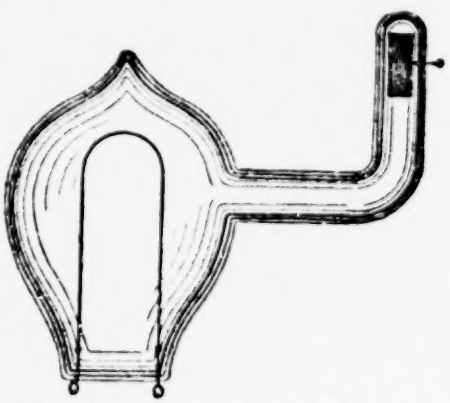


FIG. 9.—Collecting plate placed at end of an elbow tube opening out of the bulb.

duced when the collecting plate is as near as possible to the base of the negative end of the loops, and, as far as possible, encloses, without touching, the carbon conductor. Time will not permit me to make more than a passing reference to the fact that the magnitude of the current flowing through the galvanometer when connected between the middle plate and the positive terminal of the lamp often "jumps" from a low to a high value, or *vice versâ*, in a remarkable manner, and that this sudden change in the current can be produced by bringing strong magnets near the outside of the bulb.

Let us now follow out into some other consequences this hypothesis that the interior of the bulb of a glow-lamp when in action is populated by flying crowds of carbon atoms all carrying a negative charge of electricity. Suppose we connect our middle collecting plate with some external reservoir of electric energy, such as a Leyden jar, or with a condenser equivalent in capacity to many hundreds of Leyden jars, and let the side of the condenser which is charged positively be first placed in connection through a galvanometer with the middle plate (see Fig. 10), whilst the negative side is placed in connection with the earth. Here is a condenser of two microfarads capacity so charged and connected. Note what happens when I complete the circuit and illuminate the lamp by passing the [fol. 3003] current through its filament. The condenser is at once discharged. If, however, we repeat the same experiment with the sole difference that the negatively charged side of the condenser is in connection with the middle plate then there is no discharge. The experimental results may be regarded from another point of view. In order that the condenser may be discharged as in the first case, it is essential that the negatively charged side of the condenser shall be in connection with some part of the circuit of the incandescent carbon loop. This experiment with the condenser discharged by the lamp may be then looked upon as an arrangement in which the plates of a charged condenser are connected respectively to an incandescent carbon loop and to a cool metal plate, both being enclosed in a highly vacuous space, and it appears that when the incandescent conductor is the negative electrode of this arrangement the discharge takes place, but not when the cooler metal plate is the negative electrode of the charged

condenser. The negative charge of the condenser can be carried across the vacuous space from the hot carbon to the colder metal plate, but not in the reverse direction.

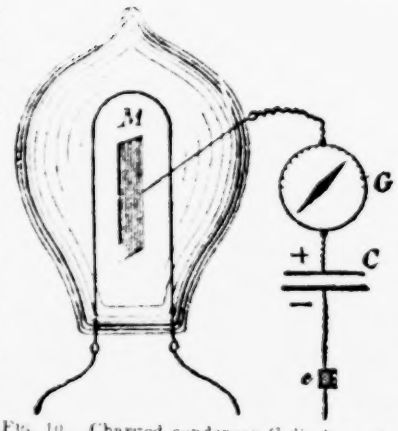


Fig. 10. Charged condenser C discharged by middle plate M, when the positively charged side of condenser is in connection with the plate and other side to earth e.

This experimental result led me to examine the condition of the vacuous space between the middle metal plate and the negative leg of the carbon loop in the case of the lamp employed in our first experiment. Let us return for a moment to that lamp. I join galvanometer between the middle plate and the negative terminal of the lamp, and find, as before, no indication of a current. The metal plate and the negative terminal of the lamp are at the same electrical potential. In the circuit of the galvanometer we will insert a single galvanic cell having an electromotive force of rather over one volt. In the first place let that cell be so inserted that its negative pole is in connection with the middle plate, and its positive pole in connection through the galvanometer with the negative terminal of the lamp (see Fig. 11). Regarding the circuit of that cell alone, we find that it consists of the cell itself, the galvanometer wire, and that half-inch of highly vacuous space between the hot carbon conductor and the middle plate. In that circuit the cell cannot send any sensible current at all, as it is at the present moment connected up. But if we reverse the direction of the cell so that its positive pole is in connection with the middle plate, the galvanometer at once gives indications of a very sensible current. This highly vacuous space, lying between the middle metal plate on the one hand, and the incandescent carbon on the other, possesses a kind of unilateral conductivety, in that it will allow the current from [fol. 3004] a single galvanic cell to pass one way but not the other. It is a very old and familiar fact that in order to send a current from a battery through a highly rarefied gas by means of metal electrodes, the electromotive force of the battery must exceed a certain value. Here, however, we have indication that if the negative electrode by which that current seeks to enter the vacuous space is made incan-

descent the current will pass at a very much lower electromotive force than if the electrode is not so heated.

A little consideration of the foregoing experiments led to the conclusion that in the original experiment, as devised by Mr. Edison, if we could by any means render the middle plate very hot, we should get a current flowing through a galvanometer when it is connected between the middle plate and the negative electrode of the carbon. This experiment can be tried in the manner now to be shown. Here is a bulb (Fig. 12) having in it two carbon loops; one

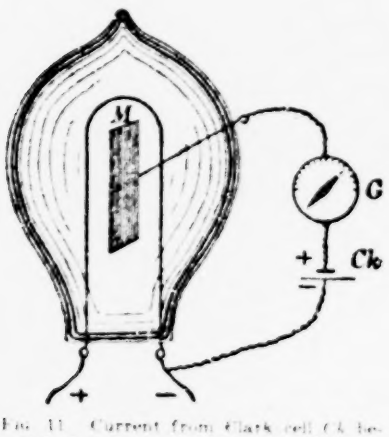


FIG. 11. Current from Clark cell *Cb* being sent across vacuous space between negative leg of carbon and middle plate *M*. Positive pole of cell in connection with plate *M* through galvanometer *G*.

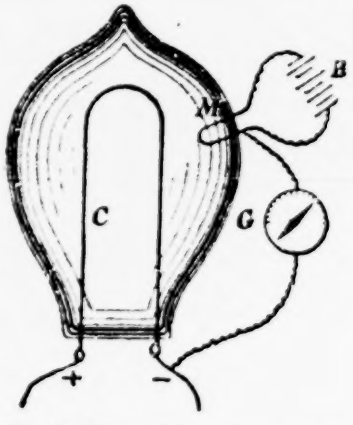


FIG. 12. Experiment showing that when the "middle plate" is a carbon loop rendered incandescent by insulated battery *B*, a current of negative electricity flows from *M* to the positive leg of main carbon *C* across the vacuum.

of these is of ordinary size, and will be rendered incandescent by the current from the mains. The other loop is very small, and will be heated by a well-insulated secondary battery. This smaller incandescent loop shall be employed just as if it were a middle metal plate. It is, in fact, simply an incandescent middle conductor. On repeating the typical experiment with this arrangement, we find that the galvanometer indicates a current when connected between the middle loop and either the positive *or* the negative terminal of the main carbon. I have little doubt but that if we could render the platinum plate in our first used lamp incandescent by concentrating on it from outside a powerful beam of radiant heat we should get the same result.

A similar set of results can be arrived at by experiments

with a bulb constructed like an ordinary vacuum tube, and having small carbon loops at each end instead of the usual platinum or aluminium wires. Such a tube is now before you (*see* Fig. 13), and will not allow the current from a few cells of a secondary battery to pass through it when the car- [fol. 3005] bon loops are cold. If, however, by means of well insulated secondary batteries we render both of the carbon loop electrodes highly incandescent, a single cell of a battery is sufficient to pass a very considerable current across that vacuous space provided the resistance of the rest of the circuit is not large. We may embrace the foregoing facts by saying that if the electrodes, but especially the negative electrode, which form the means of ingress and egress of a current into a vacuous space are capable of being rendered highly incandescent, and if at that high temperature they are made to differ in electrical potential by the application of a very small electromotive force, we may get under these circumstances a very sensible current through the rarefied gas. If the electrodes are cold a very much higher electromotive force will be necessary to begin the discharge or current through the space. These facts have been made the subject of elaborate investigation by Hittorf and Goldstein, and more recently by Elster and Geitel. It is to Hittorf that I believe we are indebted for the discovery of the fact that by heating the negative elec

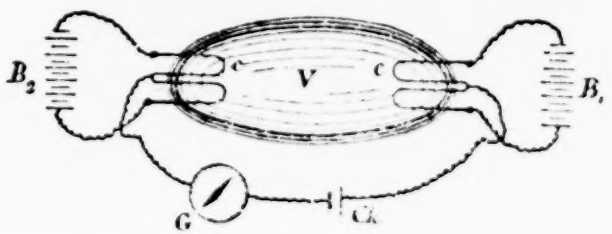


Fig. 13.—Vacuum tube having carbon loop electrodes, cc, at each end rendered incandescent by insulated batteries B_2 B_1, showing current from Clark cell, Cx, passing through the high vacuum when the electrodes are incandescent.

trode we greatly reduce the apparent resistance of a vacuum.

Permit me now to pave the way by some other experiments for a little more detailed outline of the manner in which I shall venture to suggest these negative molecular

charges are bestowed. This is really the important matter to examine. In seeking for some probable explanation of the manner in which these wandering molecules of carbon in the glow-lamp bulb obtain their negative charges, I fall back for assistance upon some facts discovered by the late Prof. Guthrie. He showed some years ago new experiments on the relative powers of incandescent bodies for retaining positive and negative charges. One of the facts he brought forward[1] was that a bright red-hot iron ball, well insulated, could be charged negatively, but could not retain for an instant a positive charge. He showed this fact in a way which it is very easy to repeat as a lecture experiment. Here is a gold-leaf electroscope, to which we will impart a positive charge of electricity, and project the image of its divergent leaves on the screen. A poker, the tip of which has been made brightly red-hot, is placed so that its incandescent end is about an inch from the knob of the electroscope. No discharge takes place. Discharging the elec- [fol. 3006] troscope with my finger, I give it a small charge of negative electricity, and replace the poker in the same position. The gold leaves instantly collapse. Bear in mind that the extremity of the poker, when brought in contiguity to the knob of the charged electroscope, becomes charged by induction with a charge of the opposite sign to that of the charge of the electroscope, and you will at once see that this experiment confirms Prof. Guthrie's statement, for the negatively-charged electroscope induces a positive charge on the incandescent iron, and this charge cannot be retained. If the induced charge on the poker is a negative charge, it is retained, and hence the positively-charged electroscope is not discharged, but the negatively-charged electroscope at once loses its charge. Pass in imagination from iron balls to carbon molecules. We may ask whether it is a legitimate assumption to suppose the same fact to hold good for them, and that a hot carbon molecule or small carbon mass just detached from an incandescent surface behaves in the same way and has a greater grip for nega-

[1] "On a New Relation between Electricity and Heat," Phil. Mag. vol. xlv. p. 308. 1873.

tive than for positive charge? If this can possibly be assumed, we can complete our hypothesis as follows:—Consider a carbon molecule or small congerie of molecules just set free by the high temperature from the negative leg of the incandescent carbon horseshoe. This small carbon mass finds itself in the electrostatic field between the branches of the incandescent carbon conductor (*see* Fig. 14). It is acted upon inductively, and if it behaves like the hot iron ball in Prof. Guthrie's experiment it loses its positive charge. The molecule then being charged negatively is repelled along the lines of electric force against the positive leg. The forces moving it are electric forces, and the repetition of this action would cause a torrent of negatively-charged molecules to pour across from the negative to the positive side of the carbon horseshoe. If we place a metal plate in their path, which is in conducting connection with the positive electrode of the lamp carbon, the negatively-charged molecules will discharge themselves against it. A plate so placed may catch more or less of this stream of charged molecules which pour across between the heels of the carbon loop. There are many extraordinary facts, which as yet I have been able only imperfectly to explore, which relate to the sudden changes in the direction of the principal stream of these charged molecules, and to their guidance under the influence of magnetic forces. The above rough sketch of a theory must be taken for no more than it is worth, viz. as a working hypothesis to suggest further experiments.

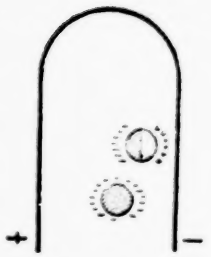
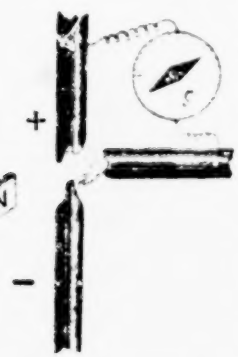


Fig. 14.—Rough diagram illustrating a theory of the manner in which projected carbon molecules may acquire a negative charge.

These experiments with incandescence lamps have prepared the way for me to exhibit to you some curious facts with respect to the electric arc, and which are analogous to those which we have passed in review. If a good electric arc is formed in the usual way, and if a third insulated carbon held at right angles to the other two is [fol. 3007] placed so that its tip just dips into the arc (*see* Fig. 15), we can show a similar series of experiments. It is rather more under control if we cause the arc to be

ed against the third carbon by means of a magnet. now formed on the screen an image of the carbon nd the arc between them, in the usual way. Placing et at the back of the arc, I cause the flame of the be deflected laterally and to blow against a third d carbon held in it. There are three insulated wires d respectively to the positive and to the negative of the arc, and to the third or insulated carbon, of which dips into the flame of the arc projected magnet. On starting the arc this third carbon is y brought down to the same electrical potential as ative carbon of the arc, and if I connect this gal- ter in between the negative carbon and the third lated carbon I get, as you see, no indication of a Let me, however, change the connections and he circuit of my galvanometer in between the posi- bon of the arc and the middle carbon, and we find evidence, by the violent impulse given to the galvanometer, that there is a strong current flowing through it. The direction of this current is equivalent to a flow of negative electricity from the middle carbon through the galvanometer to the positive carbon of the arc. We have here then the "Edison effect" repeated with the electric arc. So strong is the current flowing in a circuit connecting the middle carbon with the positive carbon that I can, as you see, ring an electric bell and light a small incandescent lamp



lectric arc projected by gainst a third carbon, and a strong electric current rough a galvanometer G, between the positive and carbon.

ese electric-current detectors are placed in con- with the positive and middle carbons.

o find that the flame-like projection of the arc be- negative carbon possesses a unilateral conductiv- in this small secondary battery of fifteen cells in th the galvanometer, and connect the two between le carbon and the negative carbon of the arc. Just analogous experiment with the incandescent lamp, e can send negative electricity along the flame of ne way but not the other. The secondary battery

causes the galvanometer to indicate a current flowing through it when its negative pole is in connection with the negative carbon of the arc (*see* Fig 16), but not when its positive pole is in connection with the negative carbon. On examining the third or middle carbon after it has been employed in this way for some time, we find that its extremity is cratered out and converted into graphite, just as if it had been employed as the positive carbon in forming an electric arc. Time forbids me to indulge in any but the briefest remarks on these experiments; but one suggestion may be made, and that is that they seem to indicate that the chief movement of carbon molecules in the electric arc is *from* the [fol. 3008] negative *to* the positive carbon. The idea suggests itself that, after all, the cratering out of the positive carbon of the arc may be due to a sand-blast-like action of this torrent of negatively-charged molecules which are projected from the negative carbon. If we employ a soft iron rod as our lateral pole, we find that, after enduring for some time the projection of the arc against it, it is converted at the extremity into *steel*.

Into the fuller discusston as to the molecular actions going on in the arc, the source and nature of that which has been called the counter-electromotive force of the arc, and the causes contributing to produce unsteadiness and hissing in the arc, I fear that I shall not be able to enter, but will content myself with the exhibition of one last experiment, which will show you that a high vacuum, or, indeed, any vacuum, is not necessary for the production of the "Edison effect." Here is a carbon horseshoe-shaped conductor, not enclosed in any receiver (see Fig. 17). Close to the negative leg or branch, yet not touching it, we have adjusted a little metal plate. The sensitive galvanometer is connected between this metal plate and the base of the other or positive leg of this carbon arch. On sending a current through the carbon sufficient to

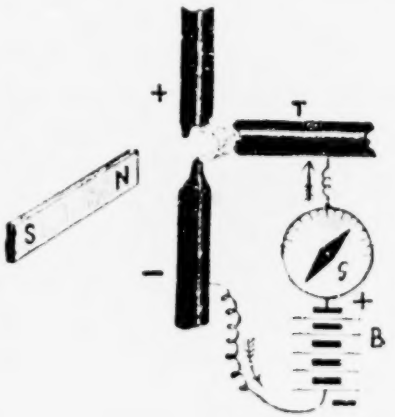


Fig. 16. Galvanometer *G* and battery *B* inserted in series between negative carbon of electric arc and a third carbon to show unilateral conductivity of the arc between the negative and third carbons.

bring it to bright incandescence, the galvanometer gives indications of a current flowing through it, and as long as the carbon endures, which is not, however, for many seconds, there is a current of electricity through it equivalent to a flow of negative electricity from the plate through the galvanometer to the positive electrode of the carbon. The interposition of a thin sheet of mica between the metal plate and the negative leg of the carbon loop entirely destroys the galvanometer current.[6]

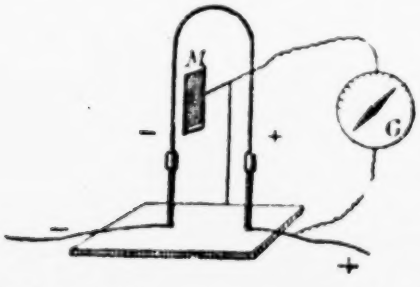


FIG. 17.—Edison effect" experiment shown with carbon in open air

These experiments and brief expositions cover a very small portion of the ground which is properly included within the limits of my subject. Such fragments of it as we have been able to explore tonight will have made it clear that it is a region abounding in interesting facts and problems in molecular physics. The glow-lamp and the electric are have revolutionized our methods of artificial lighting, but they present themselves also as subjects of scientific study, by no means yet exhausted of all that they have to teach.

[6] This last experiment is due to my assistant, Mr. A. H. Bate. [J. A. F.]

DEFENDANT'S EXHIBIT K-1

THE ELECTRICIAN:

A WEEKLY ILLUSTRATED JOURNAL OF

ELECTRICAL ENGINEERING, INDUSTRY AND SCIENCE

No. 614.—Vol. XXIV. FRIDAY, FEBRUARY 21, 1890. Price Fourpence.

NOTES.

Mr. Swinburne's Paper on "The Theory of Armature Reactions in Dynamos and Motors," read before the Institution of Electrical Engineers on the 13th inst., will be discussed conjointly with Mr. Esson's communication on "Some Points in Dynamo and Motor Design," read last night.

The simplicity introduced into dynamo and motor design by looking at the subject from the magnetic point of view first suggested by Hopkinson and Kapp has received considerable support in Mr. Swinburne's valuable Paper. The effect of the distortion of the lines of magnetic force is still further brought out by the use of the term magnetic potential. [illegible] can thus be considered in parts just as [illegible] by which the electric potential and resistance [illegible]. The most serious case of magnetic leakage is [illegible]. There is however no justification for [illegible] of magnetic current at [illegible].

The reactions of the armature on the field magnets [illegible] the position of the brushes [illegible] which the [illegible] the weakening effect [illegible] the pole pieces and its strengthening effect [illegible] are simply and clearly [illegible]. The greater amount of sparking [illegible] of single magnet dynamos [illegible].

Mr. Swinburne is probably right in considering that [illegible] in connection with reducing the distortion [illegible] to avoid sparking at the brushes, and [illegible] of the commutator to [illegible] the magnetic leakage [illegible] Mr. Swinburne's [illegible].

In connection with the subject of magnetic potential, we may remind our readers that a very simple and convenient instrument for its measurement was described before the Physical Society of London some time ago by Mr. A. P. Chattock. The instrument consists of a long solenoid of many turns wound on an elastic core so as to be flexible. One end of the helix is kept fixed while the other is moved quickly between the two places whose difference of magnetic potential is required. The ends of the coil are connected with a ballistic galvanometer and the impulse imparted to the needle is a measure of the potential difference required. This instrument might be useful in measuring the quantities referred to by Mr. Swinburne, and it seems clear that some such instrument would be of use in dynamo tests and in dynamo design.

The twenty or thirty persons who composed Mr. Heaviside's audience at the Society of Arts on Tuesday afternoon were evidently too deeply concerned with the [illegible] of cheap postage rates to pay much heed to his theories concerning telegraph cable rates, or to criticise too nicely the manner of his advocacy. People however who can be got to a five o'clock meeting of that kind are mostly enthusiasts and may perhaps be excused for patiently, though sadly, listening to Mr. Heaviside's indignant insinuations against unnamed opponents. The Chairman was apparently the only person to realise the compromising position in which the readers of the Paper was placing the Society. Addressing the meeting at the conclusion of the discussion, Sir Lyon Playfair remarked that it was not to be expected that all would agree with views put forward on that platform, but so long as they were expressed with moderation and fairness, the Society was always ready to give them a hearing.

We cannot help thinking from this and other indications that the Chairman's ideas of moderation and fairness [illegible] somewhat shocked by various passages in Mr. Heaviside's [illegible] and we shall be much disappointed if some of [illegible] mentioned before the Paper gets published in the [illegible]. The Society must guard against its [illegible] being [illegible] and intemperate [illegible].

3444

At Bath the "solid" system is being used for high-tension alternating-current and arc-lighting wires.

Besides the systems already described, the Callender Company, as is well known, also make conduits on the Callender-Webber system. This is a drawing-in-and-out system, with a separate hole for each cable. Messrs. Callender state that their experience of cables drawn into pipes several together is that, although it may be possible to add single cables when required, yet that the cables will overlay each other and get interlaced

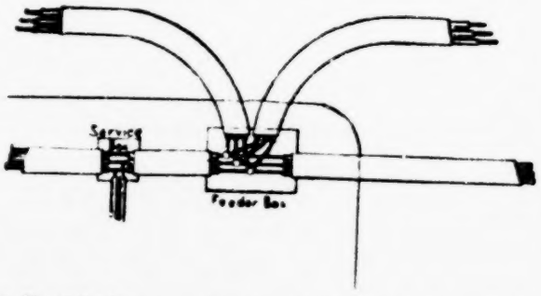


Fig. 20.—Callender Company's system. General method of running the mains and feeders (plan).

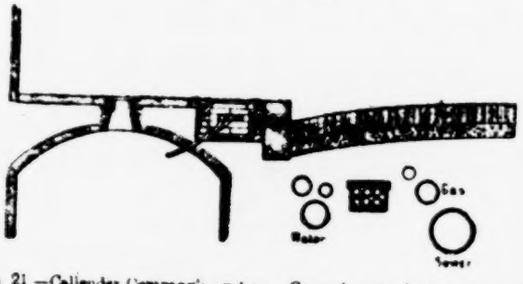


Fig. 21.—Callender Company's system. General method of running the mains and feeders (section).

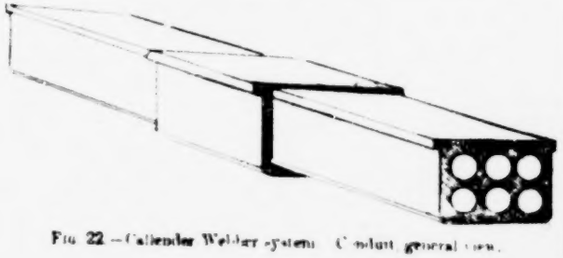


Fig. 22.—Callender Webber system. Conduit general view.

Fig. 23. Callender Webber system. Method of covering joints.

in such a way that it is very difficult to withdraw any one of them afterwards should it need repair. Figs. 20 and 21 show in plan and section the general method of running the feeders and mains. The feeders are usually carried under the road way and the service mains under the footpaths.

There are various ways in which the conduits are formed, according to the purpose for which they are to be used and the size of the cables they will have to carry. In the form which the Chelsea Electric Light Company are using the cases are laid plain, without further protection, but in the work which has been put down for Messrs. A. and S. Gatti in the Strand, the bitumen conduit is enclosed in a three-sided iron trough, which is used upside down; that is, there is iron above but none below where the conduit rests on the ground. Figs. 22 and 23 show the general form of the conduits, the method of packing them, and of covering the joints. These bitumen conduits with the holes through them are made to project a couple of inches at each end beyond their iron case. To join them together, two are brought end to end, and the mandrils of the proper size pushed through the holes into the next block so that they pass through the joints. The bitumen is then poured over the joint and the conduits pressed against its neighbour. A short piece of iron troughing of the same shape as the longer pieces containing the conduit is then made hot and slipped over the joint, melting the bitumen to some extent and making everything perfectly solid and water-tight. After the joint has had time to cool sufficiently, the mandrils are withdrawn, and the laying of the next section proceeded with. The Callender Company state that they are able to draw long lengths of cable into these conduits and to withdraw them if necessary.

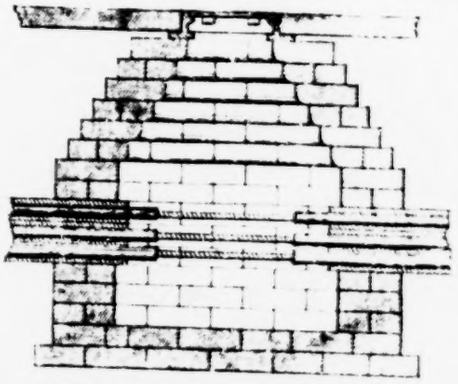


Fig. 24.—Callender-Webber system. Manhole.

Junction boxes and manholes are used with this system as per sketch (Fig. 24), being arranged to suit the requirements of each special case.

It will be noticed that in joining together the sections in the Callender-Webber system the blocks are simply made continuous, nothing being used at the joints. This is a somewhat important point, as the paper tubes used to keep the holes free at the joints, in work somewhat on the same lines in America, have proved a considerable source of subsequent trouble. It has often been objected to this class of conduit that it may crack, but in practice it is not found to do so; the bituminous being of a slightly viscous nature, has always a certain amount of give in it.

Conclusion.

The description of the leading systems of laying underground mains at present in use is now concluded, and a tabulated list is appended giving the methods and systems employed in some of the best known installations, which in this form it is hoped may prove useful, and to which the editor will be glad to receive any additions.

List of Central Electric Light Stations showing Underground Distributing Systems.

Town.	Company and System.	Underground Mains.
London	London Electric Supply Corporation; alternating 2,500 volts	In the Strand, Holborn, Victoria Street, Westminster, Kensington, Knightsbridge, Chelsea, Pimlico, Belgravia, Mayfair, Marylebone, Paddington, Bayswater, Notting Hill, Shepherd's Bush, Hammersmith, Fulham, Putney, Wandsworth, Clapham, Battersea, Brixton, Camberwell, Peckham, Dulwich, Norwood, Streatham, Tooting, Balham, Lambeth, Kennington, Stockwell, Vauxhall, Southwark, Bermondsey, Rotherhithe, Deptford, Greenwich, Lewisham, Blackheath, Woolwich, Plumstead, Charlton, Eltham, Shooter's Hill, Hampstead, Highgate, Finchley, Hornsey, Tottenham, Edmonton, Enfield, Walthamstow, Leyton, Wanstead, Woodford, Ilford, Barking, Chingford, Stratford, Bow, Poplar, Limehouse, Stepney, Whitechapel, Bethnal Green, Hackney, Shoreditch, Islington, Holloway, Kentish Town, Camden Town, St. Pancras, Hampstead, Willesden, Kilburn, Harlesden, Acton, Chiswick, Brentford, Ealing, Hanwell, Southall, Hounslow, Isleworth, Twickenham, Richmond, Kew, Barnes, Mortlake, Wimbledon, Kingston, Surbiton, Malden, Coombe, Merton, Sutton, Croydon, Penge, Beckenham, Bromley, Sydenham, Forest Hill, Lee, Catford, Eltham, Kidbrooke, Blackheath, Charlton, Woolwich, Plumstead, Shooter's Hill, Erith, Crayford, Bexley, Dartford, Sidcup, Chislehurst, Orpington, Farnborough, Keston, Hayes, Coulsdon, Purley, Caterham, Warlingham, Oxted, Limpsfield, Godstone, Tatsfield, Westerham, Edenbridge, Leatherhead, Epsom, Ewell, Cheam, Carshalton, Wallington, Mitcham, Morden, Tooting, Balham, Streatham, Norbury, Thornton Heath

Town.	Company and System.	Underground Mains.
London	Kensington and Knightsbridge Electric Lighting Company; low tension.	Cement conduits with bare copper rods on glass insulators. Callender cables when no room for this. (Crompton system.)
"	St. James and Pall Mall Electric Light Company; low tension.	Copper strips on china insulators in iron troughs.
"	Chelsea Electricity Supply Company; low tension and battery.	Callender-Webber conduits and Callender cables.
"	Gatti Bros., Strand; low tension.	Callender-Webber system.
"	Westminster Electric Supply Corporation; low tension.	Probably Crompton's system.
Bradford	Corporation; low tension.	Siemens' cables.
Leamington	Midland Electric Light and Power Company; low tension.	Brick conduits and Callender cables.
Bath	Bath Electric Light Works; arc and alternate, 2,000 volts.	Callender, solid conduits.
Eastbourne, Hastings, Brighton	Local Companies; alternating, 1,000 volts and arcs.	India rubber cables, in iron pipes when underground.
Liverpool	Liverpool Electric Supply Company; low tension.	Callender, solid bitumen conduits.
Paris	Municipality; Halles Centrales; alternating, low tension.	Rubber covered cables on insulators in conduits and sewers.
Berlin	Low tension.	Siemens' armoured cables.
Rome, Milan, Turin	Alternating, 2,000 volts.	Siemens' armoured concentric cables.
New York	Edison Company; low tension.	Edison Company's system and cables, in separate iron pipes for feeders.
New York	Illuminating Company; chiefly arc.	Board of Electrical Control subways, chiefly iron pipes and hard rubber lead protected cables.
Chicago	Illuminating Company; chiefly arc.	Principally iron pipes with ebonite cables in them, partly sewers.

PROBLEMS IN THE PHYSICS OF AN ELECTRIC LAMP.*

BY PROF. J. A. FLEMING, M.A., D.SC., M.R.I.

More than eighty years ago Sir Humphrey Davy provided the terminal wires of his great battery of 2,000 pairs of plates with rods of carbon, and, bringing their extremities in contact, obtained for the first time a brilliant display of the electric arc.† The years that have fled away since that time have seen all the marvellous developments of electro magnetic engineering, have placed in our possession the electric glow lamp, and brought the art of electrical illumination to a condition in which it progresses each year with giant strides. In addition to the importance attaching to their ever increasing industrial use, there are many questions of purely scientific interest which present themselves to our minds when we proceed to examine the actions that take place when a carbon conductor is rendered incandescent in a high vacuum, or when an electric arc is formed between two carbon poles. It is to a very few of these physical problems that I desire to direct your attention to-night, but more especially to one which is particularly interesting from the bearing which it has on the general nature of electric discharge.

We know as a very familiar fact that if we attempt to raise the temperature of a carbon conductor enclosed in a vacuum beyond a certain limit, not far removed from the melting point of platinum, the carbon begins to volatilise with great rapidity. If an electric glow lamp has passed through its carbon more than a certain strength of current, the glass bulb speedily becomes darkened by a deposit of this volatilised carbon condensed upon it; and experience shows us that we cannot raise the temperature of that carbon beyond a definite point without causing this waste of the conductor to become very rapid. In the highly rarefied atmosphere within the bulb of a glow lamp, the carbon, when at its normal incandescence, must be considered to be projecting off molecules of carbon in all directions, partly in virtue of purely thermal actions, but probably also in consequence of certain electrical effects to be presently discussed. This scattering of the material of the carbon conductor takes place with disadvantageous rapidity from an industrial point of view at and beyond a certain temperature,* but it exists as well at much lower temperatures than that which is found to determine the practical limit of durability. A curious appearance is found in many incandescent lamps which have been "over run," which shows us that this projection of carbon molecules from the hot conductor is not, perhaps, best described by calling it a vaporisation of its substance, but that the surface molecules are shot off in straight lines, and that they reach the glass envelope without being hindered to any great extent by the molecules of the residual air.

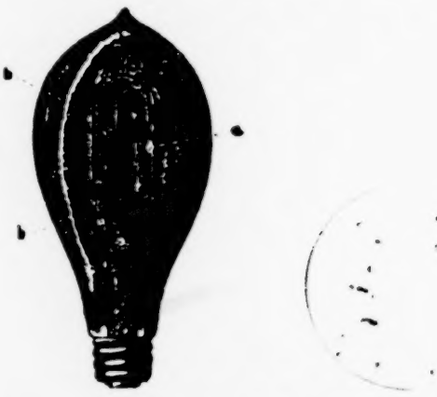


Fig. 1.—Glow lamp having the glass bulb blackened by deposit of carbon. Molecular scattering having taken place at a, and shadow of loop of deposit produced at b.

If an electric current is passed through an otherwise uniform carbon conductor, which possesses at any one place a specific resistance higher than that of the remaining portion, the current, in accordance with a well known law, there develops a higher temperature, and the molecular scattering at that spot may in consequence be greatly exaggerated. It may be that the deterioration of the conductor at that locality will be so great as to cut it through after a very short time. When the carbon has the form of a simple horseshoe loop, and when this molecular scattering takes place from some point in the middle of one branch, the molecular projection makes itself evident by producing a "molecular shadow" of the other leg upon the interior of the glass. I will project upon the screen an image of the carbon horseshoe loop taken from an old glow lamp, and you will be able to see that the filament has been cut through at one place. At that position some minute congenital defect caused the carbon to have a higher resistance, the temperature at that point when it was in use became excessive, and an intensified molecular scattering took place from that locality. On examining the glass bulb from which it was taken, we find that the glass has been everywhere darkened by a deposit of the scattered carbon except along one narrow line, (see Fig. 1), and that line is in the plane of the carbon loop and on the side opposite to the point of rupture of the filament.

* A discourse delivered at the Royal Institution on Friday evening, February 14, 1890.

† Sir Humphrey Davy had a request before the managers of the Royal Institution on July 11, 1808, that they would set on foot a subscription for the purchase of a large galvanic battery. The result of the suggestion was that a galvanic battery of 2,000 pairs of copper and zinc plates were set up in the Royal Institution, and one of the earliest experiments performed with it was the production of the electric arc between carbon poles on a large scale. It is probable, however, that Davy had produced the light on a small scale some six years before, and according to Quetelet, observed the arc between carbon points in 1802. See De Parr "Life of Sir H. Davy."

* When the rate of expenditure of energy in the carbon conductor is raised until it reaches a value of about 500 watts or 360 foot pounds per second per square inch of heated surface, a limit of useful temperature has been reached for practical working, under the usual present conditions of construction of glow lamps and in electric glow lamps.

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I might illustrate to you by a very simple experiment the way in which that "shadow" has been formed. Here is a ⋂-shaped rod: this shall represent the carbon conductor in the lamp; this sheet of cardboard placed behind it, the side of the glass receiver. I have affixed a little spray-producer to one side of the loop, and from that point blow out a spray of inky water. Consider the ink spray to represent the carbon atoms shot off from the overheated spot. We see that the cardboard is bespattered on all points except along one line where it is sheltered by the opposite side of the loop. We have thus produced a "spray shadow" on the board (Fig. 2). The existence of these molecular shadows in incandescent lamps leads us therefore to recognise that the carbon atoms must be shot off in straight lines, or else obviously no such sharp shadow could thus be formed. This phenomenon confirms in a very beautiful manner the deductions of the Kinetic theory of gases. I may remind you that at the ordinary temperature and pressure the mean free path of a molecule of air is deduced to be about four one-millionths of an inch. This is the average distance which such a gaseous molecule moves over before meeting with a collision against a neighbour which changes the direction of its path. Let the air be rarefied, as in these bulbs, to something like a millionth of the ordinary atmospheric pressure, and the mean free path is increased to several inches. The space within the bulb—though from one point of view densely populated with molecules of residual air—is yet, as a fact, in such a condition of rarefaction that a carbon molecule projected from the conductor can move over a distance of three or four inches on an average without meeting with interference by collision with another molecule, and the facts revealed to us by these shadows show that this must be the case. I have also at hand some Edison lamps in which these "molecular shadows" are finely shown, but in these cases the deposit on the interior of the bulb is not carbon but copper, because the molecular scattering has here taken place by excessive temperature developed at the copper clamps by which the carbon filament is attached to the platinum wires.

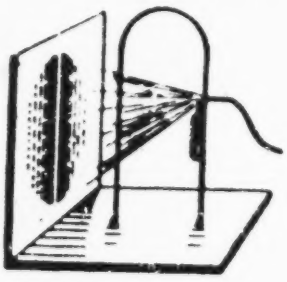

FIG. 2.—"Spray shadow" of a rod thrown on blotting paper screen to illustrate formation of molecular shadow in glow lamps.

The theory, however, is the same. The deposit of copper shows a fine green colour by transmitted light in the thinner portions. One curious lamp also before me had by an accident an aluminium plate volatilised within the bulb. The glass receiver has in consequence been covered with a mirror-like deposit of aluminium, which on the thinner portions shows a fine blue colour by transmitted light, and a silvery lustre by reflected light. This lamp also shows a fine "molecular shadow."

These facts prepare us to accept the view that when a glow-lamp is in operation the highly rarefied residual air in the interior of the bulb is being traversed in all directions by multitudinous carbon atoms projected off from the incandescent carbon conductor. I now wish to pass in review before you some facts which indicate that these carbon atoms *carry* with them electric charges, and that they are charged, if at all, with *negative electricity*. I may preface all by saying that much of what I have to show you will be seen to be closely related to the phenomena studied by Mr. Crookes in his splendid and classical researches on radiant matter. Our starting point for this purpose is a discovery made by Mr. Edison in 1884, and which received careful examination at the hands of Mr. Preece in the following year,* and by myself more recently. Here is the initial experiment. A glow-lamp having the usual horseshoe-shaped carbon (see Fig. 3) has a metal plate held on a platinum wire sealed through the glass bulb. This plate is so fixed that it stands up between the two sides of the carbon arch without touching either of them. We shall illuminate the lamp by a continuous current of electricity, and for brevity's sake speak of

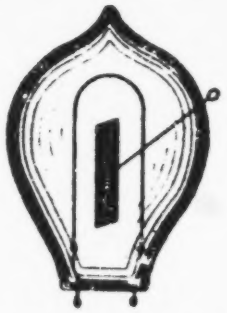

FIG. 3.—Glow lamp having insulated metal. Middle plate M sealed into bulb to exhibit "Edison effect."

that half of the loop of carbon on the side by which the current enters it as the negative leg, and the other half of the loop as the positive leg. The diagram in Fig. 4. shows the posi-

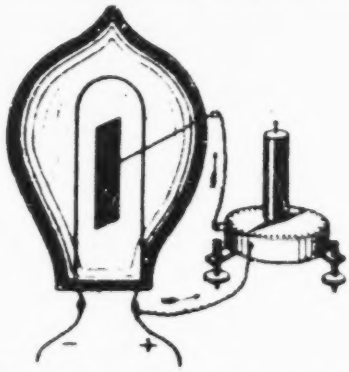

FIG. 4.—Sensitive galvanometer connected between the middle plate and positive electrode of a glow lamp, showing current flowing through it when the lamp is in action ("Edison effect").

tion of the plate with respect to the carbon loop. There is a distance of half an inch, or in some cases many inches, between either leg of the carbon and this middle plate. Setting the

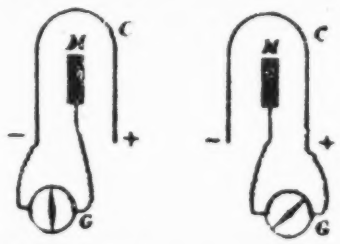

FIG. 5.—Mode of connection of galvanometer G to middle plate M and carbon-horse shoe shaped conductor C in the experiment of the "Edison effect."

lamp in action, I connect a sensitive galvanometer between the middle plate and the *negative terminal* of the lamp, and you see that there is no current passing through the instrument. If, however, I connect the terminals of my galvanometer to the middle plate and to the *positive electrode* of the lamp, we find a current of some milliamperes in passing through it. The diagrams in Fig. 5 show the mode of connection

* W. Preece's interesting Paper on this subject is published in the *Proceedings of the Royal Society* for 1885, p. 219. See also *The Electrician*, April 4, 1885, p. 436.

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of the galvanometer in the two cases. This effect, which is often spoken of as the "Edison effect," clearly indicates that an insulated plate so placed in the vacuum of a lamp in action is brought down to the same potential or electrical state as the negative electrode of the carbon loop. On examining the direction of the current through the galvanometer we find that it is equivalent to a flow of negative electricity taking place through it *from* the middle plate *to* the positive electrode of the lamp. A consideration of this fact shows us that there must be some way by which negative electricity gets across the vacuous space from the negative leg of the carbon to the metal plate, whilst at the same time a negative charge cannot pass from the metal plate across to the positive leg. Before I pass away from this initial experiment, I should like to call your

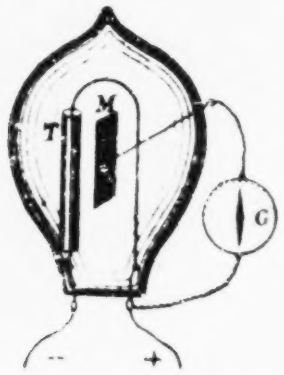

FIG. 6.—Glow lamp, having negative leg of carbon enclosed in glass tube. The "Edison effect" thereby being annulled or greatly lessened.

attention to a curious effect at the moment when the lamp is extinguished. Connecting the galvanometer as at first, between the middle plate and the negative electrode of the lamp, we notice that though made highly sensitive the galvanometer indicates no current flowing through it whilst the lamp is in action. Switching off the current from the lamp-producer, as you see, a violent kick or deflection of the galvanometer, indicating a sudden rush of current through it

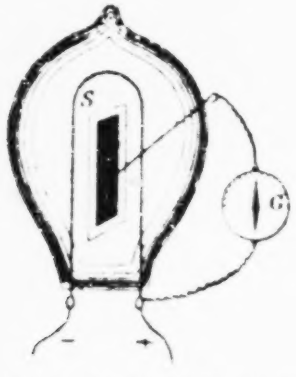

FIG. 7.—Glow lamp having one leg of carbon enclosed in glass tube, S, interposed between middle plate M and the negative leg of carbon thereby lessening the Edison effect.

In endeavouring to ascertain further facts about this effect one of the experiments which early suggested itself was one directed to determine the relative effects of different portions of the carbon conductor. Here is a lamp (see Fig. 6) in which one leg of the carbon loop has been enclosed in a glass tube of the size of a quill which shuts in one half of the carbon. The bulb contains, as before, an insulated middle plate. If we pass the actuating current through this lamp in such a direction that the covered or shielded leg is the *positive* leg, we find the effect existing as before. A galvanometer connected between the plate and positive terminal of the lamp yields a strong current, say of deflection 60 between the negative terminal and the middle plate there is no current at all. Let us, however, reverse the current through the lamp so that the shielded or enclosed leg is now the negative one, and the galvanometer is able to detect no current, whether connected in one way or in the other. We establish, therefore, the conclusion that it is the negative leg of the carbon loop which is the active agent in the production of this "Edison effect," and that if it is enclosed in a tube of either glass or metal, no current is found flowing in a galvanometer connected between the positive terminal of the lamp and this middle collecting plate.

Another experiment which confirms this view is as follows:—This lamp (see Fig. 7) has a middle plate, which is provided with a little mica flap or shutter on one side of it. When the lamp is held upright the mica shield falls over and covers one side of the plate, but when it is held in a horizontal position the mica shield falls away from the front of the plate and exposes it. Using this lamp as before we find that when the positive leg of the carbon loop is opposite to the shielded face of the plate, we get the "Edison effect" as before in any position of the lamp. Reversing the lamp current and making that same leg the *negative* one, we find that when the lamp is so held the metal plate is shielded by the interposition of the mica, and the galvanometer current is very much less than when the shield is shaken on one side and the plate exposed fully to the negative leg.

(To be continued.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

(To night) FRIDAY, February 21st.

PHYSICAL SOCIETY.

8 p.m. Papers to be read: 1. "On a Carbon Deposit in a Blake Telephone Transmitter." By E. B. HAWES. 2. "The Geometrical Construction of Direct Reading Scales for Reflecting Instruments." By A. P. TROTTER, B.A. 3. "A Parallel Motion Suitable for Recording Instruments." By A. P. TROTTER, B.A. 4. "On Electrode Refractometer." By Prof. S. P. THOMPSON.

INSTITUTION OF CIVIL ENGINEERS.

7½ p.m. Students Meeting. Paper to be read: "Some Types of American Locomotives and their Construction." By C. S. COCHRANE, Stud. Inst. C.E.

ROYAL INSTITUTION.

7 p.m. Lecture: "Magnetic Phenomena." By SHELFORD BIDWELL, F.R.S.

SATURDAY, February 22nd.

ROYAL INSTITUTION.

3 p.m. Lecture: "Electricity and Magnetism." By the Right Hon. Lord RAYLEIGH, F.R.S.

TUESDAY, February 25th.

ROYAL INSTITUTION.

3 p.m. Lecture: "The Post-Darwinian Period." By G. J. ROMANES, F.R.S.

INSTITUTION OF CIVIL ENGINEERS.

8 p.m. Ordinary Meeting. Papers to be further discussed: "The Shanghai Water Works." By J. W. HILL, M.Inst.C.E. "The Tytam Water Works, Hong Kong." By Jas. ORANGE, Assoc.M.Inst.C.E. "The Construction of the Yokohama Water Works." By C. G. W. TURNER, Assoc.M.Inst.C.E.

WEDNESDAY, February 26th.

SOCIETY OF ARTS.

8 p.m. Ordinary Meeting. Paper to be read: "The Fog Fiends." By ARTHUR MEE, F.R.A.S.

THURSDAY, February 27th.

SOCIETY OF ARTS.

4 p.m. Indian Section. Paper to be read: "The Northern Shan States and the Burma-China Railway." By WARREN SOMMER.

LONDON INSTITUTION.

5 p.m. Lecture: "The Rise of British Dominion in India." By Sir ALFRED LYALL, K.C.B.

INSTITUTION OF ELECTRICAL ENGINEERS.

8 p.m. Ordinary Meeting. Discussion on the following Papers: "The Theory of Armature Reaction in Dynamos and Motors." By JOHN SWINBURNE, M.E.E.I. "Some Points in Dynamo and Motor Design." By W. H. [illegible], M.E.E.

Vol. V

EXHIBITS

TRANSCRIPT OF RECORD

Supreme Court of the United States

OCTOBER TERM, 1942

No. 369

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA, PETITIONER,

vs.

THE UNITED STATES

No. 373

THE UNITED STATES, PETITIONER,

vs.

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA

ON WRITS OF CERTIORARI TO THE COURT OF CLAIMS

PETITIONS FOR CERTIORARI FILED { SEPTEMBER 2, 1942.
SEPTEMBER 3, 1942.

CERTIORARI GRANTED DECEMBER 14, 1942

SUPREME COURT OF THE UNITED STATES

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N-1 "Proceedings of the Physical Society of London", March 27, 1896, pp. 187-242	3033	3465
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T-1 "Philosophical Magazine", 1899, Vol. 48, Thomson article beginning p. 547	3078	3519
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JUDD & DETWEILER (INC.), PRINTERS, WASHINGTON, D. C., FEBRUARY 4, 1943.

[fol. 3016] DEFENDANT'S EXHIBIT L-1

The Electrician, London, February 21, 1890

Problems in the Physics of an Electric Lamp[1]

By Prof. J. A. Fleming, M.A., D.SC., M.R.I.

(Concluded from page 395.)

At this stage it will perhaps be most convenient to outline briefly the beginnings of a theory proposed to reconcile these facts, and leave you to judge how far the subsequent experiments confirm this hypothesis. The theory very briefly is as follows: From all parts of the incandescent carbon loop, but chiefly from the negative leg, carbon molecules are being projected which carry with them, or are charged with, negative electricity. I will in a few moments make a suggestion to you which may point to a possible hypothesis on the manner in which the molecules acquire this negative charge. Supposing this, however, to be the case, and that the bulb is filled with these negatively charged molecules, what would be the result of introducing into their midst a conductor such as this middle metal plate which is charged positively? Obviously, they would all be attracted to it and discharge against it. Suppose the positive charge of this conductor to be continually renewed, and the negatively-charged molecules continually supplied, which conditions can be obtained by connecting the middle plate to the positive electrode of the lamp, the obvious result will be to produce a current of electricity flowing through the wire or galvanometer, by means of which this middle plate is connected to the positive electrode of the lamp. If, however,

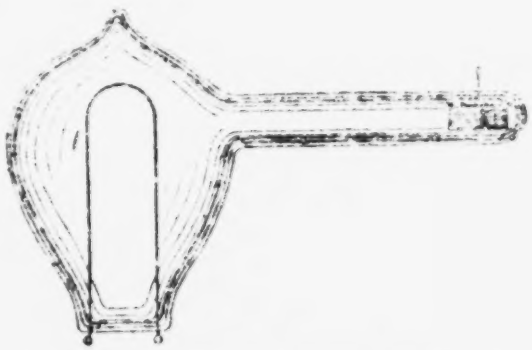


FIG 5. Collecting plate placed at end of tube in line of length, opening out of bulb

[1] A discourse delivered at the Royal Institution on Friday evening, February 14, 1890.

the middle plate is connected to the negative electrode of the lamp, the negatively-charged molecules can give up no charge to it, and produce no current in the interpolated galvanometer. We see that on this assumption the effect must necessarily be diminished by any arrangement which prevents these negatively-charged molecules from *de*ing shot off the negative leg or from striking against the middle plate. Another obvious corollary from this theory is that the "Edison effect" should be annihilated if the metal collecting plate is placed at a distance from the negative leg much greater than the mean free path of the molecules.

Here are some experiments which confirm this deduction. In this bulb (Fig. 8) the metal collecting plate, which is to be connected through the galvanometer with the positive [fol. 3017] terminal of the lamp, is placed at the end of a long tube opening out of and forming part of the bulb. We find the "Edison effect" is entirely absent, and that the galvanometer current is zero. We have, as it were, placed our target at such a distance that the longest range molecular bullets cannot hit it, or, at least, but very few of them do so. Here again is a lamp in which the plate is placed at the extremity of a tube opening out of the bulb, but bent at right angles (Fig. 9). We find in this case, as first discovered by Mr. Preece, that there is no "Edison effect." Our molecular marksman cannot shoot round a corner. None of the negatively charged molecules can reach the plate, although that plate is placed at a distance not greater than would suffice to produce the effect if the bend were straightened out. Following out our hypothesis into its consequences would lead us to conclude that the material of which the plate is made is without influence on the result, and this is found to be the case. Many of the foregoing facts were established by Mr. Preece as far back as 1885, and I have myself abundantly confirmed his results.

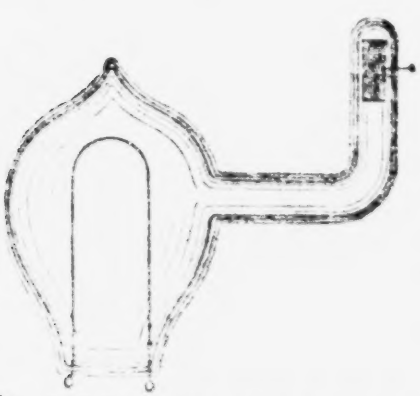


Fig. 9. Collecting plate placed at end of a bent tube opening out of bulb.

We should expect also to find that the larger we make our plate, and the nearer we bring it to the negative leg of the carbon, the

greater will be the current produced in a circuit connecting this plate to the positive terminal of the lamp. I have before me a lamp with a large plate placed very near the negative leg of the carbon of a lamp, and we find that we can collect enough current from these molecular charges to work a telegraph relay and ring an electric bell. The current which is now working this relay is made up of the charges collected by the plate from the negatively-charged carbon molecules which are projected against it from the negative leg, across the highly perfect vacuum. I have tried experiments with lamps in which the collecting plate is placed in all kinds of positions, and has various forms, some of which are here, and are represented in the diagrams before you; but the result may all be summed up by saying that the greatest effects are produced when the collecting plate is as near as possible to the base of the negative end of the loops, and, as far as possible, encloses, without touching, the carbon conductor. Time will not permit me to make more than a passing reference to the fact that the magnitude of the current flowing through the galvanometer when connected between the middle plate and the positive terminal of the lamp often "jumps" from a low to a high value, or *vice versâ*, in a remarkable manner, and that this sudden change in the current can be produced by bringing strong magnets near the outside of the bulb.

Let us now follow out into some other consequences this hypothesis that the interior of the bulb of a glow lamp when in action is populated by flying crowds of carbon atoms all carrying a negative charge of electricity. Suppose we con- [fol. 3018] nect our middle collecting plate with some external reservoir of electric energy, such as a Leyden jar, or with a condenser equivalent in capacity to many hundreds of Leyden jars, and let the side of the condenser which is charged positively be first placed in connection through a galvanometer with the middle plate (see Fig. 10), whilst the negative side is placed in connection with the earth. Here is a condenser of two microfarads capacity so charged and connected. Note what happens when I complete the circuit and illuminate the lamp by passing the current through its filament. The condenser is at once discharged. If, however, we repeat the same experiment with the sole difference that the negatively charged side of the condenser is in connection with the middle plate then there is no discharge. The experimental results may be regarded

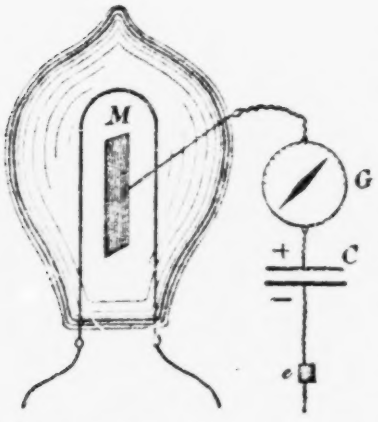


FIG. 10.—Charged condenser C discharges by middle plate M, when the positively charged side of condenser is in connection with the plate and other side to earth e.

from another point of view. In order that the condenser may be discharged as in the first case it is essential that the negatively charged side of the condenser shall be in connection with some part of the circuit of the incandescent carbon loop. This experiment with the condenser discharged by the lamp may be then looked upon as an arrangement in which the plates of a charged condenser are connected respectively to an incandescent carbon loop and to a cool metal plate, both being enclosed in a highly vacuous space, and it appears that when the incandescent conductor is the negative electrode of this arrangement the discharge takes place, but not when the cooler metal plate is the negative electrode of the charged condenser. The negative charge of the condenser can be carried across the vacuous space from the hot carbon to the colder metal plate, but not in the reverse direction.

This experimental result led me to examine the condition of the vacuous space between the middle metal plate and the negative leg of the carbon loop in the case of the lamp employed in our first experiment. Let us return for a moment to that lamp. I join the galvanometer between the middle plate and the negative terminal of the lamp, and find, as before, no indication of a current. The metal plate and the negative terminal of the lamp are at the same electrical potential. In the circuit of the galvanometer we will insert a single galvanic cell having an electromotive force of rather over one volt. In the first place let that cell be so inserted that its negative pole is in connection with the middle plate, and its positive pole in connection through the galvanometer with the negative terminal of the lamp (see Fig. 11). Regarding the circuit of that cell alone, we find that it consists of the cell itself, the galvanometer wire, and that half inch of highly vacuous space between the hot carbon conductor and the middle plate. In that circuit the [fol. 3019] cell cannot send any sensible current at all, as

it is at the present moment connected up. But if we reverse the direction of the cell so that its positive pole is in connection with the middle plate, the galvanometer at once gives indications of a very sensible current. This highly vacuous space, lying between the middle metal plate on the one hand and the incandescent carbon on the other, possesses a kind of unilateral conductivity, in that it will allow the current from a single galvanic cell to pass one way but not the other. It is a very old and familiar fact, that in order to send a current from a battery through a highly rarefied gas by means of metal electrodes, the electromotive force of the battery must exceed a certain value. Here, however, we have indication that if the negative electrode by which that current seeks to enter the vacuous space is made incandescent the current will pass at a very much lower electromotive force than if the electrode is not so heated.

A little consideration of the foregoing experiments led to the conclusion that in the original experiment, as devised by Mr. Edison, if we could by any means render the middle plate very hot, we should get a current flowing through a galvanometer when it is connected between the middle plate and the negative electrode of the carbon. This experiment can be tried in the manner now to be shown. Here is a bulb (Fig. 12) having in it two carbon loops; one of these is of ordinary size and will be rendered incandescent by the current from the mains. The other loop is very small, and will be heated by a well insulated, secondary battery. This smaller incandescent loop shall be employed just as if it were a middle metal plate. It is in fact, simply an incandescent middle conductor. On repeating the typical experiment with this arrangement we find that the galvanometer indicates a current when connected between the middle loop and either the positive or the negative terminal of the main carbon. I have little doubt but that if we could render the platinum plate in our first-used lamp incandescent by con-

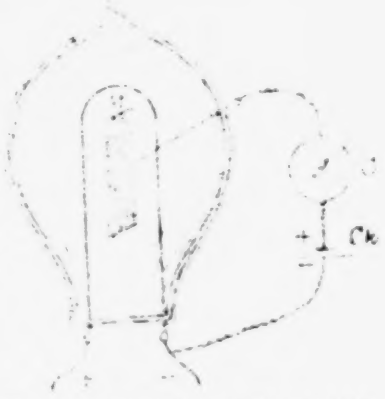


Fig. 12.—Current from Clark cell (Ck) through vacuous space between carbon loop (–) and middle plate M. Positive pole of cell in connection with plate M through galvanometer G.

centrating on it from outside a powerful beam of radiant heat we should get the same result.

A similar set of results can be arrived at by experiments with a *a* bulb constructed like an ordinary vacuum tube, and having small carbon loops at each end instead of the usual platinum or aluminum wires. Such a tube is now before you (see Fig. 13), and will not allow the current from a few cells of a secondary battery to pass through it when the carbon loops are cold. If, however, by means of well insulated secondary batteries we render both of the carbon loop electrodes highly incandescent, a single cell of a battery is sufficient to pass a very considerable current across that vacuous [fol. 3020] space provided the resistance of the rest of the circuit is not large. We may embrace the foregoing facts by saying that if the electrodes, but especially the negative electrode, which form the means of ingress and egress of a current into a vacuous space are capable of being rendered highly incandescent, and if at that high temperature they are made to differ in electrical potential by the application of a very small electromotive force, we may get under these circumstances a very sensible current through the rarefied gas. If the electrodes are cold a very much higher electromotive force will be necessary to begin the discharge or current through the space.* These facts have been made the subject of elaborate investigation by Hittorf and Goldstein, and more recently by Elster and Geitel. It is to Hittorf that I believe we are indebted for the discovery of the fact that by heating the negative electrode we greatly reduce the apparent resistance of a vacuum.

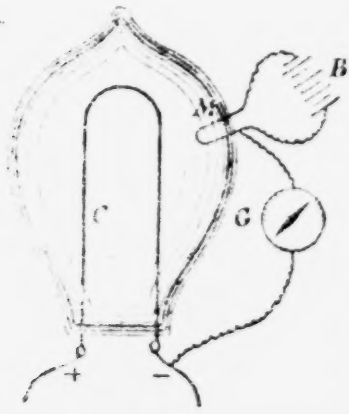


FIG. 13.—Experiment showing that when the "middle plate" is a carbon loop rendered incandescent by an insulated battery *B*, a current of negative electricity flows from *M* to the positive leg of main carbon *C* across the vacuum.

Permit me now to pave the way by some other experiments for a little more detailed outline of the manner in which I shall venture to suggest these negative molecu-ar charges are bestowed. This is really the important matter to examine. In seeking for some probable explanation of the manner in which these wandering molecules of carbon in the glow-lamp bulb obtain their negative charges, I fall

back for assistance upon some facts discovered by the late Prof. Guthrie. He showed some years ago new experiments

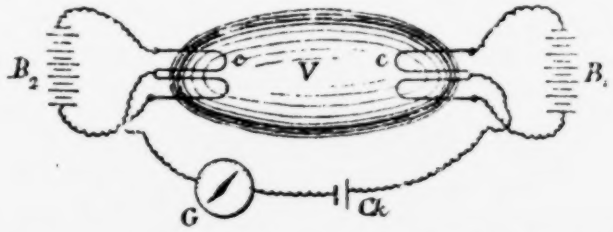


FIG. 13.—Vacuum tube having carbon loop electrodes, cc, at each end rendered incandescent by insulated batteries, B_1 B_2, showing current from Clark cell, CA, passing through the high vacuum when the electrodes are incandescent.

on the relative powers of incandescent bodies for retaining positive and negative charges. One of the facts he brought forward [2] was that a bright red-hot iron ball, well insulated, could be charged negatively, but could not retain for an instant a positive charge. He showed this fact in a way which it is very easy to repeat as a lecture experiment. Here is a gold-leaf electroscope, to which we will impart a positive charge of electricity, and project the image of its divergent leaves on the screen. A poker the tip of which had been made [fol. 3021] brightly red hot is placed so that its incandescent end is about an inch from the knob of the electroscope. No discharge takes place. Discharging the electroscope with my finger, I give it a small charge of negative electricity, and replace the poker in the same position. The gold leaves instantly collapse. Bear in mind that the extremity of the poker when brought in contiguity to the knob of the charged electroscope becomes charged by induction with a charge of the opposite sign to that of the charge of the electroscope, and you will at once see that this experiment confirms P of. Guthrie's statement, for the negatively-charged electroscope induces a positive charge on the incandescent iron, and this charge cannot be retained. If the induced charge on the poker is a negative charge it is retained, and hence the positively-charged electroscope is not discharged, but the negatively-charged electroscope at once loses its charge. Pass in imagination from iron balls to carbon molecules. We may ask whether it is a legitimate assumption to suppose the same fact to hold good for them, and that a hot

[2] "On a New Relation between Electricity and Heat," *Phil., Mag.*, Vol. XLV, p. 308. 1873.

carbon molecule or small carbon mass just detached from an incandescent surface behaves in the same way and has a greater grip for negative than for positive charge? If this can possibly be assumed, we can complete our hypothesis as follows: Consider a carbon molecule or small congerie of molecules just set free by the high temperature from the negative leg of the incandescent carbon horseshoe. This small carbon mass finds itself in the electrostatic field between the branches of the incandescent carbon conductor (*see* Fig. 14). It is acted upon inductively, and if it behaves like the hot iron ball in Prof. Guthrie's experiment it loses its positive charge. The molecule then being charged negatively is repelled along the lines of electric force against the positive leg. The forces moving it are electric forces, and the repetition of this action would cause a torrent of negatively charged molecules to pour across from the negative to the positive side of the carbon horseshoe. If we place a metal plate in their path, which is in conducting connection with the positive electrode of the lamp carbon, the negatively-charged molecules will discharge themselves against it. A plate so placed may catch more or less of this stream of charged molecules which pour across between the heels of the carbon loop. There are many extraordinary facts, which as yet I have been able only imperfectly to explore, which relate to the sudden changes in the direction of the principal stream of these charged molecules, and to their guidance under the influence of magnetic forces. The above rough sketch of a theory must be taken for no more than it is worth, viz., as a working hypothesis to suggest further experiments.

FIG. 14.—Rough diagram illustrating a theory of the manner in which projected carbon molecules may acquire a negative charge.

These experiments with incandescent lamps have prepared the way for me to exhibit to you some curious facts with respect to the electric arc, and which are analogous to those which we have passed in review. If a good electric [fol. 3622] arc is formed in the usual way, and if a third insulated carbon held at right angles to the other two is placed so that its tip just dips into the arc (*see* Fig. 15), we can show a similar series of experiments. It is rather more under control if we cause the arc to be projected against

the third carbon by means of a magnet. I have now formed on the screen an image of the carbon poles and the arc between them in the usual way. Placing a magnet at the back of the arc, I cause the flame of the arc to be deflected laterally and to blow against a third insulated carbon held in it. There are three insulated wires attached respectively to the positive and to the negative carbons of the arc, and to the third or insulated carbon, the end of which dips into the flame of the arc projected by the magnet. On starting the arc this third carbon is instantly brought down to the same electrical potential as the negative carbon of the arc, and if I connect this galvanometer in between the negative carbon and the third or insulated carbon I get, as you see, no indication of a current. Let me, however, change the connections and insert the circuit of my galvanometer in between the positive carbon of the arc and the middle carbon, and we find evidence, by the violent impulse given to the galvanometer that, there is a strong current flowing through it. The direction of this current is equivalent to a flow of negative electricity from the middle carbon through the galvanometer to the positive carbon of the arc. We have here then the "Edison effect" repeated with the electric arc. So strong is the current flowing in a circuit connecting the middle carbon with the positive carbon that I can, as you see, ring an electric bell and light a small incandescent lamp when these electric-current detectors are placed in connection with the positive and middle carbons.

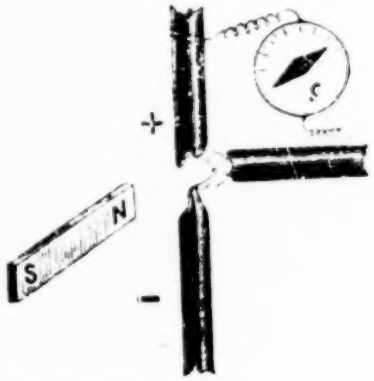


FIG. 15.—Electric arc projected by magnet against a third carbon, and showing strong electric current flowing through a galvanometer, G, connected between the positive and third carbon.

We also find that the flame-like projection of the arc between the negative carbon possesses a unilateral conductivity. I join this small secondary battery of fifteen cells in series with the galvanometer, and connect the two between the middle carbon and the negative carbon of the arc. Just as in the analogous experiment with the incandescent lamp, we find we can send negative electricity along the flame of

the arc one way but not the other. The secondary battery causes the galvanometer to indicate a current flowing through it when its negative pole is in connection with the negative carbon of the arc (*see* Fig. 16), but not when its positive pole is in connection with the negative carbon. On examining the third or middle carbon after it has been employed in this way for some time we find that its extremity is cratered out and converted into graphite, just as if it had been employed as the positive carbon in forming an electric [fol. 3023] arc. Time forbids me to indulge in any but the briefest remarks on these experiments; but one suggestion may be made, and that is that they seem to indicate that the chief movement of carbon molecules in the electric arc is *from* the negative *to* the positive carbon. The idea suggests itself that, after all, the cratering out of the positive carbon of the arc may be due to a sand-blast action of this torrent of negatively-charged molecules, which are projected from the negative carbon. If we employ a soft iron rod as our lateral pole, we find that, after enduring for some time the projection of the arc against it, it is converted at the extremity into *steel*.

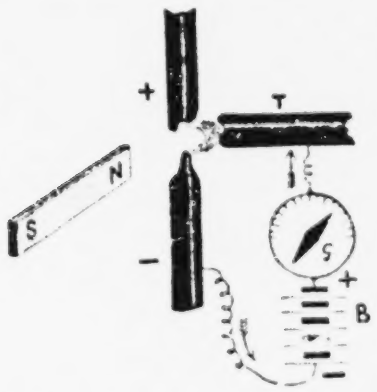


Fig. 16. Galvanometer *G* and battery *B* inserted in series between negative carbon of electric arc and a third carbon to show unilateral conductivity of the arc between the negative and third carbons.

Into the fuller discussion as to the molecular actions going on in the arc, the source and nature of that which has been called the counter-electromotive force of the arc, and the causes contributing to produce unsteadiness and hissing in the arc, I fear that I shall not be able to enter, but will content myself with the exhibition of one last experiment, which will show you that a high vacuum or, indeed, any vacuum, is not necessary for the production of the "Edison effect." Here is a carbon-horseshoe-shaped conductor, not enclosed in any receiver (see Fig. 17). Close to the negative leg or branch, yet not touching it, we have adjusted a little metal plate. The sensitive galvanometer is connected between this metal plate and the

base of the other or positive leg of this carbon arch. On sending a current through the carbon sufficient to bring it to bright incandescence, the galvanometer gives indications of a current flowing through it, and as long as the carbon endures, which is not, however, for many seconds, there is a current of electricity through it equivalent to a flow of negativ electricity from the plate through the galvanometer to the positive electrode of the carbon. The interposition of a thin sheet of mica between the metal plate and the negative leg of the carbon loop entirely destroys the galvanometer current.[3]

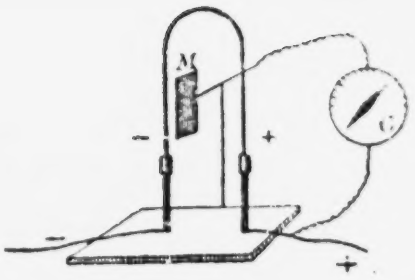


FIG. 17.—"Edison effect" Experiment shown with carbon in open air.

These experiments and brief expositions cover a very small portion of the ground which is properly included within the limits of my subject. Such fragments of it as we have been able to explore to-night will have made it clear [fol. 3024] that it is a region abounding in interesting facts and problems in molecular physics. The glow lamp and the electric arc have revolutionised our methods of artificial lighting, but they present themselves also as subjects of scientific study, by no means yet exhausted of all that they have to teach.

[fol. 3025-3026] DEFENDANT'S EXHIBIT M-1

Transactions of American Institute of Electrical Engineers, 1897

The second part of this paper, which relates to the conductivity of the vacuous space surrounding incandescent filaments, may be considered as a discussion of the paper upon the "Edison Effect" in incandescent lamps, which was read before the INSTITUTE by Professor Houston, in October, 1884, and which was the first paper read before this society.

[3] This last experiment is due to my assistant, Mr. A. H. Bate.

"Edison Effect" is the name given to the effect produced by those currents, first observed by Mr. Edison, which pass from one leg of an incandescent filament across the vacuous space to the other leg, and which can be observed by connecting a galvanometer between the positive lamp terminal and a wire sealed into the bulb and projecting into the vacuous space.

FIG. 4

Figure 4, which is taken from Professor Houston's paper, serves to illustrate Mr. Edison's original experiment. The galvanometer indicates a current flowing from the positive lamp terminal through the galvanometer and third lamp wire, and through the vacuous space to the negative leg of the incandescent filament. If the external connection of the galvanometer be changed from the positive terminal to the negative terminal, no current will flow through the galvanometer. This effect can be observed in the most highly exhausted lamps. A lamp so highly exhausted that it shows no glow when tested with an induction coil, giving a spark $\frac{3}{4}$" long, will allow a current sufficiently large to show plainly on a not very sensitive galvanometer, to pass through its vacuous space. This current increases as the temperature of the filament is increased, but in a well exhausted lamp is never greater than a very few milliamperes, when the lamp is burned at about $2\frac{1}{2}$ watts per candle.

In 1884 Mr. Preece secured from Mr. Edison some lamps having wires sealed into the bulbs, and read a paper before the Royal Society describing some experiments made upon them, illustrating the "Edison Effect."

Professor Fleming read a most elaborate paper before the Physical Society of London, in March, 1896, upon this same subject. Professor Fleming's experiments proved that in well exhausted lamps the vacuum is not a conductor in the ordinary sense of the word, and that the current which passes through it is carried by negatively charged [fol. 2027] molecules, which pass constantly from the negative leg of the incandescent filament to the positive leg and to any inserted wire, thus bringing the inserted wire to the same potential as the negative leg. Professor Fleming also proved that these molecules pass in straight lines, and that their passage is completely or almost completely stopped by a glass or mica screen placed between the negative leg and

the inserted wire. The following experiments serve to illustrate these effects:

Figure 5 shows a lamp having a glass tube surrounding one leg of the filament, and a wire sealed in the side of the bulb, which projects into the centre of the vacuous space. When the leg of the filament which is in the glass tube is made positive, and the filament heated to about a $2\frac{1}{2}$ watts-per-candle temperature, the galvanometer, which is connected between the wire and the positive lamp terminal, shows a strong deflection, but when the leg in the tube is

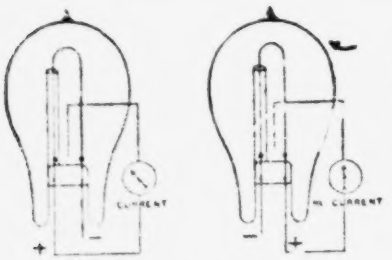


Fig. 5.

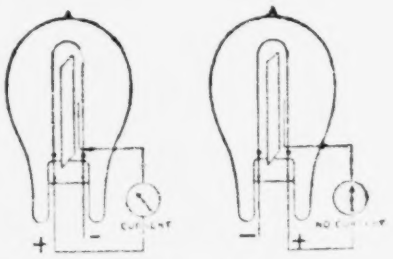


Fig. 6.

made negative, the galvanometer, being as before connected between the wire and the positive lamp terminal, shows no deflection.

Figure 6 shows a lamp having a platinum plate $2\frac{1}{4}$" long and $\frac{3}{4}$" wide between the legs of the filaments, and a wire inserted in the vacuous space. I also used lamps having a similar plate made of glass, similarly placed. In both of these lamps, when the vacuum was high, no current was produced between the wire and the positive terminal when the wire was shielded from the negative leg; but shielding the wire from the positive leg made no hindrance to the passage of the current. The facts that no current flows when the galvanometer is connected between the negative terminal of the lamp and the inserted wire, and that a shield between the positive leg and the inserted wire has no effect upon the current, show that positively charged molecules are not emitted by the positive leg; while the screen effects just described show that the negatively charged molecules pass in straight lines.

The facts, then are these: The galvanometer indicates a current flowing, as we designate the direction of currents, from the wire to the negative leg; while experiments prove that the charged molecules which carry the current actually pass from the negative leg to the wire. These facts

are entirely in accord with the results obtained by Crookes and others in their investigations of currents in high vacua. [fol. 3028] If an alternating current is used to render the filament incandescent, the galvanometer will indicate a current with the connection made to either lamp terminal, because both are equally positive. The current thus produced is a uni-directional one in the galvanometer, and illustrates very well the uni-lateral conductivity between the incandescent filament and the wire.

Mr. Preece states in his paper that lamps which show a blue glow in the vacuous space give stronger "Edison Effects" than those which do not show it. Professor Fleming also observes that poorly exhausted lamps give slightly greater effects, but neither of them paid much attention to these lamps.

The blue glow in lamps has long been associated in my mind with a condition of the vacuum which makes it a conductor. Lamps in the process of exhaustion, just before the vacuum is perfected, show this blue very plainly, if a little more than normal current is sent through the filament. The blue increases as the current is increased and becomes very dense at very high temperatures. This blue indicates a current passing from one leg of the filament across the vacuous space to the other leg.

I observed several years ago, that at a high temperature .04 or .05 of an ampere more current flowed through a lamp showing a good blue than through the same lamp, at the same voltage, when the blue had disappeared. I concluded that this extra current flowed through the vacuous space between the legs of the filament.

If a direct current about 20 or 30 per cent. greater than the normal current be passed through a lamp filament when the vacuous space shows a blue glow, the positive joint between the filament and the platinum wire gets red hot, while the negative joint remains cool.

I have always considered this as proof that the resistance to the passage of a current through a vacuous space was chiefly at the surface of the positive electrode, as the energy was chiefly developed there. If an alternating current is used, both joints get equally hot.

If a lamp be burned at normal incandescence with a direct current, when the vacuous space shows a good deal of this blue, the negative leg of the filament becomes coated with a carbon soot. This effect can be obtained in a few minutes

if the blue is dense and the filament is run above a normal incandescence. This I have considered to be due to an electrolysis of a hydrocarbon gas in the lamp.

The lamps which show only a slight amount of this blue glow, if burned at normal incandescence, will not show this carbon soot perceptibly, and the blue will entirely disappear if the lamp is burned for a few hours. This blue is caused more by the character of the residual gas than by the degree of exhaustion. Lamps having a residual of bromine vapor do not show it at all, neither do they show any "Edison Effect." I have seen ordinary lamps ready to be sealed off the pumps which showed blue and then no blue, and blue again, at regular intervals of a few seconds. Such lamps show corresponding changes in the "Edison Effect."

[fol. 3029] If the current be gradually increased in a lamp which shows good blue, the positive joint will get hotter and hotter and finally its platinum wire will fuse. At this stage the resistance to the flow of current across the vacuous space is not great, and if the conditions are such that at this time all the resistance in circuit with the lamp has been cut out, so that the current flowing will be practically determined by the resistance of the lamp and the leads, enough current will flow through the vacuous space to

* * * * * * *

showing about as strong effects as 140-volt lamps. The energy they exhibit in one direction seems to be very much

Fig. 7

greater than we would expect from molecules actuated by a potential difference of only 40 or 50 volts. The action of these molecules in carrying electricity in one direction only, may be an indication of the nature of the action between

molecules in solid conductors carrying currents, rather than an illustration of the action of statically charged molecules.

Discussion

Mr. John W. Howell: After I had written this paper, I broke the lamp having the graphite filament and took the filament out—a part of it—and measured its specific resistance. Its specific resistance (the resistance of a piece 1 inch long and 1 circular mil area) was 450 ohms. The lowest specific resistance I have ever measured of amorphous carbon is about 2200 ohms. The treatment obtained by hydrocarbon deposit is about 350 ohms, which is about six or seven times as low; and this graphite lamp was 450 ohms, which was very nearly the figure of the carbon obtained by treatment, and I think if it had been a more solid graphite it would have been lower. I can also say that the specific gravity of graphite is practically the same as the specific gravity of the carbon obtained by hydrocarbon deposit.

The President: How was that filament made?

Mr. Howell: It was simply made by making a die, filling it with graphite and solidifying it under great pressure—so great pressure that it made a solid graphite filament of it. [fol. 3030] Dr. A. E. Kennelly: I believe that I voice the general sentiment in saying that this is a very interesting paper, both by reason of what it contains of investigation and by reason of what it suggests for further inquiry.

I remember having taken part in the measurements of resistance in the lamp filament referred to. I believe that the theory given in this paper was suggested at that time for the apparently abnormal behavior of its resistances, but the additional evidence was not then forthcoming which enables Mr. Howell to make so strong a case for that theory in this paper.

It is perhaps no more surprising that graphite should differ markedly from ordinary carbon in its temperature coefficient of resistivity, than that diamond should differ markedly from ordinary carbon in its hardness.

Incidentally it is curious to observe from the curves in the paper that approximately five per cent. of the voltage needed to produce an inefficiency of three watts per candle, raised the temperature of the filaments experimented on to 500° F., or 260° C.

It has long been known that the passage of a continuous current through a Geissler tube set up a series of pulsatory currents or discharges, which are capable of producing alternating currents in a separate circuit, through the intermediary of an alternating current transformer. So far as I know, however, it has been pointed out for the first time in this paper, that an alternating current passed through an incandescent lamp giving the "Edison Effect" is capable of producing in a branch circuit through a third wire in a lamp, continuous or at least undirectional currents. Consequently it is interesting to observe that a vacuum tube, in the broadest sense of the term, is capable of supplying not only alternating currents from continuous currents, but also continuous currents from alternating currents.

As regards the results obtained in the interesting manner described, it would appear that some of these observations differ from those quoted as obtained by Dr. Fleming. It would seem that Dr. Fleming took the position that the blue discharge can only travel in straight lines, whereas in some of the experiments here referred to, as, for example, those in connection with Figs. 11 and 12, the blue discharge and the "Edison Effect" did apparently go around a corner, and a sharp corner too.

I am unable to follow the conclusion mentioned by Mr. Howell, that the change in the development of heat from the positive joint to the middle wire, when the connections are changed, indicates that no bombardment can take place. It seems to me possible that bombardment might still take place under a directive influence determined by the point of connection. No doubt Mr. Howell can make this matter clear.

Mr. E. A. Colby: I am deeply interested in Mr. Howell's paper, especially the latter part of it, referring to the so called "Edison Effect." While I am not prepared to-night [fols. 3031-3032] to present any theory as to the phenomena observed, I can say that the characteristics which Mr. Howell has mentioned are well known to me. I would like to ask if he has substituted for the galvanometer which he used in measuring the currents, the still more sensitive instrument, the telephone, and whether he has attempted with its aid to explore the vacuous space by the insertion of platinum

wires at different points in the glass bulb. Some years ago I tried an experiment of this character which was described in a discussion before the Institute. I sealed into a lamp bulb in the plane of the filament a number of platinum wires about one inch apart. Connecting the terminals of the telephone with the positive leg of the lamp, and with one of these wires I observed a note in the telephone which varied in pitch according to the position of the wire sealed into the bulb. When the telephone was connected to the positive leg on one side, and to the platinum terminal which was nearly at the middle of the filament, or more correctly on the diagonal to positive terminal of the area enclosed by the legs of the filament, I obtained the maximum note, and as I carried this terminal of the telephone near to the negative leg of the filament I got practically no sound whatever. I also inserted in a similar

. . . . . .

[fol. 3033] Defendant's Exhibit X-1

Proceedings of Physical Society of London, March 27, 1896

XVII. A Further Examination of the Edison Effect in Glow Lamps. By J. A. Fleming, M.A., D.Sc. F.R.S., Professor of Electrical Engineering in University College, London [1]

1. The experiments described in this paper had for their object the further examination of an effect which can be produced in certain forms of electric incandescence lamps and to which attention was first drawn by Mr. Edison in 1884. This effect may be generally described as follows: A carbon filament incandescence lamp having the ordinary horse-shoe loop carbon has a metallic plate placed in the exhausted bulb, the plate being carried on a platinum wire sealed through the globe, and fixed so as to stand up between the legs of the horse-shoe (see fig. 1). If the lamp is set in action at the usual incandescence by a continuous current of the proper strength, and a suitable sensitive galva-

[1] Read March 27, 1896

nometer is connected between the insulated metal plate and the *positive* terminal of the lamp, it will in general be found to indicate a current of some milliamperes flowing through it. The direction of this current is *from* the positive electrode of the lamp through the galvanometer *to* the insulated metal plate, or wire. When the same galvanometer is connected between the *negative* pole of the lamp and the middle plate, unless it is very sensitive, it indicates no current. This effect was very carefully examined by Mr. W. H. Preece in 1885, and he subjected it to a systematic examination by the aid of a number of lamps having such metal plates [fol. 3034] placed in various positions.[2] By this observer a number of very interesting facts were collected, the result of which was to point out the general nature of the phenomenon. A sufficient number of new questions were, however, suggested by the information so acquired to invite further inquiry. Whilst confirming and re-examining the experimental results obtained by Mr. Preece, some facts that

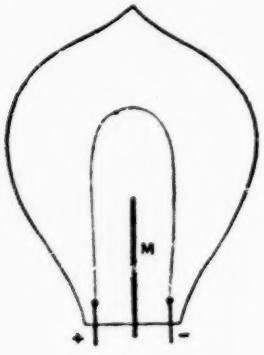


FIG. 1.

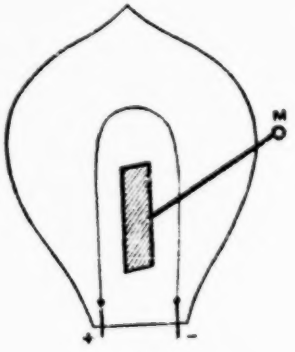


FIG 2.

had previously escaped notice presented themselves, which it is the object of this paper to describe.

§ 2. The first experiments were made with a lamp of the form shown in fig. 2, similar to some used by Mr. Preece in his experiments. A metal plate, generally of aluminum, is

[2] "On a Peculiar Behaviour of Glow-Lamps when raised to High Incandescence," by W. H. Preece, F.R.S. Proceedings of the Royal Society, 1885, p. 219.

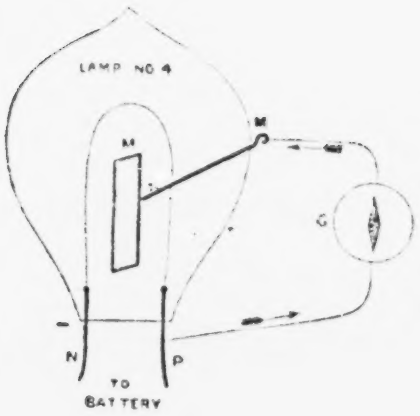


FIG. 3

supported on a platinum wire sealed through the bulb or glass receiver, the plate being so fixed that its plane is at right angles to the plane of the loop of the carbon, and as nearly as possible midway between the legs. The plate therefore projects between the legs of the horse-shoe carbon, and the carbon conductor arches over it without touching it. The plate is entirely insulated from the carbon.

The preliminary experiments with this normal type of middle-plate lamp consisted in determining the effective potential difference between the third terminal and one or other of the two electrodes of the carbon filament when the lamp was subjected to varying steady electromotive forces sufficient to raise the temperature of the carbon from dull red to vivid incandescence, and in determining the magnitude of the current flowing in a circuit connecting the middle plate with one or other of the electrodes of the lamp.

3. *Experiment 1.*—An ordinary carbon filament electric lamp, having the horse-shoe shaped conductor, had a plati- [fol. 3035] num plate (see fig. 3) about 2.5 centimetres long by 1.5 centimetres wide welded to a platinum wire, sealed through the side of the bulb. The plate was so placed as to project between the legs of the carbon conductor, having its plane at right angles to the plane of the horse-shoe, and initially fixed about halfway between the two legs. This lamp will be described in the subsequent paragraphs as Lamp No. 4. Under a steady electromotive force of 40 volts, this lamp took .3 amperes when working at the normal temperature corresponding to about 3.5 watts per candle-power. When a milliamperemeter having a resistance of 6872 ohms was joined between the base P of the *positive* leg of the carbon (see fig. 4) and the middle plate M, a current was found passing through the galvanometer from the terminal P to the plate M. This current had a magnitude of

about 3 milliamperes when the carbon was in the normal state of incandescence.

If the milamperemeter was connected between the negative electrode of the lamp and the middle plate, no current perceptible by this galvanometer was found. On replacing the milamperemeter by a more sensitive Elliott mirror galvanometer (resistance 7142 ohms) it was found that a small

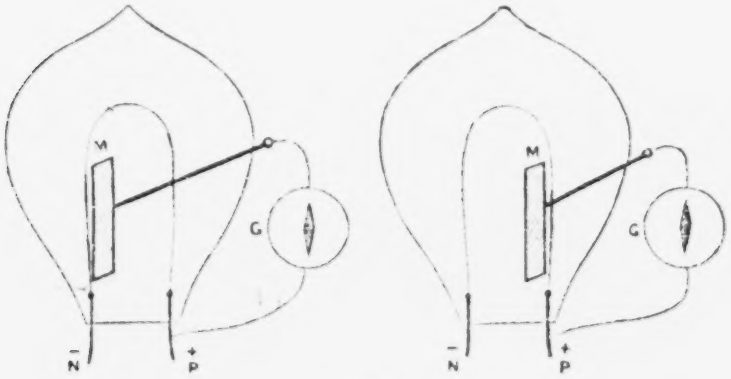


Fig. 4.

current passed through it, when joined in between the negative electrode of the lamp and the middle plate, but that this current had a magnitude hardly exceeding .0001 of a milliampere when the lamp was at its normal incandescence.

In order to avoid repetition, it may be here said that, unless otherwise stated, the terminal of the lamp in connexion with the positive pole of the working battery will be spoken of as the positive electrode of the lamp; that in connexion with the negative pole of the battery as the negative electrode. For brevity's sake, the half of the carbon filament between the centre of the filament and the positive electrode will be called the *positive leg*, and the other half the *negative leg*.

4. A preliminary series of experiments was made with lamp No. 4 by placing the lamp in a photometer and deter- [fol. 3536] mining the watts per candle-power and the current taken by the lamp corresponding to various working electromotive forces, taken over the whole range of electromotive force from that necessary just to render the filament incandescent to the highest the lamp could with safety endure. In any subsequent experiments, the simple measurement of the potential-difference between the electrodes of

the lamp enabled the rate of dissipation of energy in the filament and the watts per candle power to be deduced. It may here be remarked that in the preliminary experiments some difficulties arose from the occlusion of residual gas by the middle metal plate, but finally this was overcome, and the vacuum in these experimental bulbs made and preserved as perfect as in good ordinary commercial lamps. The following results were then obtained with this lamp No. 4. The lamp was raised to various degrees of incandescence by varying the working volts by the aid of a rheostat in series with the lamp.

The milliamperemeter was employed to measure the effective potential-difference between the positive electrode of the lamp and the middle plate and then, tabulating against the working volts of the lamp the current in milliamperes flowing through the galvanometer, the potential-difference between the middle plate and the positive electrode of the lamp was calculated from these figures. The results are given in the table below (Table No. 1).

TABLE No. 1. *Lamp No. 4, milliamperemeter*

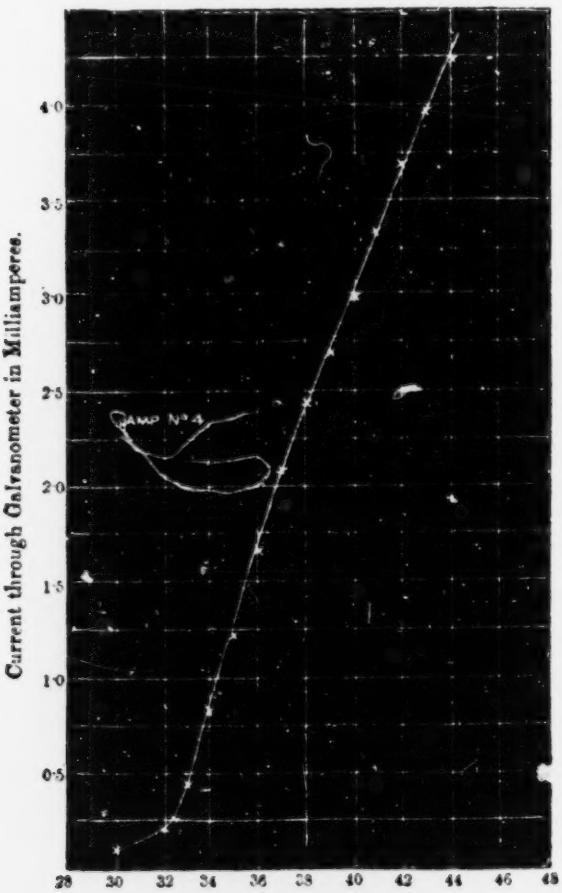
Table showing the volts between the middle plate and the positive electrode, and the current flowing through a galvanometer of 6372 ohms resistance connecting them, taken for various working voltages of the lamp.

Working volts of lamp	Volts between plate and positive lamp electrode	Current in milliamperes through galvanometer	Working volts of lamp	Volts between plate and positive lamp electrode	Current in milliamperes through galvanometer
30	54	085	36	10 7	1 69
32	1 2	190	37	12 7	2 01
32 5	1 6	25	38	14 9	2 36
33	2 8	44	39	17 1	2 71
33 5	4 7	74	40	18 9	2 99
34	5 3	84	41	21 4	3 37
34 5	7 1	1 12	42	23 4	3 71
35	7 8	1 23	43	25 2	3 99
			44	26 8	4 25

The results given in table No. 1 are plotted in curve No. 1, in which horizontal abscissae represent to scale the working volts of the lamp and vertical ordinates the milliampere currents through the galvanometer. It will be seen that the curve representing the current from lamp electrode to plate takes a rather sharp turn upwards at a point corresponding to 35 working volts, and this occurs when the

lamp is working at about 7.8 watts per candle-power. Beyond this point the curve is very approximately a straight line. Accordingly, at and beyond the volts at which the carbon filament becomes fairly well incandescent, [fol. 3037] the effective potential-difference between the

TABLE No. 1.—*Curve No. 1*



middle plate and the positive lamp electrode is very nearly a linear function of the lamp voltage; and at the normal working volts, viz. 40 volts, this potential-difference between the middle plate and the positive electrode so determined is apparently about half that between the lamp terminals, the plate being nearly midway between the carbon legs. The results given in Table 1 are the mean of several observations, but it was noticed that when the lamp was main-

tained at a steady voltage, the potential-difference between the middle plate and the positive electrode would often *jump suddenly* from one value to another. This effect renders it difficult to obtain the stable values of the plate and positive electrode potential-difference. Corresponding to any definite steady voltage on this lamp, the current may have one or other of two values, but not always permanently preserving either; a galvanometer deflection indicating say [fol. 3038] 10 volts between the plate and positive electrode of the lamp will often slowly increase until after a few minutes it is 12 or 14 volts, yet all the time the working volts on the lamp are remaining perfectly constant. It will then often suddenly jump perhaps to 22 volts, and then slowly decrease to 19 volts, or so. This tendency of the potential-difference between the middle plate and positive lamp electrode to jump from a low to a high value, or *vice versâ*, is most marked in lamps in which the plate is about half-way, and symmetrically placed, between the legs of the carbon. We shall speak of these two values as the high and low value of the current through the galvanometer, and defer until later a discussion of some other causes tending to make the current pass from a high to a low value or the reverse, as well as its possible explanation. In Table No. 2 are tabulated a set of observations on the same lamp No. 4, showing these double values which the potential-difference and current may have, and it may be here noted that in the previous Table No. 1, the higher values have been taken in those cases in which double values exist.

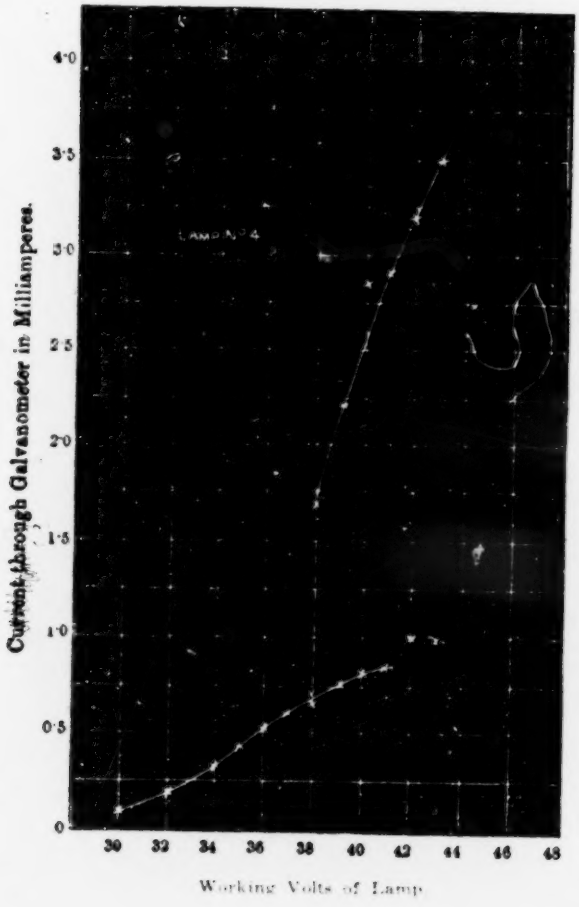
TABLE No. 2.—*Lamp No. 4, milampèremeter.*

Table showing the multiple values of the potential-difference between the middle plate and positive electrode of the lamp corresponding to various given working voltages.

Working volts of the lamp	Volts between the middle plate and positive electrode of the lamp	Current through the graded galvanometer in milli-amperes	Working volts of the lamp	Volts between the middle plate and positive electrode of the lamp	Current through the graded galvanometer in milli-amperes
39	6	085	39	4 3	761
42	1 1	174	"	14 0	2 22
34	2 0	317	40	5 1	809
35	2 6	412	"	18 1	2 87
36	3 2	507	41	5 3	841
37	3 9	618	"	18 4	2 91
38	4 3	682	42	6 4	1 01
"	4 5	714	"	20 0	3 17
"	11 0	1 74	43	6 2	983
			"	22 0	3 49

These observations are plotted in Curve No. 2, in which the abscissæ represent the working volts of the lamp and the ordinates the current in milliamperes flowing through the galvanometer connecting the positive electrode and the middle plate. It is seen that corresponding to any working pressure above 38 volts for this lamp, which is equivalent

TABLE No. 2.—*Curve No. 2*



to 4.2 watts per candle-power, there are two possible values of the effective potential-difference between the middle plate and the positive electrode. As the working voltage of the lamp is gradually raised, the reading of the galvanometer inserted between the middle plate and positive electrode is also increased, but there is a great tendency to jump from a certain low value to a higher one, and this occurs

when the working pressure of the lamp is preserved steady. There is also an effect produced by the presence of a magnet near the lamp bulb. When the current is at the low value corresponding to any working voltage, the galvanometer reading does not seem to be perceptibly altered by bringing [fol. 3039] a magnet near the lamp, but when it is at its high value, the reading is sometimes increased for a little, showing a steady deflexion, and then immediately falls to its low value.

5. *Experiment 2.*—The difference of potential between the middle plate and the positive electrode of the lamp depends to a considerable extent upon the position of the middle plate. Supposing the plate to be placed with its plane perpendicular to the plane of the carbon horse-shoe and then moved to various positions between the two legs of the carbon, it is found that the difference of potential between the plate and the positive electrode will have different values according to the position of the plate. This fact was elucidated by means of the same lamp No. 4 as used above. By carefully tapping the lamp, the supporting platinum wire carrying the platinum middle plate could be bent so as to displace the plate from its symmetrical position as regards the two carbon legs, and bring it nearer to one or other of the legs. In several different positions the current flowing through the milamperemeter, when connected between the middle plate and positive electrode, was [fol. 3040] measured, the lamp being kept meanwhile at the same working electromotive force.

Estimating as nearly as possible the fractional distances, the plate was placed at distances from the negative leg equal to $^1/_{10}$, $^1/_4$, $^1/_2$, $^3/_4$, and $^9/_{10}$ of the whole distance between the positive and negative legs, and the lamp being taken through a definite cycle of volts, the potential-difference between the middle plate and the positive electrode was measured with the milamperemeter. The results are collected in the following tables. The diagrams in fig. 6 represent the horse-shoe carbon loop and the middle plate M in various positions, the galvanometer G being inserted between the plate M and the positive electrode P. By the phrase "whole distance" in the following tables is meant the whole distance or width of the space between the positive and negative carbon leg.

TABLE No. 3.—*Lamp No. 4, milliampere meter*

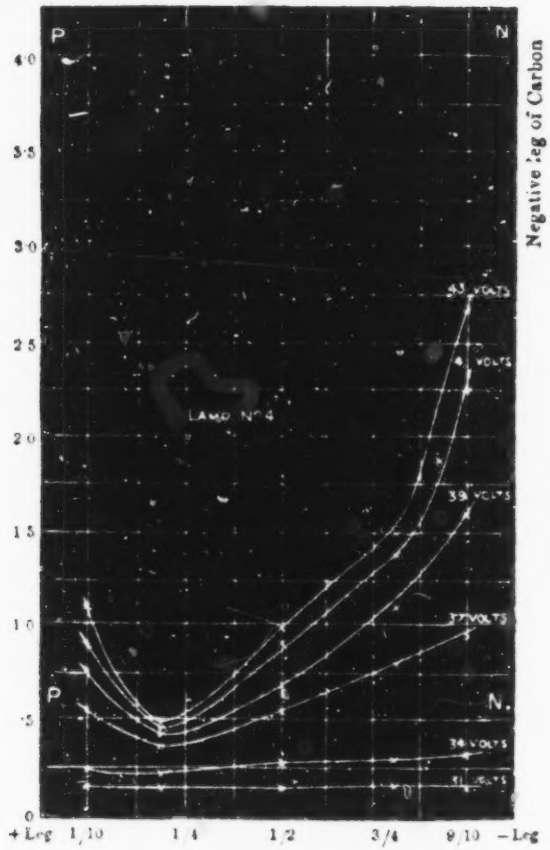
Table showing the potential-difference between the middle plate and positive electrode of the lamp at various positions of the plate and at various working voltages.

Working volts of the lamp	Volts between the middle plate and positive electrode	Current through the galvanometer in milliamperes
Middle plate at 1/10 of whole distance from negative leg		
31	9	142
34	2 2	317
37	6 0	952
39	10 2	1 61
41	14 2	2 24
43	16 8	2 66
Middle plate at $\frac{1}{4}$ of whole distance from negative leg		
31	9	142
34	1 8	285
37	5 1	809
39	7 0	1 11
41	8 7	1 38
43	9 5	1 50
Middle plate $\frac{1}{2}$ of whole distance from negative leg		
31	9	142
34	1 7	269
37	3 5	555
39	4 3	682
41	5 6	888
43	6 2	983
Middle plate $\frac{3}{4}$ of whole distance from negative leg		
31	9	142
34	1 4	222
37	2 2	349
39	2 5	396
41	2 9	460
43	3 0	476
Middle plate 9/10 of whole distance from negative leg		
31	9	142
34	1 5	238
37	3 4	539
39	4 8	761
41	5 7	904
43	6 8	1 07

[fol. 3041] The results of this Table No. 3 are plotted in the curves No. 3. These curves are to be interpreted as follows:—The two vertical lines P and N represent the two legs of the carbon horse-shoe. At various distances on the way from P to N the milliampere current through a galvanometer connected between the middle plate, placed at that point, and the positive electrode of the lamp is represented by the magnitude of the vertical ordinate of each curve. For every one of the different voltages at which the lamp is worked, there is therefore a curve representing by its ordinates this current strength through a galvanometer inserted between the middle plate, placed at these positions, and the positive electrode of the lamp, and it is seen that there is a *minimum value* for this current at a position

TABLE No. 3.—*Curve No. 3*

The middle plate was moved along into different positions between the two carbon legs indicated by the horizontal distances, and at each position the current between the middle plate and positive electrode of the lamp is represented by the vertical ordinate of a curve. The several curves correspond to different working volts on the lamp.



Position of Plate between legs

equal to $\frac{2}{3}$ of the whole distance between the legs reckoned from the negative leg.

[fol. 3042] Imagine the middle plate therefore connected through a galvanometer with the positive electrode of the lamps, and let the middle plate be first placed close to the positive leg and then moved continuously nearer towards the negative leg. The current through the galvanometer would first fall off as the plate receded from the positive leg, and after reaching a minimum at a point about $\frac{1}{4}$ of the whole distance between the legs reckoned from the positive leg, would rise up to a maximum when the middle plate was as nearly in contact with the negative leg as possible without actually touching it.

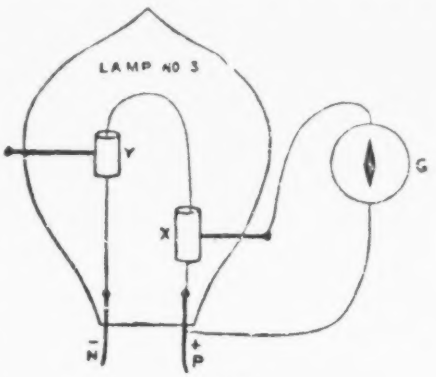


Fig. 5.

6. *Experiment 3.* In order to explore more thoroughly the action of the different portions of the incandescence carbon conductor in producing this effect, a lamp was taken having a horse-shoe shaped carbon, and a pair of small platinum cylinders, held on platinum wires sealed through the glass, so placed as to embrace without touching the carbon conductor. One of these cylinders, X, was placed so as to embrace the carbon near the bottom of the leg, and the other, Y, near the spring of the arch (see fig. 5). These small cylinders had a length of about 12 millims. and a diameter of about 8 millims. so that the distance from the

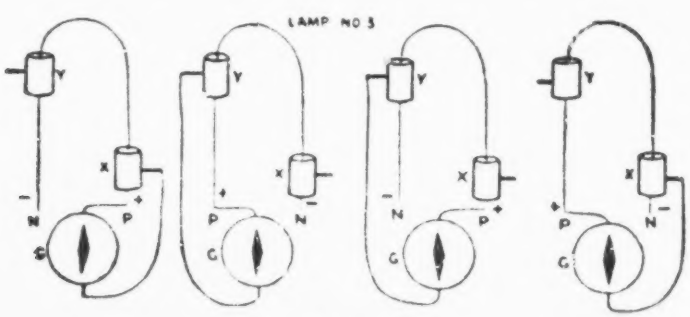
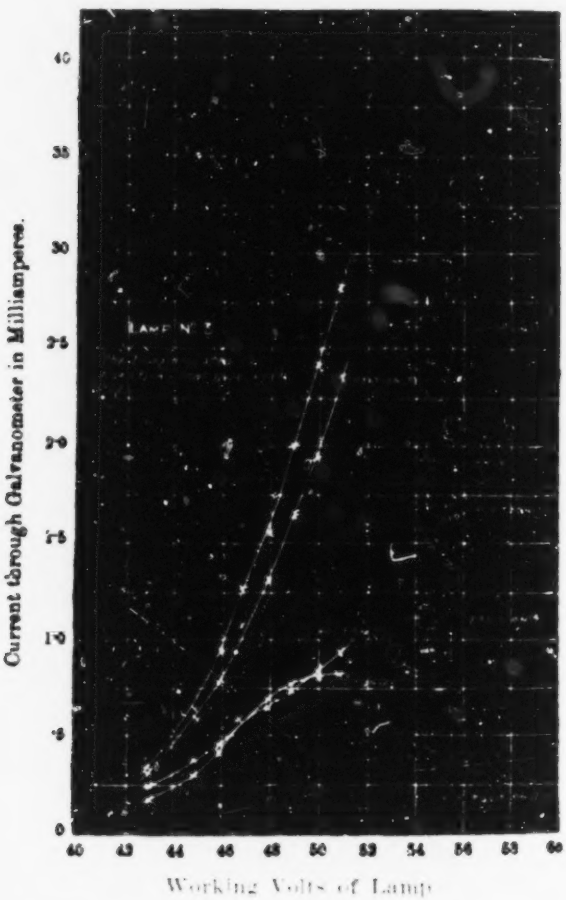


Fig. 6.

Position (1) Position (2) Position (3) Position (4)

carbon filament to the inner surface of the cylinder was about 3 or 4 millims. The lamp had a rather thick carbon, and at an electromotive force of 48 volts took a current of 1.32 amperes to raise it to its normal incandescence of 18.8 candles, corresponding to 3.3 watts per candle-power. This lamp will be alluded to as Lamp No. 3.

TABLE No. 4.—*Curve No. 4*



It is obvious that there are four possible arrangements in which a current can be obtained between an embracing [fol. 3043] cylinder and a positive electrode of the lamp. These are illustrated in fig. 6, in which the horse-shoe shaped line stands for the carbon filament, X and Y are the platinum cylinders, P and N are the positive and negative electrodes of the lamp, and G is the galvanometer.

We will call these arrangements (1), (2), (3), (4), as

figured. It will be seen that if we imagine the carbon filament straightened out, these four arrangements are equivalent to being able to slide a cylinder along the filament into four positions, and in each position measuring the potential-difference between the cylinder and the positive end of the carbon. We are thus able to place an embracing collecting-plate at four different places along the carbon conductor, and determine the potential difference between this embracing cylinder and the positive electrode of the lamp. A series of experiments was made with lamp No. 3, in which the working volts of the lamp were raised to various values, and in each case the potential-difference between one of the cylinders X or Y and the positive electrode of the lamp was observed as before by means of the milamperemeter. The results are given in Table 4.

TABLE No. 4.—*Lamp No. 3, milamperemeter*

Table showing the potential-difference between a platinum cylinder embracing the carbon and the positive electrode of the lamp, and the current flowing through the galvanometer in milliamperes; for the four positions shown in fig. 6.

Working volts of the lamp	Volts between cylinder and positive electrode	Current in milliamperes through the galvanometer	Working volts of the lamp	Volts between cylinder and positive electrode	Current in milliamperes through the galvanometer
	Position (1)			Position (2)	
43	1·6	25	43	1·2	19
45	2·4	38	45	2·0	31
46	2·9	46	46	2·9	36
47	3·7	58	47	3·7	58
48	4·2	67	48	4·2	67
49	4·7	74	49	4·9	78
50	5·2	82	50	5·1	81
51	5·9	93	51	5·3	84
	Position (3)			Position (4)	
43	2·1	33	43	2·2	35
45	3·9	62	45	4·0	63
46	4·9	78	46	5·9	94
47	6·8	1·08	47	8·0	1·26
48	8·2	1·30	48	9·8	1·55
49	10·4	1·65	49	12·6	1·99
50	12·3	1·95	50	15·1	2·38
51	14·9	2·36	51	18·0	2·85

These observations are plotted in Curve No. 4

[fol. 3044] This table of observations shows us that taking the lamp at any definite voltage, the potential-difference be-

tween the positive electrode and a cylinder embracing the carbon filaments is greatest when that cylinder is as low down near the foot of the negative leg of the carbon as possible. If the cylinder is placed near the top of the negative leg that potential-difference becomes less. If the cylinder is taken near the top of the positive leg or near the base of the positive leg it is least, and it seems to be a minimum when the cylinder surrounds the top of the positive leg, and is as far as possible away from the foot of the negative leg. We have here a confirmation of the fact observed with respect to lamp No. 4, viz.: that the potential-difference between the positive lamp electrode and the metal plate held somewhere near the incandescent carbon conductor is greatest when the plate is as near as possible to the foot of the negative leg or negative electrode.

In this lamp No. 3, in which in all positions the cylinder employed is placed very near some point on the incandescing [fol. 3045] conductor, the current through the galvanometer joining the positive electrode and the cylinder has never been observed to jump or to take double values as in the case of lamp No. 4.

If a sensitive galvanometer is connected to the two insulated cylinders X and Y, and if in addition there is a battery in series with this galvanometer, then no current can be detected in such an arrangement even when the battery has an electromotive force of 120 volts, whether the lamp carbon is incandescent or not. Just as in the case of lamp No. 4, the current obtained by connecting either cylinder with the negative electrode of the lamp is excessively small.

In order to obtain curves showing the mode of variation of the effective difference of potential between one or other of the metal cylinders X and Y and the positive electrode of the lamp, a set of observations was made on the lamp when submitted to various working voltages, and at the same time the milliamperemeter was connected first between the positive electrode and cylinder X and then between the positive electrode and cylinder Y, with the following tabulated results (p. 204).

These results, when plotted out in curves in which horizontal ordinates represent the working volts of the lamp and the vertical ones the milliampere currents going through the galvanometer, in both cases have the same general form as curve No. 1 plotted for the case of lamp No. 4.

TABLE No. 5.—*Lamp No. 3, milliampere meter*

Table showing the potential-differences between the positive electrode of the lamp and the two cylinders X and Y respectively, and the corresponding currents through the galvanometer.

Working volts of the lamp	Volts between cylinder X and the positive electrode P of the lamp. Position (1)	Milliampere current through the galvanometer connecting X and P	Volts between cylinder Y and the positive electrode P of the lamp. Position (3)	Milliampere current flowing through the galvanometer connecting Y and P
34	1	015	1	015
35	15	023		
36	20	031	3	045
37			4	060
38	6	095	7	11
39	8	126	9	14
40	1 05	166	1 1	17
41	1 3	206	1 6	25
42	1 8	285	2 0	31
43	2 1	333	2 8	44
44	2 6	412	3 5	55
45	3 0	476	4 5	77
46	3 6	571	5 8	92
47	4 2	659	7 2	1 12
48	4 9	791	8 8	1 39
49	5 6	889	10 9	1 72
50	6 2	984	13 6	2 15
51			15 1	2 39
52			18 6	2 95

7. *Experiment 4.*—The magnitude of the current found on connecting any galvanometer between one of the cylinders and the positive electrode of the lamp was found to be [fol. 3046] dependent to some degree on the perfection of the vacuum. Lamp No. 3 when first made had not a very perfect vacuum. A series of measurements was, however, made with it, and the same repeated after re-exhaustion. The results are tabulated together below.

TABLE No. 6. *Lamp No. 3, Elliott galvanometer*

Table showing the relative values of the potential-difference between cylinder Y and the positive electrode for good and imperfect vacua in the case of lamp No. 3.

Working volts of the lamp	Very high vacuum in the lamp		Imperfect vacuum in the lamp	
	Watts per candle-power taken up in carbon	Volts between cylinder Y and positive electrode	Watts per candle-power taken up in carbon	Volts between cylinder Y and positive electrode
40	6 75	2 02	9 1	4 17
41	5 75	2 89	7 9	7 25
42	5 30	3 62	6 5	8 39
43	4 90	4 54	5 9	9 80
44	4 50	6 08	4 3	11 96
45	4 15	7 50	4 0	13 76
46	3 84	9 25	3 7	15 08
47	3 55	10 33	3 4	16 21
48	3 30	13 2	3 2	18 28
49	3 07	16 3	3 0	22 05
50	2 90	18 4	2 8	22 99
52	2 74	21 8	2 6	23 93
52	2 58	24 4	2 4	28 26

The imperfection of the vacuum is indicated by the higher watts per candle power absorbed at low voltages, and we see that at any given working pressure the potential-difference between the positive electrode and the cylinder Y embracing the top of the negative leg is *greater* when the vacuum is imperfect than when it is very good. The presence of residual air tends to bring down the potential of the embracing cylinder more nearly to that of the carbon at the point adjacent to it.

18. *Experiment 5.* A series of observations was next made in which the potential difference between the middle plate and the positive electrode was determined by the aid of a condenser. If a condenser of capacity C in microfarads is charged to a potential of V volts and discharged through a ballistic galvanometer, we can determine the ballistic constant of the galvanometer. A second observation of a like nature in which the "throw" of the same galvanometer is observed when the same condenser is charged by contact with two points concerning which we require to know the potential difference, gives us the means of calculating the electrostatic potential difference in volts. A condenser of .987 microfarad capacity carefully determined was charged to a potential of 54 volts and discharged through a certain ballistic galvanometer having a needle whose periodic time

of vibration was about three seconds. The resulting "throw" of the galvanometer was 5° 30′. Hence a discharge of $54 \times .987 = 53.3$ microcoulombs through the gal- [fol. 3047] vanometer produces a "throw" of 5° 30′. Neglecting a very small correction for the logarithmic decrement, in this case not of importance, we have for the ballistic constant R the value

$$53.3 = R \sin \tfrac{1}{2}(5° 30') = R \times .04798;$$

hence

$$R = 1110.$$

The same condenser was then connected between the middle plate and positive electrode of lamp No. 4 and then discharged through the same ballistic galvanometer. The lamp was subjected to a working pressure of 39 volts as determined by a corrected voltmeter attached to the electrodes of the lamp. The charge of the condenser was sent through the ballistic galvanometer, and a "throw" of 4° obtained. If v is the potential-difference between the middle plate and positive electrode of the lamp, we have the following equation for v in terms of the ballistic constant and angle of "throw":

$$\begin{aligned} .987\, v &= 1110 \sin 2° \\ &= 1110 \times .0349 \\ &= 111 \times 349 \end{aligned}$$

or

$$v = \frac{111 \times 349}{987} = 39 \text{ nearly.}$$

The potential-difference between the middle plate and the positive electrode as determined by this method is therefore *exactly the same* as the potential-difference between the positive and negative electrodes of the lamp. In other words, when the filament is brought to full incandescence, the middle metal plate is brought to the same potential as the negative electrode of the lamp. This observation was repeated with several other lamps having middle plates in various positions and of various forms, and always with the same result, viz., that the potential of the middle plate when insulated is brought down nearly to that of the negative electrode.

[9. *Experiment 6.*—In order to confirm the results obtained by the condenser method and to eliminate all the conditions which necessarily exist when we attempt to measure potential-difference galvanometrically, an electrostatic method of measuring the potential-difference at any instant

between the metal plate and the positive electrode of the lamp was next used. For this purpose a Kelvin multicellular electrostatic voltmeter was employed to determine the potential-difference between the positive and negative electrodes of the lamp and between the positive electrode of the lamp and the middle plate, with the following results:

A lamp (No. 4) having the plate fixed between the carbon legs was raised to various working voltages and the potential-differences above mentioned taken.

[fol. 3048]

TABLE No. 7.—*Lamp No. 4. Kelvin electrostatic voltmeter.*

Working volts of the lamp	Static potential-difference in volts between middle plate and positive electrode of the lamp
41	41
58·1	58·7
61·0	61·5

These observations confirm conclusively the previous results. The insulated metal middle plate is in this case brought to the *same potential* as the base of the negative leg of the carbon; and hence, on measuring electrostatically the potential-difference between that metal plate and the positive electrode of the lamp, we find it to be the same as the potential-difference between the two electrodes of the lamp.

10. *Experiment 7.*—In order to see if this was the case when the metal collecting plate had a very small surface placed at some distance from the negative electrode of the lamp, the lamp called No. 1 was employed. In this lamp a platinum wire [illegible] threaded through the turns of a double spiral 100 volt carbon lamp (see 11). The lamp was raised to various working voltages, and the electrostatic voltmeter employed to measure at the same time the static potential-difference between the positive electrode of the lamp and the platinum wire, with the following results:

TABLE No. 8.—*Lamp No. 1, electrostatic voltmeter.*

Working volts of the lamp	Static potential-difference in volts between platinum wire and positive electrode of the lamp
62	53
79	75·5
97	85
118	107

The figures in the above Table No. 8 show that when the surface of the collecting-plate is very small and is placed some distance from the base of the negative leg of the carbon it is brought down only to the potential of some point (probably the nearest point) on the carbon conductor, and that therefore the potential-difference between the plate and positive electrode of the lamp is somewhat less than the potential-difference between the working terminals of the lamp. At the same time, however, the electrostatic voltmeter shows no measurable potential-difference between the negative terminal of the lamp and the platinum wire, and the most sensitive galvanometer between these points gives no indication of any current.

[fol. 3049] By means of the electrostatic voltmeter it was, however, ascertained that in those cases in which the metallic plate presented considerable surface (several square centimetres) and was placed so that some portion of it was not removed by more than a centimetre or two from the base of the negative leg of the carbon, it was brought down almost immediately to the potential of the negative terminal of the lamp. If the middle plate is placed at a little distance from the carbon loop then, on testing by the condenser method, it is found that the plate is not instantly brought down to the potential of the negative terminal, but that some few seconds have to elapse before this is the case.

11. A series of experiments was then undertaken in order to determine the effect of varying (1) the surface, and (2) the position of the metal plate in the bulb, and in these experiments the plate was sometimes of platinum and sometimes of aluminium. In all cases the vacuum was a very perfect one, any occluded gases in the plates being got rid of by special means.

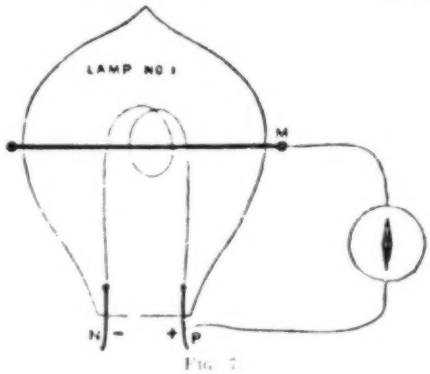


Fig. 7.

Experiment 8.—A normal 100-volt carbon-filament lamp, having a carbon filament coiled in a spiral of two turns (see fig. 7) had a short stout platinum wire (.024 inch diam.) sealed across the bulb so as to thread through, without touching, the spirals of the carbon. The lamp at 100 volts took 1.54 am-

peres and gave an illumination of 40 candles, equivalent to a power absorption of 3.9 watts per candle-power. The vacuum was very good. This lamp will hereafter be called Lamp No. 1. As before, no current could be detected by a galvanometer when joined up between the platinum wire and the negative electrode, but when the galvanometer was connected between the platinum wire and the positive electrode of the lamp a current of some milliamperes was found passing through it. As in the case of lamp No. 4, this lamp was characterized by a great tendency to change suddenly the value of the current flowing through the galvanometer when the working volts on the lamp were kept perfectly constant. In the first series of observations the milamperemeter was employed to measure the current flowing between the positive electrode of the lamp and the platinum wire when it was connected between these points, and at and beyond a working-pressure of 90 volts or so the galvanometer would often jump suddenly from one reading to another, when the lamp working volts were kept perfectly constant.

In the following table, No. 9, are collected the results when the working pressure of the lamp was gradually raised from 80 to 100 volts:

[fol. 3050] TABLE No. 9.—*Lamp No. 1, milamperometer.*

Table showing the potential difference between the positive electrode and the platinum wire, and the current flowing through the galvanometer connecting them, for various voltages of the lamp.

Working volts of the lamp	Volts between platinum wire and positive electrode	Milliampere current through the galvanometer	Working volts of the lamp	Volts between platinum wire and positive electrode	Milliampere current through the galvanometer
80	1	016	92	1 7	270
"	2	032	"	2 4	381
82	3	048	93	1 9	302
83	2	032	"	2 6	413
84	4	064	94	3 2	509
86	4	064	"	9 4	1 49
"	7	114	95	4 9	78
87	5	080	96	5 8	92
88	8	127	97	7 1	1 13
"	9	142	98	8 3	1 32
90	1 0	159	99	8 9	1 41
"	1 3	206	100	8 6	1 37
91	1 4	222	"	10 3	1 64

These figures show that at any definite working electromotive force of the lamp the current between the positive electrode and the middle plate has very variable values, and that it suddenly changes from one value to another without any apparent reason, the working volts of the lamp remaining constant all the time.

If the surface of the collecting-plate is large, say several square centimetres, the potential-difference existing between it and the positive electrode is not found to be so much reduced by attempting to measure it with a galvanometer of about 6000 ohms resistance as it is when the collecting wire presents, as in this lamp No. 1, only a small total surface of about one square centimetre.

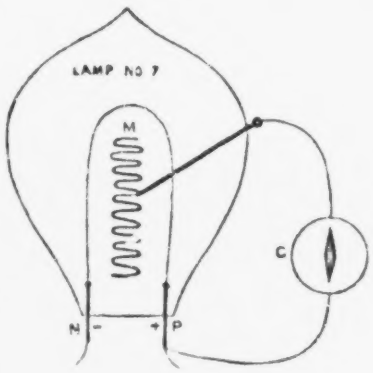


FIG. 8.

12. *Experiment 9.*—A horse-shoe carbon filament, taking 1.3 ampere of current at a working-pressure of 42.5 volts, had a middle plate made of a long piece of platinum wire bent up in a zigzag shape so as to form a rectangular-shaped grating (see fig. 8). The object of this was to ascertain whether a middle plate offering a surface pierced with many apertures was as effective in producing the current as a solid plate of about the same general outline. Practically it was found that this was the case.

The magnitude of the currents obtained at various working voltages are of the same magnitude approximately as in the case of a lamp like No. 4, that is to say some 3-4 milliamperes at full incandescence.

13. A set of experiments was then undertaken with the object of examining the special effect of varying the posi- [fol. 3051] tion of the middle plate, and a series of lamps was used in which platinum or aluminum plates held on platinum wires were placed in the lamp bulb, or in tubes opening into it, in various positions. These lamps are generally 50-volt lamps of usual type, and had single horse-shoe shaped filaments.

Experiment 10.—A lamp-bulb had a side tube blown on it (see fig. 9) and a plate about 6 centims. long and 1.5 centims. wide welded to a platinum wire was sealed into it. The platinum plate was placed vertically and edgeways in the

side tube and the side tube was in such a position that the plane of the platinum plate coincided with the plane of the horse-shoe filament. This lamp, called henceforth No. 2, when worked at 48 volts took 1.3 amperes of current and gave a light of 17.5 candles, equivalent to a power-consumption of 3.55 watts per candle-power. The vacuum was very good. In the case of this lamp the current between the positive electrode of the lamp and the platinum plate was found to be numerically very much smaller at the usual working pressure of the lamp than was found to be the case in those lamps in which the middle plate was placed between the carbon legs or in the form of a cylinder embracing the carbon.

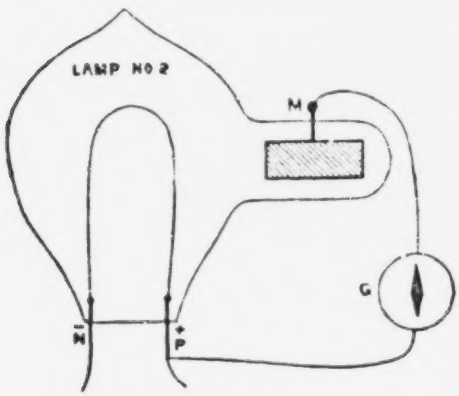


FIG. 9

The current obtained at any definite working voltage was considerably greater when the leg of the carbon nearest the plate was the *positive* leg than when it was the *negative* leg. A series of observations were taken using the lamp at different voltages and measuring with the Elliott galvanometer the potential-difference between the platinum plate and positive electrode of the lamp, and these results were as tabulated below in Table No. 10.

TABLE No. 10.—*Lamp No. 2, Elliott galvanometer*

Table showing the potential-difference between the platinum plate and the positive electrode of the lamp at various working voltages. Positive leg of carbon nearest the platinum plate.

Working volts of the lamp	Watts per candle-power	Volts between platinum plate and positive electrode	Working volts of the lamp	Watts per candle-power	Volts between platinum plate and positive electrode
43	6·26	088	48	3·55	190
44	5·80	111	49	3·32	236
45	4·42	144	50	3·12	289
46	4·10	156	51	2·94	352
47	3·80	172			

[Vol. 3052] If we compare together the results obtained with this lamp No. 2, in which a plate is placed edgeways on and outside the carbon loop, with the results obtained in the case of lamp No. 3, in which the plates embraced the carbon in the form of cylinders, we see the difference produced by the change of position of the plate. Both these lamps, No. 2 and No. 3, are 48-volt lamps when working at normal incandescence. Referring to Table No. 7 in § 7, we see that for lamp No. 3 at 48 volts the voltage difference of the positive electrode and the platinum cylinders was respectively 13.2 and 18.3 volts as measured with the Elliott galvanometer, and this indicated a current of about 1.3 and 1.8 milliamperes flowing through the resistances from the positive lamp electrode to the metal plate; but in the case of lamp No. 2, at 48 volts the potential-difference between the platinum plate and the positive lamp electrode was only .2 volt, and this corresponded to a current of .03 milliampere nearly. Accordingly the current is greatly diminished when the collecting-plate is placed edgeways to and someway outside the loop of the carbon. At normal incandescence the current between the positive lamp electrode and the middle plate when joined by the galvanometer is about .03 or .04 milliampere when the *positive* leg of the carbon is nearest the middle plate, but only about .02 or .03 milliampere when the negative leg is nearest the plate.

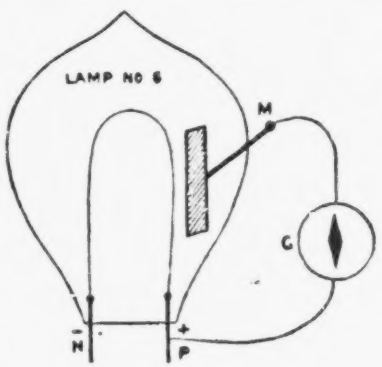


Fig. 10

14. *Experimental 1.*—In order to compare the previous results just given with those obtained when the collecting-plate was placed broadside to and yet outside the carbon loop, a lamp was made as in fig. 10 in which an aluminium plate was held on a platinum wire just outside one leg of the carbon and with its plane perpendicular to the plane of the horse-shoe.

The aluminium plate was .5 centims. long and 1 centim. wide, and distant from the nearest leg of the carbon about .5 centim. This lamp therefore differed from lamp No. 4 in having the plate outside the carbon loop rather than between the legs. It may be noticed that in this lamp the current here obtained by joining the positive lamp electrode to

the plate through a galvanometer was slightly greater when the leg nearest the plate was *negative* than when it was the positive leg, whereas in the case of lamp No. 2 it is just the reverse. This lamp exhibited also the same effect as lamp No. 4, in that the current flowing between electrode and plate is very liable to "jump" from one value to another even when the lamp is kept at constant volts. The following tabular result of the observations shows this. This lamp is called Lamp No. 6 and was a 50-volt horse-shoe carbon lamp, taking 1.33 amperes of current at a working electromotive force of 50 volts.

[fol. 3053] TABLE No. 11.—*Lamp No. 6, milamperometer*

Table showing the potential-difference between the positive electrode of the lamp and the aluminium plate, and the current in milliamperes flowing through a galvanometer connecting them. Vacuum good.

Working volts of the lamp	Potential-difference of the positive electrode and plate in volts	Milliampere current through the galvanometer	Working volts of the lamp	Potential-difference of the positive electrode and plate in volts	Milliampere current through the galvanometer
32	1	016	46	3 8	601
34	3	047	"	3 5	555
36	6	085	"	14 1	2 23
37	8	126	47	3 8	602
38	1 0	158	"	16 2	2 57
39	1 2	190	48	4 1	650
40	1 7	221	"	17 7	2 80
41	2 0	317	49	4 2	666
42	2 3	364	"	18 3	2 90
43	2 8	444	50	19 5	3 03
44	3 1	491	"	20 0	3 17
45	4 0	634	"	4 1	650

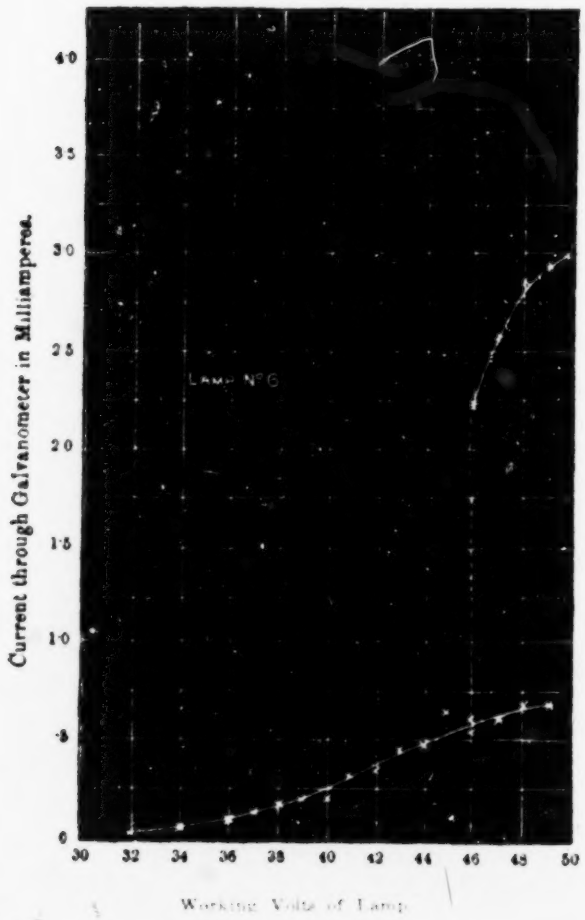
The results in Table No. 11 are plotted in curve No. 5.

[fol. 3054] This table shows that when the lamp is kept at a constant voltage the current through the galvanometer jumps from one value to another. The fluctuation of the current takes place when the negative leg of the carbon is the one farthest from the plate. When the leg adjacent to the aluminium plate is the negative one then the current is steady at any definite voltage of the lamp.

§ 15. From the above experiments it is clear that the current obtained when a galvanometer is connected between a

metallic plate and the positive electrode of the lamp is greater in proportion as the collecting-plate is larger and in proportion as it is brought into close proximity to the base

TABLE No. 11.—*Curve no. 5*



of the negative leg of the carbon. Also that a plate so placed is brought down to the potential of the negative electrode. It seemed desirable to see how far the removal of the collecting-plate to a great distance from the negative leg would influence these results, and experiments were accordingly tried with a tube of the form shown in fig. 11.

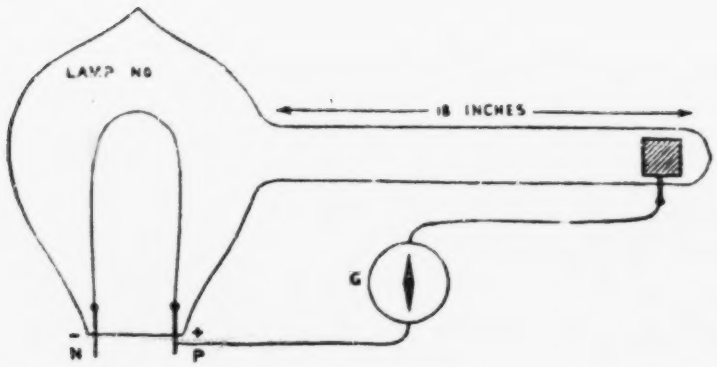


FIG. 11

Experiment 12.—In this case a glass tube about eighteen inches long and three-quarters of an inch in diameter was attached to a lamp bulb. The end of the glass tube farthest from the bulb was closed and an aluminium plate welded to a platinum wire was sealed in near this closed end. The plate had a length of about 3 centimetres and a width of about 1 centimetre. The tube formed an extension of the bulb space, and accordingly this arrangement formed a device by which a metal plate could be removed to a distance of some eighteen inches from the incandescent conductor contained in the bulb. On placing this lamp on a circuit and bringing the carbon to normal incandescence and connecting the terminals of the Elliott galvanometer respectively to the aluminium plate and the positive electrode of the lamp, a very small current was found to be passing through it, not, however, exceeding one ten-thousandth of a milliampere. When the galvanometer was joined in between the aluminium plate and the negative leg of the carbon no current whatever could be detected with this galvanometer, which was sufficiently sensitive to show one hundred-thousandth of a milliampere. We thus find that the removal of [fol.3055] the plate to a distance of some eighteen inches from the incandescent conductors practically extinguishes the phenomenon.

Experiment 13.—Another similar bulb was provided having a side tube blown on it of half the length, viz. about 9 inches long. At the end of this tube was placed a small

aluminium plate as before, and the tube was bent up about the middle at right angles (see fig. 12). When the carbon conductor in the bulb, which was that of an ordinary 50-volt 16 candlepower lamp, was rendered incandescent by being connected to a circuit of appropriate electromotive force, and the Elliott galvanometer connected in between the aluminium plate and the positive electrode of the lamp, a current of not more than about one twenty-thousandths of a milliampere was detected. The fact that the "Edison effect" was extinguished when the collecting-plate was placed at the extremity of an elbow-tube was first observed and recorded by Mr. Preece.

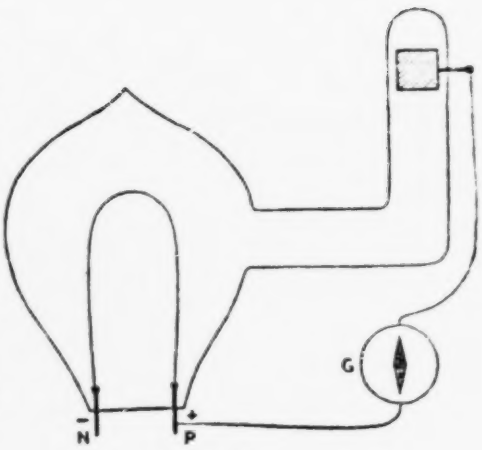


FIG. 12.

§ 16. The effect of position and size of the plate having been examined, the next step which naturally suggested

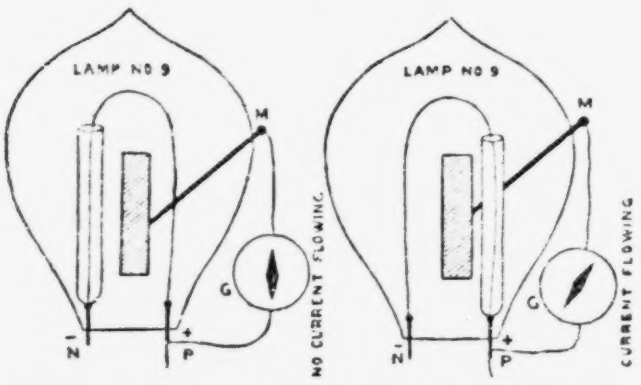


FIG. 13.

itself was to determine the effect of the different portions of the incandescent conductor in the production of it.

Experiment 14.—A lamp like No. 4 was provided, but in which one leg of the carboa was enclosed in a glass tube of the size of a quill. The glass tube was sealed on to the platinum wire and extended nearly up to the bend of the

carbon (see fig. 13). This lamp, called No. 9, was placed [fol. 3056] on the circuit in such a manner that the shielded leg was the *positive* leg, and a series of observations taken as usual of the current flowing through the milamperemeter when connected between the middle plate, placed between the carbon legs, and the positive electrode of the lamp. The results are as tabulated below in Table No. 12. The lamp took 1.25 ampere of current at a working electromotive force of 42 volts.

TABLE No. 12.—*Lamp No. 9, milamperometer*

Table showing the potential difference between the middle plate and positive electrode of the lamp, and the current flowing through a galvanometer connecting them, when the *positive* leg of the carbon is shielded in a glass tube.

Working volts of the lamp	Potential-difference of middle plate and positive electrode in volts	Milliampere current through galvanometer	Working volts of the lamp	Potential-difference of middle plate and positive electrode in volts	Milliampere current through galvanometer
39	0·2	0·032	45	6·9	0·936
38	3	048	46	7·5	1·19
40	95	12	47	9·7	1·53
41	1·2	19	48	12·4	1·96
42	1·8	29	49	15·1	2·39
43	3·1	49	50	19·1	3·03
44	4·2	66	51	23·1	3·66

So far the results are quite normal, and if the results in the above Table No. 12 are compared with those in Table 2 for a similarly constructed lamp with no tubular shield, we find that the magnitude of the current flowing from the positive electrode to the middle plate is in the two cases very much the same. The lamp No. 9 was then placed on the circuit in such a manner that the leg shielded by the glass tube was the *negative* leg, and a similar series of observations of the current between the positive leg (now the uncovered leg) and the middle plate was made. The results were as follows in Table No. 13:—

TABLES No. 12 AND 13. *Curve No. 6*

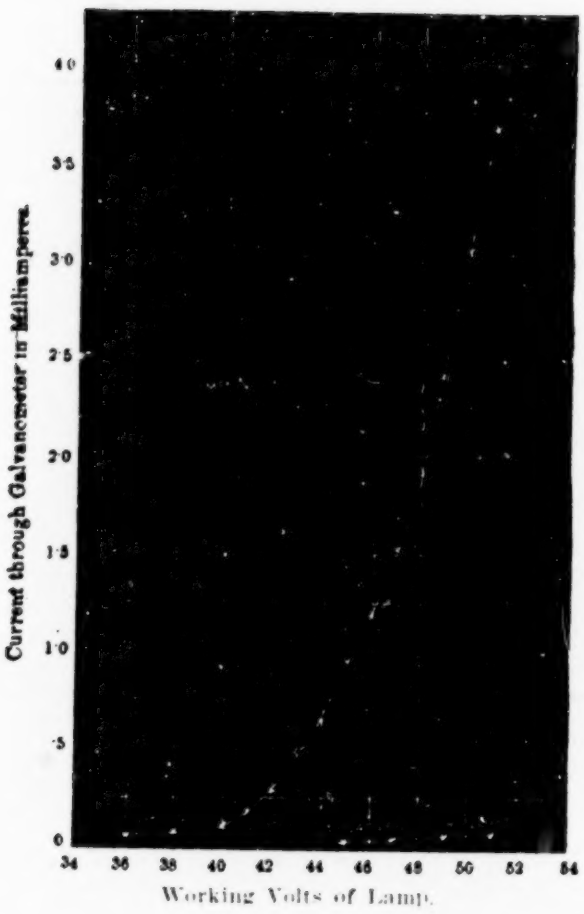


TABLE No. 13.—*Lamp No. 9. Milliampere-meter*

Table showing the potential-difference between the middle plate and positive electrode, and the current flowing through a galvanometer connecting them, when the *negative* leg of the carbon is shielded in a glass tube.

Working volts of the lamp	Potential-difference of middle plate and positive electrode in volts	Milliampere current through galvanometer
45	10	016
47	15	024
49	25	039
51	30	044

On comparing the results in Table No. 13 and the previous one No. 12 we see what an immense reduction in the [fol. 3057] current flowing between the positive electrode and the middle plate is produced by shielding the *negative* leg. Hence the action in virtue of which the current is produced is greatly interfered with by enclosing or covering up the negative leg of the carbon. In this particular case at 51 volts the current between the positive electrode of the lamp and the middle plate when the *negative* leg is covered up is only 1·83 of that which it is when the *positive* leg is covered up. The results in Tables Nos. 12 and 13 are plotted together in Curve No. 6.

17. The question remained to be settled whether the nature of the tubular screen in any way affected the results, and the glass tube was accordingly replaced by a metal (aluminium) tube and a lamp (No. 10) taken in which one of the carbon legs (see fig. 14) was surrounded by an aluminium cylinder extending nearly the whole length of the leg, and also a middle plate of aluminium was placed between the legs. Both the plate and the cylinder were held on platinum wires sealed through the glass. The lamp took 1.25 amperes of current at 41.5 volts.

[fol. 3058] *Experiment 15.*—The lamp was placed on a circuit so that the leg shielded by the aluminium cylinder was the *positive* leg. The milamperemeter was then connected between the positive electrode of the lamp and the middle plate, and the usual measurements made. It was found that the current "jumped" a good deal, and that high and low values of the galvanometer current occurred, even when the terminal voltage of the lamp was kept perfectly constant.

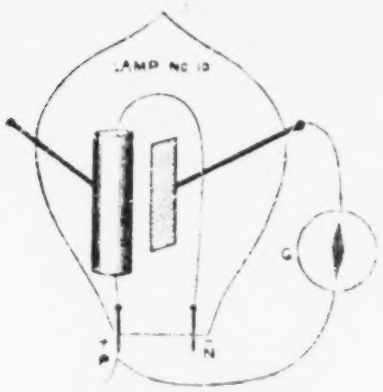


Fig. 14

The lamp was then reversed on the circuit so that the shielded leg was the *negative* one, all other arrangements remaining the same. The current now between the positive electrode and the middle plate was practically zero, at any rate too small to be measured with this galvanometer. Hence we see that shielding the negative leg, whether by glass or

a metallic cylinder, entirely cuts off the production of a current between the positive lamp electrode and the middle plate.

18. *Experiment 16.*—Another series of experiments was made with the lamp No. 10 in which the galvanometer was connected between the positive electrode of the lamp and the aluminium cylinder (see fig. 15), the leg inside the cylinder being either the positive *or* the negative leg. In this case the middle plate remained unused and insulated

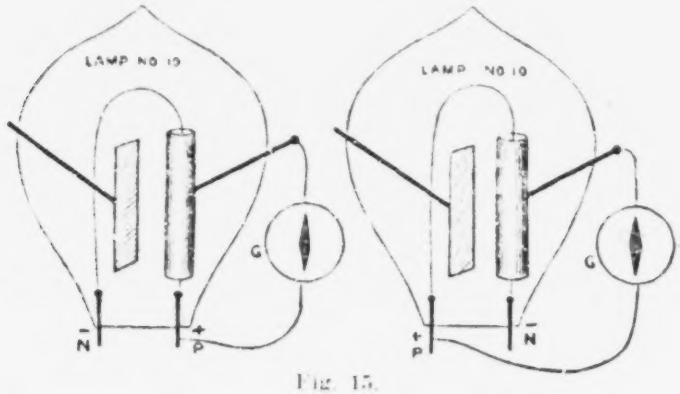


Fig. 15.

and acted as a shield between the cylinder and the carbon leg which was not contained in the cylinder.

It was found that when the cylinder surrounds the negative leg and its surface is, therefore, as much exposed to it as possible the current is a maximum, but that when it includes the positive leg the current is greatly diminished, both by reason of the fact that it opposes less surface to the negative leg, and also because the middle plate acts as a shield between it and the negative leg of the carbon.

[fol. 3059] 19. *Experiment 17.* In order finally to demonstrate that the negative leg of the carbon loop was the chief active agent in this production of a current between the middle plate and the positive electrode, a lamp like No. 4 was taken having a metal middle plate between the legs, and this middle plate had attached to it a mica screen (see fig. 16) a little larger than the plate, and so fixed by a loose rivet that it could be shaken in front of the plate so as to shield one side of it, or shaken on one side so as to fully expose the plate. This device was in fact a removable shield attached to one surface of the metal middle plate,

and when placed up against it, it shielded one surface from, and when jerked on one side it exposed that surface to, the carbon leg opposite to that surface. This lamp (called No. 5) was set on the circuit in the first place so that the leg of the carbon horse shoe opposite to the mica-shielded side of the middle plate was the *positive* leg. If the carbon was brought up to an incandescence corresponding to about 3.5 or 4 watts per candlepower and the galvanometer connected between the positive electrode and the middle plate, then it was found that the effect on the galvanometer current which was produced by the interposition or withdrawal of the screen of mica between the positive leg and the plate was not very great. It reduced the current through the galvanometer from about .44 milliampere to .38 milliampere. If, however, the current flowing through the lamp carbon is reversed in direction so that the mica screen is interposed on that side of the middle metal plate which faces the *negative* leg, the result is very different. When the screen is down, the current flowing through the galvanometer from the positive electrode to the middle plate being as before .44 milliampere, the interposition of the mica screen on the side of the plate facing the negative leg reduced the current at once to zero. We find therefore, that the interposition of a mica screen between the middle plate and the negative leg reduces to zero the current flowing between the positive lamp electrode and the middle plate. As in all other lamps with a middle plate set exactly between the legs, the current through the galvanometer joining the middle plate and positive electrode is very liable to "jump" from a low to a higher value or *vice versâ*. When the current has its higher value corresponding to any given voltage on the lamp terminals, the effect of screening is less marked, and although the interposition of the mica screen on the side facing the negative leg has an effect of reducing the current flowing through

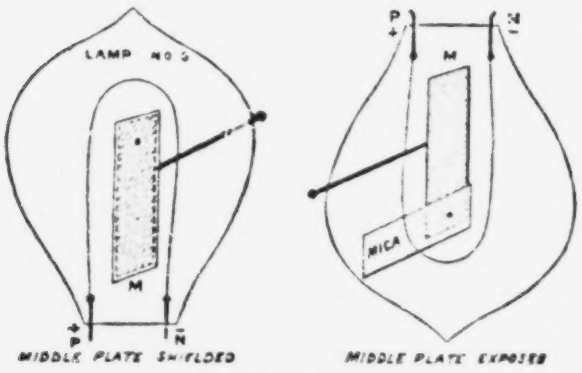


FIG. 16

[fol. 3060] the galvanometer connected between the middle plate and positive electrode, it is not by any means reduced to zero.

§ 20. The foregoing experiments afford proof that the production of the current through a galvanometer joined between the positive electrode of the lamp and a metal plate placed somewhere in the vacuous bulb, is an effect due chiefly to the *negative* leg of the carbon, and that shielding the negative leg by enclosing it in a glass or metal tube, or covering with a mica screen that surface of the plate which is exposed to the negative leg, either quite prevents or greatly reduces the production of this current. The experiments also have shown that the magnitude of the current flowing through the galvanometer is increased by bringing the plate near to the base of the negative leg, or, better still, making the metal plate in the form of a cylinder and making this cylinder surround the *negative* leg near its base; and correspondingly it is diminished by removing it from the negative leg to a considerable distance, or by shielding this collecting-plate from the radiation from the negative leg of the carbon. The experiments with the condenser have also given evidence that when an insulated metal plate is sealed into a lamp, this plate is brought down either instantly or in a very short period of time to the potential of the *negative* leg near its base or to that of the *negative electrode* of the lamp. In looking for an explanation of these facts we are assisted by our previous knowledge that in carbon incandescence lamps, when working at an efficiency equivalent to 3 to 4 watts per candle-power, there is a gradual loss of carbon from all parts of the conductor. We know also that the carbon molecules which are projected from the conductor are thrown off into a space so highly vacuous that their mean free path is of a length comparable with, or greater than that of the dimensions of the glass bulb. The existence of molecular shadows in incandescence lamps[3] affords evidence that from intensely heated portions of the carbon conductor carbon molecules are projected in straight lines and move freely forward until they impinge against the glass. Commercial experience informs us that at and above a temperature corresponding to 3 watts per candle-power this loss of carbon becomes

[3] See J. A. Fleming, "Philosophical Magazine," August 1885, p. 141, vol. XIV.

very rapid and thins away the filament in one place, or generally reduces the diameter of the carbon conductor. Hence we have every reason to believe that when in a normal state of incandescence the carbon conductor in a lamp is throwing off in all directions carbon molecules, and that in the vacuum usually obtained the mean free path of these projected molecules is comparable with the dimensions of the vessel containing the conductor. The whole of the experiments which are detailed here seem to be capable of consistent interpretation if we may justifiably make the hypothesis that these carbon molecules or atoms so projected from the conductor when intensely heated by the current flowing through it are all *negatively* charged. Some of the observed [fol. 3061] facts seem to point to the conclusion that the molecules projected from the incandescent conductor, whether they are portions of the conductor itself or molecules of the residual gases, respectively carry away negative charges proportional in magnitude to the potential of the conductor at the point from which they are thrown off. They may, therefore, be looked upon as condensers of small but definite electrostatic capacity charged to the potential (negative) of that part of the incandescent conductor at which they separate from it. We have then in addition to explain how it comes to pass that there are few or no projected molecules charged positively. Two suggestions may be made on this point: either the radiation of matter is wholly confined to that half of the conductor at a negative potential or the incandescent carbon molecule thrown off from the heated conductor cannot retain a positive charge. There is much to lead to the conclusion that from *all parts* of the incandescent carbon conductor there is a constant radiation of matter carrying a negative electric charge. The nearer down to the negative electrode of the carbon we select our point of observation the greater is this molecular charge found to be. It will be convenient to denote this conveyance of electric charge by moving charged molecules by the term *molecular electric*

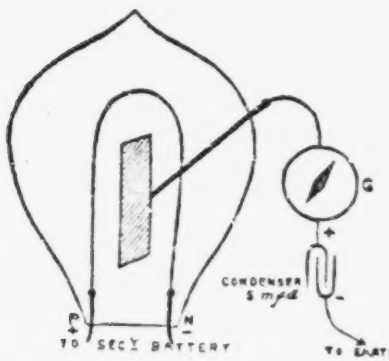


Fig. 1.

vection. We can then state the hypothesis thus—from all portions of the negative leg of the carbon loop a process of molecular electrovection is going on when the conductor is incandescent, the molecular charge being negative, and equal in potential to that of the point on the conductor from which it is projected.

21. On the assumption that a molecular shower of negatively charged atoms was being projected against the middle plate when the conductor of the lamp was incandescent it was considered probable that a positively charged conductor connected to the middle plate would be discharged, and this was found to be the case.

Experiment 18.—A lamp of the form of No. 4, having a middle metal plate placed between the carbon legs, had its middle plate connected to one terminal of the Elliott galvanometer. The other terminal of the galvanometer was connected to one terminal of a condenser of 5 microfarads capacity. The other terminal of the condenser was connected by a wire to the gas pipes of the laboratory. The lamp was actuated by secondary batteries (see fig. 17) not very well insulated. If the condenser was charged to a potential of 50 volts so that the plate next the galvanometer was *positively* charged, then this positive charge was *instantly discharged* when the carbon was rendered incandescent. If, however, the plate of the condenser in connexion with the middle plate through the galvanometer was [fol. 3062] charged *negatively* the condenser was not discharged when the lamp was illuminated by rendering its carbon incandescent. It is a very striking experiment to see a condenser charged with this amount (250 microcoulombs) of electricity instantly discharged when its positive coating is brought into connexion with the middle plate of such a lamp. The discharge may be brought about either by joining up the positive side of the condenser to the middle plate first, and then rendering the carbon of the lamp incandescent by switching on the lamp, or the lamp may be first of all illuminated and then the junction of the condenser effected. In both cases the middle plate when positively electrified is instantly discharged.

It was found that if the lamp carbon is rendered incandescent by a highly insulated secondary battery, then in order to produce the discharge, the plate of the condenser not in connexion with the middle plate, and which is *negatively* charged, must be somewhere connected with the bat-

tery circuit. It does not matter, however, whether the wire from the negative side of the condenser is in connexion with the positive or the negative pole of the secondary battery actuating the lamp; all that is necessary is that the negative side of the condenser should be in conducting connexion with the circuit of the incandescent carbon. The experiment may be interpreted by considering that this negative charge of the condenser can escape out of the incandescent conductor and discharge across the highly vacuous space to the positively electrified cool middle metal plate; but that a positive charge cannot be discharged out of the hot conductor, or, which amounts to the same thing, a negative charge cannot discharge across from the cool metal plate to the incandescent carbon which is positively charged. We have then a unilateral conductivity exhibited by this highly vacuous space bounded by two electrodes one of which is incandescent and the other of which is cold. Negative electricity is discharged at once out of the hot surface but not out of the cold, and a negative discharge can take place from hot to cold but not *vice versâ*. When the discharge of a charged condenser is effected by connecting the positive plate, through a galvanometer, with a metal plate sealed into the lamp and the negative plate with the lamp circuit, and then switching on the lamp, there is a curious instant of delay before the discharge begins. When the metal plate is placed very near the negative leg of the carbon the discharge of the condenser is complete in one instant. This — the case when a lamp of the type No. 4 (fig. 18) is used. If, however, we employ a lamp of the type No. 2 (fig. 10), in which the metal plate is at some distance from the negative leg of the carbon, the discharge of the condenser is long drawn out and the electric charge in it is as it were tapped off slowly and not in one short sharp discharge.

Moreover this effect of discharging a condenser takes place only when the carbon is above a fair red heat. At brilliant incandescence and when the carbon is above a temperature corresponding to 3 watts per candle-power, the discharging power of a lamp of the type of No. 4 is very great. A condenser of 10 or 20 microfarads capacity [fol. 3063] charged to 50 volts is discharged instantly if its positive plate is connected to the metal plate placed not far from the negative end of the incandescent carbon conductor.

The foregoing results were confirmed with lamps of other types. Using, for instance, a lamp like No. 6 with the aluminum plate placed outside the carbon horse-shoe and near the leg, the same discharging power for positive electricity was found. It was not dependent on the direction of the current through the lamp carbon, although it seemed a little more vigorous when the leg nearest the plate was the negative leg. As above observed, the rate of discharge was much reduced when employing a lamp having the metal plate placed edgeways on to the carbon and some way from it, as, for instance, when employing a lamp of the form of No. 2.

§ 22. *Experiment 19.*—A series of experiments was in this case also tried to determine the effect of shielding the negatives leg of the carbon. The lamp No. 9 was employed, in which one leg of the carbon was enclosed in a glass tube connecting the positive plate of a charged condenser through a galvanometer with the middle plate of the lamp, and the negative plate of the condenser somewhere to the battery circuit; it was found that when the shielded leg of the carbon was the positive leg the condenser was discharged as before. If, however, the shielded leg or enclosed in the glass tube was made the negative leg, which could be done by reversing the current through the carbon conductor, then the condenser was not discharged when its positive plate was connected with the middle plate.

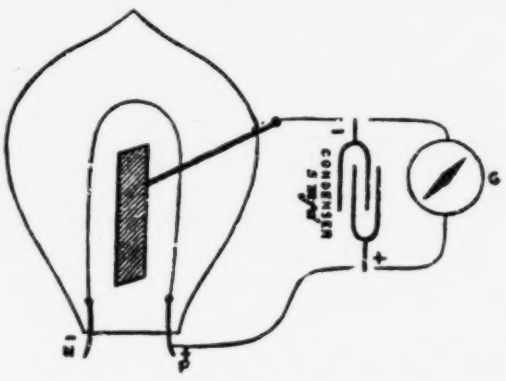


FIG. 18.

The same fact was less perfectly exhibited by employing the lamp with the middle plate having a removable mica shield on one side. We are thus able to assure ourselves that the active agent in producing this discharging effect upon a positively charged body connected to the middle plate is the negative leg of the carbon conductor. The experiments were varied in many ways, but all pointed to the conclusion that if a charged condenser is connected to two terminals, one of which is a metal plate and the other a

carbon conductor, both enclosed in a high vacuum but yet separated from each other by an inch or so of distance, the condenser is discharged instantly when the carbon terminal is rendered highly incandescent, provided that the negative plate of the condenser is in connexion with it.

23. If the condenser is left in contact with the middle plate under some circumstances, not only is it discharged if previously charged but is charged again in an opposite direction.

[Vol. 3064] *Experiment 20.* A condenser of 5 microfarads capacity perfectly discharged has its poles or terminals connected for one instant, one with the middle plate of No. 4 lamp and the other with the positive electrode of the lamp (see fig. 18). On removing it and testing it with the galvanometer G it is found that the condenser plate in connexion with the middle plate of the lamp has received a negative charge and the other plate of the condenser a positive charge.

If, however, the condenser is connected between the negative electrode of the lamp and the metal middle plate of the lamp, on insulating and testing it we find it has not the slightest charge.

It is very astonishing to see how instantly a condenser of very large capacity is charged when one pole of the condenser is connected to the middle plate and the other to the positive electrode of the lamp.

24. In considering the behaviour of the heated carbon electrode and the cool metal plate in their respective powers of discharging the positive or negative charge of the condenser, it seemed that the fundamental fact was the power of the heated surface to discharge negative electricity out of itself. Hence arose the question, how far the observed facts would be modified if the middle metal plate itself could be also heated. One way by which this might have been done would have been to have rendered this plate incandescent by heating it by radiant heat concentrated by means of a powerful mirror or lens. Some

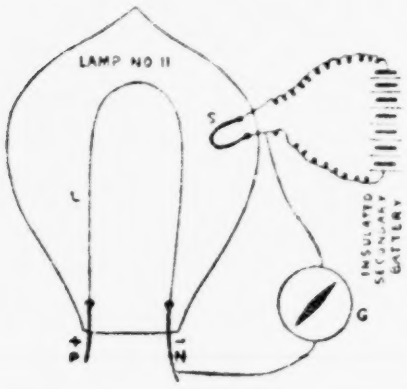


FIG. 19

experiments tried in this way were not satisfactory, and consequently a method was adopted in which a middle plate of carbon could be rendered incandescent electrically.

Experiment 21.—A vacuum tube was provided with two carbon conductors (see fig. 19), one the ordinary carbon filament L of a 50 volt lamp, and the other the small carbon S of a 4 volt lamp. The smaller carbon was sealed in the usual way through the glass and placed so as to stand symmetrically between the legs of the larger carbon loop.

The smaller carbon could be rendered incandescent by an insulated battery of fifteen secondary cells, appropriate resistance being introduced. The larger carbon also could be rendered incandescent by the proper electromotive force. If the smaller carbon was kept cold and employed simply as a third electrode or middle plate, all the phenomena previously described as happening with metal middle plates of aluminum or platinum took place. If the small (cold) carbon loop is connected through a galvanometer with the positive electrode of the larger carbon loop when this last is rendered incandescent by a current, we find as usual a [fol. 3065] current of a few milliamperes passing through the galvanometer from the positive electrode of the larger carbon to the small carbon. If the small carbon (still cold) is connected through the galvanometer to the negative electrode of the larger carbon, we get no current. This is the normal effect, and it is the same for a cold carbon conductor used as a middle plate as for a metal middle plate.

Experiment 22.—The next experiment consisted in making this small carbon incandescent by an insulated secondary battery, appropriate resistance being inserted so that the carbon was brought to the normal condition of temperature as indicated by its incandescence. When this was done the galvanometer was inserted between the positive electrode of the large carbon loop and one of the electrodes of the small carbon loop. A current was obtained as before. On connecting the galvanometer between the *negative* elec-

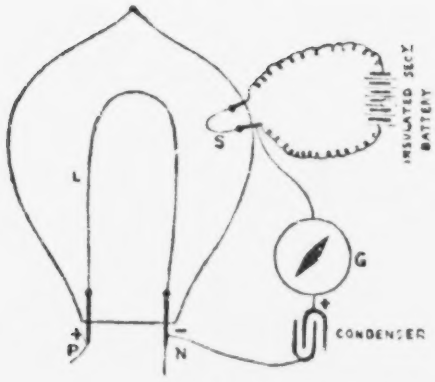


FIG. 20.

trode of the large carbon loop and one of the electrodes of the small carbon loop, a current of nearly equal value was now obtained. In this last experiment it was found to be immaterial whether the terminal of the galvanometer was joined to the positive or to the negative electrode of the small carbon loop. Hence we find that when the small carbon loop is not incandescent and is used as a middle plate or electrode, it is brought down together with the insulated battery attached to it to the same potential as the negative end of the large incandescent carbon, and we get as usual a current through a galvanometer connected between the positive electrode of the large incandescent carbon and any point on the small cold carbon, and no current between the negative electrode of the large hot carbon and the small cold one. On rendering the smaller carbon loop incandescent this is all changed. The smaller carbon, now hot, is not brought down to the potential of the negative ends of the larger carbon, and we get a current through a galvanometer connected between either positive or negative electrode of the large hot carbon and any point on the circuit of the smaller equally hot carbon.

25. *Experiment 23.*—With this same vacuum tube having double carbons, further experiments were performed on the discharging power of the hot and cold electrodes for positive and negative electricity. The two carbons could be rendered incandescent either simultaneously or singly by two sets of insulated secondary batteries attached to each respectively. For the sake of distinction we shall speak of the large carbon loop in this bulb as the L loop and the smaller one as the S loop. A condenser of 5 microfarads capacity (see fig. 20) was employed, which was charged to a potential of about 50 volts. When the positive plate of [fol. 3066] this charged condenser was attached to the carbon L and the negative side to the carbon S, then on making L incandescent by its own insulated battery and keeping S

cold, the condenser was found not to be discharged when insulated and tested by a galvanometer. If, however, the same charged condenser was connected in the same way to the two carbons and the carbon S, to which the negative side of the condenser was attached, was made incandescent, the condenser was instantly discharged. If the direction of the charging of the condenser was reversed the same rule was found to hold good. The condenser was discharged if the *negatively* charged plate of the condenser was connected to the *incandescent* carbon loop, but not if it was connected to the cold carbon loop. Beginning with the condenser charged and connecting it in between the two carbon loops, neither of them being incandescent, then the condenser was discharged instantly if that loop to which the *negatively* charged side of the condenser was attached was rendered incandescent, but not discharged if the loop to which the positive side of the condenser was connected was rendered incandescent. If both loops were rendered incandescent simultaneously the condenser in any case was discharged, but apparently at an accelerated rate. These experiments show again that if two carbon electrodes are sealed into a high vacuum, negative electricity escapes very freely out of either electrode if it is rendered incandescent, but that the escape or discharge of positive electricity is not in the same way facilitated by heating the positive electrode. Accordingly a highly vacuous space bounded by two carbon electrodes separated by a distance less than the mean free path of the gaseous molecule at that pressure, presents a unilateral conductivity when one of these electrodes is cold and the other highly incandescent. For if the hot electrode is connected to a negatively charged body and the cold electrode to a positively charged body, discharge takes place across the vacuous space, but if the charges are reversed then no discharge takes place. The negative charge can escape from the heated electrode but not from the cold one.

§ 26. *Experiment 24.*—The question of the apparent unilateral conductivity of the vacuous space bounded by a hot and a cold electrode was then further examined by the aid of the lamp No. 6 formerly used.

In this lamp an aluminum plate is sealed into the vacuum and placed just outside the carbon horse-shoe. If a sensitive galvanometer (the high resistance *Elliott* galvanometer) is joined up between the metal plate and the negative

electrode of the lamp, then, as in other cases when the lamp is in action, no current of a magnitude much greater than .0001 of a milliampere is detected. If a single Clark standard cell is inserted in the galvanometer circuit (see fig. 21) with its negative pole attached to the middle plate and its positive pole to the galvanometer terminal, the current is barely if at all increased. In this case the negative pole of the Clark cell is in connexion with a cold metal electrode and the *positive* pole is in connexion through the galvanometer with the incandescent carbon electrode, and under these circumstances the galvanometer detects no current [fol. 3967] flowing. The position of the Clark cell is now reversed, and it is joined up so that its positive pole is in connexion with the middle plate and its *negative* pole in connexion, through the galvanometer, with the incandescent carbon electrode. It is then found that a considerable current of some few milliamperes in magnitude is flowing through the galvanometer. The direction of this current in the ordinary way of speaking is *from* the negative electrode of the lamp through the galvanometer *to* the metal plate sealed into the bulb. We thus find that a negative current of electricity can be made to flow across the vacuous space between the incandescent carbon and the metal plate *from* the hot carbon *to* the cooler metal plate, but not in the reverse direction. The space presents an apparently unilateral conductivity.

27. *Experiment 25.*—The same experiment was repeated, only using instead of a Clark cell an insulated sec-

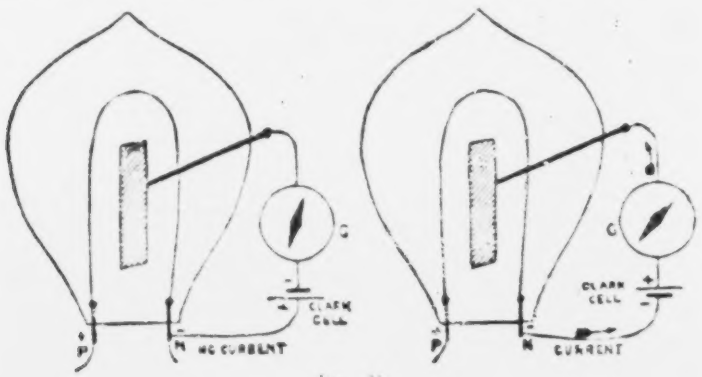


FIG. 21

ondary battery of 25 small cells. When the secondary battery (see fig. 21) was connected with its negative pole to the metal plate and its positive pole through the galvanometer

to the negative electrode of the carbon, no current greater than that found with the Clark cell similarly arranged was found; but if the secondary battery was reversed and joined up with its positive pole to the middle plate and its negative pole through the galvanometer to the negative electrode of the incandescent carbon, then so strong a current flowed through the galvanometer that it could not be measured without shunting down the galvanometer considerably. The same experiments were repeated with the lamps having the zigzag wire as a metal plate, No. 7, and the same general results obtained. These experiments therefore show that in a circuit which consists partly of a galvanometer-wire and partly of a highly vacuous space bounded by two electrodes—one a metal plate and the other an incandescent carbon surface—the insertion of an electromotive force in one direction can produce a very sensible current, but that if the electromotive force is reversed then no current flows. The direction of the electromotive force must be such as to urge negative electricity from the hot surface to the cold across the vacuous space.

[fol. 3068] 28. *Experiment 29.*—In order to make use of different parts of the incandescent conductor as the electrode opposed to the metal plate, recourse was had to the lamp No. 3, with metal (aluminum) cylinders embracing without touching the carbon at two different places. These

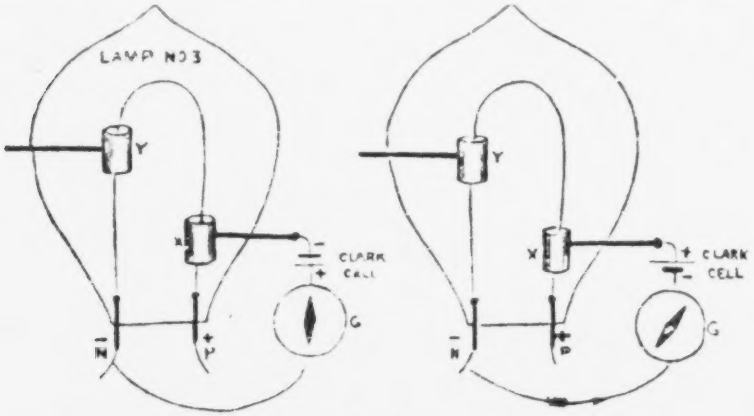


FIG. 22

cylinders, as before, we will call X and Y (see fig. 22). Cylinder X was the one near the base of the positive leg of the carbon, and cylinder Y was the one near the top of the negative leg.

When the galvanometer was connected between the negative electrode of the lamp and the cylinder X surrounding the lower part of the positive leg, no perceptible current was found to be passing when the carbon was rendered incandescent. On inserting a single Clark cell in series with the galvanometer so that the negative pole of the cell was in connexion with the cylinder X and the positive pole of the cell through the galvanometer in connexion with the negative electrode of the lamp, hardly any perceptible current was found to be passing (see fig. 22). The Clark cell was then reversed, connecting the positive pole of the cell to the cylinder X and the negative pole through the galvanometer to the negative electrode of the lamp. On bringing the lamp into action, a considerable current of several milliamperes was found to be passing in such a direction that a current of positive electricity was flowing across the vacuous space from the metal cylinder to the hot carbon, or a negative current from the hot carbon to the cooler metal cylinder. On switching off the lamp, there was a curious "kick" or "throw" of the galvanometer, indicating a sudden rush of current in the same direction as the steady current which the cell had been sending. These effects occurred also when the cylinder Y was employed, and the galvanometer with or without the cell in series joined in between the negative electrode of the lamp and the cylinder Y embracing the top part of the negative leg of the carbon (see fig. 22); but in the last case the steady current sent by the cell across the vacuous space between the cylinder and the hot carbon was only about a quarter as great in magnitude as when the cylinder X was employed. There was the same kind of [fol. 3069] "kick" of the galvanometer on breaking the lamp circuit. These experiments evidently show that the highly vacuous space between the hot carbon traversed by its own current, which rendered it incandescent, and the insulated cylinder possessed a sort of unilateral conductivity, negative electricity from a separate source of small electromotive force being able to be forced through it from the hot carbon surface to the cooler metal surface, but not in an opposite direction.

29. In the above-recorded experiments the carbon conductor was rendered incandescent by a unidirectional or continuous current in a highly perfect vacuum. In seeking for an hypothesis to connect them together, it became essen-

tial to ascertain how the effects would be modified if the vacuum was imperfect and if the current was alternating instead of continuous.

Experiment 27.—The fundamental experiment was therefore repeated with the normal type of lamp (No. 4), having a middle metal plate placed symmetrically between the legs of the carbon. A lamp of this type was set in action by an alternating current of suitable strength and of which the frequency was some 80 to 100 per second. On connecting the milamperemeter between *either* of the electrodes of the lamp and the middle plate, a *continuous* electric current was found flowing through the galvanometer. The direction of this current was such that positive electricity was found to flow from either lamp terminal to the middle plate of the lamp. In other words, a continuous current of negative electricity flowed out of the middle plate to one or other of the two terminals of the lamp, viz. to that terminal to which the other extremity of the galvanometer was joined. Hence, since in this case each leg of the carbon becomes in rapid succession positive *and* negative when the lamp is operated with an alternating current, the unilateral effect observed of a current flowing between the middle plate and the positive leg, when the current through the carbon is a continuous current, is here found to exist equally between the middle plate and *both* terminals of the lamp. This is only what might have been expected. The potential of the middle plate is then not the same as that of the base of either leg of the carbon, but something between the two depending upon the position of the plate.

§ 30. *Experiment 28.*—The effect of lowering the vacuum was also the subject of experiment. In a lamp with a highly perfect vacuum no current greater than about .0001 milliampere is observed when a very sensitive high-resistance galvanometer is joined up between the negative electrode of the carbon and the insulated middle plate, and, as we have seen the experiments with the electrostatic voltmeter showed that the plate was brought down under these circumstances to the potential of the base of the negative leg of the carbon. If, instead of employing a very perfect vacuum, a bad one is produced by imperfectly exhausting the lamp, then it is found that under these conditions the Elliott galvanometer indicates a not inconsiderable current of something approaching to a milliampere when joined in be-

tween the negative electrode of the lamp and the middle [fol. 3070] plate. Hence, when the vacuum is imperfect the equality in potential between the middle plate and the negative electrode is not maintained.

The direction of the current in this last case is such as to show that negative electricity is flowing through the galvanometer from the negative electrode of the lamp to the middle plate. In other words, negative charge is carried over from the plate to the positive leg of the carbon across the imperfectly vacuous space; and the means by which this is effected is the residual air. This seems to afford proof that the normal effect of the molecular electrovection of negative electricity from the negative leg is due to carbon molecules, and that the presence of residual air exhibits itself, when present beyond a certain amount, in producing an effect which the carbon molecular electrovection cannot produce.

31. *Experiment 29.*—It seemed very desirable to ascertain if the effect of molecular electrovection exists in the case of an incandescent platinum wire rendered vividly incandescent in a highly perfect vacuum. A bulb was accordingly constructed similar in every way to lamp No. 4, but having a platinum wire horse-shoe conductor and a platinum middle plate. When this wire was rendered highly incandescent by a continuous current, a sensitive galvanometer (the high resistance Elliott) showed a current of about one five-thousandth of a milliampere when connected between the positive electrode of the incandescent wire and the middle plate, but little or no current when connected between the negative electrode and the middle plate. This molecular *electrovection* current was thus very much less in magnitude than that observed in the case of the carbon filament lamps, but it is in the *same direction*. We are, however, enabled to state that at a condition of vivid incandescence just short of fusion a platinum wire *in vacuo* exhibits the same effects as a carbon filament, and that it can disturb the electrical condition of an insulated metal plate near it sealed into the same vacuum and tends to bring it down towards the potential of the negative end of that platinum wire.

On the hypothesis that all these effects are due to a scattering of negatively charged molecules from the incandescent conductor, we must affirm that the same process goes on in a platinum wire rendered incandescent in a vacuum,

only that the radiation of matter is far greater in the case of the incandescent carbon than it is in the case of the incandescent platinum.

§ 33. If a lamp is selected having an insulated plate fixed between the legs of the carbon filament it is found that under certain conditions the electric conductivity of the vacuous space between the plate and the negative leg is much affected by the presence of a magnetic field. If a galvanometer, preferably a movable coil galvanometer, having a resistance of about 500 or 600 ohms, is connected between the middle plate and the negative leg it will show but little current passing when the lamp is incandescent at normal temperature. If the volts on the lamp terminal are raised so that the filament is brought into a state of incandescence corresponding to about 2.5 or 3 watts per candle, then the [fol. 3071] galvanometer will show a small current passing through it. If then a horse-shoe magnet is held so as to create a magnetic field the direction of which is across the space between the plate and the negative leg, the current indicated by the galvanometer immediately decreases considerably. This happens irrespective of the direction of the field so long as it is across the direction of the line joining the negative leg and the middle plate. This indicates that the presence of this transverse field increases the resistance of the rarefied gas. The galvanometer current responds to the presence of the magnet in a manner which shows that the resistance to the flow of the current through the gas is increased by creating a magnetic field at right angles to the line of the current. The general fact that gaseous resistance is increased by such a transverse magnetic field has been already noted and described by Professor J. J. Thomson. The behaviour of bismuth as regards electrical resistance in a magnetic field is strikingly similar.

The "jumping" of the current from one value to a higher, which has been already mentioned, appears to be due to something equivalent to a sudden change in the resistance of the space between the negative leg and the middle plate when the lamp is in action and at high incandescence. The fact of sending a small current through this space seems to effect a change in the qualities of the rarefied gas as a conductor which makes it conduct better. There are certain after-effects in some cases which are strongly similar to the polarization of electrodes observed in the case of liquid elec-

trolysis, and which seem to point to the validity of the view that gaseous conduction is effected by a similar process.

The experiments also confirm the opinion of Professor J. J. Thomson that gases, or at least certain gases in a rarefied condition, are very good conductors, and they show that the greatest part of the obstacle to conduction through a vacuum tube is at the electrodes and may be largely removed by heating the kathode to incandescence.

Discussion

Prof. S. P. Thompson said he would like to have some information as to the state of exhaustion of the lamps; whether this was such as is found in ordinary commercial lamps, or whether it more nearly approached that used by Crookes. A great change in the conductivity, &c., took place at an exhaustion slightly greater than that ordinarily found in incandescent lamps. It would be of interest to vary the size of the kathode, and to investigate whether the magnitude of the effects observed depended on the fall of potential per unit length along the filament. Another point was whether the position of the plate for which the effect was a minimum was the same for all lamps, or whether it changed with the volts and the length of the filament employed. Again, did the minimum occur at a certain fraction of the distance between the positive and negative leads, or, as was the case in some of the phenomena observed by Crookes, at a definite distance from either of the leads? These points might be [fol. 3072] investigated by means of a lamp with a straight filament, where the fall of potential per unit length along the filament could be made the same as with the loop-shaped filament but the fall of potential per unit length in the vacuum would be different. The author's proposed experiment of heating the kathode by concentrating on it the rays of a lamp did not seem to him (Prof. Thompson) to differ materially from Crookes' experiment in which an incandescent wire, heated by a current, was used as the kathode.

Mr. Skinner said that the heating of the kathode by means of a "burning-glass" could easily be carried out.

Mr. Blakesley pointed out that it would be quite possible to produce an increase of the current by means of a magnet.

Mr. Searle said that Prof. J. J. Thomson had shown that a magnet affected the conductivity of a gas.

Prof. Fleming, in his reply, said that no doubt the effects

were largely dependent on the vacuum in the lamps. The lamps employed were exhausted to the ordinary commercial vacuum. Since it was found that the "treating" was more worn off the negative leg of the filament, and that a screen placed between the legs of the filament was more blackened on the side turned towards the negative leg, it would appear that the particles of carbon were shot off from the negative leg, and hence perhaps the charge was carried by these carbon molecules.

[fol. 3073] DEFENDANT'S EXHIBIT P-1

Physikalische Zeitschrift—Oct. 20, 1904, pp. 680-81

Translation of Wehnelt Article

A Wehnelt (Erlangen), in reference to the exit of negative ions from incandescing metallic oxids and phenomena connected therewith.[1]

In a treatise with the same heading in Vol. 14, pp. 425-468 of the Annalen der Physik (1904) I have set forth a series of experiments and measurements which showed that certain metallic oxids, and in fact, especially the oxids of the earth alkali metals in an incandescing state, both under atmospheric pressure and also in a vacuum, emit numerous negative ions. (electrons)

In intimate connection with this quality stands the fact also discovered by me, that the cathode drop in a glimmer charge completely disappears on glowing oxid cathods even under the deepest pressures, provided that the current density (current strength per square centimeter of incandescing oxid surface) remains below a value depending upon the temperature and increasing with this. That current density at which a cathode drop begins to show I have called the limit current density. It attains, under high incandescence of the oxid, values up to three amperes.

I wish today to first bring before you some experiments which explain that which has been said above, and then to show you a practical application of incandescing oxide cathodes.

---

[1] Read in Division 2 on the 21st of Sept. Exhaustive literary references are to be found in Annalen der Physik Vol. 14, p. 425-468, 1904.

Emission of Negative Ions by Incandescing Metallic Oxids. A glass tube R (Fig. 1), exhausted to a moderate extent, contains a brass cylinder C in the axis of which [fol. 3074] there is situated a thin platinum wire D covered with CaO. The wire can be heated to high temperatures by the current of two accumulators A. If I connect the wire D with the one pole, the cylinder C through a galvanometer G with the other pole, of a source of current B, then there only flows a current through the tube if D is connected with the negative pole of B. The experiment shows consequently that only negative ions are emitted from the incandescing oxid.

If I take another tube, which is otherwise exactly similar, but which contains a platinum wire carefully cleaned, and heat the same to the same temperature as previously the wire covered with CaO, then the current is under an equally high negative charge of the wire only exceedingly weak, and in fact, only about 1 1000 of that in the former experiment.

Incandescing Metallic Oxids as Cathodes in Discharge Tubes. The tube R (Fig. 2) contains as cathode K a platinum sheet P covered with CaO which can be electrically heated red hot, and as an anode an iron wire A. The surface of the incandescing metallic oxid cathode amounting to several square centimeters, allows of sending through the tube considerable current strengths, even under deep pressures without there being present a cathode drop.

Since the anode drop constantly amounts to about 20 volts and the drop on the positive cells under strong currents and low pressures, as special measurements have shown, amounts to only one to two volts per centimeter, I can, by using the light conductor of 220 volts potential, send through the tube Fig. 2 currents of several amperes strength. The incandescing oxid cathodes furnish us consequently with a means of investigating the processes in the positive column with any gas whatever and under any pressures however deep, up to very high current strengths. The remarkable brightness of the positive strata under high current strength promises to be serviceable to the spectroanalytical investigation of gas spectra. Quartz windows on [fol. 3075] the tube would also make the ultra violet portion of the light of the strata accessible to investigation.

Weak Cathode Rays: If we exceed the limit current density either by increasing the current strength or decreasing the temperature of the incandescing oxid cathode, then we can impart to the cathode drop any desired value, and consequently produce cathode rays of any desired velocity.

The tube, Fig. 3, contains as cathode K a small platinum sheet P upon which there is located a small speck of calcium oxid.

A brass rod A serves as anode. If the sheet P is electrically brought to a glowing heat and the electrodes A, K, by throwing in a suitable resistance are connected with the light conductor of 220 volts potential, then the entire current goes only through the calcium oxid coating on the cathode sheet P, since here the cathode drop is much lower than on the clean platinum sheet, whereby there proceeds an intensely blue cathode beam of rays from the coating. By changing the temperature of the platinum sheet, there can be imparted to the cathode rays then any desired velocity, and this can then be measured according to well-known methods.

Application of Discharge Tubes with Glowing Metal Oxid Cathodes in Practice. If in an exhausted discharge tube R (Fig. 4)[1] we push one or several metallic electrodes A [fols. 3076-3077] close to the glowing metallic oxid electrode K (platinum sheet P covered with CaO) then the discharge potential, if A is anode and K is cathode, amounts to only about twenty volts. If we reverse the direction of current, so that now A is cathode and K is anode, the discharge potential now amounts to some thousands of volts, since under deep pressures the cathode drop on metals takes on exceedingly high values. If, therefore, we connect the electrodes A and K with an alternating source of current, the potential of which lies below the value which the cathode drop on the metallic electrode A has, then the tube acts as an electric valve, in that it allows to pass through only one phase of the alternating current. The tube (Fig. 4) can consequently serve for the purpose of transforming alternating current into pulsating direct current.

The maximum current strength to be sent through the tube (valve tube) depends as follows, from what has been

[1] The cathode K is assumed to be turned 90° as regards the plane of the picture.

said above, upon the size of the glowing oxid surface. The efficiency of the valve tube depends upon the working potential employed, and increases with this, since the tube up to the strongest allowable current strength, entirely independent of this, absorbs always only 20 volts potential. In applying a working potential of 120 volts alternating current, taking into consideration the consumption of watts for heating of the metal oxid cathode, the efficiency of the valve tube amounted to about 65%.

By using the well-known Graetz system of connection, both phases of the alternating current can be utilized. By using three metallic anodes, we can as with a Hewitt transformer, also transform rotary current into pulsating direct current.

Discussion.

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DEFENDANT'S EXHIBIT T-1

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WILLIAM FRANCIS, Ph.D. F.L.S. F.R.A.S. F.C.S.

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TABLE IV.—Selected Fusing and Boiling Points on the Proposed British Association Scale.

Substance.	F.P.	Substance.	B.P.
Tin	2319	Aniline	1841
Bismuth	2692	Naphthalene	2180
Cadmium	3207	Benzophenone	3078
Lead	3277	Mercury	3567
Zinc	4190	Sulphur	4115
Antimony	6205	Cadmium	7361
Aluminium	6545	Zinc	9161

My thanks are due to several Members of the Electrical Standards Committee of the British Association and others, who have kindly revised the proofs of this article

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LVIII. *On the Masses of the Ions in Gases at Low Pressures.* *By* J. J. THOMSON, *M.A., F.R.S., Cavendish Professor of Experimental Physics, Cambridge* *.

IN a former paper (Phil. Mag. Oct. 1897) I gave a determination of the value of the ratio of the mass, m, of the ion to its charge, e, in the case of the stream of negative electrification which constitutes the cathode rays. The results of this determination, which are in substantial agreement with those subsequently obtained by Lenard and Kaufmann, show that the value of this ratio is very much less than that of the corresponding ratio in the electrolysis of solutions of acids and salts, and that it is independent of the gas through which the discharge passes and of the nature of the electrodes. In these experiments it was only the value of m/e which was determined, and not the values of m and e separately. It was thus possible that the smallness of the ratio might be due to e being greater than the value of the charge carried by the ion in electrolysis rather than to the mass m being very much smaller. Though there were reasons for thinking that the charge e was not greatly different from the electrolytic one, and that we had here to deal with masses smaller than the atom, yet, as these reasons were somewhat indirect, I desired if possible to get a direct measurement of either m or e as well as of m/e. In the case of cathode rays I did not

* Communicated by the Author: read at the Meeting of the British Association at Dover.

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see my way to do this; but another case, where negative electricity is carried by charged particles (*i. e.* when a negatively electrified metal plate in a gas at low pressure is illuminated by ultra-violet light), seemed more hopeful, as in this case we can determine the value of e by the method I previously employed to determine the value of the charge carried by the ions produced by Röntgen-ray radiation (Phil. Mag. Dec. 1898). The following paper contains an account of measurements of m/e and e for the negative electrification discharged by ultra-violet light, and also of m/e for the negative electrification produced by an incandescent carbon filament in an atmosphere of hydrogen. I may be allowed to anticipate the description of these experiments by saying that they lead to the result that the value of m/e in the case of the ultra-violet light, and also in that of the carbon filament, is the same as for the cathode rays; and that in the case of the ultra-violet light, e is the same in magnitude as the charge carried by the hydrogen atom in the electrolysis of solutions. In this case, therefore, we have clear proof that the ions have a very much smaller mass than ordinary atoms; so that in the convection of negative electricity at low pressures we have something smaller even than the atom, something which involves the splitting up of the atom, inasmuch as we have taken from it a part, though only a small one, of its mass.

The method of determining the value of m/e for the ions carrying the negative electrification produced by ultra-violet light is as follows:—Elster and Geitel (Wied. *Ann.* xli. p. 166) have shown that the rate of escape of the negative electrification at low pressures is much diminished by magnetic force if the lines of magnetic force are at right angles to the lines of electric force. Let us consider what effect a magnetic force would have on the motion of a negatively electrified particle. Let the electric force be uniform and parallel to the axis of x, while the magnetic force is also uniform and parallel to the axis of z. Let the pressure be so low that the mean free path of the particles is long compared with the distance they move while under observation, so that we may leave out of account the effect of collisions on the movements of the particles.

If m is the mass of a particle, e its charge, X the electric force, H the magnetic force, the equations of motion are:—

$$m\frac{d^2x}{dt^2} = Xe - \mathrm{H}e\frac{dy}{dt},$$

$$m\frac{d^2y}{dt^2} = \mathrm{H}e\frac{dx}{dt}.$$

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Eliminating x we have :—

$$m\frac{d^2y}{dt^2} = \frac{He}{m}\left(Xe - He\frac{dy}{dt}\right).$$

The solutions of these equations, if x, y, dx/dt, dy/dt all vanish when $t=0$, is expressed by

$$y = \frac{Xm}{eH^2}\left\{\frac{e}{m}Ht - \sin\left(\frac{e}{m}Ht\right)\right\},$$

$$x = \frac{Xm}{eH^2}\left\{1 - \cos\left(\frac{e}{m}Ht\right)\right\}.$$

The equations show that the path of the particle is a cycloid, the generating circle of which has a diameter equal to $2Xm/eH^2$, and rolls on the line $x=0$.

Suppose now that we have a metal plate AB exposed to ultra-violet light, placed parallel to a larger metal plate CD perforated so as to allow the light to pass through it and fall upon the plate AB. Then, if CD is at a higher electric potential than AB, all the negatively electrified particles which start from AB will reach CD if this plate is large compared with AB, the particles travelling along the lines of electric force. Let us now suppose that a uniform magnetic force equal to H, and at right angles to the electric force, acts on the particles; these particles will now describe cycloids and will reach a distance $2Xm/eH^2$ from the place from which they start, and after reaching this distance they will again approach the plate. Thus if the plate CD is distant from AB by less than $2Xm/eH^2$, every particle which leaves AB will reach CD provided CD stretches forward enough to prevent the particles passing by on one side. Now the distance parallel to y through which the particle has travelled when it is at the greatest distance from AB is $\pi Xm/eH^2$: hence if CD stretches beyond AB by this distance at least, all the particles will be caught by CD and the magnetic field will produce no diminution in the rate of leak between AB and CD. If, on the other hand, the distance between the plates is greater than $2Xm/eH^2$, then a particle starting from AB will turn back before it reaches CD: it will thus never reach it, and the rate at which CD acquires negative electrification will be diminished by the magnetic force. Hence, if this view of the action of the magnetic field is correct, if we begin with the plates very near together and gradually increase the distance between them, we should expect that, at first with the plates quite close together, the rate at which CD received a negative charge would not be affected by the magnetic force, but as

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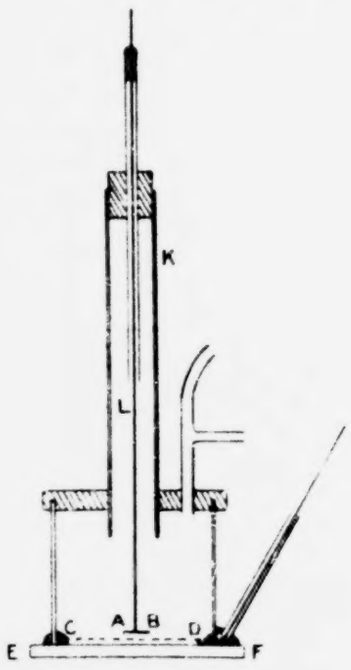
soon as the distance between the plates was equal to $2X\,meH^2$ the magnetic force would greatly diminish the rate at which CD received a negative charge, and would in fact reduce the rate almost to zero if all the negatively electrified particles came from the surface of AB. Hence, if we measure the distance between the plates when the magnetic force first diminishes the rate at which CD receives a negative charge, we shall determine the value of $2Xm/eH^2$; and as we can easily determine X and H, we can deduce the value of m/e.

The way in which this method was carried into practice was as follows, the apparatus being shown in fig. 1.

Fig. 1.



AB is a carefully polished zinc plate about 1 centim. in diameter, while CD is a grating composed of very fine wires crossing each other at right angles, the ends being soldered into a ring of metal; the wires formed a network with a mesh about 1 millim. square. This was placed parallel to AB on the quartz plate EF, which was about 1 millim. thick. The grating was very carefully insulated. The system was enclosed in a glass tube which was kept connected with a mercury-pump provided with a McLeod gauge. The ultra-violet light was supplied from an arc about 3 millim. long between zinc terminals. The induction-coil giving the arc was placed in a metal box, and the light passed through a window cut in the top of the box; over this window the quartz base of the vessel was placed, a piece of wire gauze connected with the earth being placed between the quartz and the window. The plate AB was carried by the handle L which passed through a sealing-wax stopper in the tube K. The magnet used was an electromagnet of the horseshoe type. The magnetic force due to the magnet was determined by observing the deflexion of a ballistic galvanometer when an exploring coil, of approximately the same vertical dimen-

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sion as the distance between the plates AB and CD, was withdrawn from between its poles. The coil was carefully placed so as to occupy the same part of the magnetic field as that occupied by the space between AB and CD when the magnet was used to affect the rate of leak of electricity between AB and CD. In this way the intensity of the magnetic field between the poles of the magnet was determined for a series of values of the current through the magnetizing-coils of the electromagnet ranging between 1 and 15 amperes, and a curve was drawn which gave the magnetic force when the magnetizing-current (observed by an amperemeter) was known.

The pressure of the gas in the tube containing the plate was reduced by the mercury-pump to 1/100 of a millim. of mercury. As the mean free path of hydrogen molecules at atmospheric pressure and 0° C. is $1{\cdot}85 \times 10^{-5}$ centim. (Emil Meyer, *Kinetische Theorie der Gase*, p. 142), and of air 10^{-5} centim., the mean free paths of these gases at the pressure of 1/100 of a millim. of mercury are respectively 11 and 7·6 millim., and are consequently considerably greater than the greatest distance, 1 millim., through which the electrified particles have to travel in any of the experiments. These are the free paths for molecules of the gas; if, as we shall see reason to believe, the actual carriers of the negative electrification are much smaller than the molecules, the free paths of these carriers will be larger than the numbers we have quoted.

The rate of leak of negative electricity to CD when AB was exposed to ultra-violet light was measured by a quadrant-electrometer. The zinc plate was connected with the negative pole of a battery of small storage-cells, the positive pole of which was put to earth. One pair of the quadrants of the electrometer was kept permanently connected with the earth, the other pair of quadrants was connected with the wire gauze CD. Initially the two pairs of quadrants were connected together, the connexion was then broken, and the ultra-violet light allowed to fall on the zinc plate: the negative charge received by the wire gauze in a given time is proportional to the deflexion of the electrometer in that time. By this method the following results were obtained: when the difference of potential between the illuminated plate and the wire gauze was greater than a certain value depending upon the intensity of the magnetic force and the distance between AB and CD, no diminution in the deflexion of the electrometer was produced by the magnetic field, in fact in some cases the deflexion was just a little greater in the magnetic field. The theory just given indicates that the deflexion

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ought to be the same: the small increase (amounting to not more than 3 or 4 per cent.) may be due to the obliquity of the path of the particles in the magnetic field, causing more of them to be caught by the wires of the grating than would be the case if the paths of the particles were at right angles to the plane of the gauze. When the difference of potential is reduced below a certain value, the deflexion of the electrometer is very much reduced by the magnetic field; it is not, however, at once entirely destroyed when the potential-difference passes through the critical value. The simple theory just given would indicate a very abrupt transition from the case when the magnetic force produces no effect, to that in which it entirely stops the flow of negative electricity to CD. In practice, however, I find that the transition is not abrupt: after passing a certain difference of potential the diminution in the electric charge received by CD increases gradually as the potential-difference is reduced, and there is not an abrupt transition from zero effect to a complete stoppage of the leak between AB and CD. I think this is due to the ionization not being confined to the gas in contact with the illuminated plate, but extending through a layer of gas whose thickness at very low pressures is quite appreciable. The existence of a layer of this kind is indicated by an experiment of Stoletow's. Stoletow found that the maximum current between two plates depended at low pressures to a considerable extent upon the distance between the plates, increasing as the distance between the plates was increased. Now the maximum current is the one that in one second uses up as many ions as are produced in that time by the ultra-violet light. If all the ions are produced close to the illuminated plate, increasing the distance between the plates will not increase the number of ions available for carrying the current; if, however, the ions are produced in a layer of sensible thickness, then, until the distance between the plates exceeds the thickness of this layer, an increase in the distance between the plates will increase the number of ions, and so increase the maximum current. If this layer has a sensible thickness, then the distance d which has to be traversed by the ions before reaching the gauze connected with the electrometer ranges from the distance between the plates to the difference between this distance and the thickness of the layer. The first ions to be stopped by the magnetic field will be those coming from the surface of the illuminated plate, as for these d has the greatest value: hence we may use the equation

$$d = \frac{2Xm}{eH^2} \quad \ldots\ldots\ldots \quad (1)$$

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if d represents the distance between the plates, X the value of the electric field when the rate of leak first begins to be affected by the magnetic force H. Assuming that the field is uniform,

$$X = V/d,$$

where V is the potential-difference between the plates; and equation (1) becomes

$$d^2 = \frac{2Vm}{eH^2}$$

The negative ions travelling between the plates will disturb to some extent the uniformity of the field between the plates; but if the intensity of the ultra-violet light is not too great, so that the rate of leak and the number of ions between the plates is not large, this want of uniformity will not be important. A calculation of the amount of variation due to this cause showed that its effect was not large enough to make it worth while correcting the observations for this effect, as the variation in the intensity of the ultra-violet light was sufficient to make the errors of experiments much larger than the correction.

The following is a specimen of the observations:—

Distance between the plates ·29 centim.

Strength of magnetic field 164. Pressure 1/100 millim.

Potential-difference between Plates, in volts.	Deflexion of Electrometer in 30 secs.	
	Magnet off.	Magnet on.
240	180	190
120	180	165
80	180	140
60	180	75

These observations showed that the critical value of the potential-difference was about 80 volts. A series of observations were then made with potential-differences increasing from 80 volts by 2 volts at a time and it was found that 90 volts was the largest potential-difference at which any effect due to the magnet could be detected. The results of a number of experiments are given in the following table:—

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d (in cm.)	H.	V in absolute measure.	e/m.
·18	170	40×10^8	$8\cdot5\times10^6$
·19	170	30×10^8	$5\cdot8\times10^6$
·20	181	38×10^8	$7\cdot0\times10^6$
·29	167	84×10^8	$7\cdot1\times10^6$
·29	164	90×10^8	$7\cdot6\times10^6$
·30	160	86×10^8	$7\cdot4\times10^6$
·45	100	80×10^8	$7\cdot9\times10^6$

giving a mean value for e/m equal to $7\cdot3\times10^6$. The value I found for e/m for the cathode rays was 5×10^6; the value found by Lenard was $6\cdot4\times10^6$. Thus the value of e/m in the case of the convection of electricity under the influence of ultra-violet light is of the same order as in the case of the cathode rays, and is very different from the value of e/m in the case of the hydrogen ions in ordinary electrolysis when it is equal to 10^4. As the measurements of e, the charge carried by the ions produced by ultra-violet light to be described below, show that it is the same as e for the hydrogen ion in electrolysis, it follows that the mass of the carrier in the case of the convection of negative electricity under the influence of ultra-violet light is only of the order of 1/1000 of that of the hydrogen atom. Thus with ultra-violet light, as with cathode rays, the negative electrification at low pressures is found associated with masses which are exceedingly small fractions of the smallest mass hitherto known—that of the hydrogen atom.

I have examined another case in which we have convection of electricity at low pressures by means of negatively electrified particles—that of the discharge of electricity produced by an incandescent carbon filament in an atmosphere of hydrogen. In this case, as Elster and Geitel (Wied. *Ann.* xxxviii. p. 27) have shown, we have negative ions produced in the neighbourhood of the filament, and the charge on a positively electrified body in the neighbourhood of the filament is discharged by these ions, while if the body is negatively electrified it is not discharged. If the filament is negatively, and a neighbouring body positively electrified, there will be a current of electricity between the filament and the body, while there will be no leak if the filament is positively and the body negatively electrified. Elster and Geitel (Wied.

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Ann. xxxviii. p. 27) showed that the rate of leak from a negatively electrified filament was at low pressures diminished by the action of the magnetic field. On the theory of charged ions, the effect of the magnet in diminishing the rate of leak could be explained in the same way as the effect on the convection due to ultra-violet light. A series of experiments were made which showed that the effects due to the magnetic field were consistent with this explanation, and led to a determination of e/m for the carriers of the negative electricity.

The apparatus was of the same type as that used in the preceding experiments. The wire gauze and the zinc plate were replaced by two parallel aluminium disks about 1·75 centim. in diameter; between these disks, and quite close to the upper disk, there was a small semicircular carbon filament which was raised to a red heat by the current from four storage-cells. The carbon filament was placed close to the axis of the disks; the object of the upper disk was to make the electric field between the disks more uniform. The lower plate was connected with the electrometer. The plates and filaments were enclosed in a glass tube which was connected with a mercury-pump, by means of which the pressure, after the vessel had been repeatedly filled with hydrogen, was reduced to ·01 millim. of mercury. Great difficulty was found at first in getting any consistent results with the incandescent carbon filament: sometimes the filament would discharge positive as well as negative electricity; indeed sometimes it would discharge positive and not negative. Most of these irregularities were traced to gas given out by the incandescent filament; and it was found that by keeping the filament almost white-hot for several hours, and continually pumping and refilling with hydrogen, and then using the filament at a much lower temperature than that to which it had been raised in this preliminary heating, the irregularities were nearly eliminated, and nothing but negative electrification was discharged from the filament. When this state was attained, the effect of magnetic force showed the same characteristics as in the case of ultra-violet light. When the difference of potential between the filament and the lower plate was small, the effect of the magnetic force was very great, so much so as almost to destroy the leak entirely; when, however, the potential-difference exceeded a certain value, the magnetic force produced little or no effect upon the leak. An example of this is shown by the results of the following experiment:—

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The distance between the carbon filament and the plate connected with the electrometer was 3·5 millim., the strength of the magnetic field 170 C.G.S. units.

Difference of Potential between wire and plate, in volts.	Leak in 5 seconds.		Ratio of leaks
	Without magnetic field.	With magnetic field.	
40	43	1	·023
80	170	50	·29
120	300	250	·83
140	345	343	1·0
160	400	430	1·07

Taking 140 volts as the critical value of the potential-difference, we find by equation (1) that

$$\frac{e}{m} = 7{\cdot}8 \times 10^6.$$

The results of this and similar experiments are given in the following table; V denoting the critical potential-difference in C.G.S. units, and H the magnetic force:

d.	V.	H	e/m.
·35	140×10^8	170	$7{\cdot}8 \times 10^6$
·35	220×10^8	220	$7{\cdot}5 \times 10^6$
·35	170×10^8	170	$9{\cdot}6 \times 10^6$
·35	130×10^8	170	$7{\cdot}2 \times 10^6$
·35	120×10^8	120	$11{\cdot}3 \times 10^6$

giving $8{\cdot}7 \times 10^6$ as the mean value of e/m. This value does not differ much from that found in the case of ultra-violet light. In the case of the incandescent filament the ions are only produced at a small part of the plate, and not over the whole surface as in the case of ultra-violet light, so the conditions do not approximate so closely to those assumed in the theory. We conclude that the particles which carry the negative electrification in this case are of the same

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nature as those which carry it in the cathode rays and in the electrification arising from the action of ultra-violet light.

The unipolar positive leak which occurs from an incandescent platinum wire in air or oxygen, and in which the moving bodies are positively electrified, was found not to be affected by a magnetic field of the order of that used in the experiments on the negative leak. This had already been observed by Elster and Geitel (Wied. *Ann.* xxxviii. p. 27).

On the theory of the effect given in this paper, the absence of magnetic effect on the positively charged carriers indicates that e/m is much smaller or m/e much larger for the positive ions than it is for the negative. I am engaged with some experiments on the effect of the magnetic field on the convection of electricity by positive ions, using very strong magnetic fields produced by a powerful electromagnet kindly lent to me by Professor Ewing. From the results I have already got, it is clear that m/e for the positive ions produced by an incandescent wire must be at least 1000 times the value for the negative ions, and this is only an inferior limit.

The positive and negative ions produced by incandescent solids show the same disproportion of mass as is shown by the positive and negative ions in a vacuum-tube at low pressures. W. Wien (Wied. *Ann.* lxv. p. 440) and Ewers (Wied. *Ann.* lxix. p. 187) have measured the ratio of m/e for the positive ions in such a tube, and found that it is of the same order as the value of m/e in ordinary electrolysis; Ewers has shown that it depends on the metal of which the cathode is made. Thus the carriers of positive electricity at low pressures seem to be ordinary molecules, while the carriers of negative electricity are very much smaller.

Measurement of the Charge on the Ion produced by the Action of Ultra-Violet Light on a Zinc Plate.

This charge was determined by the method used by me to measure the charge on the ions produced by the action of Röntgen rays on a gas (Phil. Mag. Dec. 1898); for the details of the method I shall refer to my former paper, and here give only an outline of the principle on which the method is based. Mr. C. T. R. Wilson (Phil. Trans. 1898) discovered that the ions produced by ultra-violet light act like those produced by Röntgen rays, in forming nuclei around which water will condense from dust-free air when the supersaturation exceeds a certain definite value.

Suppose, then, we wish to find the number of ions produced by ultra-violet light in a cubic centimetre of air. We cool the air by a sudden expansion until the supersaturation

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produced by the cooling is sufficient to form a cloud round the ions: the problem of finding the number of ions per cub. centim. is now reduced to finding the number of drops per cub. centim. in this cloud. We can do this in the following way:—If we know the amount of the expansion we can calculate the amount of water deposited per cub. centim. of the cloud; this water is deposited as drops, and if the drops are of equal size, the number of drops per cub. centim. will be equal to the volume of water per cub. centim. divided by the volume of one of the drops. Hence, if we know the size of the drops, we can calculate the number. The size of the drops in the cloud was determined by observing v, the velocity with which they fall under gravity, and then deducing a, the radius of the drop, by means of the equation

$$v = \frac{2}{9}\frac{ga^2}{\mu},$$

where μ is the coefficient of viscosity of the gas through which the drop falls.

In this way we can determine n the number of ions per cub. centim.: if e is the charge on an ion, v the velocity with which it moves under a known electric force, the quantity of electricity which crosses unit area in unit time under this force is equal to $ne nu$. We can determine this quantity if we allow the negative ions to fall on a plate connected with a condenser of known capacity and measure the rate at which the potential falls. We thus determine the product $ne nu$, and we already know u; u has been determined by Mr. Rutherford (Proc. Camb. Phil. Soc. ix. p. 401); for air at atmospheric pressure u is proportional to the potential gradient, and when this is one volt per centim., u is 1·5 centim. per second; for hydrogen at atmospheric pressure u is 4·5 centim. per second for the same potential gradient. Hence, as in the known product $ne nu$ we know u and u, we can deduce the value of e the charge on the ion.

There are some features in the condensation of clouds by ultra-violet light which are not present in the clouds formed by the Röntgen rays. In the first place, the cloud due to the ultra-violet light is only formed in an electric field. When there is no electric field, the ions remain close to the surface of the illuminated plate, and are not diffused through the region in which the cloud has to be formed; to get the negative ions into this region we must electrify the plate negatively; when this is done, expansion produces a cloud. Again, if the ultra-violet light is very strong, Mr. C. T. R. Wilson has shown (Phil. Trans. 1899) that large nuclei are produced

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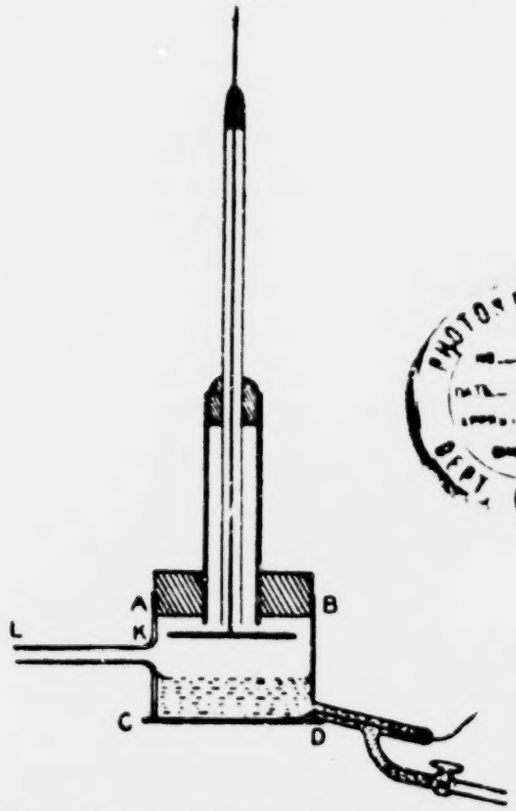
in the gas through which the light passes; these are distinct from those produced near a metal plate on which the light falls, and they can produce a cloud with very little supersaturation; these nuclei are not ions, for they do not move in an electric field, and the drops formed round these nuclei ought therefore not to be counted in estimating the number of negative ions. For this reason it is necessary to use ultra-violet light

Fig. 2.



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of small intensity, and there are in addition other reasons which make it impossible to work with strong light. I found when working with the ions produced by Röntgen rays, that it was impossible to get good results unless the rays were weak and the clouds therefore thin. If the rays were strong, one expansion was not sufficient to bring down all the ions by the cloud; sometimes as many as five or six expansions were required to remove the ions from the vessel. Another

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reason why the strong rays do not give good results is that there are slight convection-currents in the vessel after the expansion, for the walls of the vessel are warmer than the gas; this gives rise to convection-currents in the gas, the gas going up the sides and down the middle of the vessel. The velocity of the convection-current is added on to the velocity of the ions due to gravity; and if the velocity of the ions is very small, as it is when the rays are strong and the drops numerous, a very small convection-current will be sufficient to make the actual rate of fall of the drops very different from that of a drop of the same size falling through air at rest. All the reasons are operative in the case of ultra-violet light, and it is only when the intensity of the light is small that I have got consistent results.

The vessel in which the expansion took place is shown in fig. 2. AB is a glass tube about 3·6 cm. in diameter; the base CD is a quartz plate about ·5 cm. thick; on the top of this there is a layer of water in electrical connexion with the earth about 1 cm. in thickness; the illuminated zinc plate was 3·2 cm. in diameter, and was 1·2 cm. above the surface of the water. The ultra-violet light was produced by an arc about ·3 cm. long, between zinc terminals connected with an induction-coil; the arc was about 40 cm. below the lower face of the quartz plate. The space between the zinc plate and the water surface was illuminated by an arc-light so as to allow the rate of fall of the drops to be accurately measured. The tube LK connected this vessel with the apparatus used in the previous experiments; a figure of this is given in the Phil. Mag. Dec. 1898.

To observe the current of electricity through the gas, the illuminated plate was connected with one pair of quadrants of an electrometer, the other pair of quadrants being kept connected with the earth. The capacity C of the system, consisting of the plate, connecting wires and quadrants of the electrometer, was determined. The plate was then charged to a negative potential, and the deflexion of the electrometer-needles observed. The induction-coil was now set in action, and the ultra-violet light allowed to fall on the zinc plate; the deflexion of the electrometer-needle immediately began to decrease; the rate at which it decreased was determined by measuring the diminution of the deflexion in 30 seconds.

Let D be the original deflexion of the electrometer, let this correspond to a potential-difference equal to αD between the plate and the earth. If h is the distance between the zinc plate and the surface of the water, the potential gradient is $\alpha D/h$. If A is the area of the plate, n the number of ion-

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per cub. centim., e the charge on an ion, u_0 the velocity of the ion under unit potential gradient, then the quantity of negative electricity lost by the plate in one second is

$$A n e u_0 \alpha D / l.$$

But the plate is observed to fall in potential by $\alpha/$ per second, and the capacity of the system attached to the plate is C; hence the loss of electricity by the plate per second is

$$C \alpha l.$$

Equating these two expressions for the loss of electricity, we get

$$A n e u_0 \alpha D / l = C \alpha l$$

or

$$e = \frac{l^2 C d}{n u_0 A D}$$

Hence knowing l, C, A, and u_0, if we measure n and d D we can determine e.

To calculate n we begin by finding the volume of water deposited in consequence of the expansion in each cub. centim. of the expansion. In my previous paper I show how this can be determined if we know the ratio of the final to the initial volumes and the temperature before expansion. In the present experiments the final volume was 1·36 times the initial volume, and the temperature before expansion was 18°·5 C. It follows from this that 50×10^{-7} cub. centim. of water were deposited in each cub. centim. of the expansion chamber.

If a is the radius of one of the drops, the volume of a drop is $4\pi a^3/3$, and hence $n' = \frac{3 \times 50 \times 10^{-7}}{4\pi a^3}$; here n' is the number of ions per cub. centim. of the expanded gas.

If v is the velocity of fall

$$v = \frac{2}{9} \frac{g a^2}{\mu}$$

Since for air $\mu = 1{\cdot}8 \times 10^{-4}$, we find

$$a = \frac{v^{\frac{1}{2}}}{1{\cdot}1 \times 10^{3}}$$

and

$$\frac{4}{3}\pi a^3 = 3{\cdot}14\, v^{\frac{3}{2}} \times 10^{-9}$$

$$n' = \frac{5000}{3{\cdot}14\, v^{\frac{3}{2}}}$$

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This is the number in 1 cub. centim. of the expanded gas; the number in 1 cub. centim. of the gas before expansion is $1{\cdot}36\,n'$. To find n the number of ions we must subtract from $1{\cdot}36\,n'$ the number of drops which are formed when the ultra-violet light does not fall on the plate. With an expansion as large as 1·36, Mr. Wilson has shown that a few drops are always formed in dust-free air, even when free from the influence of Röntgen rays or ultra-violet light. If V be the velocity with which these drops formed in the absence of the light fall, then the number of drops due to these nuclei is

$$\frac{1{\cdot}36\times 5000}{3{\cdot}14\,Vt}.$$

Subtracting this from $1{\cdot}36\,n'$, we find

$$n=2{\cdot}07\times 10^3\left\{\frac{1}{rt}-\frac{1}{Vt}\right\}.$$

In making this correction we have assumed that the clouds form round these nuclei even when the negative ions due to the ultra-violet light are present. If the cloud formed more readily about the negative ions than about the nuclei, the ions would rob the nuclei of their water, and we should not need the correction. The following table gives the result of some experiments; in making the observation on the cloud the same potential-difference between the plate and the water was used as when observing the value of d/D: u_0 was determined by Prof. Rutherford as $1{\cdot}5\times 3\times 10^2$, and A was $\pi(1{\cdot}6)^2$ throughout the experiments.

b.	C.	d/D.	r.	V.	$e\times 10^{10}$
1·2	62	·0017	·15	·3	7·9
1·2	62	·0019	·11	·3	7·3
·9	50	·0012	·14	·3	5·3
1·2	65	·0035	·08	·3	7·3
1·2	50	·0018	·11	·3	6
1·2	40	·0018	·14	·3	7

The mean value of e is $6{\cdot}8\times 10^{-10}$. The values differ a good deal, but we could not expect a very close agreement unless we could procure an absolutely constant source of ultra-violet light, as these experiments are very dependent on the constancy of the light; since the electrical part of the experiment measures the average intensity of the light over 30

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seconds, while the observations on the cloud measure the intensity over an interval of a small fraction of a second.

The value of e found by me previously for the ions produced by Röntgen rays was $6{\cdot}5 \times 10^{-10}$: hence we conclude that e for the ions produced by ultra-violet light is the same as e for the ions produced by the Röntgen rays; and as Mr. Townsend has shown that the charge on these latter ions is the same as the charge on an atom of hydrogen in electrolysis, we arrive at the result previously referred to, that the charge on the ion produced by ultra-violet light is the same as that on the hydrogen ion in ordinary electrolysis.

The experiments just described, taken in conjunction with previous ones on the value of m/e for the cathode rays (J. J. Thomson, Phil. Mag. Oct. 1897), show that in gases at low pressures negative electrification, though it may be produced by very different means, is made up of units each having a charge of electricity of a definite size; the magnitude of this negative charge is about 6×10^{-10} electrostatic units, and is equal to the positive charge carried by the hydrogen atom in the electrolysis of solutions.

In gases at low pressures these units of negative electric charge are always associated with carriers of a definite mass. This mass is exceedingly small, being only about $1{\cdot}4 \times 10^{-3}$ of that of the hydrogen ion, the smallest mass hitherto recognized as capable of a separate existence. The production of negative electrification thus involves the splitting up of an atom, as from a collection of atoms something is detached whose mass is less than that of a single atom. We have not yet data for determining whether the mass of the negative atom is entirely due to its charge. If the charge is e, the apparent mass due to the charge supposed to be collected on a sphere of radius a is $\frac{1}{3}e^2/\mu a$: hence m/e in this case is $e/3\mu a$. Substituting the values of m/e and e found above, we find that a would be of the order 10^{-13} centim.

We have no means yet of knowing whether or not the mass of the negative ion is of electrical origin. We could probably get light on this point by comparing the heat produced by the bombardment by these negatively electrified particles of the inside of a vessel composed of a substance transparent to Röntgen rays, with the heat produced when the vessel was opaque to those rays. If the mass was "mechanical," and not electrical, the heat produced should be same in the two cases. If, on the other hand, the mass were electrical, the heat would be less in the first case than in the second, as part of the energy would escape through the walls.

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Hitherto we have been considering only negative electrification; as far as our present knowledge extends positive electrification is never associated with masses as small as those which invariably accompany negative electrification in gases at low pressures. From W. Wien's experiments on the ratio of the mass to the electric charge for the carriers of positive electrification in a highly exhausted vacuum-tube (Wied. *Ann.* lxv p. 440), it would seem that the masses with which positive electrification is associated are comparable with the masses of ordinary atoms. This is also in accordance with the experiments of Elster and Geitel (Wied. *Ann.* xxxviii. p. 27), which show that when positive ions are produced by an incandescent platinum wire in air they are not affected to anything like the same extent as negative ions produced by an incandescent carbon filament in hydrogen.

It is necessary to point out that the preceding statements as to the masses of the ions are only true when the pressure of the gas is very small, so small that we are able to determine the mass of the carriers before they have made many collisions with the surrounding molecules. When the pressure is too high for this to be the case, the electric charge, whether positive or negative, seems to act as a nucleus around which several molecules collect, just as dust collects round an electrified body, so that we get an aggregate formed whose mass is larger than that of a molecule of a gas.

The experiments on the velocities of the ions produced by Röntgen or uranium rays, by ultra-violet light, in flames or in the arc, show that in gases at pressures comparable with the atmospheric pressure, the electric charges are associated with masses which are probably several times the mass of a molecule of the gas, and enormously greater than the mass of a carrier of negative electrification in a gas at a low pressure.

There are some other phenomena which seem to have a very direct bearing on the nature of the process of ionizing a gas. Thus I have shown (Phil. Mag. Dec. 1898) that when a gas is ionized by Röntgen rays, the charges on the ions are the same whatever the nature of the gas: thus we get the same charges on the ions whether we ionize hydrogen or oxygen. This result has been confirmed by J. S. Townsend ("On the Diffusion of Ions," Phil. Trans. 1899), who used an entirely different method. Again, the ionization of a gas by Röntgen rays is in general an additive property; *i. e.*, the ionization of a compound gas AB, where A and B represent the atoms of two elementary gases, is one half the sum of the ionization of A_2 and B_2 by rays of the same intensity, where

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A_2 and B_2 represent diatomic molecules of these gases (Proc. Camb. Phil. Soc. vol. x. p. 9). This result makes it probable that the ionization of a gas in these cases results from the splitting up of the atoms of the gas, rather than from a separation of one atom from the other in a molecule of the gas.

These results, taken in conjunction with the measurements of the mass of the negative ion, suggest that the ionization of a gas consists in the detachment from the atom of a negative ion; this negative ion being the same for all gases, while the mass of the ion is only a small fraction of the mass of an atom of hydrogen.

From what we have seen, this negative ion must be a quantity of fundamental importance in any theory of electrical action; indeed, it seems not improbable that it is the fundamental quantity in terms of which all electrical processes can be expressed. For, as we have seen, its mass and its charge are invariable, independent both of the processes by which the electrification is produced and of the gas from which the ions are set free. It thus possesses the characteristics of being a fundamental conception in electricity; and it seems desirable to adopt some view of electrical action which brings this conception into prominence. These considerations have led me to take as a working hypothesis the following method of regarding the electrification of a gas, or indeed of matter in any state.

I regard the atom as containing a large number of smaller bodies which I will call corpuscles; these corpuscles are equal to each other; the mass of a corpuscle is the mass of the negative ion in a gas at low pressure, i. e. about 3×10^{-26} of a gramme. In the normal atom, this assemblage of corpuscles forms a system which is electrically neutral. Though the individual corpuscles behave like negative ions, yet when they are assembled in a neutral atom the negative effect is balanced by something which causes the space through which the corpuscles are spread to act as if it had a charge of positive electricity equal in amount to the sum of the negative charges on the corpuscles. Electrification of a gas I regard as due to the splitting up of some of the atoms of the gas, resulting in the detachment of a corpuscle from some of the atoms. The detached corpuscles behave like negative ions, each carrying a constant negative charge, which we shall call for brevity the unit charge; while the part of the atom left behind behaves like a positive ion with the unit positive charge and a mass large compared with that of the negative ion. On this view, electrification essentially involves the splitting up of the atom, a part of the mass of the atom getting free and becoming detached from the original atom.

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A positively electrified atom is an atom which has lost some of its "free mass," and this free mass is to be found along with the corresponding negative charge. Changes in the electrical charge on an atom are due to corpuscles moving from the atom when the positive charge is increased, or to corpuscles moving up to it when the negative charge is increased. Thus when anions and cations are liberated against the electrodes in the electrolysis of solutions, the ion with the positive charge is neutralized by a corpuscle moving from the electrode to the ion, while the ion with the negative charge is neutralized by a corpuscle passing from the ion to the electrode. The corpuscles are the vehicles by which electricity is carried from one atom to another.

We are thus led to the conclusion that the mass of an atom is not invariable: that, for example, if in the molecule of HCl the hydrogen atom has the positive and the chlorine atom the negative charge, then the mass of the hydrogen atom is less than half the mass of the hydrogen molecule H_2; while, on the other hand, the mass of the chlorine atom in the molecule of HCl is greater than half the mass of the chlorine molecule Cl_2.

The amount by which the mass of an atom may vary is proportional to the charge of electricity it can receive; and as we have no evidence that an atom can receive a greater charge than that of its ion in the electrolysis of solutions, and as this charge is equal to the valency of the ion multiplied by the charge on the hydrogen atom, we conclude that the variability of the mass of an atom which can be produced by known processes is proportional to the valency of the atom, and our determination of the mass of the corpuscle shows that this variability is only a small fraction of the mass of the original atom.

In the case of the ionization of a gas by Röntgen or uranium rays, the evidence seems to be in favour of the view that not more than one corpuscle can be detached from any one atom. For if more than one were detached, the remaining part of the atom would have a positive charge greater than the negative charge carried by each of the detached corpuscles. Now the ions, in virtue of their charges, act as nuclei around which drops of water condense when moist dust-free gas is suddenly expanded. If the positive charge were greater than the individual negative ones, the positive ions would be more efficient in producing cloudy condensation than the negative ones, and would give a cloud with smaller expansion. As a matter of fact, however, the reverse is the case, as C. T. R. Wilson (Phil. Trans. 1899) has shown that it requires a considerably greater expansion to produce a

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PLAINTIFF'S EXHIBIT A-2

RÉPUBLIQUE FRANÇAISE.

MINISTÈRE DU COMMERCE ET DE L'INDUSTRIE.

DIRECTION DE LA PROPRIÉTÉ INDUSTRIELLE.

Copie officielle
d'un brevet d'invention délivré sous le n° 328.687

MÉMOIRE DESCRIPTIF annexé au brevet d'invention de Guinée ans pris le 27 Janvier 1903 par Monsieur Gillet de Valbuse / Robert / représenté par Monsieur Hermengaud aîné, et Cie Ingénieurs à Paris

et qui a été délivré par arrêté du Ministre du Commerce, de l'Industrie des Postes et des Télégraphes en date du 7 Mai 1903.

pour Cinq au mode de transmission par ondes électriques connu sous le nom générique de télégraphie sans fil

RÉPUBLIQUE FRANÇAISE. 3541

OFFICE NATIONAL DE LA PROPRIÉTÉ INDUSTRIELLE.

BREVET D'INVENTION

du 21 janvier 1903.

XII. — Instruments de précision.

1. — Télégraphie, téléphonie.

N° 328.687

Brevet de quinze ans demandé le 21 janvier 1903 par **M. Robert GILLET de VALBREUZE** (France).

Perfectionnements au mode de transmission par ondes électriques connu sous le nom générique de télégraphie sans fil.

Délivré le 7 mai 1903; publié le 18 juillet 1903.

Cette invention se rapporte à des perfectionnements au mode de transmission par ondes électriques connu sous le nom générique de télégraphie sans fil.

Il est nécessaire, pour bien comprendre le but de cette invention, de rappeler le principe des appareils actuels et les raisons pour lesquelles leur emploi ne permet pas d'obtenir la syntonisation. On emploie actuellement comme transmetteurs des excitateurs montés en dérivation sur le secondaire d'une bobine d'induction dont les extrémités sont reliées d'une part à la terre et d'autre part à l'antenne, soit directement soit par l'intermédiaire d'un transformateur. Pour les récepteurs on utilise les propriétés de certains contacts imparfaits dont la résistance électrique s'abaisse considérablement lors du passage d'une onde électromagnétique.

La sécurité des communications exige que les signaux émis par un transmetteur donné ne soient décelés que par un récepteur déterminé et que les signaux décelés par ce récepteur ne proviennent que du transmetteur donné. Pour obtenir cette syntonisation, il est absolument nécessaire d'accorder les mouvements vibratoires transmis avec les oscillations que le circuit récepteur serait capable d'émettre s'il était employé comme transmetteur; quand ces conditions sont remplies, c'est-à-dire quand la fréquence propre du récepteur est accordée avec la fréquence du transmetteur, il y a résonance entre les deux appareils, exactement comme entre deux diapasons accordés.

Les divers procédés de syntonisation imaginés jusqu'ici n'ont donné aucun résultat véritablement sélectif : la raison doit en être cherchée dans ce que l'on emploie comme transmetteur un excitateur. En effet, dans l'excitateur, l'étincelle remplit le rôle d'un déclenchement brutal entre deux charges contraires d'électricité et donne lieu dans le circuit transmetteur à des oscillations amorties dont l'amplitude et la période décroissent rapidement; en outre, les variations continuelles de la résistance, dues aux variations de l'étincelle oscillante, changent à chaque instant la nature des oscillations; la perturbation d'un excitateur est donc complexe et résulte de la superposition de nombreuses vibrations dissemblables. Or pour obtenir la syntonisation, il faut avoir recours aux phénomènes dits de résonance, et pour pouvoir faire de la résonance il faut qu'un régime permanent ait pu s'établir.

Le problème est donc insoluble avec les appareils actuels. Le système objet de cette invention permet d'obtenir la syntonisation avec des appareils reposant sur l'emploi de tubes à vide.

Prix du fascicule : 1 franc.

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RÉSUMÉ.

Les points caractéristiques de cette invention sont :

Dans les systèmes de transmission à distance par ondes électriques, connus sous le nom générique de télégraphie sans fil :

1° L'emploi d'un tube à vide accompagné d'un condensateur pour produire, avec l'énergie fournie par une source d'électricité, des courants alternatifs de fréquence très rapide et bien déterminée;

2° Emploi d'un organe dit soupape électrique, constitué par un tube à vide, ou de plusieurs soupapes semblables combinées entre elles, pour transformer en courants toujours de même sens les courants alternatifs de fréquence très rapide transmis aux appareils récepteurs.

Par procuration de M. Gilbet de Valbreuze :

ARMENGAUD aîné.

IMPRIMERIE NATIONALE. — Pour la vente, s'adresser à la SOCIÉTÉ BELIN ET C^ie, 56, rue des Francs-Bourgeois, Paris (3e)

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Fig. 1

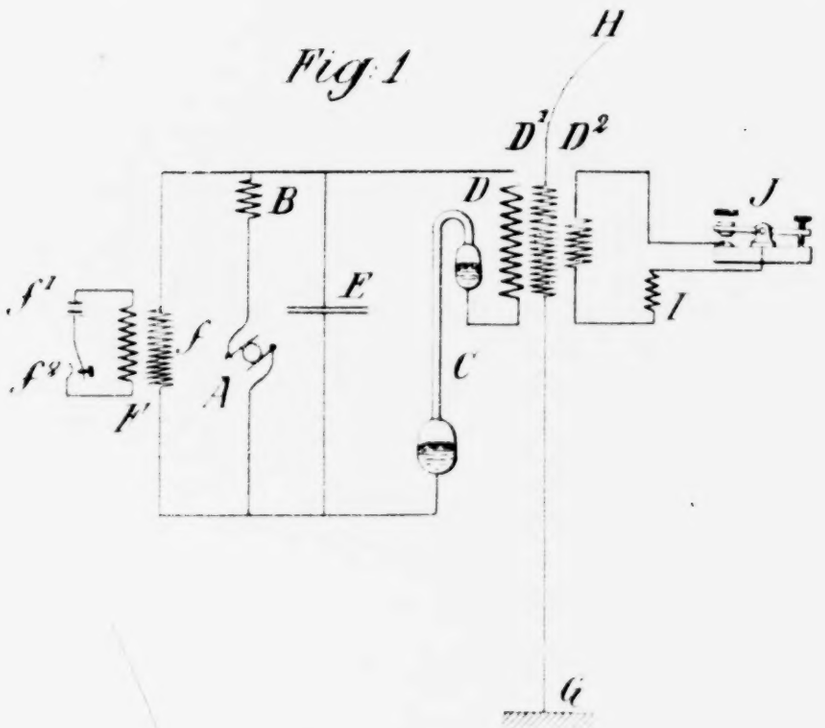
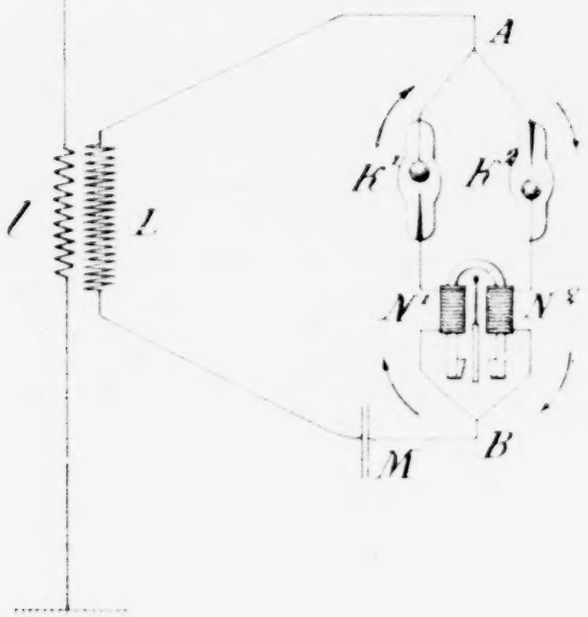


Fig. 2



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Le Directeur de la Propriété Industrielle soussigné, certifie que les dates de dépôt de délivrance et de publication portées sur la copie imprimée du brevet ci-joint, N° 328.687. pris le 27 Janvier 1903, sont bien les dates réelles de dépôt de délivrance et de publication dudit brevet.

pour Le Directeur
de la Propriété Industrielle
Le Chef de Bureau

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Collationné
Une demi-feuille manuscrite
Deux feuilles et demie imprimées
Une planche annexée.

Paris, le 8 MAI 1923
Pour expédition certifiée conforme
Le Chef de Bureau

JUILLET 1844

3105

[fol. 3106] DEFENDANT'S EXHIBIT B-2

French Republic.

Minister of Commerce and Industry

Bureau of Industrial Property

Official Copy of a Patent of Invention Delivered under the No. 328,687

Specification Annexed to the patent of invention of August 15 taken the 27th of January, 1903 by Mr. Gillet of Valbreuze (Robert) represented by Mr. Armengaud, Jr., 21 Boulevard Poissonniere of Paris and which has been delivered by decree of the Minister of Commerce and Industry of Posts and Telegraphs under date of May 7, 1903 for improvements in the mode of transmission by electric waves known under the generic name of wireless telegraphy.

[fol. 3107] French Republic

National Bureau of Industrial Property

Patent of Invention of Jan. 21, 1903

XII Instruments of Precision 4 Telegraphy & Telephony

328,687

Patent for fifteen years, filed January 21, 1903, by Mr. Robert Gillet de Balbreuze (France).

Improvements in the method of transmission by electric waves known under the generic name of telegraphy without wires.

Delivered May 7, 1903; published July 18, 1903.

This invention relates to improvements in the method of transmission by electric waves known under the generic name of wireless telegraphy.

It is necessary in order to well understand the object of this invention to recall the principle of the present apparatus-es and the reasons why their use does not permit of obtaining syntonism. There are at present employed as transmitters, exciters mounted in shunt on the secondary

of an induction coil, the extremities of which are connected on the one hand to the earth and on the other hand to the antenna, either directly or by means of a transformer. For the receivers there are utilized the properties of certain imperfect contacts, the electrical resistance of which is considerably lowered on the passage of an electromatic wave.

Safety of communication demands that the signals emitted by a given transformer be disclosed only by a pre-determined receiver, and that the signal disclosed by this receiver should come only from the respective transmitter. In order to obtain this syntonism, it is absolutely necessary to tune the vibratory movements transmitted with the oscillations which the receiving circuit would be capable of emitting, if it should be employed as a transmitter; when these conditions are fulfilled, that is to say, when the natural frequency of the receiver is tuned to the frequency of the transmitter, there is *resonance* between the two apparatuses, exactly as between two tuned tuning forks.

The various processes of syntonization devised up to the present time have given no truly selective result; the reason therefore is to be sought in the fact that an exciter is employed as a transmitter. In fact, in the exciter the spark fulfills the role of a rough release between two opposite charges of electricity, and gives rise in the transmitting circuit to damped oscillations, the amplitude and period of which decrease rapidly; moreover, the continual variations of the resistance, due to the variations of the oscillating spark, change the nature of the oscillation at every instant. [fol. 3108] The disturbance of an exciter is then complex, and follows from the superposition of numerous dissimilar vibrations. Now, in order to obtain syntonization, it is necessary to have recourse to phenomena called resonance, and to be able to produce resonance, it is necessary that a permanent regime may be able to be established.

The problem is then unsolvable with the present apparatus. The system forming the subject matter of this invention allows of obtaining syntonism with apparatus based upon the use of vacuum tubes.

In 1875 Mr. W. de LaRue, having subjected a vacuum tube to the action of a battery of 1080 elements, proved that the continuous, luminous vein was stratified as soon as there was interposed a condenser in parallel, and he shows that the circuit was then traversed by an alternating current of a very high frequency and very definite.

Recently Mr. Hewitt has brought to incandescence by the effect of a continuous current of 110 volts, a vacuum tube with mercury electrodes (Cooper Hewitt lamp). This tube requires a preliminary excitation obtained by means of a Ruhmkorff coil, or a coil of self-inductance.

Mounting a condenser in parallel with a Hewitt tube fed by a continuous current, there is obtained in the circuit an alternating current of very high and well determined frequency, as in the experiment of W. de LaRue. It is probable that by the aid of this same apparatus, suitably modified, we could succeed also in transforming industrial alternating current of low frequency into a current of high frequency.

The system forming the subject matter of this invention consists essentially in using as a transmitter, in transmissions to a distance, known commonly under the name of wireless telegraphy, a vacuum tube of the class mentioned above, accompanied by a condenser for the purpose of obtaining alternating currents of high frequencies suitable for the transmissions.

Fig. 1 of the annexed drawing represents diagrammatically an installation, according to this system, of transmitter for Morse signals.

A circuit comprises any source whatever A of continuous current of above 100 volts, and of a choking coil B, the vacuum tube C on primary D of a transformer without iron core. A condenser E and secondary f of a small Ruhmkorff coil F, serving for the excitation are mounted in parallel with this circuit. f^1 indicates the battery feeding this coil and f^2 the switch by which it is momentarily placed in circuit.

The transformer comprises two secondary coils D^1 and D^2, the extremities of one of them, D^1, are connected to earth, G, and to the transmitting antenna H, the extremities of the other, D^2, are connected to a damping circuit, I, comprising a not very large self-induction and a Morse key, J, serving for the transmission. The object of this arrangement is to not cool off the tube in the intervals of the dashes or dots representing the alphabet, as would [fols. 3109-3110] happen if the interruptor were cranched on the principal circuit. With this transmitter the antenna is the seat of induced currents of a constant amplitude, and of a high and well-determined frequency. Their period $t = 2\pi\sqrt{LC}$ should be rendered equal to the natural period of the

receiver $t^2 = 2. L'C'$ in order to have perfect resonance: for that LC' will be made equal to $L'C'$ by varying L by means of an additional self-induction coil, of a variable number of windings.

As receiver there is employed an apparatus which allows of re-transforming the alternating current into a continuous current, actuating a relay. For that recourse is had to apparatus called electric valves, placed as described hereinafter, and diagrammatically represented by Fig. 2. Two tubes K^1 and K^2 are taken, having for electrodes a point and ball very close together. The degree of vacuum is determined by the blue tint of the luminosity due to the passage of a current. It is probable that with tubes containing an electrode of mercury and an electrode of iron or of nickel, we should obtain similar valves applicable to strong currents). These tubes are mounted in multiple, the electrodes being opposite each other, and interposed in a circuit containing the secondary L of a transformer without iron core and a condenser M; the primary 1 of the transformer is in series with the antenna and the earth. Each of these two coils N^1 and N^2 of a polarized relay extremely sensitive, is mounted in series with one of the tubes. When an alternating current of high frequency is received by the antenna, it induces in the circuit a periodic current, the positive portions of which pass through one of the tubes, while the negative portions pass through *through* the other. The circuit A, K^1, N^1, B, N^2, K^2, A is then traversed by currents always of the same direction actuating the relay N^1, N^2; the self-induction of these two coils controls the redressed currents, and there is produced a current practically continuous.

Resume.

The characteristic points of this invention are:

In systems of transmitting to a distance by means of electric waves known under the generic name of wireless telegraphy.

1. The use of a vacuum tube accompanied by a condenser in order to produce, with the energy furnished by a source of electricity, alternating current of a very rapid and well determined frequency.

2. The use of a device called an electric valve formed by a vacuum tube, or of several similar valves combined together in order to transform into currents always in the

same direction, the alternating currents of very rapid frequency transmitted to the receiving apparatus.

By power of attorney, by Robert Gillet de Valbreuze.

[fol. 3111] DEFENDANT'S EXHIBIT C-2

The Thermionic Valve and its Developments in Radio Telegraphy and Telephony, by J. A. Fleming, 1919

Chapter III.—The Three-Electrode Valve

1. An improvement on the hot and single cold electrode oscillation valve described in the previous chapter was effected by the introduction of a second cold electrode in the form of a grid, wire zig-zag or perforated plate placed in between the hot cathode and cold electrode of the Fleming valve.

This modification enabled the appliance to be used not merely to rectify electric oscillations, but to relay or repeat them on a magnified scale, so that when employed with a telephone, as below described, a considerable increase in oscillation-detecting power ensued. Also it made it possible to use the instrument as a telegraphic relay of a certain kind. The credit for this structural improvement must be given to Dr. Lee de Forest, who arrived at it by a series of steps presently to be mentioned.

Underrating, however, the author's previous work in the invention of the two-electrode valve, he took the view that his improvement constituted a new invention originating entirely with himself, independent of everything that had been done before, and radically different in operation from the Fleming valve.

Hence he availed himself of many opportunities for disparaging the author's prior work, incorrectly, representing the two-electrode oscillation valve as a comparatively useless laboratory device appropriated from Mr. Edison, or else "taken from the early German scientists by Professor Fleming."[1]

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[1] See letter of L. de Forest in *The Electrician*, vol. lxi., p. 804, September 4th, 1908. A prolonged controversy took place on this subject. See de Forest's letters in *The Electrician*, vol. lviii., p. 425, December 28th, 1906; vol. lxi.,

The judgment of Judge Mayer and the confirmatory unanimous judgment of the Court of Appeals in the action-at-law already mentioned in Chapter II have cleared away these misconceptions and shown that his improvements are of the nature of modifications of the original invention of the oscillation valve, but involve the same physical prin-[fol. 3112] ciples, and cannot be exercised in the United States of America in commercial manufacture without infringing certain claims in the author's fundamental valve patent as long as it remains in force.

The stages by which de Forest reached this modification or improvement, were as follows:- In or before 1904 he was engaged in researches on the production of some new detector devices he called "oscillation responsive devices," in which two electrodes were immersed in the flame of a Bunsen burner and connected respectively to the earth and to a receiving aerial. They were also joined by a circuit containing a battery and a telephone. The idea seems to have been that the oscillations in the aerial would put the "gaseous medium"—*i.e.*, the flame, "into a condition of molecular activity," and that it would then become a conductor and pass the current from the battery through the telephone in series with it and thus produce a sound.

He applied, on February 2nd, 1905, for a United States patent for these devices, the specification having been actually signed by him on November 4th, 1904, a few days before the application of the author for the British valve patent, No. 24,850, of 1904, and some weeks before the application for the corresponding United States patent, No. 803,684.

In this specification, No. 979,275, of 1905, Lee de Forest included amongst his Bunsen burner oscillation responsive devices one consisting of a bulb filled with air or gas, in which were two electrodes intended to be heated by a dynamo, but as the electrodes are shown in the diagram connected by a telephone, it is not at all clear how they could carry a heating current from the dynamo (see p. 106, Fig. 56*a*).

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p. 804, September 4th, 1908; vol. lxi., p. 1006, October 9th, 1908; and vol. lxxii., p. 659, January 23rd, 1914. Also the author's replies in *The Electrician*, vol. lviii, p. 263, November 30th, 1906; vol. lviii., p. 464, January 4th, 1907; vol. lxi., p. 843, September 11th, 1908; vol. lxxii., p. 377, December 5th, 1913; vol. lxxii., p. 660, January 23rd, 1914.

The specification contains forty-one claims and abounds in such vague phrases as "a sensitive constantly receptive oscillation responsive device comprising in its construction a sensitive conducting gaseous medium." The various items in this United States patent of de Forest, No. 979,275, were subsequently divided into separate applications and formed the subject-matter of three subsidiary specifications—viz., No. 867,876, application of April 4th, 1906; No. 867,877, application of June 12th, 1907; No. 867,878, application of June 12th, 1907.

It is not at all certain that any of these devices were ever put into practical operation, but, nevertheless, their patentee referred to this United States patent, No. 979,275, some ten years afterwards as his "basic American patent."[2]

When, however, in 1916, the question of its real value came to be discussed impartially in a Court of Law, Judge Mayer, who tried the case, in giving judgment on September 20th, 1916, in the action brought by the Marconi Wireless Telegraph Company of America against de Forest Radio Telephone and Telegraph Company, after a prolonged legal contest on the Fleming and de Forest patents, said: "This burner detector of de Forest has never been commercially used and thus has not made any impression on the art. A mere inspection of the device in operation will show that [fol. 3113] this flickering flame is impracticable. The most that can be said for it is that it may contain the germ of an idea which in this rapidly progressing art may hereafter be utilised in some way. Whilst, therefore, it is not necessary to declare this patent and its three subsidiaries invalid, it may be eliminated from this case for all practical purposes."

Soon after the date of application for the Bunsen burner patent de Forest had brought to his notice the paper published by the author in the *Proceedings of the Royal Society of London* issue of March 16th, 1905, which had been read to the Society on February 9th of that year entitled, "On the Conversion of Electric Oscillations into Continuous Currents by means of a Vacuum Valve."

It is clear from subsequent events that this paper was the means of starting trains of though in his mind which had certainly not been there before its perusal. He must then

[2] See a letter by Dr. Lee de Forest to *The Electrician* (London), on January 23rd, 1914, vol. lxxii., p. 659; and reply by J. A. Fleming, *ibid.*, p. 660.

have become strongly impressed with the idea that what was required was not "a gaseous medium in a state of molecular activity," but some means of rectifying, as the author had shown, the trains of electric oscillations into unidirectional currents to make them affect a telephone or other instrument. Accordingly, in his next U. S. patent application, No. 823,402, filed December 9th, 1905, covering inventions in radiotelegraphy, we find he made use of the Fleming valve, and gave also a reference to its published description in the *Proceedings of the Royal Society*, March 16th, 1905.

Very ingeniously, however, he couples with this valve, and as equivalent to it, one of his Bunsen burner detectors, the flame of which is rendered more conducting by sodium or other salts, and this flame is now described as having a non-symmetrical conductivity. He states that positive electricity passes more readily in one direction in the flame than in the opposite.

The Bunsen burner had thus been transmitted into a rectifier of oscillations, and is described as a "valve" in this de Forest specification. His next step was to apply, on January 18th, 1906, for a United States patent, No. 824,637, for an oscillation-responsive device "of great simplicity and sensitiveness." In this specification great cleverness is shown in the treatment by which the oscillation responsive device, shown in his Bunsen burner patent, No. 979,275 (Fig. 6) and its subsidiary or divided application, No. 867,876, of April 4th, 1906, is gradually transformed into an identity with the author's oscillation valve, but disguised by the use of pseudo-scientific language, so as to appear to be something quite novel.

The glass bulb is described as a "receptacle," and the more or less perfect vacuum is a "gaseous medium, which is to be put into a condition of "molecular activity," "highly sensitive to electrical oscillations," when an electric current is employed "to heat two highly-resistant electrodes."

Diagrams are then given in this specification in which there is, as it were, a slow evolutionary transformation from the sterile oscillation responsive device of specification No. 979,275 (Fig. 6) to a nearly complete identity with the [fol. 3114] author's previously described valve detector. The diagrams *a*, *b*, *c*, *d*, in Fig. 56 are taken from de Forest's U. S. specifications, and show how ingeniously this metamorphosis was managed. The series, in fact, reminds us forcibly of the illustrations in books on geology, showing the gradual

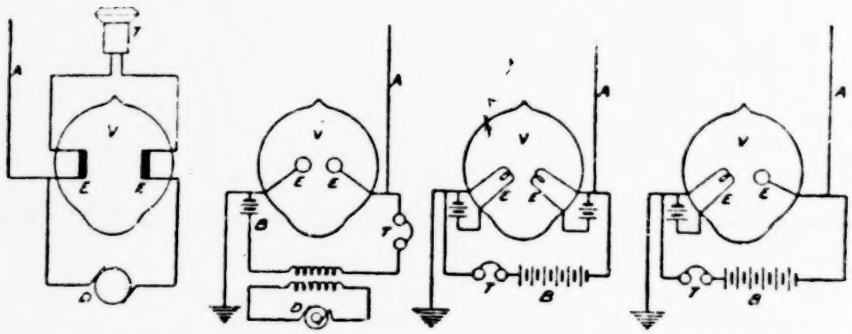

Fig. 56(a).—Fig. 6, U.S. Patent, No. 979,275, Nov. 4th, 1904.
Fig. 56(b).—Fig. 5, U.S. Patent, No. 824,637, Jan. 18th, 1906.
Fig. 56(c).—Fig. 1, U.S. Patent, No. 824,637, Jan. 18th, 1906.
Fig. 56(d).—Fig. 3, U.S. Patent, No. 824,637, Jan. 18th, 1906.

Fig. 56.—Diagrams taken from U.S. Patent Specifications of Lee de Forest.

evolution of present-day forms of animal life from ancient prehistoric types now extinct.

In the above specification it was stated that heating the electrodes is not even necessary, and that the gas may be "rendered sensitive to electrical oscillations by heating or by any other suitable means." As an example of such "suitable means" it is sufficient to cover the electrodes with "some radio-active substance such as radium bromid."

The next step was to sub-divide this broad specification into others covering its separate parts—viz., No. 836,070 (application of May 19th, 1906), and No. 836,071 (application of May 19th 1906). The first of these includes and describes identically the same article as a Fleming valve. The "receptacle" is now "partially exhausted." Two electrodes are sealed into it. One electrode, *E*, may be an "ordinary incandescent lamp carbon filament," the other "a disk of platinum or other material." The "gaseous medium" between them is rendered sensitive to electrical oscillations by the radiation of heat from the electrode, *E*, the said electrode being heated by a source of energy.

Influenced by this verbal camouflage, the United States Patent Office examiners could hardly help believing that the above specification described something entirely new and different from the simple Fleming valve for which a United States patent had been applied and issued months before, the only difference being that in the former specification the valve is shown associated with a telephone and

boosting battery as signal detector, and in the latter with a galvanometer or other current-detecting instrument.

In order to maintain the tradition that the Bunsen burner detector was the real parent of all subsequent forms of valve, Dr. Lee de Forest continued his course on January 20th, 1906, by filing an application, No. 824,638, for another Bunsen burner patent. In this case electrodes are placed in a Bunsen flame. "These may consist of platinum or carbon, or may be of platinum and the other of carbon." "When [fol. 3115] electrical oscillations are developed in the antenna by electromagnetic signal waves the passage of such oscillations through the sensitive gaseous conducting medium between the electrodes alters the conductivity thereof and thereby alters what may be termed the internal resistance of the flame battery constituted by the electrodes and the flame." There is no proof that any "sensitive gaseous medium" ever acted in this manner or that a single wireless message was ever received by this suggested form of "oscillation-responsive device."

In his next patent application the pendulum swings back again in the direction of the Fleming valve, and on February 14th, 1906, we find de Forest making another patent application, No. 837,901, in which he again declares he has "discovered that if a gaseous medium intervening between two separated electrodes be put into a condition of molecular activity by heating the same or otherwise putting it into a condition of molecular activity, said medium becomes highly sensitive to electrical oscillations." The actual instrument figured in the diagrams of this specification is, however, an incandescent electric lamp arranged as an oscillation valve having a projection on the bulb filled with mercury which acts as the cold electrode. An electromagnet is shown in the diagram placed near the bulb, which is said "will greatly increase the sensitiveness of the detector."

This application was followed by another on August 27th, 1906, No. 331,286, in which an oscillation detector is described which is said to have many uses. It comprises now "an exhausted vessel of glass or other suitable material, having two separated electrodes, between which intervenes the gaseous medium which when sufficiently heated or otherwise made highly conducting forms the sensitive element of the oscillation detector." One of these electrodes is to be a carbon or tantalum filament and the other a cold metal

plate or pair of plates. In the diagrams the filament is shown connected to a battery through a rheostat and outside the lamp the plates are connected with the lamp filament terminals through a telephone and a boosting battery. In some cases magnets are to be placed outside the bulb or coils of wire surrounding it.

In order carefully to distinguish this oscillation-responsive device from the Fleming valve, to which it had unfortunately so strong a resemblance, a new name for it was coined. It was called an *audion*. The patentee says this name is to include other devices of his invention "employing a conducting gaseous medium as the sensitive element."

It is curious how de Forest returns again and again in his specification to such meaningless expressions as the above.

2. Having secured, as he no doubt thought, a sound position — regard to patent priority, Dr. Lee de Forest next read a paper to the *in* American Institute of Electrical Engineers, New York, in October, 1906 (see *Transactions, American Institute of Electrical Engineers*, vol. xxv., p. 735, 1906), entitled "The Audion: A New Receiver for Wireless Telegraphy." The paper was discursive and also remarkable for the absense of any correct and proper history of the subject.

[fol. 3116] The author of it began by giving an account of his Bunsen burner experiments as the foundation of all his work and he then gives a single reference to a paper by Elster and Geitel, published in *Wiedemann's Annalen*, vol. xvi., 1882, and he also gives a diagram taken from one of their subsequent papers. The paper of Elster and Geitel which he quotes—viz., *Wied. Ann.*, vol. xvi., 1882—contains no reference to the diagram he gives of the apparatus, consisting of a glass bulb having a wire stretched across it, intended to be heated by an electric current, and an insulated metal plate placed near it and carried on a wire sealed through the glass (see Fig. 19 of Chap. I. of this book). The title of Elster and Geitel's 1882 paper is "On the Electricity of Flames," and no apparatus is described in this paper such as that de Forest depicts. This bulb was not used by Elster and Geitel until five years later and is described by them in a paper entitled "On the Ionisation of Gases by Incandescent Bodies," printed in *Wiedemann's Annalen* for 1887, vol. xxxi., p. 109.

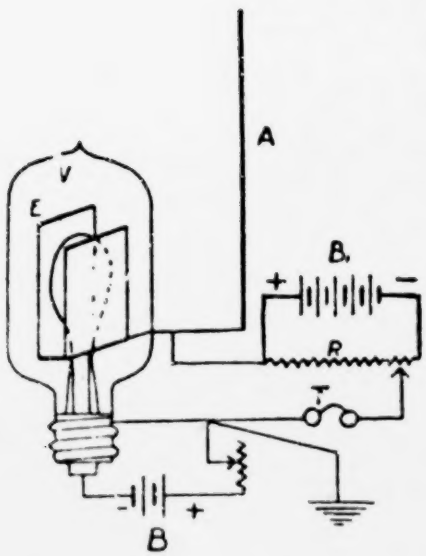

FIG. 57. Lee de Forest's Two-Electrode Audion of 1906

Moreover in this 1887 paper, Elster and Geitel only used a *platinum* wire across the bulb, and it was not until two years later, in 1889 (see *Wied. Annalen*, vol. xxxvii., p. 319, 1889), that they experimented with a carbon filament and found that it gave off negative electricity when incandescent.

It was in December, 1889, that the author sent to the Royal Society of London a paper dealing with the "Edison effect" in carbon glow lamps and in the electric arc and the transference of negative electricity from hot to cold electrodes in vacuum bulbs. There is not the slightest reference to this work in de Forest's paper.

This point is important, as it shows clearly the want of care and fairness in collecting information and verifying references. Moreover, de Forest refers to the author's prior work in connection with the use of a glow lamp having a plate sealed into the bulb for rectifying high frequency currents as experiments with an "Elster and Geitel tube" (see below). He then went on to describe as a new invention of his own a detector for wireless telegraphy consisting of a glass bulb evacuated of its air having in it a horseshoe-shaped filament of carbon or tantalum carried on wires sealed through the glass and rendered incandescent by the current from a battery. On either side of the filament were fixed two metal plates he calls "wings" carried on a platinum wire sealed through the glass. Outside the lamp the two plates were connected with the positive terminal of the filament through a circuit containing a [fol. 3117] galvanometer, a telephone, and a battery of cells having its positive terminal joined to the wings (see Fig. 57).

He omitted to mention that this arrangement had already been patented by the author in Great Britain as a radio-telegraphic detector. He also gave other diagrams of

audions with coils of wire round the lamp bulb, the diagrams being taken from his then recently filed United States Specification, No. 841,386.[3] Judging by the discussion which followed, his explanations of the action of his "audion" were not considered very satisfactory and objections were raised to his newly coined name as a bastard and unsuggestive word.

Broadly speaking, he attributed the operation to the ionisation of the residual gas by the incandescent filament, but he gave no very clear account of the physical processes at work. As regards the line of thought which led him to invent this detector, he stated that it occurred to him that the attenuated and ionised gases around an incandescent filament would undergo very considerable changes when subjected to Hertzian oscillations. He appeared chiefly desirous of proving that his audion was not an oscillation valve but something very superior to it. He strongly insisted that the important novel element was the use of a voltaic battery in series with the telephone supplying a boosting voltage and that this circuit was connected outside the lamp between the "wing" plates and the *positive* terminal of the incandescent filament.

He felt bound, however, to forestall some mention of the Fleming valve patented in Great Britain nearly two years before, and fully described in the author's book, *Principles of Electric Wave Telegraphy*, published nearly six months before the date when he read his paper. Hence he says, *loc. cit.*: "I have arrived as yet at no completely satisfactory theory as to the exact means by which the high frequency oscillations affect so markedly the behaviour of an ionised gas. Fleming points out that when the cold plate of an Elster-Geitel tube is connected to the positive end of the filament and the two put in a high-frequency oscillation circuit, only the positive half of the oscillation can pass from the plate to the filament across the gas. He uses this principle to rectify the Hertzian oscillations, and applies the unidirectional currents of the oscillations themselves to operate a sensitive galvanometer or direct current instrument for quantitative measurements over short

[3] This patent of de Forest was subsequently held by the United States Circuit Court of Appeals to be void. See Appendix for the full text of this important judgment.

distances. When an independent source of electromotive force is applied in the manner I have described the action becomes quite different. It then operates as a *relay* to the Hertzian energy instead of merely rectifying this energy, so that it can be used directly to give the sense signal."

When, in the discussion, he was asked point blank by Mr. C. B. Ehret to state exactly wherein his audion differed from a Fleming valve, he could only repeat the assertion that his audion was a relay and the valve only a rectifier. He confidently asserted that the Fleming valve was useless in commercial wireless telegraphy.

[fol. 3118] He did not know that at that time the author's valve had been in practical use in radiotelegraphy in Great Britain for nearly eighteen months, and that it had been employed with a telephone, as a receiver, just in accordance with the diagram in his paper.

He was quite wrong in asserting that the form of Fleming valve he called an audion was a relay. Later on he did succeed in devising a form of valve, to be mentioned presently, which does or can act as a relay.

The instrument he described in this 1906 paper was simply a Fleming valve, and it did not operate as a true relay. If Dr. de Forest had studied a little more carefully the Royal Society paper of the author published in March, 1905, he would have seen there a series of characteristic curves delineated for one particular valve, showing the relation of thermionic current to potential difference of the plate and filament. These observations were made by inserting a battery in the external circuit joining the plate and filament, exactly as he did in his experiments, but employing a galvanometer as a current measurer. These curves give a full explanation of the action of the valve when used with such a boosting voltage and a telephone in the valve circuit. They show that for a particular voltage, or P.D., the thermionic current rises with great rapidity, and hence that when that critical steady auxiliary voltage is applied, a small additional voltage, such as is obtained by the superposition of an alternating E.M.F. on the steady E.M.F., may give rise to a large increase in the thermionic current.

Every electrical student was also aware long before 1906 that the telephone is sensitive only to *change of current*, and not to steady or unvarying current. Hence when a telephone is used in place of a galvanometer as a signal-recording

instrument it is an advantage to add such a boosting or additional steady E.M.F. in the valve circuit as will bring the effective P.D. between filament and plate to that point on the characteristic curve at which the thermionic current begins to rise rapidly. This, however, is not a true relay action.

Summing up the criticism with regard to this paper of de Forest, we may say that there were three facts which ought in fairness to have been brought to the notice of his audience at the time to enable them to judge of the novelty of this *new* receiver described to them. The first of these was that an exactly similar instrument—viz., an incandescent lamp having a plate or plates sealed into the bulb—had been patented, or patents applied for, as a detector in wireless telegraphy in Great Britain, the United States, German, France, Italy, and other countries by J. A. Fleming and Marconi's Wireless Telegraph Company months before the date when this paper was read by de Forest. Secondly, that it was not new to introduce a boosting or auxiliary voltage into the external or valve circuit; and thirdly, that Senatore Marconi had used such appliances supplied to him by the author of this book eighteen months before October, 1906, with a telephone as a receiver for wireless telegraphy.

There is no intention of suggesting any want of good faith or integrity on the part of Dr. Lee de Forest. He was at that date evidently quite sure that he had full right to [fol. 3119] make use of an incandescent electric lamp having a plate or plates sealed into the bulb as a detector in wireless telegraphy, and he was firmly convinced that his substitution of a battery-boosted telephone in place of a galvanometer was an important invention. Exactly ten years later he had these opinions corrected by the judgment of Judge Mayer, subsequently upheld by the Court of Appeals.

8. Shortly after reading this paper de Forest filed another application on October 25th, 1906, for a United States Patent No. 841,387, entitled "Device for Amplifying Feeble Electrical Currents," and in this we have the first indication of a genuine improvement.

The principal item in this specification is an incandescent lamp having in addition to the carbon or metal loop filament two metal plates sealed into the bulb. This in itself was not novel, because the author had shown in his Royal Society paper of February, 1905, *loc. cit.*, and in the first

edition of his book, *Principles of Electric Wave Telegraphy*, published April, 1906 (see Chapter VI) an oscillation valve with two such cold electrode plates.

Nevertheless, de Forest made a scheme of connections outside the valve as follows:

One of the plates and one terminal (the negative) of the filament in the bulb were connected to the aerial wire and earth of the wireless receiving set, whilst the second plate was connected with the positive terminal of the filament through a telephone and boosting battery. This arrangement was stated to work in virtue of the fact that the electrostatic attraction of the filament and plate connected to the wireless antenna would draw them together and so vary the distance between the filament and the second plate and thus alter the current through the telephone. It may be doubted very much whether any such attractions could be so controlled as to give rise to the required variations in the thermionic current flowing to the second plate to transmit intelligible signals. Moreover, the thermionic current is not sensibly altered by varying slightly the distance between a hot and cold electrode.

This patent specification, however, contained two claims (4 and 6) for a detector device for *amplifying* electric currents. The wording of them was as follows:

Claim 4.—In a device for amplifying electrical currents, an evacuated vessel, three electrodes, sealed within said vessel, means for heating one of said electrodes, a local receiving circuit, including two of said electrodes and means for passing the current to be amplified between one of the electrodes which is included in the receiving circuit and the third electrode.

Claim 6.—In a device for amplifying electrical currents, an evacuated vessel, a heated electrode and two non-heated electrodes seated within said vessel, the non-heated electrodes being unequally spaced with respect to said heated electrode, a local receiving circuit including said heated electrode and that one of the non-heated electrodes which has the greater separation from the heated electrode and means for passing the current to be amplified between the heated electrode and the other non-heated electrode.

[fol. 3120] As these claims constituted the first mention of what may be called a split cold electrode, the two parts be-

ing differently connected to the hot electrode, and as this formed the basis of a subsequent patent for a three-electrode amplifying valve of true relay action, the Marconi Wireless Telegraph Company of America, who were the plaintiffs in the action against the de Forest Radio Telephone and Telegraph Company in 1916, confessed judgment as to the two above claims, 4 and 6, in U. S. Patent No. 841,387, whilst the defendants withdrew issue on claim 5 of the above patent, which reads as follows:

Claim 5.—In a device for amplifying electrical currents an evacuated vessel enclosing a gaseous medium, means other than the received energy for maintaining said gaseous medium in a condition of molecular activity, means for impressing the current to be amplified upon said gaseous medium and a local receiving circuit having its electrodes within said vessel.

On January 29th, 1907, de Forest filed another application for a United States patent for an improvement in oscillation detectors of the type described in his United States Patents Nos. 824,637 and 836,070. These we have already seen are Fleming valves used with a telephone and boosting battery in series connected to the filament and the collecting plate or cold electrode.

The feature of the new specification, No. 879,532, is the introduction of a second cold electrode in the form of a grid placed between the incandescent filament and the other cold electrode plate. The scheme of connections is shown in Fig. 58.

Dr. de Forest gave no explanation in this specification as to the mode of action of the arrangement, but he states that the effect is to give louder sounds in the telephone used as a signal-receiving instrument. He may have been led to try this type of thermionic detector by his previous experiments, but at any rate the result was to furnish for the first time a modification of the thermionic valve which *can* act as a relay or amplifier under certain conditions.

The corresponding British patent to the above was applied for on January 21st, 1908, and is No. 1,427 of 1908; but under the Patents and Designs Act of 1907 the date claimed for this British patent is January 29th, 1907, being the date of application for the equivalent United States patent. This British patent of de Forest was, however, allowed

to lapse in 1911 and is therefore no longer in force. The name "audion" is now commonly applied in the United States of America to this grid and plate or three electrode thermionic detector. In Great Britain it is usually called an *amplifying valve*.

Discussions and controversies have taken place over the theory of its physical action, and it was the subject of the above mentioned hotly contested patent action in the United States in 1916 between Marconi's Wireless Telegraph Company of America as plaintiffs, owners of the United States Patent No. 803,684, of April 19th, 1905, issued November [fol. 3124] 7th, 1905, granted to John Ambrose Fleming, of London, England; and de Forest Radio Telephone and Telegraph Company and Lee de Forest, as defendants. The suit was brought for infringement of claims 1 and 37 in the above Fleming patent specification by the defendants.

The defendants made counter-claims on various claims of ten patents by Lee de Forest. At the opening of the trial plaintiffs confessed judgment as to claims 4 and 6 of United States Letters Patent No. 841,387, and defendants withdrew from issue claim 5 of the same patent. Plaintiffs also confessed judgment as to the claims in issue of United States Letters Patent No. 879,532, and defendants withdrew United States Letters Patent No. 837,901.

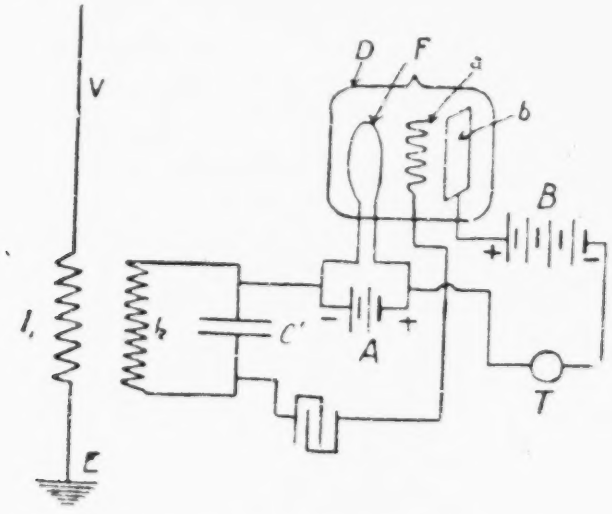

Fig. 3a. Lee de Forest's Three-Electrode Audion of 1907. D Glass Bulb. F Filament. a Grid. b Plate. A Filament Battery. B Plate Battery. T Telephone.

Of the counter-claim there remained in issue certain claims of seven patents—viz., Nos. 979,275, 867,876, 867,877,

DEFENDANT'S EXHIBIT E-2

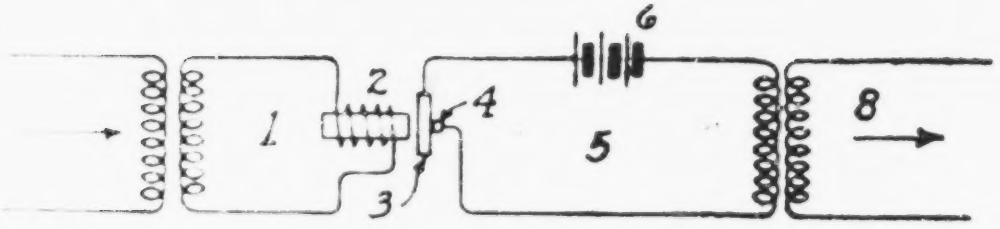

Fig. 1

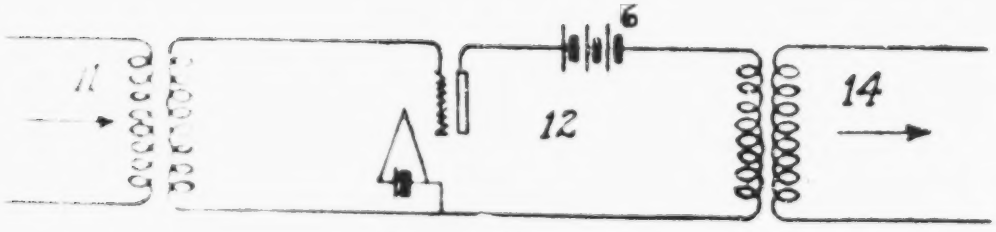

Fig. 2

DEFENDANT'S EXHIBIT F-2

HERTZ'S RESEARCHES ON ELECTRICAL OSCILLATIONS.

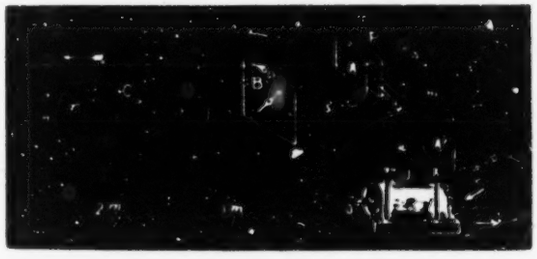

Fig. 11

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...flow round B towards A in the upper portion and ... B to A in the lower portion. The electrostatic and electrodynamic E.M.Fs are therefore in opposite phases and oppose each other's action. If the secondary circuit is rotated through 90deg., through the first principal position, the direct action changes its sign, but not so the action of the waves, so that the two tend to strengthen each other. The same reasoning holds when the air space is at the lowest point of B.

Greater lengths of wire were then included between *m* and *n*, and it was found that the interference became gradually less marked, until with a length of 2·5 metres it disappeared entirely, the sparks being of equal length whether the normal was directed towards or away from P. When the length of wire between *m* and *n* was further increased, the distinction between the different quadrants reappeared, and with a length of 4 metres the disappearance of the sparks was fairly sharp. The disappearance, however, then took place (with the air space at the highest point) when the normal was directed away from P, the opposite direction to that in which the disappearance previously took place. With a still further increase in the length of the wire the interference reappeared and returned to its original direction with a length of 6 metres. These phenomena are clearly to be explained by the retardation of the waves in the wire, and show that here again the direction of action in the advancing waves changes its sign at intervals of about 2·8 metres.

For certain interference phenomena with the secondary circuit in the third principal position the rectilinear wire must be removed from its original position, and placed in the horizontal plane through C, either on the side of the plate A or of the plate A'. Practically it is sufficient to stretch the wire loosely and to fix it by means of an insulated clamp on each side of C alternately. It was found that when the wire was on the same side as the plate P the waves in it diminished the previous sparking, and when on the opposite side the sparking was increased, both results being unaffected by the position of the air space in the secondary circuit. Now it has been already pointed out that at the moment when the plate A has its maximum positive charge, and at which, therefore, the primary current begins to flow from A, the current at the first node of the rectilinear wire begins to flow away from the origin. The two currents therefore flow round C in the same direction when C lies between the rectilinear wire and A, and in opposite directions when the wire and A are on the same side of C. The fact that the position of the air space is indifferent confirms the conclusion formerly arrived at, that the direction of oscillation is that due to the electrodynamic E.M.F. These interferences are also changed in direction when the wire *m n*, 1 metre in length, is replaced by a wire 4 metres in length.

Dr. Hertz also resorted to obtaining interference phenomena ... the results of the second method was not in the least ... these results were of no special importance, except ... confirming the previous conclusions.

Interference Phenomena at Greater Distances. Interference ... produced with the secondary at greater distances than ... of the null point, but care must then be taken that ... action of the waves in the wire is of about the same magnitude as the direct action of the primary circuit through the air. This can be effected by increasing the distance between C and A.

Now if the velocity of propagation of the electrodynamic disturbances through the air is infinite, the interference will change its sign at every half wave length in the wire, that is to say, at intervals of about 2·8 metres. If the velocities of propagation through the air and through the wire are equal, the interference will be in the same direction at all distances. Finally, if the velocity of propagation through the air is finite, but different from the velocity in the wire, the interference will change its sign at intervals greater than 2·8 metres.

The interferences first investigated were those which occurred when the secondary circuit was rotated from the first into the second principal position, the air space being at the highest point. The distance of the secondary from the null point was observed by half metre stages from 0 up to 8 metres, and at each of these positions an observation was made of the effects ... the normal towards and away from P respectively. The points at which no difference in the sparking was observed in the two positions of the normal are marked 0 in the table below. Those in which the sparking was least, showing the existence of interference, when the normal was directed towards P are marked +, and those in which the sparking was least when the normal was directed away from P are marked −. The experiments were repeated with different lengths of wire *m n*, varying by steps of half a metre from ½ metre up to 6 metres. The first horizontal line in the table gives the distances in metres of the centre of the secondary circuit from the null point, while the first vertical line gives the lengths of the wire *m n*, also in metres.

TABLE I.

	0		1		2		3		4		5		6		7		8
100	+	+	0	−	−	−	−	−	0	0	0	0	0	+	+	+	+
150	+	0	−	−	−	−	0	0	0	0	0	−	+	+	−	−	0
200	0		−	−	−	−	0	+	+	+	+	0	0	0	0	0	0
250	0		−	−	−	0	0	+	+	+	0	0	0	0	0	0	0
300		−	−	−	0	+	+	+	+	+	0	0	0	0		−	−
350		−	−	0	+	+	+	+	+	0	0	0					−
400		−	0	+	+	+	+	0	0	0	0						−
450		−	0	+	+	+	+	0	0	0		−	−			−	0
500		−	0	+	+	+	0	−		−	−	−	0	0	0	0	+
550	0	+	+	+	+	0	0	−		−	−	−	0	0	0	0	
600		+	+	+	0	0	−	−			−	0	0		+	+	

An inspection of this table shows, in the first place, that the changes of sign take place at longer intervals than 2·8 metres, and, in the second place, that the change of phase is more rapid in the neighbourhood of the origin than at a distance from it. As a variation in the velocity of propagation is very unlikely, this is probably due to the fact indicated by theory that the electrostatic E.M.F., which is more powerful than the electrodynamic E.M.F. in the neighbourhood of the primary oscillation, has a greater velocity of propagation than the latter.

In order to obtain a definite proof of the existence of similar phenomena at greater distances Dr. Hertz continued the observations, in the case of three of the lengths *m n*, up to a distance of 12 metres, and the result is given in the table below.

TABLE II.

	0	1	2	3	4	5	6	7	8	9	10	11	12
100	−	0	−	−	0	0	0	−	−	−	−	−	0
250	0	−	−	0	+	−	0	0	0	0	−	−	−
400	−	0	−	−	0	0	−				0	0	0

If we make the assumption that at the greater distance it is only the E.M.F. of induction which produces any effect, the experiments would show that the interference of the waves excited by the E.M.F. of induction with the original waves in the wire changes its sign only at intervals of about seven metres.

In order to investigate the E.M.F. of induction close to the primary oscillation, where the results are of special importance, Dr. Hertz made use of the interferences which were obtained when the secondary circuit was in the third principal position, and the air space was rotated through 90deg. from the base line. The direction of the interference at the null point, which has already been considered, was taken as negative, the interference being considered positive when it was produced by the passage of waves on the side of C remote from P, which makes the signs correspond with those of the previous experiments. It must be borne in mind that the direction of the resultant E.M.F. at the null point is opposed to that of the E.M.F. of induction, and therefore the first table would have begun with a negative sign if the electrostatic E.M.F. could have been eliminated. The present experiments showed that up to a distance of three metres interference continued to occur, and always of the same sign as at the null point. It was unfortunately impossible to extend these observations to a greater distance than four metres, on account of the feebleness of the sparks, but the results obtained were sufficient to give distinct evidence of a finite velocity of propagation of the E.M.F. of induction. These observations, like the former ones,

were repeated with various lengths of the wire as a in order to exhibit the variation in phase, and the results obtained are given in the table below :—

TABLE III.

	0	1	2	3	4
100	-	-	-	-	0
150	-	-	0	0	0
200	0	0	0	+	+
250	0	+	+	+	+
300	+	+	+	+	+
350	+	+	+	+	0
400	+	+	+	+	0
450	+	+	+	0	0
500	+	+	0	0	0
550	+	0	0	0	-
600	0	-	-	-	-

which shows that as the distance increases the phase of the interference changes in such a manner that a reversal of sign takes place at intervals of from seven to eight metres. This result is further confirmed by comparing the results of Table III. with the results for greater distances given in Table II., for in the former series the effect of the electrostatic E.M.F. is eliminated owing to the special position of the secondary circuit, while in the former it becomes insensible at the greater distances owing to its rapid decrease with increasing distance. We should therefore expect the results given in the first table for distances beyond four metres to follow without a break the results given in Table III. for distances up to four metres. This was found to be the case, as is evident from inspection of Tables II. and III.

To show this more clearly the signs of the interference of the waves, due to the electro-dynamic E.M.F., with the waves in the wire, are collected together in Table IV., the first four columns of which are taken from Table III., and the remaining columns from Table II.

TABLE IV.

	0	1	2	3	4	5	6	7	8	9	10	11	12
100	-	-	-	-	0	0	0	+	+	+	+	+	0
250	0	+	+	+	+	+	0	0	0	0	-	-	-
400	+	+	+	+	0	0	-	-	-	-	0	0	0

From the results given in this table the author draws the following conclusions :—

(1) The interference does not change its sign at intervals of 2·8 metres. The electro-dynamic actions are therefore not propagated with an infinite velocity.

(2) The interference is not in the same phase at all points. Therefore the electro-dynamic actions are not propagated through air with the same velocity as electric waves in wires.

(3) A gradual retardation of the waves in the wire has the effect of displacing a given phase of the interference towards the origin of the waves. The velocity of propagation through the air is therefore greater than through a wire.

(4) The sign of the interference is reversed at intervals of 7·5 metres, and therefore in traversing this distance an electro-dynamic wave gains one length of the waves in the wire.

Thus, while the former travels 7·5 metres, the latter travels 7·5 – 2·8 = 4·7 metres, and therefore the ratio of the velocities is 75 : 47, which gives for the half-wave length of the electro-dynamic action 2·8 × 75/47 = 4·5 metres. Since this distance is traversed in 1·4 hundred-millionths of a second, the absolute velocity of propagation through the air must be 320,000 kilometres per second. This result can only be considered reliable as far as its order is concerned; but its true value can hardly exceed half as much again, or be less than two-thirds of this amount. In order to obtain a more accurate determination of the true value it will be necessary to determine the velocity of electric waves in wires with greater exactness.

It does not necessarily follow from the fact that in the immediate neighbourhood of the primary oscillation the interference changes its sign after an interval of 2·8 metres that the velocity of propagation of the electrostatic action is infinite, for such a conclusion would rest upon a single change of sign, which might, moreover, be explained, independently of any change of phase, by a change in the sign of the amplitude of the resultant force at a certain distance from the primary oscillation. Quite independently, however, of any knowledge of the velocity of propagation of electrostatic actions, there exist definite proofs that the rates of propagation of electrostatic and electro-dynamic E.M.F.s are unequal.

In the first place the total force does not vanish at any point on the base line. Now, near the primary the electrostatic E.M.F. is the greater, while the electro-dynamic E.M.F. is the greater at greater distances. There must, therefore, be some point at which they are equal, and since they do not balance they must take different times to reach this point.

In the second place, the existence of points at which the direction of the resultant E.M.F. becomes indeterminate does not seem capable of explanation, except on the supposition that the electrostatic and electro-dynamic components perpendicular to each other are in appreciably different phases, and, therefore, do not compound into a rectilinear oscillation in a fixed direction. The fact that the two components of the resultant are propagated with different velocities is of considerable importance, in that it gives an independent proof that one of them at any rate must have a finite velocity of propagation.

(To be continued.)

THE TESLA MOTOR AND WESTINGHOUSE STATION SWITCH-BOARD ARRANGEMENT.

As announced some time ago, work has been actively prosecuted, says the *Electrical World*, by the Westinghouse Electric Company in the construction of an alternating-current motor by which the value of the alternating system as a method of power distribution is largely increased. This new motor, which is illustrated in the

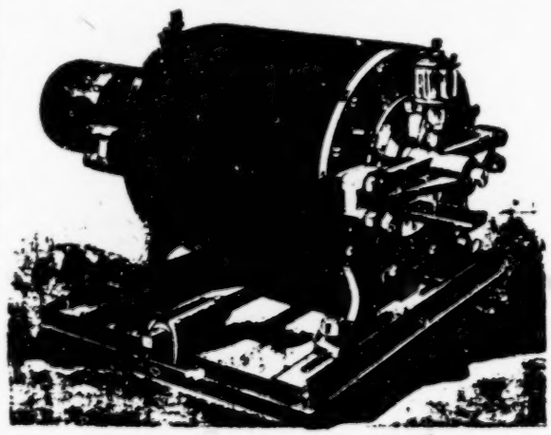

FIG. 1.

The New Westinghouse Alternating Current Motor.

accompanying illustration (Fig. 1), is based on the method of electro-dynamic rotation devised by Mr. Nikola Tesla,* and is so constructed that no commutator or contact brush of any kind is required, the armature being without any external electrical connection, and the rotative effort being exerted entirely from the changing polarity of the field-magnets.

As will be seen, the motor consists of a series of field-magnets built up of laminated sheet iron and wound with two sets of coils, the ends of which are connected to the two binding posts shown. These binding posts form the only connection with the regular lighting circuits, with the addition of a single return wire. By the aid of this return wire two alternating currents are sent through the field of the motor at the same time, the pulsations of the two currents being equal in strength, but the one lagging a quarter phase behind the other in the two sets of field coils respectively.

* See *The Electrician*, June 15, 1888.

This gives us the value of the inverse induced current at any time during the breaking of the primary. Expand the above expression by the exponential theorem and it becomes

$$i = \frac{M}{L} I - \frac{M}{L^2} \frac{R \delta t}{1 \cdot 2} + \frac{M}{L^3} \frac{R^2 \delta t^2}{1 \cdot 2 \cdot 3} - \text{etc.}$$

At the instant when the removal of lines of force or the cessation of the induction through the secondary takes place the impressed electromotive force ceases and the secondary current begins to die away. If we suppose the "break" of the primary to be very sudden, δt becomes practically zero, and we have

$$i = \frac{M}{L} I ;$$

that is to say, the secondary current starts with a value equal to $\frac{M}{L}$ of that of the steady primary.

The state of things in the secondary circuit immediately after the break of the primary is, then, this: the electromotive impulse due to stoppage of the primary has generated a current of initial value $\frac{M}{L} I$ in the secondary, but there is no impressed electromotive in the secondary circuit. If at any instant after the break the current in the secondary circuit is i, the law of decay of this current is expressed by the equation

$$L \frac{di}{dt} + R i = 0.$$

The solution of this is

$$i = C e^{-\frac{R}{L} t}$$

and the constant C is found from the condition that when $t = 0$, $i = \frac{M}{L} I$. Hence we have

$$i = \frac{M}{L} I e^{-\frac{R}{L} t} \quad \ldots \ldots \quad (7)$$

This gives us the value of the direct or "break" induced current in the secondary at any instant after the break of the

FIG. 10.

primary. Graphically, this may be represented by a curve, such as that in Fig. 10. During the time O T in which the primary is being broken the induced electromotive force is creating an induced current, the rising strength of which is represented by the rise O P. The time occupied by the break is O T. As O T is diminished in value, the magnitude of the maximum ordinate P T, approximates to $\frac{M}{L} I$, and this is the initial value of the inverse secondary current when the break is very sudden. After the break the current decays away along a path represented by P Q, and becomes zero only after an infinite time.

The whole quantity of the induced current is obtained by integrating equation (7) with respect to the time from zero to infinity, thus

$$\int_0^\infty i \, dt = \int_0^\infty \frac{M}{L} I e^{-\frac{R}{L} t} = \frac{M I}{R}$$

We see, then, that both the maximum value and whole quantity of the direct secondary current are proportional to the coefficient of mutual induction and to the strength of the primary current, and, moreover, that the whole quantity of electricity set in motion in a secondary circuit of total resistance R by suddenly removing from it M I lines of force is equal to the quotient of number of lines removed by the total resistance of the secondary circuit.

If the induced current is sent through a galvanometer the indications are proportional to the magnitude of $\frac{M I}{R}$. If, however, the induced current is employed to magnetise steel needles, the magnetisation acquired is dependent upon the magnitude of $\frac{M I}{L}$, and is therefore greater in proportion as the coefficient of self-induction of the secondary circuit is less. Lord Rayleigh has pointed this out,* and shown by experiment that within certain limits the magnetising effect of the break-induced current on steel needles is *greater* the smaller the number of turns of which the secondary consists, the opposite being, of course, true of the galvanometer. The galvanometer takes account of the induced current as a whole; whilst the magnetising power depends mainly on the magnitude of the current at the first moment of its formation, without regard to the time which it takes to subside.

(To be continued.)

HERTZ'S RESEARCHES ON ELECTRICAL OSCILLATIONS.

BY O. W. DE TUNZELMANN, B.SC.

(Concluded from page 18.)

The latest researches of Dr. Hertz on electrical oscillations of which accounts have been published at present are described in a Paper "On Electro-Dynamic Waves in Air, and their Reflection," in Wiedemann's *Annalen*, Vol. XXXIV., p. 609. The author had been endeavouring to find a more striking and direct proof of the finite velocity of propagation of electro-dynamic waves than those which he had hitherto given, for, though these are quite sufficient to establish the fact, they can only be properly appreciated by one who has obtained a grasp of the results of the entire series of researches.

In many of the experiments which have been described Dr. Hertz had noticed the appearance of sparks at points in the secondary conductor, where it was clear from geometrical considerations that they could not be due to direct action, and it was observed that this occurred chiefly in the neighbourhood of solid obstacles. It was found, moreover, that in most positions of the secondary conductor the feeble sparks produced at a great distance from the primary became considerably stronger in the vicinity of a solid wall, but disappeared with considerable suddenness quite close to the wall. The most obvious explanation of these experiments was that the waves of inductive action were reflected from the wall and interfered with the direct waves, especially as it was found that the phenomena became more distinct when the circumstances were such as to favour reflection to the greatest possible extent. Dr. Hertz therefore determined upon a thorough investigation of the phenomena.

The experiments were made in the Physical Lecture Theatre, which is 15 metres in length, 14 metres in width, and 6 metres in height. Two rows of iron columns, running parallel to the sides of the room, would collectively act almost like a solid wall towards electro-dynamic action, so that the available width of the room was only 8·5 metres. All pendant gas fittings were removed, and the room left empty, with the exception of wooden tables and forms, which would not exert any appreciable disturbing effect. The end wall, from which the waves were to be reflected, was of solid sandstone, with two

* *Phil. Mag.*, Ser. 4, Vol. XXXIX., 1870, p. 429.

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doors in it, and the numerous gas pipes attached to it gave it, to a certain extent, the character of a conducting surface, and this was increased by fastening to it a sheet of zinc 4 metres high and 2 metres broad, connected by wires to the gas pipes and a neighbouring water pipe. Special care was taken to provide an escape for the electricity at the upper and lower extremities of the zinc plate, where a certain accumulation of electricity was to be expected.

The primary conductor was the same that was employed in the experiments described in my last Paper, and was placed at a distance of 13 metres from the zinc plate, and, therefore, two metres from the wall at the other end of the room. The connecting wire was placed vertically, so that the E.M.F.s to be considered increased and diminished in a vertical direction. The centre of the primary conductor was 2.5 metres above the floor of the room, which left a clear space for the observations above the tables and benches. The point of intersection of the reflecting surface with the perpendicular from the centre of the primary conductor will be called the point of incidence, and the experiments were limited to the neighbourhood of this point, as the investigation of waves striking the wall at a considerable angle would be complicated by the differences in their polarisation. The plane of vibration was therefore parallel to the reflecting surface, and the plane of the waves was perpendicular to it, and passed through the point of incidence.

The secondary conductor consisted of the circle of 35 centimetres radius, which has been already described. It was movable about an axis through its centre perpendicular to its plane, and the axis itself was movable in a horizontal plane about a vertical axis. In most of the experiments the secondary conductor was held

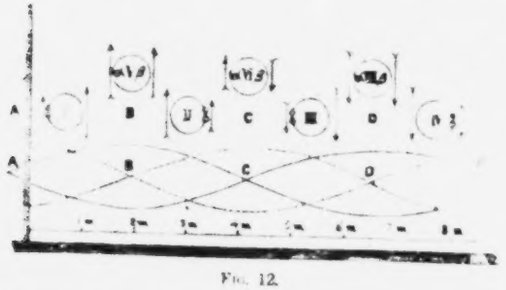

FIG. 12.

in the hand by its insulating wooden support, as this was the most convenient way of bringing it into the various positions required. The results of these experiments, however, had to be checked by observations made with the observer at a greater distance from the secondary, as the neighbourhood of his body exerted a slight influence upon the phenomena. The sparks were distinct enough to be observed at a distance of several metres when the room was darkened, but when the room remained light they were practically invisible even when the observer was quite close to the secondary.

When the centre of the secondary was placed in the line of incidence and with its plane in the plane of vibration, and the air space was turned first towards the reflecting wall and then away from it, a considerable difference was generally observed in the strength of the sparks in the two positions. At a distance of about 0.8 metre from the wall the sparks were much stronger when the air space was directed towards the wall, and its length could be adjusted so that while there was a steady stream of sparks when in this position, they disappeared entirely when the air space was directed away from the wall. These phenomena were reversed at a distance of 3 metres, and recurred, as in the first case, at a distance of 5.5 metres. At a distance of 8 metres the sparks were stronger when the air space was turned away from the wall, as at the distance of 3 metres, but the difference was not so well marked. When the distance was increased beyond 8 metres no further reversal took place, owing to the increase in the direct effect of the primary oscillation and the complicated distribution of the E.M.F. in its neighbourhood.

The positions I., II., III., and IV. (Fig. 12) of the secondary circle are those in which the sparks were strongest, the distance from the wall being shown by the horizontal scale at the foot. When the secondary circle was in the positions V., VI., and VII., the sparks were equally strong in both positions of the air space, and quite close to the wall the difference between the sparking in the two positions again diminished. Therefore the points A, B, C, D in the diagram may in a certain sense be regarded as nodes. The distance between two of these points must be, however, be taken as the half wave length, for at all the electrical motions changed their directions on passing through one of these points the phenomena observed in the secondary circuit would be repeated without variation, since the direction of oscillation in the air space is indifferent.

The conclusion to be drawn from the experiments is that on passing any one of these points part of the action is reversed, while another part is not. The experimental results, however, warrant the assumption that twice the distance between two of these points is equal to the half wave length, and when this assumption is made the phenomena can be fully explained.

For, suppose a wave of E.M.F., with oscillations in a vertical direction, to impinge upon the wall, and to be reflected with only slightly diminished intensity, thus giving rise to stationary waves. If the wall were a perfect conductor, a node would necessarily be formed in its surface, for at the boundary and in the interior of a perfect conductor the E.M.F. must be intrinsically small. The wall cannot, however, be considered as a perfect conductor, for it was not metallic throughout, and the portion which was metallic was not of any great extent. The E.M.F. would therefore have a finite value at its surface, and would be in the direction of the impinging waves. The node which in the case of perfect conductivity would occur at the surface of the wall, would, therefore, actually be situated a little behind it, as shown at A in the diagram. If, then, twice the distance A B—that is to say, the distance A C—is half the wave length the steady waves will be as represented by the continuous lines in Fig. 12. The E.M.F.s acting on each side of the circles, in the positions I., II., III., and IV., will therefore at a given moment be represented in magnitude and direction by the arrows on each side of them in the diagram. If, therefore, in the neighbourhood of a node the air space is turned towards the node the strongest E.M.F. in the circle will act under more favourable conditions against a weaker one under less favourable conditions. If, however, the air space is turned away from the node, the stronger E.M.F. acts under less favourable conditions against a weaker one under more favourable conditions. In the latter case the resultant action must be less than in the former, whichever of the two E.M.F.s has the greater effect, which explains the change of sign of the phenomenon at each quarter wave length.

This explanation is further confirmed by the consideration that if it is the true one the change of sign at the points B and D must take place in quite a different manner from that of the point C. The E.M.F.s acting on the secondary circle, in the positions V., VI., and VII., are shown by the corresponding arrows, and it is clear that in the positions B and D, if the air space is turned from one side to the other, the vibration will change its direction round the circle, and, therefore, the sparking must during the rotation vanish either once or an uneven number of times. In the position C, however, the direction of vibration remains unaltered, and therefore the sparks must disappear an even number of times, or not at all.

The experiments showed that at B and D the sparking diminished as the air space revolved from α, vanished at the highest point, and again attained its original value at the point β. At C, on the other hand, the sparking continued throughout the rotation, being a little stronger at the highest and lowest points. If, then, there is any change of sign in the position C, it must occur with very much smaller displacement than in the other positions, so that in any case there is a distinction such as required between this and the other two cases.

Another very direct proof of the truth of Dr. Hertz's hypothesis of the nature of the waves was obtained. If the secondary circle lies in the plane of the waves instead of in the plane of vibration, the E.M.F. must be equal at all points of the circle, and for a given position of the air space the sparking must be directly proportional to its intensity. When the experiment was made it was found, as expected, that at all

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distances the sparking vanished at the highest and lowest points of the circle, and attained a maximum value at the points in the horizontal plane through the point of incidence.

The air space was then placed at such a point and close to the wall and was then moved slowly away from the wall, when it was found that while there was no sparking quite close to the metal plate, it began at a very small distance from it, rapidly increased, reached a maximum at the point B, and then diminished again. At C the sparking again became excessively feeble, and increased as the circle was moved still further away. The sparking continued steadily to increase after this, as the motion of the circle was continued in the same direction, owing, as before, to the direct action of the primary oscillation.

The curves shown by the continuous lines in Fig. 12 were obtained from the results of these experiments, the ordinates representing the intensity of the sparks at the distances represented by the corresponding abscissæ.

The existence in the electrical waves of nodes at A and C, and of loops at B and D, is fully established by the experiments which have been described; but in another sense the points B and D may be regarded as nodes, for they are the nodal points of a stationary wave of magnetic induction which, according to theory, accompanies the electrical wave and lags a quarter wave-length behind it.

This can easily be shown to follow from the experiments, for when the secondary circle is placed in the plane of vibration with the air space at its highest point, there will be no sparking if the E.M.F. is uniform throughout the space occupied by the secondary. This can only take place if the E.M.F. varies from point to point of the circle, and if its integral round the circle differs from zero. This integral is proportional to the number of magnetic lines of force passing backwards and forwards across the circle, and the intensity of the sparks may be considered as giving a measure of the magnetic induction, which is perpendicular to the plane of the circle. Now in this position vigorous sparking was observed close to the wall, diminishing rapidly to zero as the point B was approached, then increasing to a maximum at C, falling to a well-marked minimum at D, and finally increasing continuously as the secondary approached still nearer to the primary. If the intensities of these sparks are taken as ordinates, positive and negative, and the distances from the wall as abscissæ, the curve shown by the dotted lines in Fig. 12 is obtained, which therefore represents the magnetic waves.

The phenomena observed in the first series of experiments described in this Paper may therefore be regarded as due to the resultant electric and magnetic actions. The former changes sign at A and C, the latter at B and D, so that at each of these points one part of the action changes sign, while the other does not, and therefore the resultant action which is their product must change sign at each of these points, as was found to be the case.

When the secondary circle was in the plane of vibration the sparking in the vicinity of the wall was observed to be a maximum on the side towards the wall, and a minimum at the opposite side, and as the circle was turned from one position to the other there was found to be no point at which the sparks disappeared. As the distance from the wall was increased the sparks on the remote side gradually became weaker, and vanished at a distance of 1·08 metre from the wall. When the circle was carried further in the same direction the sparks appeared again on the side remote from the wall, but were always weaker than on the side next to it; the sparking, however, no longer passed from a maximum to a minimum merely, but vanished during the rotation once in the upper and once in the lower half of the circle. The two null points gradually receded from their original coincident positions, until at the point B they occurred at the highest and lowest points of the circle. As the circle was moved further in the same direction, the null points passed over to the side next to the wall, and approached each other again, until when the centre was at a distance of 2·35 metres from the wall the two null points were again coincident. B must be exactly half-way between this point and the similar point previously observed, which gives 1·72 metre as the distance of B from the wall, a result which agrees, within a few centimetres, with that obtained by direct observation. Moving further in the direction of C, the sparking at different points of the circle became more nearly equal, until at C it was exactly so. In this position there was no null point, and as the distance was further increased the phenomena recurred in the same order as before.

Dr. Hertz found that the position of C could be determined within a few centimetres, the determinations of its distance from the wall varying from 4·10 to 4·15 metres; he gives its most probable value as 4·12 metres. The point B could not be observed with any exactness, the direct determinations varying from 6 to 7·5 metres as its distance from the wall. It could, however, be determined indirectly, for the distance between B and C being found to be 2·4 metres, taking this as the true value, A must have been 0·68 metre behind the surface of the wall, and 6·52 metres in front of it. The half-wave length would be 4·8 metres, and by an indirect method it was found to be 4·5 metres, so that the two results agree fairly well. Taking the mean of these as the true value, and the velocity of light as the velocity of propagation, gives as the vibration period of the apparatus 1·55 hundred millionths of a second, instead of 1·4 hundred millionths, which was the theoretically calculated value.

A second series of experiments were made with a smaller apparatus, and though the measurements could not be made with as much exactness as those already described, the results showed clearly that the position of the nodes depends only on the dimensions of the conductors and not on the material of the wall.

Dr. Hertz states that after some practice he succeeded in obtaining indications of reflection from each of the walls. He was also able to obtain distinct evidence of reflection from one of the iron columns in the room, and of the existence of electrodynamic shadows on the side of the column remote from the primary.

In the preceding experiments the secondary conductor was always placed between the wall and the primary conductor—that is to say, in a space in which the direct and reflected rays were travelling in opposite directions, and gave rise to stationary waves by their interference.

He next placed the primary conductor between the wall and the secondary, so that the latter was in a space in which the direct and reflected waves were travelling in the same direction. This would necessarily give rise to a resultant wave, the intensity of which would depend on the difference in phase of the two interfering waves. In order to obtain distinct results it was necessary that the two waves should be of approximately equal intensities, and therefore the distance of the primary from the wall had to be small in comparison with the extent of the latter, and also in comparison with its distance from the secondary.

To fulfil these conditions the secondary was placed at a distance of 14 metres from the reflecting wall, and, therefore, about 1 metre from the opposite one, with its plane in the plane of vibration, and its air space directed towards the nearest wall, in order to make the conditions as favourable as possible for the production of sparks. The primary was placed parallel to its former position, and at a perpendicular distance of about 30 centimetres from the centre of the reflecting metallic plate. The sparks observed in the secondary were then very feeble, and the air space was increased until they disappeared. The primary conductor was then gradually moved away from the wall, when isolated sparks were soon observed in the secondary, passing into a continuous stream when the primary was between 1·5 and 2 metres from the wall—that is, at the point B. This might have been supposed to be due to the decrease in the distance between the two conductors, except that as the primary conductor was moved still further from the wall the sparking again diminished, and disappeared when the primary was at the point C. After passing this point the sparking continually increased as the primary approached nearer to the secondary. These experiments were found to be easy to repeat with smaller apparatus, and the results obtained confirmed the former conclusion, that the position of the nodes depends only on the dimensions of the conductor, and not on the material of the reflecting wall.

Dr. Hertz points out that these phenomena, which are exactly analogous to the acoustical experiment of approaching a vibrat-

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ing tuning fork to a wall, when the sound is weakened in certain positions and strengthened in others, and also to the optical phenomena illustrated in Lloyd's form of Fresnel's mirror experiments; and as these are accepted as arguments tending to prove that sound and light are due to vibration, his investigations give a strong support to the theory that the propagation of electro-magnetic induction also takes place by means of waves. They, therefore, afford a confirmation of the Faraday-Maxwell theory of electrical action. He points out, however, that Maxwell's, in common with other electrical theories, leads to the conclusion that electricity travels through wires with the velocity of light, a conclusion which his experiments show to be untrue. He states that he intends to make this contradiction between theory and experiment the subject of further investigation.

LETTERS FOR LEARNERS AND UN-PROFESSIONAL READERS.

BY H. D. WILKINSON.

SECTION II.—ELECTRO-MAGNETIC FIELDS.

(*Continued from page 821, Vol. XXI.*)

135. *Electro-Magnetisation of Annealed Iron Wire.*—In order to observe the magnetisation of a piece of iron when there is practically no demagnetising effect from its own poles, it has been stated that a rod or wire must be selected whose length is at least 300 times its diameter. Now, if the magnetic moment is measured by either of the two methods of Gauss already detailed (para. 125), the iron wire tested must be very small in diameter, as it is not convenient to test a very long wire by these methods. And the strength of pole developed in a wire of small diameter is necessarily very small even when the iron has acquired a high magnetisation in consequence of

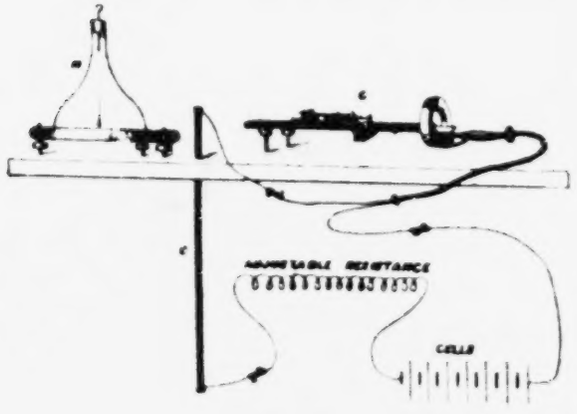

Fig. 116.

which the magnetometer can only be deflected to very small angles. With a light mirror attached to the needle, the amplitude of the deflections can be considerably increased by a ray of light reflected from the mirror on to a screen, and in this manner very small movements of the needle can be accurately observed. We are here, however, employing a magnetometer without a mirror attachment, and it is therefore advisable to arrange matters so that the needle is deflected to a considerable angle, say to 30 deg. or 60 deg., when the iron is near its highest magnetisation. The intermediate deflections can then be read with ease and accuracy. This may be effected conveniently by using a long core and placing it vertically, as shown at C (Fig. 116). As large a diameter as No. 11 B.W.G. iron wire may be used for a core 3ft. long, and yet be over the necessary ratio of length to diameter. This gives sufficient sectional area of iron to develop, at high magnetisations, enough strength of pole to strongly deflect the needle, the top end of the core being within 20 centimetres from the needle. In this diagram, C is the magnetising coil wound round a brass tube, and fixed vertically by passing it through a hole in the table. The iron wire core of the same length as the tube should slip easily into it, and the upper end of the latter be fixed a little above the level of the magnetometer needle, in order that the pole which is formed at a little distance from the end, may set itself nearly in a horizontal line with the needle. As the iron becomes more magnetised the poles move up more to the ends, but are always some slight distance off, even when most strongly magnetised. By this method the upper pole acts powerfully on the needle, and with a long core the action of the lower pole is very feeble. If we neglect the action of the lower pole, the intensity of field at the needle placed R centimetres away from the upper pole, is

$$\frac{m}{R^2} \text{ C.G.S. units,}$$

where m is the strength of pole (see paras. 108 and 109). But where accuracy is required the action of the lower pole must be taken into account. Taking the point of p (Fig. 117) as the centre of the magnetometer needle and SN as the magnetised core, it will be seen that the lower pole (R centimetres from p) would repel a unit north pole at p with a force of

$$\frac{m}{R'^2} \text{ dynes.}$$

But this force is in an oblique direction, and the needle moving in a horizontal plane is only influenced by horizontal forces. It is therefore only the horizontal component of the above force that we have to deal with. Resolving by the parallelogram of forces we have by similar triangles

$$\frac{\text{horizontal component}}{\frac{m}{R'^2}} = \frac{x}{R'}$$

whence the horizontal force $= \frac{mx}{R'^3}$ dynes.

Fig. 117.

The resultant force f at the needle is then the difference between the forces due to each pole, viz.

$$\frac{m}{R^2} - \frac{mx}{R'^3} \text{ dynes.}$$

Now, the force in dynes on unit pole at a point is the same thing as the intensity of field at that point, and the value of f above value of f represents the strength of field at the needle centre due to both poles of the core. This field deflects the needle at right angles to the earth's horizontal field H, and therefore (by para. 119)

$$f = H \tan \alpha,$$

where α is the angular deflection of needle. (Glancing at the figure it will be noticed that the coil of the magnetometer needle is viewed, the earth's meridian being supposed to be at right angles to the plane of the paper, and the magnetising coil C being placed east or west of the needle.

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HERTZ'S RESEARCHES ON ELECTRICAL OSCILLATIONS.

BY DR. W. DE GUNZBURG, PH.D.

(Continued from page 758.)

It was shown in the experiments described in my last Paper that when variable electrical forces act in the interior of dielectrics of specific inductive capacity not equal to unity, the corresponding electrodisplacements produce electrodynamic effects (see paper "On the Velocity of Propagation of Electro Dynamic Actions," in Wiedemann's *Annalen*, Vol. XXXIV., p. 551). Dr. Hertz shows that similar actions take place in the air, which proves, as was previously pointed out, that electrodynamic actions must be propagated with a finite velocity.

The method of investigation was to excite electrical oscillations in a rectilinear conductor in the same manner as in former experiments, and then to produce effects in a secondary conductor by exciting electrical oscillations in it by means of those in the rectilinear conductor, and at the same time by the primary conductor acting through the intervening space. This distance was gradually increased, when it was found that the phase of the vibrations at a distance from the primary lagged behind those in its immediate neighbourhood, showing that the action is propagated with a finite velocity, which was found to be greater than the velocity of propagation of electrical waves in wires in the ratio of about 15 to 25, so that the former is of the same order as the velocity of light. Dr. Hertz was unable to obtain any evidence with respect to the velocity of propagation of electrostatic actions.

Fig. 11.

The primary conductor A A (fig. 11) consisted of a pair of square brass plates with sides 40 centimetres in length, connected by a copper wire 30 centimetres in length, at the middle point of which was an air space, across which sparks were made to pass by means of powerful discharges from the induction coil. The conductor was fixed at a height of 2 metres above the base plate of the coil with its plates vertical and the connecting wire horizontal. A straight line, drawn horizontally through the air space of the primary and perpendicular to the direction of the primary oscillation will be called the base line, a point in this situated at a distance of 1 centimetre from the air space will be referred to as the base point.

The experiments were made in a large lecture room with nothing near the apparatus for a distance of 12 metres from the primary conductor. The room was darkened during the experiments.

The secondary conductor consisted of a circular wire of 35 centimetres radius, and a circular piece of wire D with a micrometer screw. The primary and secondary air spaces were both capable of adjustment by means of micrometer screws. With the secondary conductor so arranged that the plane of the ball end was parallel to the base line, and at a distance of 1 centimetre from it, sparks were observed in the micrometer air space of the secondary, and on account of self-induction. It is doubtful whether the ordinary theory of electrical oscillations would hold for circuits of such dimensions as those of the experiments, but as it gives correct numerical results in the case of Leyden jar discharges, it may be expected to be correct as far as the order of the results is concerned. When the centre of the secondary lies in the base line, and its plane coincides with the vertical plane through the base line, no sparks are observed in the secondary, the E.M.F. being everywhere perpendicular to the direction of the wire. This will be referred to as "the first principal position" of the secondary. When the plane of the secondary is vertical and perpendicular to the base line, the centre still being in the base line, the secondary will be said to be in the "second principal position." Sparking then occurs in the secondary, and its air space is either above or below the base line, but not when it is exactly through the base line, but not when it is exactly through the base line, but not when it is exactly through

[illegible] waves in the rectilinear wire were of the [illegible] as that of the primary oscillations, as was [illegible] their being shown to be in unison with each [illegible] secondary conductors previously described. [illegible] of stationary waves showed that the waves [illegible] wire were of a steady character in space as [illegible] time. The nodal points were determined in the [illegible] manner. The further end of the wire was left free, [illegible] secondary conductor was brought near to it, in such [illegible] that the wire lay in its plane, and had the air space [illegible] it. As the secondary was moved along the [illegible] of no sparking were observed to recur periodically. [illegible] from the point *a* to the first of these was [illegible], and the length of the wire made equal to a multiple [illegible] distance. The experiments were then repeated, and it [illegible] that the nodal points occurred at approximately [illegible] intervals along the wire.

The nodes could also be distinguished from the loops in [illegible] ways. The secondary conductor was brought near to [illegible] with its plane perpendicular to it, and with its air [illegible] neither directed completely towards the wire nor com- [illegible] away from it, but in an intermediate position, so as to [illegible] E.M.F.s perpendicular to the wire. Sparks were then [illegible] at the nodes, while they disappeared at the loops. [illegible] sparks were taken from the rectilinear wire by means [illegible] insulated conductor, they were found to be stronger at [illegible] nodes than at the loops; the difference, however, was [illegible] and was, indeed, scarcely distinguishable unless the [illegible] of the nodes and loops was previously known. The [illegible] that this and other similar methods do not give a well [illegible] result lies in the fact that irregular oscillations are [illegible] upon the waves considered; the regular waves, however, can be picked out by means of the secondary, just [illegible] definite notes are picked out by means of a Helmholtz reso- [illegible]. If the wire is severed at a node, no effect is produced [illegible] the waves in the portion of wire next to the origin, but [illegible] the severed portion of wire is left in its place, the waves [illegible] to be propagated through it, though with somewhat [illegible] strength.

The possibility of measuring the wave lengths leads to [illegible] applications. If the copper wire hitherto used is re- [illegible] by one of different diameter, or by a wire of some other [illegible], the nodal points retain their position unchanged. It [illegible] from this that the velocity of propagation in a wire [illegible] a definite value independent of its dimensions and material. [illegible] iron wires offer no exception to this, showing that the [illegible] susceptibility of iron does not play any part in the [illegible] of such rapid motions. It would be interesting to investi- [illegible] the behaviour of electrolytes in this respect. In their case we should expect a smaller velocity of propagation, because the electrical motions are accompanied by motions of the mole- [illegible] carrying the electric charges. It was found that no [illegible] propagation of the waves took place through a tube 10 milli- [illegible] metres in diameter, filled with a solution of sulphate of copper; but this may have been due to the resistance being too high. By the measurement of wave lengths the relative vibration periods of different primary conductors can be determined, and it therefore becomes possible to compare in this manner the [illegible] vibration periods of plates, spheres, ellipsoids, &c.

In the experiments made by Dr. Hertz nodes were very distinctly produced when the wire was severed at a distance of either 8 metres or 5·5 metres from the null point of the base [illegible]. In the first case the nodes occurred at distances from the null point of −0·2 metre, 2·3 metres, 5·1 metres, and [illegible] metres, and in the latter case at distances of −0·1 metre, [illegible] metres, and 5·5 metres. It appears, therefore, that the [illegible] wave length in a free wire cannot differ much from [illegible] metres. The fact that the wave lengths nearest to P were somewhat smaller was to be expected from the influence of the plates and of the curvature of the wire. This wave length, with a period of 1·4 hundred millionths of a second, gives 300,000 kilometres per second for the velocity of propagation of electrical waves in wires. Fizeau and Gounelle (Poggendorff's *Annalen*, Vol. LXXX., p. 158, 1850) obtained for the velocity in iron wires 100,000 kilometres per second, and 200,000 in copper wires. W. Siemens (Poggendorff's *Annalen*, Vol. CLVII., p. 309, 1876), by the aid of Leyden jar discharges, obtained a velocity of from 200,000 to 260,000 kilometres per second in iron wires. Dr. Hertz's result is very nearly the mean of these, from which we may conclude that the order at any rate, of the vibration period as calculated by him is correct. The value obtained cannot be regarded, independently of its agreement with experimental results otherwise obtained, as a fresh determination of the velocity, since it rests upon a theory which is open to doubt.

(To be continued.)

THE ELECTROLYTIC PURIFICATION OF ALCOHOL.

M. Pontbriere, of the University of Lemberg, has published some interesting information with regard to the methods employed in France for purifying the products of the distillation of various substances containing sugar or starch, by means of the electrolytic process of M. Naudin. The alcohol of beetroot, for instance, when subjected to this treatment, and afterwards rectified in the usual manner, is entirely free from the unpleasant smell which characterises the crude product, whilst the alcohol of the Jerusalem artichoke, which is, as a rule, completely useless, yields as good results if treated by the Naudin process as that distilled from maize.

The earliest attempts in this direction were made by M. Esenmann, who, although he employed electricity, made no use of electrolysis. M. Esenmann passed a current of ozonised air at 70° C. through the liquid to be purified. To ozonise the air, it was sent through a glass tube placed between the terminals of an inductive coil. This process certainly oxidised some of the deleterious constituents of the liquid, but did not seem to act on the aldehydes which form the principal impurity of crude alcohol.

In the Naudin process the liquid is first hydrogenised by means of a Gladstone and Tribe zinc copper element. At M. Boulet's works, at Bapaume-lez-Rouen, wood or iron vats are used containing a number of zinc plates which are alternately flat and corrugated. The weight of zinc in a 150 hectolitre (3,300 gals.) vat is 800 kg. (0·8 tons); the number of plates is 116, and the active surface equals 1,800 square metres (19,380 square feet). Sulphate of copper is dissolved in the alcohol to be treated, and the reduced copper is deposited on the zinc plates. Five solutions containing 1 per cent. of copper sulphate are employed in succession. The total weight of copper deposited is 350 kg. (0·35 tons) in the case of the 150 hectolitre vat. The temperature at which the deposit is made is a matter of supreme importance; it ought to be from 30° C. to 35° C.; five degrees more or less injuriously affect the process. If the temperature is too low, the action ceases; if it is too high, the copper does not adhere firmly to the zinc plates. Each solution requires 24 hours to completely deposit the copper contained in it, so that the entire zinc copper process requires five days. Owing to the formation of oxidised zinc hydrate, 5 kg. of hydrochloric acid are added every week for every 150 hectolitres of alcohol treated.

The above process is generally sufficient to completely purify the crude alcohol, but owing to the presence of other impurities it is sometimes necessary to employ electrolysis before rectification. The voltameters in which this latter process takes place are glass cylinders 125mm. in diameter and 600mm. long, furnished with ebonite caps, through which pass the copper electrodes and the supply and overflow pipes. To treat 300 hectolitres in twenty-four hours M. Naudin employs twelve voltameters, two in series and six in parallel, using a total current of 30·15 amperes and an E.M.F. of 113·5 volts. The current is furnished by a four horse power Siemens shunt-wound dynamo. To neutralise the small quantity of hydrochloric acid employed to acidulate the solution some zinc is placed in the vat supplying the still in which the spirit is rectified.

M. Naudin has furnished the following figures as to the cost of each of the above operations in producing one hectolitre (twenty-two gallons) of pure alcohol.

Treatment of 300 hectolitres of products of the first distillation by the zinc-copper process in twenty-four hours.

Commercial hydrochloric acid, 1·25 kilog., at 6*fr.* the 100 kilog.		0·075*fr.*
Sulphate of copper, 1·25 kilog., at 56*fr.* the 100 kilog. zinc consumed		0·70 ,,
By the acid on sulphate of copper, 2 kilog.	}	2·10 ,,
By the liberation of hydrogen, 1·5 kilog., at 60*fr.* the 100 kilog.		
Labour, 24 hours		7· ,,
Power		2· ,,
Maintenance and repairs		1·60 ,,
Depreciation, 15,000*fr.* in ten years		4·50 ,,
Total		17·875*fr.*

HERTZ'S RESEARCHES ON ELECTRICAL OSCILLATIONS.

BY G. W. DE TUNZELMANN, B.SC.

(*Continued from page 726.*)

Dr Hertz's next Paper in order of publication in Wiedemann's *Annalen*, "On Some Induction Phenomena arising from Electrical Actions in Dielectrics" (Wiedemann's *Annalen*, Vol XXXIV., p. 273), contains an account of some researches undertaken with a view of obtaining direct experimental confirmation of the assumption involved in the most suggestive theory of electrical actions, viz., that of Faraday and Maxwell, that the well known electrostatic phenomena observed in dielectrics are accompanied by corresponding electrodynamic actions. The method of observation consisted in placing a secondary conductor adjusted to unison, as regards electrical oscillations, with the primary, as near as possible to the former, and in such a relative position that the sparks in the primary produced no sparking in the secondary. As the equilibrium could be disturbed and sparking induced in the secondary by the approach of conductors, it formed a kind of induction balance; but the point of special interest in connection with it was that a similar effect was produced when the conductors were replaced by insulators, provided the latter were of comparatively large size. The observed rapidity of the oscillations induced in the dielectrics showed

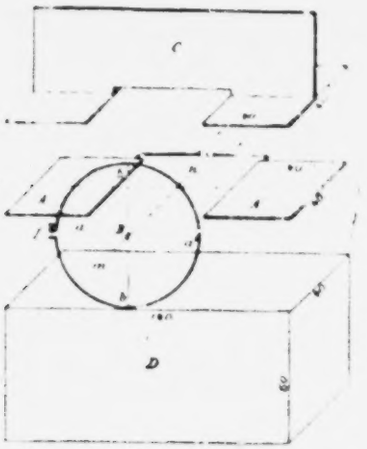

FIG. 10.

that the quantities of electricity in motion under the influence of dielectric polarisation were of the same order of magnitude as in the case of metallic conductors.

The apparatus employed is shown diagrammatically in Fig. 10, and was supported on a light wooden framework, not shown in the illustration. The primary conductor consisted of two brass plates, A A', with sides 40 centimetres in length, joined by a copper wire 70 centimetres long and half a centimetre in diameter, containing an air space of three quarters of a centimetre, with terminals formed of polished brass spheres. When placed in connection with a powerful induction coil, oscillations are set up, the period of which, determined by the dimensions of the primary, can be determined to within a hundred millionth of a second. The secondary conductor consisted of a circle, 35 centimetres in radius, of copper wire two millimetres in diameter, containing an air space, the length of which could be varied by means of a screw from a few hundredths of a millimetre, up to several millimetres. The dimensions stated were such as to bring the two conductors into unison, and secondary sparks up to six or seven millimetres in length could be obtained.

The circle was movable about an axis through its centre perpendicular to its plane, to enable the position of the air space to be varied. The axis was fixed in the position *m n* in the plane of A and A', and halfway between them. The centre of the circle was at a distance of 12 centimetres from the nearest points of A and A'.

When *f* was in either of the positions *a* or *a'* lying in the plane of A A' no sparking occurred in the secondary, while maximum sparking took place at *b* and *b'* 90° from the former positions. The E.M.F. giving rise to the secondary sparks is, as in previous experiments, partly electrostatic and partly electromagnetic, and the former being the greater will determine the sign of the resultant E.M.F. The oscillations must, for the reason previously explained, be considered as produced in the part of the secondary most remote from the air space. Assuming the E.M.F. and the amplitude of the resulting oscillation to be positive when *f* is in the position *b*, they will both be negative when *f* is at *b'*.

When the circle was slightly lowered in its own plane the sparking distance was increased at *b* and diminished at *b'*, and the null points lay at a certain distance below *a* and *a'*. The electrostatic E.M.F. is scarcely affected by such a displacement, but the integral of the E.M.F. of induction taken round the circle is no longer zero, and therefore gives rise to an oscillation which will be of positive sign whatever be the position of *f*, for the direction of the resultant E.M.F. of induction is opposite to that of the electrostatic E.M.F. in the upper half of the circle, and coincides with it in the lower half where the electrostatic E.M.F. has been assumed to be positive. Since the new oscillation so produced is in the same phase as the previously existing one their amplitudes must be added to give the resultant amplitude, which explains the phenomena.

Effects of the Approach of Conductors.—In making these observations it was found necessary to remove all conductors to a considerable distance from the apparatus, in order to obtain a complete disappearance of sparking at the points *a* and *a'*. Even the neighbourhood of the observer was sufficient to set up sparking when the air space *f* was in either of these positions, and the sparks had therefore to be observed from a distance. The conductors used for the experiments was of the form shown at C, Fig. 10, and consisted of thin metal foil. The objects kept in view in selecting the material and dimensions were to obtain a conductor which would give a moderately large effect, and having an oscillation period less than that of the primary.

When the conductor C was brought near to A A', it was found that the sparking distance decreased at *b* and increased at *b'*, and the null points were displaced upwards—that is, in the direction of C.

From the results of experiments already described it is evident that the effect of displacing A A' upwards would be the same, qualitatively, as that of a current in the same direction as that in A A directly above it. The effect produced by the approach of C was the reverse of this, and could be explained by an inductive action, supposing there were a current in C in the opposite direction to that in A A', which is exactly what must occur; for the electrostatic E.M.F. would give rise to such a current, and since the oscillations in C are more rapid than those of this E.M.F., the current must be in the same phase as the inducing E.M.F. The truth of this explanation was confirmed by the following experiments. The horizontal plates of the conductor C being left in the same position as before, the vertical plate was removed, and successively replaced by wires of increasing length and fineness, in order to lengthen the oscillation period of C. The effect of this was to displace the null points more and more in an upward direction, while at the same time they became less sharply defined, a minimum sparking taking the place of the previous absolute disappearance. The sparking distance at the highest point has previously been much less than at the lowest point, but after the disappearance of the null points it began to increase. At a certain stage the sparking distance at the two positions became equal, and then no definite minimum points could be found, but sparking took place freely at all positions of *f*. Beyond this stage the sparking distance at the lowest point diminished, and very soon two minimum points made their appearance close to it, not clearly defined at first, but gradually becoming more distinct, and at the same time

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approaching the points $a a'$, with which they ultimately coincided, when the minimum points again became absolute null points. These results are in agreement with the conclusion drawn from the former observations, for as the oscillation period of C approaches that of A A', the intensity of the current in the former increases, but a difference of phase arises between it and the exciting E.M.F. When the two are in unison the current in C attains its maximum, and, as in other cases of resonance, the difference of phase gives rise to a slightly damped oscillation, having a period of about a quarter that of the original one, which makes any interference between the oscillations excited in the circle B by A A' and C respectively impossible. These conditions clearly correspond to the stage at which the sparking distances at b and b' were equal. When the oscillation period of C becomes decidedly greater than that of A A', the amplitude of the oscillation in the former will again diminish, so that the difference in phase between it and the exciting E.M.F. will approach half of the original period. The current in C will therefore always be in the same direction as that in A A', so that interference between the two oscillations excited in B will again become possible, and the effect of C will then be opposite to its original effect. When the conductor C was made to approach A A' the sparks in B became much smaller, which is explained by the fact that its effect will be to increase the oscillation period of A A', and therefore to throw it out of unison with B.

Effects of the Approach of Dielectrics.—A very rough estimate shows that when a dielectric of large mass is brought near to the apparatus, the quantities of electricity set in motion by dielectric polarisation are at least as large as in metallic wires or thin rods. If, therefore, the action of the apparatus were unaffected by the approach of such masses it would show that, in contradiction to the theories of Faraday and Maxwell, no electro-dynamic actions are called into play by means of dielectric polarisation, or, as Maxwell calls it, electric displacement. The experiments, however, showed an effect similar to that which would be produced if the dielectric were replaced by a conductor with a very small oscillation period. In the first experiment made, the mass of dielectric consisted of a pile of books, 1·5 metre long, 0·5 metre broad, and 1 metre high, placed under the plates A A'. Its effect was to displace the null points through about 10° towards the pile. A block of asphalt (D, in Fig. 10), weighing 800 kilogrammes, and measuring 1·4 metre in length, 0·4 metre in breadth, and 0·6 metre in height, was then used in place of the books, the plates being allowed to rest upon it.

The following results were then obtained:—

(1.) The spark at the highest point of the circle was now decidedly stronger than that at the lowest point, which was nearer to the asphalt.

(2.) The null points were displaced through about 23° downwards—that is, in the direction of the block—and at the same time were transformed into mere points of minimum sparking, a complete disappearance being no longer obtainable.

(3.) When the plates A A' rested on the asphalt block the oscillation period of the primary was increased, as shown by the fact that the period of B had to be slightly increased in order to obtain the maximum sparking distance.

(4.) When the apparatus was moved gradually away from the block its action steadily diminished without changing its character.

(5.) The action of the block could be compensated by bringing the conductor C over the plates A A', while they rested on the block, the null points being brought back to a and a' when C was at a height of 11 centimetres above the plates. When the upper surface of the asphalt was 5 centimetres below the plates compensation was obtained when C was placed at a height of 17 centimetres above them, showing that the action of the dielectric was of the order of magnitude which had been anticipated.

The asphalte contained about 5 per cent. of aluminium and iron compounds, 40 per cent. of calcium compounds, and 17 per cent. of quartz sand. In order to make sure that the observed effects were not due to the conductivity of some of these substances, a number of further experiments were made.

In the first place the asphalte was replaced by a mass of the same dimensions of the so-called artificial pitch prepared from coal, and effects of a similar kind were observed, but slightly weaker, the greatest displacement of the null points amounting to 19°. Unfortunately this pitch contains free carbon, the amount of which it is difficult to determine, and this would have some conductivity.

The experiments were then repeated with a conductor, C, of half the linear dimensions of the former one, and smaller blocks of various substances, on account of the great cost of obtaining large blocks of pure materials. The substances used were asphalt, coal pitch, paper, wood, sandstone, sulphur, paraffin, and also a fluid dielectric, namely petroleum. With the smaller apparatus it was not possible to obtain quantitative results of the same accuracy as before, but the effects were of an exactly similar character, and left little room for doubt of the reality of the action of the dielectric.

The results might possibly be supposed to be due to a change in the distribution of the electrostatic E.M.F. in the neighbourhood of the dielectric, but in the first place Dr. Hertz states that he has been unable to explain the details of the observations on this hypothesis, and in the second place it is disproved by the following experiment.

The smaller apparatus was placed with the line $r s$ on the upper near corner of one of the large blocks, in which position the dielectric was bounded by the plane of the plates A A' and the perpendicular plane through $r s$, both of which are equipotential surfaces, so that if the action were electrostatic no effect should be produced by the dielectric. It was found, however, to produce the same effect as in other positions. It might also be supposed that the effects were due to a slight conductivity, but this could hardly be the case with such good insulators as sulphur and paraffin. Suppose, moreover, that the conductivity of the dielectric is sufficient to discharge the plate A in the ten thousandth of a second, but not much more rapidly. Then, during one oscillation, the plates would lose only the ten thousandth part of their charge, and the conduction current in the substance experimented on would not exceed the ten thousandth part of the primary current in A A', so that the effect would be quite insensible.

(To be continued.)

REVIEWS.

Traite Elementaire de l'Accumulateur Voltaique. By Fauré Kervigg. (Paris: Baudry and Co., 1888.)

Taken as a whole this book may be pronounced to be well worth the attention of all who are interested in the construction or the management of accumulators. The work is divided into four parts, dealing respectively with elementary principles, a description of various types of cells, technological data, and practical applications. In each section much useful matter is to be found, but in the author's desire to serve the *l'intérêt supérieur de la vérité* by discriminating between real inventions and mere adaptations, some curious omissions result. Of course, a book written by a Frenchman for Frenchmen is necessarily French; and it is no matter for surprise that the principal part is occupied with Gallic inventions. But, judging from the rate at which accumulators are being made both in England and Belgium, it seems strange that only a few pages should be given to the "foreign" manufacturer. We are disposed to attribute this to the patriotism of the author.

Chapter IV. contains sketches of some plates perhaps not generally known in England to the ordinary electrician, though most of them have been tried in approximately the same form by more than one manufacturer in this country. The Faure-Sellon Volckmar type is briefly discussed, and some comparative tables are given, showing weights, outputs, &c., for lighting and traction cells. The use of oxygenated water with the electrolyte, according to the author, gives an increased rate of discharge, a higher voltage, and a greater capacity. Non-oxidisable sulphates are also mentioned as possessing the same virtue. But, unfortunately, we are told that this increase of activity results in damage to the plate, as ordinarily made.

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No.	Time of passage of quantity Q in seconds	Voltmeter coupled in circuit.	Area of each compound electrode. sq. cm.	Capacity K, inserted in A.	Cardew reading.	Corresponding mean alternating Volts.	Length of tube filled by gas. in.	Corresponding volume.	Equivalent current, c, absolute units.	Calculated volume V. c.c.	Volume corrected to temp. 19° C.	Ratio of observed vol. to calculated vol.	Density of current in amps. per sq. cm. at either electrode in amperes.
1	600	1, 2, 3, 4, 5, 6	$21\cdot56 \times 10^{-2}$	4	87·45	97·3	5·15	1·383	$12\cdot4 \times 10^{-2}$	29·87	22·32	0·0·2	1·12
2	300	4, 5, 6	$3\cdot02 \times 10^{-2}$	4	87·	96·8	18·7	5·02	$2\cdot39 \times 10^{-2}$	12·37	15·23	0·340	7·9
3	240	5, 6	$0\cdot75 \times 10^{-2}$	4	85·30	95·7	30·55	8·20	$2\cdot36 \times 10^{-2}$	9·78	10·46	0·784	31·5
4	180	6	$0\cdot165 \times 10^{-2}$	4	82·	93·1	9·3	2·50	$1\cdot15 \times 10^{-2}$	2·38	2·55	0·980	69·7
5	180	6	$0\cdot165 \times 10^{-2}$	4	84·20	94·8	27·7	7·44	$2\cdot34 \times 10^{-2}$	7·27	7·76	0·950	141·8
6		6	$0\cdot165 \times 10^{-2}$	4	83·	93·9	On making contact one of the electrode of couple No. 6 burned.						
7	180	one of 5 and opposite of 6	$0\cdot585 \times 10^{-2}$ / $0\cdot165 \times 10^{-2}$	4	85·15	95·4	27·75	7·45	$2\cdot35 \times 10^{-2}$	7·31	7·02	0·953	·· 52·6
8	180	ditto	ditto	2	81·	92·4	11·65	3·13	$1\cdot16 \times 10^{-2}$	3·54	3·78	0·826	·· 30·4
9	180	ditto	ditto	5	82·	93·9	19·05	5·11	$1\cdot73 \times 10^{-2}$	5·35	5·72	0·893	·· 18·1
10	—	ditto	ditto	5	80·	91·9	On making contact the other electrode of No. 6 burned.						
11	120	5	$0\cdot585 \times 10^{-2}$	5	85·	95·3	24·5	6·57	$2\cdot93 \times 10^{-2}$	6·09	6·51	1·004	50·1
12	120	5	$0\cdot585 \times 10^{-2}$	5	85·15	95·4	24·5	6·57	$2\cdot94 \times 10^{-2}$	6·10	6·53	1·006	50·1
13	600	5	$0\cdot585 \times 10^{-2}$	*72·ω	80·20	92·1	26·25	7·04	$1\cdot22 \times 10^{-2}$	12·65	13·53	0·520	20·9
14	135	5	$0\cdot585 \times 10^{-2}$	*Lamp off	78·00	90·4	30·80	8·26	$3\cdot47 \times 10^{-2}$	8·09	8·65	0·955	59·3
15	135	5	$0\cdot585 \times 10^{-2}$	ring 230ω	78·00	90·4	30·65	8·22	$3\cdot47 \times 10^{-2}$	8·09	8·65	0·950	59·3

* Resistance inserted in place of A.

decomposed by a continuous current, c, in absolute measure equivalent to the passage of this quantity, Q, we have

$$c = n w e l \times 10^{-7} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

and

$$V_0 = 5\cdot43 \frac{n}{c} k l t \times 10^{-7} \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Besides the Cardew voltmeter steady potential indication, a quadrant electrometer, not shown in the diagram, with its needle connected to one pair of quadrants, was employed to measure the potential difference at the voltameter terminals, and thus indicate its mean resistance.

The above table gives the results of ten measurements. The volume of the gas is corrected for temperature, but no correction is introduced for the barometric pressure or the tension sustained by the gas in the tube.

The condenser used was adjustable from 0·001 up to 5 microfarads, and is probably accurate to at least 0·5 per cent.

The last two columns show that—

When the density of current per square centimetre of either electrode was	The percentage of gas actually generated of that calculated as due was
1·12 ampere	6·2 per cent.
7·9	38 ,,
30·03 average	82·6 ,,
31·35	78·4 ,,
46·1 average	89·3 ,,
50·1	100·8 ,,
62·6 average	96·3 ,,
69·7	98·0 ,,
141·6	95·6 ,,

The trials Nos. 13, 14, and 15 were taken without condenser, and with non-inductive resistances in its place. In trial No. 13 this resistance was a length of fine platinum wire (hot). In trial Nos. 14 and 15 the resistance was a 96 volt 10 candle power Edison lamp, offering 230 ohms resistance at equivalent illumination. In calculating the current strengths for these three observations, the resistance of the voltameter itself was required. It was measured in two ways—1st, by means of the quadrant electrometer, and the potential differences it indicated on the known resistance, and on the voltameter; 2nd, by rapidly substituting a non inductive resistance alternately with the voltameter in the lamp circuit, and adjusting this resistance until the illumination was equal in both cases. These two methods concurred in showing the resistance of the voltameter to be 30 ohms, and the maximum resistance it offered through the whole series was 35 ohms.

The table shows that

When the current density per square centimetre of either electrode was—	The per cent. of calculated gas actually liberated was—
20·0	52
59·3	96·3

These results, corroborated by several previous series, go to show that for a rate of alternation of 200 per second, and currents of between 0·1 and 0·35 amperes, the quantity of gas generated by an alternating current in a voltameter is approximately equal to that generated by an equal continuous current when the mean current density at the surface of the electrode is above 50 amperes per square centimetre of each; that below that density the quantity of gas developed rapidly diminishes, and that below one ampere per square centimetre soon disappears.

Also that the resistance of a voltameter with very small plates, traversed by an alternating current, is much less than that it would offer to an equal continuous current. Were this not the case, the resistance of a voltameter for alternating current measurements might for many purposes prove prohibitively great.

HERTZ'S RESEARCHES ON ELECTRICAL OSCILLATIONS.

BY G. W. DE TUNZELMANN, B.Sc.

(Continued from page 696.)

Other Positions of the Secondary Circuit.—Dr. Hertz made numerous observations with the secondary circuit in other positions, but in no case were any phenomena observed which were not completely in accordance with theory. As an example of these consider the following experiment.

The secondary was first placed in the horizontal plane in the position V. (Fig. 8*), and the air space was in the position relatively to the primary. The circle was then turned about a horizontal axis through its centre and parallel to the primary, so as to raise the air space above the horizontal plane. During this rotation θ remained equal to 90°, and the value of β remained nearly constant, but α varied approximately in the same ratio as $\cos \Psi$, Ψ being the angle between the plane of the circle and the horizontal, for α is proportional to the number of magnetic lines of force passing through the circle. Let α_0 be the value of α in the initial position, then in the other positions its value would be $\alpha_0 \cos \Psi$, and therefore the sparking distance should be given by the expression $\alpha_0 \cos \Psi + \beta$, in which α_0 was known to be greater than β. This was confirmed by observation, for it was found that as the air space increased its height above the horizontal plane the sparking distance diminished from 6 millimetres down to 2 millimetres, its value when the air space was at its greatest distance above the horizontal plane. During the rotation through the next quadrant the sparking distance diminished almost to zero, and then increased to the smaller maximum of 2·5 millimetres, which it attained when the circle had turned though 180°, and was therefore again horizontal. Similar results were obtained in the opposite order, as the circle was rotated from 180° to 360°. When the circle was kept with the air space at its maximum

* See *The Electrician*, October 5th, 1888, page 697.

height above the horizontal plane, and then raised or lowered bodily without rotation, the sparking distance was found to diminish in the former case and to increase in the latter, results completely in accordance with theory.

Forces at Greater Distances.—Experiments with the secondary at greater distances from the primary are of great importance, as the distribution of E.M.F. in the field of an open circuit is very different according to different theories of electrodynamic action, and the results may, therefore, serve to eliminate some of them as untenable. In making these experiments, however, an unexpected difficulty was encountered, as it was found that at distances of from 1 to 1·5 metres from the primary the maximum and minimum, except in certain positions, became indistinctly defined; but when the distance was increased to upwards of two metres, though the sparks were then very small, the maximum and minimum were found to be very sharply marked when the sparks were observed in the dark. The positions of maximum and minimum were found to occur with the circle in planes at right angles to each other. At considerable distances the sparking diminished very slowly as the distance was increased. Dr. Hertz was not able to determine an upper limit to the distance at which sensible effects took place, but in a room 14 metres by 12, sparks were distinctly observed when the primary was placed in one corner of the room, wherever the secondary was placed. When, however, the primary was slightly displaced, no effects could be observed, even when the secondary was brought considerably nearer. The interposition of solid screens between the two circuits greatly diminished the effect.

Dr. Hertz mapped-out the distribution of force throughout the room by means of chalk lines on the floor, putting stars at the points where the direction of the E.M.F. became indeterminate. A portion of the diagram obtained in this manner is

FIG. 9.

shown on a reduced scale in Fig. 9, with respect to which the following points are noteworthy:—

1. At distances beyond three metres the E.M.F. is everywhere parallel to the primary oscillation. Within this region, therefore, the electrostatic E.M.F. is negligible in comparison with the E.M.F. of induction. Now, all the theories of the mutual action of current elements agree in giving an E.M.F. of induction inversely proportional to the distance, while the electrostatic E.M.F., being due to the differential action of the two extremities of the primary, is approximately inversely proportional to the cube of the distance. Some of these theories, however, are not in accordance with the experimental result, that the effect diminishes much more rapidly in the direction of the primary oscillation than in a direction at right angles to it, induced sparks being observed at a distances exceeding 12 metres in the latter direction, while they disappeared at a distance of about four metres in the former direction.

2. That, as already proved, for distances less than one metre the distribution of E.M.F. is practically that of the electrostatic E.M.F.

3. There are two straight lines, at all points of which the direction of the E.M.F. is determinate, namely, the line in which the primary oscillation takes place, and the perpendicular to the primary through its middle point. Along the latter the E.M.F. does not vanish at any point, the sparking diminishes gradually as the distance is increased. This, again, is inconsistent with some of the theories of mutual action of current elements, according to which it should vanish at a certain definite distance. A very important result of the investigation is the demonstration of the existence of regions within which the direction of the E.M.F. becomes indeterminate. These regions form two rings encircling the primary circuit. Since the E.M.F. within them acts very nearly equally in every direction, it must assume different directions in succession, for, of course, it cannot act in different directions simultaneously.

The observations, therefore, lead to the conclusion that within these regions the magnitude of the E.M.F. remains very nearly constant, while its direction varies through all the points of the compass at each oscillation. Dr. Hertz states that he has been unable to explain this result, as also the existence of overtones, by means of the simplified theory in which the higher terms of the expansion of F are neglected, and he considers that no theory of simple action at a distance is capable of explaining it. If, however, the electrostatic E.M.F. and the E.M.F. of induction are propagated through space with unequal velocities, it admits of very simple explanation. For within these annular regions the two E.M.F.'s are at right angles and of the same order of magnitude; they will therefore, in consequence of the distance traversed, differ in phase, and the direction of the resultant will turn through all the points of the compass at each oscillation.

This phenomenon appears to him to be the first indication which has been observed of a finite rate of propagation through space of electrical actions, for if there is a difference in the rate of propagation of the electrostatic and electrodynamic E.M.F., one at least of them must be finite.

At the end of the Paper in which the preceding experiments are described Dr. Hertz describes some observations which he has made on the conditions at the primary sparking point which affect the production of sparks in the secondary circuit. He finds that illuminating the primary spark diminishes its power of exciting rapid oscillations, the sparks in the secondary being observed to cease when a piece of magnesium wire was burnt, or an arc lamp lighted, near the primary sparking point. The observed effect on the primary sparks is that they are no longer accompanied by a sharp crackling sound as before. The effect of a second discharge is especially noteworthy, and it was found that the secondary sparks could be made to disappear by bringing an insulated conductor close to the opposed surfaces of the spheres forming the terminals at the primary air space, even when no visible sparking took place between the latter and the insulated conductor. The secondary sparking could also be stopped by placing a fine point close to the primary air space, or by touching one of the opposed surfaces of the terminals with a piece of sealing-wax, glass, or mica. Dr. Hertz states that further experiments have led him to conclude that, even in these cases, the effect is due to light too feeble to be perceived by the eye, arising from a side discharge. He points out that these effects afford another example of the effects of light on electric discharges, which have been observed by E. Wiedemann, H. Ebert, and W. Hallwachs.

(To be continued.)

ALUMINIUM AND ALUMINIUM ALLOYS.*

The Swiss Metallurgical Society in Lauffen-Neuhausen, Canton Schaffhausen, has succeeded in producing aluminium alloys in large quantities by means of Héroult's method. In this method the electric current is employed for fusing refractory earths containing aluminium. The negative electrode is composed of the metal, copper, iron, or tin, with which it is desired to alloy the aluminium; the positive electrode is composed of a group of carbons dipping into the molten argillaceous earth. The current is generated at these works by means of a vertical 300 horse-power Jonval turbine (Fig. 1) driving two dynamos of 6,000 amperes and 20 volts each, which are excited by a smaller Erreger

* Abstracted from the *Schweizerische Bauzeitung*, 4th August 1888.

fundamental vibration of the secondary, since it is symmetrical on opposite sides of the air space.

The term $B \cos \frac{2\pi s}{S}$ will give a force acting in the same direction in the two quadrants opposed to the air space, and will excite the fundamental vibration. In the two quadrants adjacent to the air space it will give a force in the opposite direction, but its effect will be less than that of the former one. For the current is zero at the extremities of the circuit, and therefore the electricity cannot move so freely as near the centre. This corresponds to the fact that if a string fastened at each end has its central portion and ends acted on respectively by oppositely directed forces, its motion will be that due to the force at the central portion, which will excite the fundamental vibration if its oscillations are in unison with the latter. The intensity of the vibration will be proportional to B. Let E be the total E.M.F. in the uniform field of the secondary, ϕ the angle between its direction and the plane of the latter, and θ the angle which its projection on this plane makes with the radius drawn to the air space. Then we shall have approximately

$$E = E \cos \phi \sin \left(\frac{2\pi}{S} s + \theta \right),$$

and therefore, $B = E \cos \phi \sin \theta$.

B therefore, is a function simply of the total E.M.F. due both to the electrostatic and electrodynamic actions. It will vanish when $\phi = 90$ —that is to say, when the total E.M.F. is perpendicular to the plane of the circle, whatever be the position of the air space on the circle. B will also vanish when $\theta = 0$—that is to say, when the projection of the E.M.F. on the plane of the circle coincides with the radius through the air space. If the position of the air space on the circle is varied, the angle θ will vary, and, therefore, also the intensity of the vibration and the sparking distance. The sparking distance corresponding to the second term of the expansion for E can, therefore, be represented approximately by a formula of the form $\beta \sin \theta$.

Now the oscillations giving rise to sparks of lengths α and $\beta \sin \theta$ respectively are in the same phase. The resulting oscillations will therefore be in the same phase, and their amplitudes must be added together. The sparking distance being approximately proportional to the maximum total amplitude may therefore also be obtained by adding the sparking distances due to the two oscillations respectively. The sparking distance will therefore be given as a function of the position of the air space on the secondary circuit by the expression $\alpha + \beta \sin \theta$. Since the direction of the oscillation in the air space does not come into consideration we are concerned only with the absolute value of this expression, and not with its sign. The determination of the absolute values of the quantities α and β would involve elaborate theoretical investigations, and is, moreover, unnecessary for the explanation of the experimental results.

Experiments with the Secondary Circuit in a Vertical Plane.—When the circle forming the secondary circuit was placed with its plane vertical, anywhere in the neighbourhood of the primary, the following results were obtained:—

The sparks disappeared for two positions of the air space, separated by 180°, namely, those in which it lay in the horizontal plane through the primary, but in every other position sparks of greater or less length were observed.

From this it followed that the value of α must have been constantly zero, and that θ was zero when the air space was in the horizontal plane through the primary.

The electromagnetic lines of force must therefore have been perpendicular to this horizontal plane, and therefore consisted of circles with their centres on the primary, while the electrostatic lines of force must have been entirely in the horizontal plane, and therefore this system of lines of force consisted of curves lying in planes passing through the primary. Both of these results are in agreement with theory.

When the air space was at its greatest distance from the plane the sparking distance attained a maximum value of from 2 to 3 millimetres. The sparks were shown to be due to the fundamental vibration, by slightly varying the secondary, so as to throw it out of unison with the primary, when the sparking distance was diminished, which would not have been the case if the sparks had been due to overtones. Moreover, the sparks disappeared when the secondary was cut at its points of intersection with the horizontal plane through the primary, though these would be nodal points for the first overtone.

When the air space was kept at its greatest possible distance from the horizontal plane through the primary, and turned about a vertical axis, the sparking distance attained two maxima at the points for which $\phi = 0$, and almost disappeared at the points for which $\phi = 90$.

The lower half of Fig. 8 shows the different positions of minimum sparking. A A is the primary conductor, and the lines $a\ a$ represent the projections of the secondary circuit on the horizontal plane. The arrows perpendicular to these give the direction of the resultant lines of force. As this did not anywhere vanish in passing from the sphere A to the sphere A, it could not change its sign.

The diagram brings out the two following points:—

(1) The distribution of the resultant E.M.F. in the vicinity of the rectilinear vibration is very similar to that of the electrostatic E.M.F. due to the action of its two extremities. It should be specially noted that near the centre of the primary the direction is that of the electrostatic E.M.F., showing that it is more powerful than the electrodynamic, as required by theory.

(2) The lines of force deviate more rapidly from the line A A than the electrostatic lines, though this is not so evident

Fig. 8.

on the reduced scale of the diagram as in the author's original drawings on a much larger scale.

It is due to the components of the electrostatic E.M.F. parallel to A A being weakened by the E.M.F. of induction, while the perpendicular components remain unaffected.

Experiments with the Secondary Circuit in a Horizontal Plane.—The results obtained when the plane of the secondary was horizontal can best be explained by reference to the upper half of the diagram in Fig. 8.

In the position I., with the centre of the circle in the line A A' produced, the sparks disappeared when the air space occupied either of the positions A_1 or A_2, while two equal maxima of the sparking distance were obtained at a_1 and a_2, the length of the spark in these positions being 2·5 millimetres. Both these results are in accordance with theory.

In the position II. the circle is cut by the electromagnetic lines of force, and, therefore, α does not vanish. It will, however, be small, and we should expect that the expression $\alpha + \beta \sin \theta$ would have two unequal maxima $\beta + \alpha$ and $\beta - \alpha$, both for $\theta = 90°$, and having the line joining them perpendicular to the resultant E.M.F., and between these two maxima we should expect two points of no sparking near to the smaller maximum. This was confirmed by the observations.

The maximum sparking distances were 3·5 millimetres at a_2 and 2 millimetres at a'_2. Now with the air space at a_2 the sphere A being positive, the resultant E.M.F. in the opposite portion of the circle will repel positive electricity from A, and therefore tend to make it flow round the circle clockwise. Between the two spheres the electrostatic E.M.F. acts from A

towards A, and the opposite E.M.F. of induction in the neighbourhood of the primary acts from A to A, parallel to the former, and acting more strongly on the nearer than on the farther portion of the secondary, tends to cause a current in the same direction as that due to the former, namely, in a clockwise direction. Thus the resultant E.M.F. is the sum of the two as required by theory, and in the same way it is easily seen that when the air space is at a'_2 the resultant E.M.F. is equal to their difference.

As the position III. is gradually approached, the maximum disappears, and the single maximum sparking distance a was found to be 4 millimetres in length, having opposite to it a point of disappearance a_1. In this case clearly $a = \beta$, and the sparking distance is given by the expression $a(1 + \sin\theta)$. The line $a_1 a$ is again perpendicular to the resultant E.M.F.

As the circle approaches further towards the centre of A A, α will become greater than β, and the expression $\alpha + \beta \sin\theta$ will not vanish for any value of θ, but will have a maximum $\alpha + \beta$ and a minimum $\alpha - \beta$, and in the experiments it was found that the sparks never entirely disappeared, but varied between a maximum and a minimum, as indicated by theory.

In the position IV. a maximum sparking distance of 5·5 millimetres was observed at a_4 and a minimum of 1·5 millimetre at a'_4.

In the position V. there was a maximum sparking distance of 6 millimetres at a_5 and a minimum of 2·5 millimetres at a'_5. In these experiments the air space should be screened off from the primary in the latter positions as well as in the earlier ones, in which it is unavoidable, as otherwise the results would not be comparable.

In passing from the position III. to the position V. the line $a_1 a$ rapidly turned from its position of parallelism to the primary circuit into a position perpendicular to it. In the latter positions the sparking was essentially due to the inductive action, and therefore the author was justified, in the experiments described in my previous Papers, in assuming the effect in these positions to be due to induction.

Even in these positions, however, the sparking is not totally independent of electrostatic action, except when the air space is half way between the maximum and minimum positions, and therefore $\sin\theta = 0$.

(To be continued.)

THE USE OF ELECTRIC MOTORS ON SHIPBOARD.*

The use of electric motors is extending very rapidly ashore, and naturally raises the question whether there is a field for them on shipboard. The transmission of energy by electricity possesses many points of advantage over any other system in being more economical when energy is to be transmitted to a distance, or when it has to be subdivided into a number of parts. The former has no application on shipboard, where distances are short, but the latter becomes almost essential for the modern navy.

A good dynamo will give 90 per cent. of the mechanical energy it receives in the form of available electrical energy in its external circuits. If a good motor is placed in this circuit 90 per cent. of this electrical energy, or about 81 per cent. of the work of the engine, can be obtained as mechanical work. The loss in transmission is 20 per cent., and the cost of dynamo and motor renders such a system inadmissible in comparison with the simple one of placing a steam engine where the work is to be done. If, however, the power is required in twenty places instead of in one, the question becomes materially different, and this is the one inviting our attention.

In the new cruisers one of the first impressions received is that of complexity and confusion arising from the number of small engines scattered over the vessels. Nor is the feeling dispelled by a closer examination, for the ship is found to be a labyrinth of steam, exhaust, and circulating pipes, complex in arrangement, and requiring constant care and attention to keep in order. Joints and valves leak, steam condenses, and water freezes, totally disabling some part of the mechanism. If injuries occur, repairs are difficult and frequently impossible with the ships resources, and an important engine may be disabled for months, or until the arrival of the vessel in port. A still more important objection to this complicated system of steam circulation in men of war is found in its liability to injury in action, and the danger to the crew which such injury might bring about. A single pipe cut by shot might disable a very important part of the ship's offensive apparatus, and pipes so injured are difficult to repair, and require time which could not be spared. The escape of steam in such a case would inevitably interfere with the fighting of the ship, and might cause loss of life or even a panic in the crew. If, therefore, it is necessary to use so many auxiliary motors, is steam the best vehicle for the transmission of power?

The electric motor is for equal power smaller than also is the steam engine, is more efficient, involves less waste in transmission, and has small mains, which are therefore less liable to injury, and admit of rapid repair of injuries. With the low potential used on shipboard there is, moreover, no danger to the persons, and a broken main could be stopped without the delay of turning off the current. Every objection against the indiscriminate use of steam engines is removed by the use of the electric motor. A motor is moreover, portable, and power may thus be quickly obtained in any place in the ship where the motor may be fastened down.

On grounds of utility, therefore, the motor appears to possess decided advantages. These appear to exist equally in economy. Small engines are notoriously uneconomical as compared with large ones. Small motors and dynamos are less so. By concentrating the whole auxiliary power of the ship in the dynamo room large economical compound condensing engines may be used in driving high efficiency dynamos, and the power thus obtained distributed through large mains to the motors with very slight loss. The question of economy therefore rests upon the amount of subdivision, and is apparently in favour of the electric motor under just the circumstances in which distribution by steam becomes complex, and the loss due to using a number of uneconomical engines forms a large total aggregate. The question of economy of coal is one of the most important to be faced, and becomes paramount in a ship, which, without plenty of coal in her bunkers, is a mere helpless steel box, drifting at sea. Is it not advisable to seriously consider the saving and general advantages to be obtained by the high economy of large engines of the best type, and the high efficiency of well-designed dynamos and motors, in place of the notorious wastefulness, heat, dirt, and noise of small auxiliary engines?

In order to carry out such a plan it is only necessary to connect the motors to the incandescent light mains. It will be necessary to closely analyse the demands for power, and to place in the dynamo room a sufficient number of dynamos to supply the maximum required to be used at any time. The paramount consideration should be to have a reserve in action, and it is probable that more power will be needed then, through the use of gun carriages and other motors and search lights, than will be saved by the diminished use of incandescent lights. The dynamo room in this case becomes a central station for light and power, and valuable information may be derived from the experience of central stations ashore. It seems to be settled now in ordinary practice that, in cases where the load varies largely, it is in the long run most economical to use several engines of medium size, throwing in one after the other as the demand increases, rather than to employ one or two large engines which must generally be operated at partial load.

The objection to such a system is, that although the danger of action is not diffused over the whole ship it is concentrated in one place, and any injury there would cripple the ship. This is merely placing the dynamos in the same category as the engines and boilers, and, like them, the dynamos room must have all protection that can be given it. It should always be below the protective deck, when there is one, and in other cases below the water line. The mains should consist of several parts in parallel connected together by copper wire spans at intervals. Each main becomes then a net work of conductors, and although this entails greater first cost, it reduces loss in transmission to a negligible quantity, and guarantees safety and durability. The distribution should be made as much as possible below the protective deck, branch mains being generally vertical. Every circuit necessary in action should be thoroughly accessible for repairs, while at the same time receiving all possible protection. The highest insulation is of course demanded.

The simplicity of such a system is in marked contrast with that of steam distribution. All incandescent lights, search lights, motors are connected in parallel, and any one may be put into or out of action by the movement of a single switch.

Apart from all advantages of distribution, the electric motor is the most efficient, compact, noiseless and simple vehicle for the transmission of energy that is known. If well made, it requires only ordinary care and attention to be always ready for use. Its principal danger on shipboard is from salt water, but with proper care this is small.

Nothing like a complete presentation of so wide a subject can be given within the limits of a single article, but the foregoing may call attention to some of the necessities of our service, and also to some fields in which experimental work may well be carried on.

* Extract from an official report to the United States Government.

of a flash being enormous, a very high difference of potential exists between every point of the conductor and the earth, however well the two are connected; hence the neighbourhood of a lightning conductor is always dangerous during a storm, and great circumspection must be exercised as to what metallic substances are wittingly or unwittingly brought near or into contact with it. When a building is struck the oscillations are energetic all through its neighbourhood are so violent that every piece of metal is liable to give off sparks, and gas may be ignited even in neighbouring houses. If one end of a rain water gutter is attached to a struck lightning conductor the other end is almost certain to spit off a long spark, unless it is also metallically connected. Electric charges splash about a metallic mass of metal, as does the sea during an earthquake when a mountain top drops into it.* Even a small space near combustible substances is to be dreaded.

The electrical disturbance is conveyed to a conductor through the ether or space surrounding it, and so the more surface it exposes the better. Better than a single rod or tape is a number of separate lengths of wire, each thick enough not to be easily melted, and well separated so as not to interfere with each other by mutual induction.

The liability of rods to be melted by a flash can be easily overestimated. A rod usually fails by reason of its inertia or obstruction, and consequent inability to carry off the charge without spittings and side flashes; it very seldom fails by reason of being melted. In cases where a thin wire has got melted, the energy has been largely dissipated in the effort, and it has acted as an efficient protector, though, of course, for that time only. Large sectional area offers very little advantage over moderately small sectional area, such as No. 8 B.W.G.

Points, if numerous enough, serve a very useful purpose in neutralising the charge of a thunder cloud hovering over them, and thus often prevent a flash; but there are occasions when, if not mitigated in the laboratory, when they are of no avail. For instance, when one upper cloud sparks into a lower one, which then suddenly overflows to earth. In the case of these sudden rushes, there is no time for a path to be prepared by points, no time for points to exert any protective influence, and points then get struck by a violent flash just as if they were knobs. Discharges of this kind are the only ones likely to occur during a violent shower, because all leisurely effects would be neutralised by the raindrops better than by an infinitude of points.

The path chosen by a galvanic current is no secure indication of the course which will be taken by a lightning flash. The course of a trickle down a hill side does not determine the path of an avalanche. Lightning will not select the easiest path alone; it can distribute itself among any number of possible paths, and can make paths for itself. Ordinary testing of conductors is therefore no guarantee of safety, and may be misleading. At the same time it is quite right to have some system of testing and of inspection, else rust and building alterations may render any protector useless.

There is no space near a rod which can be definitely styled an area of protection, for it is possible to receive violent sparks or shocks from the conductor itself. Not to speak of the innumerable secondary discharges which, by reason of electro-kinetic momentum and of induction and of the curious recently discovered effect of the ultra violet light of a spark, are liable to occur as secondary effects in the wake of the main flash.

Just one word on the subject of iron *versus* copper. The writer last year thought and stated that, in so far as the substance of the conductor was magnetised by a discharge, iron would obstruct a lightning flash or any other rapidly varying current enormously more than copper does. But the fact is, that the substance of a conductor is, by sufficiently rapidly alternating currents, not magnetised at all. The current is tubular, keeps wholly to the outer surface, and magnetises nothing inside. Hence the magnetisability of the substance of the conductor is of no moment at all, and iron, therefore, will do every bit as well as copper. Mr. Preece's experience with half a mile of iron wire telegraph post protectors leads him to uphold iron as entirely satisfactory. So on the one point, as well as on the necessity existing for a good earth, a portion of the practical and of the theoretical camp have been able to agree.

Immediately after the discussion Dr. Lodge exhibited some preliminary attempts at photographing lightning taken with a double-necked camera, having two sensitive plates, one fixed, the other revolving 30 times a second.* The same flash was depicted on both plates, but on the moving plate it was separated into two or three distinct streaks, showing its multiple character. Each constituent, however, was as clear and distinct on the rotating as on the fixed plate, and had in fact exactly the same shape and appearance, so that one could be superposed on the other exactly; thus proving its instantaneous character. The rate of spin was naturally nothing like sufficient to exhibit the alternating character of each constituent.

It is to be hoped that many more photographs of flashes will be taken on this plan, because they are evidently in many kinds of composite flashes, and it is an excellent way of analysing them and correcting the impressions, often erroneous, formed by the eye.

On the whole, the Bath meeting, though not largely attended by the temporary class of members and associates, may be considered, so far as Section A is concerned, as one of the most interesting and important that have ever been held; thanks largely to the excellent arrangements made by the Secretaries, and the discussions of Hertz's researches by the President in his address, mark a distinct epoch in our acquaintance with electromagnetic phenomena.

HERTZ'S RESEARCHES ON ELECTRICAL OSCILLATIONS.

BY C. W. DE TUNZELMANN.

(Continued from page 636.)

Node.—The vibrations in the micrometer circuit which have been considered are the simplest ones possible, but not the only ones. While the potential at the ends alternates between two fixed limits, that at the central portion of the circuit retains a constant mean value. The electrical vibration, therefore, has a node at the centre, and this will be the only nodal point. Its existence may be proved by placing a small insulated sphere close to various portions of the micrometer circuit while sparks are passing at the discharger of the coil, when it will be found that if the sphere is placed close to the centre of the circuit the sparking will be very slight, increasing as the sphere is moved further away. The sparking cannot, however, be entirely got rid of, and there is a better way of determining the existence and position of the node. After adjusting the two circuits to unison, and drawing the micrometer terminals so far apart that sparks can only be made to pass by means of resonant action, let different parts of the circuit be touched by a conductor of some capacity, when it will be found that the sparks disappear, owing to interference with the resonant action, except when the point of contact is at the centre of the circuit. He then endeavoured to produce a vibration with two nodes, and for this purpose he modified the apparatus previously used by adding to the micrometer circuit a second resonator, E F, exactly similar to the first (as shown in Fig. 7), and joining the points of the circuit near the terminals by wires L and L, as shown in the diagram.

The whole system then formed a closed metallic circuit, the fundamental vibration of which would have two nodes. Since the period of this vibration would necessarily agree closely with that of each half of the circuit, and, therefore, with that of the circuit C C, it was to be expected that the vibration would have a pair of loops at the junctions L1 and 21,

* The Eruption of Krakatoa, a pamphlet by E. Douglas Archibald, Tunbridge Wells; or the Report of the Krakatoa Committee.

* See a letter in *Nature*, July 12, 1888.

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and a pair of nodes at the middle points of *cd* and *gh*. The vibrations were determined by measuring the sparking distance between the micrometer terminals 1 and 2. It was found that, contrary to what was expected, the addition of the second reet[illegible] diminished this sparking distance from about 5 millimetres to about 1 millimetre. The existence of resonant action between the circuit C C and the micrometer circuit was, however, fully demonstrated for any alteration in the circuit *e f g h*, whether it consisted in motion of a slider decreasing its length, diminished the sparking distance. It was also found that much weaker sparks took place between *e f g h* and an insulated sphere, than between it and the same sphere, showing that the nodes were in *f* and *g*, as expected. Further, when the sphere was made to touch *ef* or *gh* it had no effect on the sparking distance of 1 and 2; but when the point of contact was at any other portion of the circuit the sparking distance was diminished, showing that these nodes really belong to the circuit to the resonant action of which increased this spark distance.

The wire joining the points 1 and 1 was then removed. As the strength of the induced oscillatory current should be zero at these points the removal ought not to disturb the vibrations, and this was shown experimentally to be the case, the resonant effect and the position of the nodes remaining unchanged. The vibration with two nodal points was, of course, not the fundamental vibration of the circuit, which consisted of a vibration with a node between *e* and *c*, and for which the highest value of the potential were at the points 1 and 1.

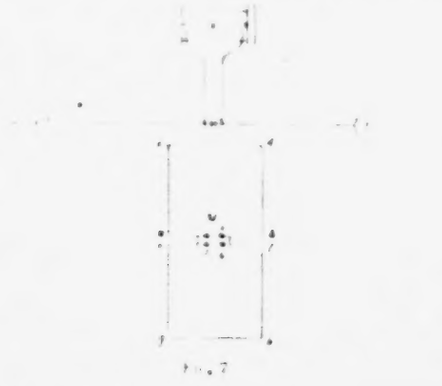

Fig. 7.

When the spheres forming the terminals at these points were brought close together slight sparking was found to take place between them, which was attributed to the excitation, though only to a small extent, of the fundamental vibration. This explanation was confirmed in the following manner. The sparks between 1 and 1 were broken off, leaving only the sparks between 2 and 4, which measured the intensity of the fundamental vibration. The period of vibration of the circuit C C was then increased by drawing it out to its full length, and thereby increasing its capacity, when it was observed that the sparking gradually increased to a maximum, and then began to diminish again. The maximum value must evidently occur when the period of vibration of the circuit C C is the same as that of the fundamental vibration of the micrometer circuit, and it was shown that when the sparking distance between 2 and 4 had its maximum value, the sparks corresponded to a vibration with only one nodal point, for the sparks ceased when the previously existing nodes were touched by a conductor, and the only point where contact could take place without effect on the sparking was between *e* and *g*. These results show that it is possible to excite at will in the same conductor, either the fundamental vibration or its first overtone, to use the language of acoustics.

Hertz appears to consider it very doubtful whether it will be possible to get higher overtones of electrical vibration, the difficulty of obtaining such lying not only in the method of observation, but also in the nature of the oscillations themselves. The intensity of these is found to vary considerably during a series of discharges from the coil even when all circumstances are maintained as constant as possible, and the comparative feebleness of the resonant effects shows that there must be a considerable amount of damping. There are, however, many secondary phenomena which seem to indicate that irregular vibrations are superposed upon the regular ones, as would be expected in complex systems of conductors. If, therefore, we wish to compare electrical oscillations from a mathematical point of view, with those of acoustics, we must seek our analogy in the high notes intermixed with irregular vibrations, obtained say, by striking a wooden bar with a hammer rather than in the comparatively simple harmonic vibration of tuning forks, or strings; and in the complex vibrations of the former class we have to be contented to rest in the study of acoustics, with little more than indications of such phenomena as resonance and nodal points.

Referring to the conditions to be fulfilled in order to obtain the best results, should other physicists desire to repeat the experiments Dr. Hertz notes a fact of very considerable interest and novelty, namely, that the spark from the discharger should always be visible from the micrometer, as when this was not the case, though the phenomena observed were of the same character, the sparking distance was invariably diminished. This effect of the light from the spark of an induction coil in increasing the sparking distance in the secondary circuit of another coil excited great interest when referred to by Dr. Lodge in the course of the recent discussion on lightning conductors at the British Association, and he pointed out that the same effect was produced by light from burning magnesium wire, or other sources rich in the ultra violet rays.

Theory of the Experiments.—The theories of electrical oscillations which have been developed by Sir William Thomson, Helmholtz and Kirchhoff have been shown* to hold good for the open circuit oscillations of induction apparatus, such as for the oscillation Leyden jar discharge, and, although Dr. Hertz has not succeeded in obtaining definite quantitative results to compare with theory, it is of interest to inquire whether the observed results are of the same order as those indicated by theory.

Hertz considers, in the first place, the vibration period. Let T be the period of a single or half vibration proper to the conductor existing the micrometer circuit. If its coefficient of self induction in absolute electromagnetic measure, expressed therefore, in centimetres, C the capacity of one of the terminals in electrostatic measure, and, therefore, also expressed in centimetres, and v the velocity of light in centimetres per second.

Then if the resistance of the conductor is small,

$$T = \pi \sqrt{LC}$$

In the case of the resonance experiments the capacity C was approximately the radius of the sphere forming the terminal, so that C = 1·5 centimetre. The coefficient of self induction was that of a wire of length 1·5 centimetre and diameter 0·2 centimetre.

According to Neumann's formula

$$L = 4\left(\log\frac{4l}{d} - 0{\cdot}75\right)$$

which gives in the case considered

$$L = 22\left(\log\frac{1}{d} - 0{\cdot}75\right) = 19{\cdot}62\text{cm}$$

As, however, it is not quite certain that Neumann's formula is applicable to an open circuit, it is better to use von Helmholtz's more general formula, containing an undetermined constant *k*, according to which

$$L = 2\left(\log\frac{4l}{d} - 0{\cdot}75 + \frac{k}{2}\right)$$

Putting *k* = 1 this reduces to Neumann's formula, for which it reduces to that of Maxwell, and for *k* = 0 to Weber's. The greatest difference in the values of L obtained by giving these different values to *k* would not exceed a sixth of its mean value, and, therefore, for the purposes of the present approx-

* Lorentz, Wied. Ann. d. Phys. Vol. VII. p. 161. 1879.

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[illegible] it is enough to assume that l is not a large positive or negative number, for if the number 1·07 does not give [illegible] value of the coefficient for the wire [illegible] in length, [illegible] give the value corresponding to a coefficient not differ[illegible] from it in length.

[illegible] we have $= \frac{1}{2}CP$ [illegible] which gives the distance travelled by light during the oscillation according to Maxwell's theory, the length of an electromagnetic wave. The value of P is then found to be [illegible] millionths of a second, which is of the same order as [illegible] results.

The ratio of damping is then considered. In order that [illegible] may be possible the resistance of the open circuit [illegible] less than $2\sqrt{LC}$. For the existing circuit [illegible] ohms as the upper limit of resistance. If the actual [illegible] is sensibly below this limit, the ratio of [illegible]

[illegible] The amplitude will therefore be reduced in [illegible] in

$$2P \quad \text{[illegible]}$$

$$e^{\frac{P}{T}} = N \quad \text{[illegible]}$$

[illegible] We have unfortunately no means of determining [illegible] of the air space traversed by the spark, but as [illegible] of a strong electric arc is never less than a few [illegible] he justified in assuming this as the minimum. [illegible] from this it would follow that the number of oscillations [illegible] to a single impulse must be reckoned in tens and [illegible] hundreds of thousands which is in accordance with the [illegible] of the experimental results and agrees with the [illegible] discussed in the case of the oscillatory [illegible] jar.

In the case of closed metallic circuits on the other [illegible] theory indicates that the number of oscillations before [illegible] is attained must be reckoned by millions and [illegible]

[illegible] Congress lastly, the order of the [illegible] of [illegible] according to theory and [illegible] observed. Besides this it must be noted that the maximum [illegible] induced by the oscillation in its own circuit is approximately [illegible] to the maximum potential difference [illegible] that there were no damping these quantities would be [illegible] since at a moment the potential difference at the extremities and the E.M.F. of induction would be a counterbalance. In the experiments under consideration the potential difference at the extremities was such as to give a spark 7 to 8 mm. in length, which must therefore represent the maximum induction exerted in its own circuit by the oscillation. Now at any instant the induced E.M.F. in the micrometer [illegible] must be to that in the exciting conductor in the same ratio as that of the coefficient of mutual induction M of the two circuits to the coefficient of self-induction P of the exciting circuit. The value of M for the case considered is easily calculated from the ordinary formulæ, and it is found to be between one-tenth and one-twelfth of P. This would only give a spark of from 7/10 to 8/12 mm. in length, so that according to theory visible sparks ought in any case to be obtained; but, on the other hand, sparks several millimetres in length, as obtained in the experiments previously described, can [illegible] explained on the assumption that the successive impulses produce an accumulative effect, so that theory indicates the necessity of the existence of the resonant effects [illegible] observed.

(To be continued.)

ON THE APPLICATION OF ELECTRICITY TO THE WORKING OF A 20 TON TRAVELLING CRANE.*

[illegible] ATKINSON, M. Inst. C.E.

[illegible] traveling cranes in the foundry of the Leith [illegible] are usually constructed to be worked by hand [illegible] but it had been much desired for the application of water [illegible] of the future time.

The crane is 70ft. span, and consists of a pair of wrought iron girders resting on end carriages, each running on two wheels on an elevated line of rails. The gearing for hoisting, for longitudinal and for cross traverse is secured on [illegible] the opposite ends of the crane-beam projection from the [illegible] which [illegible] the same time [illegible] a pulley [illegible] the chain [illegible] to pull on the cross traverse [illegible] which [illegible] to the main girders. By this arrangement the crane can [illegible] both and the hook can come within 4ft. of the wall.

The [illegible] and were attended [illegible] of [illegible] [illegible] a long main [illegible] and the cost and special attention required by a [illegible] induced the writer to try whether electricity might not be used with [illegible] Messrs. Lowell Parker, of Wolverhampton, were [illegible] and these gentlemen undertook to supply the dynamo and a motor suitable for the purpose, [illegible] a heavy crane.

The [illegible] which is considerably larger than is needed for the crane in question, is arranged to give [illegible] at 120 volts with 1,000 revolutions per minute. The armature of the cylinder type, but it [illegible] would [illegible] [illegible] of armature of 0·1 ohm and of the magnets 0·2 ohm. It is [illegible] to the main boiler house of the [illegible] and driven by a horizontal engine having a cylinder [illegible] stroke, running at 150 revolutions with [illegible] to [illegible] of a link belt. The leads from the boiler to [illegible] the [illegible] on the foundry floor [illegible] and [illegible] 0·1 W.G. copper wire, which the conductor in the trolley is formed [illegible] [illegible] the whole [illegible] that the [illegible] is [illegible] ground, and protected [illegible] and [illegible] the main pillar supporting the [illegible] by wood blocks. The [illegible] [illegible] which the crane runs, the [illegible] especially by copper strips. The [illegible] Lowell Parker's latest type, which [illegible] [illegible] armature, without wood [illegible] [illegible] [illegible] [illegible] the armature [illegible] [illegible] the [illegible] [illegible] [illegible] the working gear [illegible] the crane beside [illegible] the main girder. It [illegible] [illegible] carries a steel pinion, which [illegible] [illegible] bevel [illegible] a shaft which [illegible] [illegible] the top of the girder, and is connected [illegible] [illegible] with friction clutch connection to the [illegible] shaft which [illegible] mand the several movements of the crane, the means of using the hand power being still retained. Two sets of speed are arranged for each of the movements, namely:

	Slow speed	Fast speed
Hoisting	[illegible] ft.	10ft.
Cross traverse	25 ,,	100 ,,
Longitudinal traverse	75 ,,	213 ,,

To provide against [illegible] current passing through the motor an automatic magnetic cut-out is fixed on the crane, and as an additional security a fusible wire is placed close to the dynamo to provide for the contingency of a short circuit. For the purpose of varying the power and speed to meet the requirements of the foundry a set of resistance coils is provided, governed by a special switch by means of which different resistances can be introduced into the armature circuit of the motor, and the current can be cut off altogether, but so that it must be done by steps and not suddenly. In starting the motor the reverse action takes place. The shunt coils of the magnets are connected to the two collectors so that the fields are always excited when the dynamo is running, whether the motor is working or not, the switch controlling only the armature circuit. The collector for the angle-iron conductor consists of a pair of insulated brass blocks pressed against it by means of a flat spring having a considerable range. An ordinary wire brush serves to collect the current from the rail, but the axle of one of the wheels is [illegible] to this brush to provide for the contact being in any way interrupted.

The handles for operating the several movements, the brake lever, the switch, and the automatic cut-out are all collected

of some electricity, either with or through a conductor. Now, whenever electricity moves, it at once has magnetic properties, its motion generates a magnetic field. When the motion ceases the field at once subsides, and in subsiding it may produce a succession of diffusing and dying away induction currents in neighbouring conductors, or it may, if the circuit be an incomplete one, leave a permanent vestige of itself in the dielectric as a field of strained ether this state of strain being what we call electrostatic potential, and the field being familiar to us as an electrostatic field.

Generating it in this way, all distinction between rate of propagation of electrostatic and electromagnetic potential vanishes, they both travel together with the velocity of light, or rather, the thing which travels is the magnetic potential, and its permanent effect is *sita* is the electrostatic potential.

Thus, once more, the difficulty of a longitudinal or pressural wave disappears from the electrical theory of light, into which it had seemed to intrude itself, and Ψ is left to enjoy "a long and useful career," though it is not permitted an infinite or any other rate of propagation in its own proper nature. The question of the incompressibility or compressibility of the ether thus remains unanswered, and, as it would seem, unanswerable, by any such experiments as those of Hertz, or by any experiments on the rate of transmission of electrostatic potential. If any one asks how soon will the pull of a suddenly electrified body be felt at a distance? one may answer, "As soon as the charging spark is seen." But if it be asked at what rate electrostatic potential travels, the answer is that it does not travel, but is generated in *situ* by the subsidence of a magnetic potential which travels with the velocity of light.

It must be understood that the last word has by no means been said on these great problems, and that what I have here written must be digested with salt. It is proper also to record the conviction expressed by the President that most of these refined points would probably be found mathematically treated somewhere in the writings of Mr. Heaviside.

(To be continued.)

HERTZ'S RESEARCHES ON ELECTRICAL OSCILLATIONS.

BY G. W. DE TUNZELMANN, B.SC.

(Continued from page 589.)

In a note in Wiedemann's *Annalen*, Vol. XXXI., page 545, Dr. Hertz states that since the publication of his Paper in the same volume, he had found that von Bezold had published a Paper in 1870 (Poggendorff's *Annalen*, Vol. CXL., page 541), in which he had arrived by a different method of experimenting at similar results and conclusions as those given by him under the head of Preliminary Experiments.

Induction Phenomena in Open Circuits.—In order to test more fully his conclusion that the sparks obtained in the experiments described in my last Paper were due to self-induction, Dr. Hertz placed a rectangle of copper wire with sides 10 and 20 centimetres in length respectively, broken by a short air space, with one of its sides parallel and close to various portions of the secondary circuit of the coil, and of the micrometer circuit, with solid dielectrics interposed, to obviate the possibility of sparking across, and he found that sparking in this rectangle invariably accompanied the discharges of the induction coil, the longest sparks being obtained when a side of the rectangle was close to the discharger.

A copper wire, *i g k* (Fig. 3), was next attached to the discharger, and a side of the micrometer circuit, which was supported on an insulating stand, was placed parallel to a portion of this wire, as shown in the diagram. The sparks at M were then found to be extremely feeble until a conductor, C, was attached to the free end, *k*, of the copper wire, when they increased to one or two millimetres in length. That the action of C was not an electrostatic one was shown by its producing no effect when attached at *g* instead of at *k*. When the knobs of the discharger B were so far separated that no sparking took place there, the sparks at M were also found to disappear, showing that these were due to the sudden discharges and not to the charging current. The sparks at the discharger which produced the most effect at the micrometer were of the same character as those described in my last Paper. Sparks were also found to occur between the micrometer circuit and insulated conductors in its vicinity. The sparks became much shorter when conductors of larger capacity were attached to the micrometer knobs, or when these were touched by the hand, showing that the quantity of electricity in motion was too small to charge these conductors to a similarly high potential. Joining the micrometer knobs by a wet thread did not perceptibly diminish the strength of the sparks. The effects in the micrometer circuit were not of sufficient strength to produce any sensation when it was touched or the circuit completed through the body.

In order to obtain further confirmation of the oscillatory nature of the current in the circuit *k i h g* (Fig. 3), the conductor C was again attached to *k*, and the micrometer knobs drawn apart until sparks only passed singly. A second conductor, C', as nearly as possible similar to C, was then attached to *k*, when a stream of sparks was immediately observed, and it

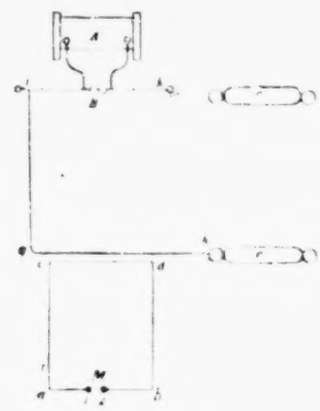

Fig. 3.

continued when the knobs were drawn still further apart. This effect could not be ascribed to a direct action of the portion of circuit *i k*, for in this case the action of the portion of circuit *g h* would be weakened, and it must therefore have consisted in C acting on the discharging current of C', a result which would be quite incomprehensible unless the current in *g h* were of an oscillatory character.

Since an oscillatory motion between C and C' is essential for the production of powerful inductive effects, it will not be sufficient for the spark to occur in an excessively short time, but the resistance must at the same time not exceed certain limits. The inductive effects will therefore be excessively small if the induction coil included in the circuit C C' is replaced by an electrical machine charging and discharging itself, or if too small an induction coil is used; or, again, if the air space between the discharger knobs is too great, as in all these cases the motion ceases to be oscillatory.

The reason that the discharges of a powerful induction coil gives rise to oscillatory motion is that, firstly, it charges the terminals C and C' to a high potential; secondly, it produces a sudden spark in the intervening circuit; and, thirdly, as soon as the discharge begins the resistance of the air space is so much reduced as to allow of oscillatory motion being set up. If the terminal conductors are of very large capacity, for example, if the terminals are in connection with a battery, the current of discharge may indefinitely reduce the resistance of the air space, but when the terminal conductors are of small capacity this must be done by a separate discharge, and there-

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fore, under the conditions of the author's experiments, an induction coil was absolutely essential for the production of the oscillations.

As the induced sparks in the experiment last described were several millimetres in length, the author modified it by using the arrangement shown in Fig. 4, and greatly increasing the distance between the micrometer circuit and the secondary circuit of the induction coil. The terminal conductors C and C' were three metres apart, and the wire between them was of copper, 2 millimetres in diameter, with the discharger B at its centre.

The micrometer circuit consisted, as in the preceding experiments, of a rectangle 80 centimetres broad by 120 centimetres long. With the nearest side of the micrometer circuit at a distance of half a millimetre from C B C sparks two millimetres in length were obtained at M, and though the length of the sparks decreased rapidly as the distance of the micrometer circuit was increased, a continuous stream of sparks was still obtained at a distance of one and a half metres. The intervention of the observer's body between the micrometer circuit and the wire C B C produced no visible effect on the stream of sparks at M. That the effect was really due to the rectilinear conductor C B C was proved by the fact that when one or other, or both halves of this conductor were removed, the sparks at M ceased. The same effect was produced by drawing the knobs of the discharger B apart until sparks ceased to pass, showing that the effect was not due to the electrostatic potential difference of C and C', as this would be increased by separating the discharger knobs beyond sparking distance.

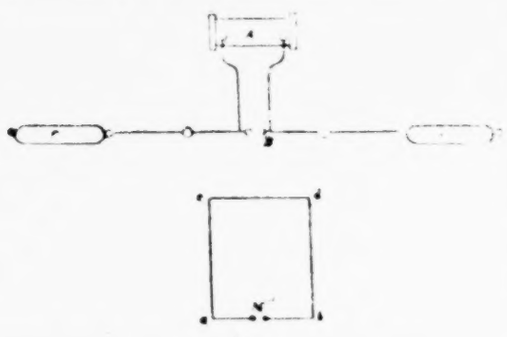

FIG. 4.

The closed micrometer circuit was then replaced by a straight copper wire, slightly shorter than the distance C C', placed parallel to C B C', and at a distance of 60 centimetres from it. This wire terminated in knobs, 10 centimetres in diameter, attached to insulating supports, and the spark micrometer divided it into two equal parts. Under these circumstances, sparks were obtained at the micrometer, as before.

With the rectilinear open micrometer circuit sparks were still observed at the micrometer when the discharger knobs of the secondary coil circuit were separated beyond sparking distance. This was, of course, due simply to electrostatic induction, and shows that the oscillatory current in C C' was superposed upon the ordinary discharges. The electrostatic action could be got rid of by joining the micrometer knobs by means of a damp thread. The conductivity of this thread was therefore sufficient to afford a passage to the comparatively slow alternations of the coil discharge, but was not sufficient to provide a passage for the immeasureably more rapid alternations of the oscillatory current. Considerable sparking took place at the micrometer when its distance from C B C was 1·2 metres, and faint sparks were distinguishable up to 3 metres. At these distances it was not necessary to use the damp thread to get rid of the electrostatic action, as, owing to its diminishing more rapidly with increase of distance than the effect of the current induction, it was no longer able to produce sparks in the micrometer, as was proved by separating the discharger knobs beyond sparking distance, when sparks could no longer be perceived at the micrometer.

Resonance Phenomena.—In order to determine whether, as some minor phenomena had led the author to suppose, the oscillations were of the nature of a regular vibration, he availed himself of the principle of resonance. According to this principle, an oscillatory current of definite period would, other conditions being the same, exert a much greater inductive effect upon one of equal period than upon one differing even slightly from it.*

If, then, two circuits are taken having as nearly as possible equal vibration periods, the effect of one upon the other will be diminished by altering either the capacity or the coefficient of self induction of one of them, as a change in either of them would alter the period of vibration of the circuit.

This was carried out by means of an arrangement very similar to that of Fig. 4. The conductor C C' was replaced by a straight copper wire 2·6 metres in length and 5 millimetres in diameter, divided into two equal parts as before by a discharger. The discharger knobs were attached directly to the secondary terminals of the induction coil. Two hollow zinc spheres, 30 centimetres in diameter, were made to slide on the wire, one on each side of the discharger, and since, electrically speaking, these formed the terminals of the conductor, its length could be varied by altering their position. The micrometer circuit was chosen of such dimensions as to have, if the author's hypothesis were correct, a slightly shorter vibration period than that of C C'. It was formed of a square, with sides 75 centimetres in length, of copper wire 2 millimetres in diameter, and it was placed with its nearest side parallel to C B C', and at a distance of 30 centimetres from it. The sparking distance at the micrometer was then found to be 0·9 millimetre. When the terminals of the micrometer circuit were placed in contact with two metal spheres 8 centimetres in diameter, supported on insulating stands, the sparking distance could be increased up to 2·5 millimetres. When these were replaced by much larger spheres the sparking distance was diminished to a small fraction of a millimetre. Similar results were obtained on connecting the micrometer terminals with the plates of a Kohlrausch condenser. When the plates were far apart the increase of capacity increased the sparking distance, but when the plates were brought close together the sparking distances again fell to a very small value.

The simplest method of adjusting the capacity of the micrometer circuit is to suspend to its ends two parallel wires, the distance and lengths of which are capable of variation. By this means the author succeeded in increasing the sparking distance up to three millimetres, after which it diminished when the wires were either lengthened or shortened. The decrease of the sparking distance on increasing the capacity was naturally to be expected, but it would be difficult to understand, except on the principle of resonance, why a decrease of the capacity should have the same effect.

The experiments were then varied by diminishing the capacity of the circuit C B C' so as to shorten its period of oscillation, and the results confirmed those previously obtained, and a series of experiments in which the lengths and capacities of the circuits were varied in different ways, showed conclusively that the maximum effect does not depend on the conditions of either one of the two circuits, but on the existence of the proper relation between them.

When the two circuits were brought very close together and the discharger knobs separated by an interval of 7 millimetres, sparks were obtained at the micrometer, which were also 7 millimetres in length, when the two circuits had been carefully adjusted to have the same period. The induced E.M.F.s must in this case have attained nearly as high a value as the inducing ones.

To show the effect of varying the coefficient of self induction, a series of rectangles, *a b c d* (Fig. 4), were taken, having a constant breadth, *a b*, but a length, *a c*, continually increasing from 10 centimetres up to 250 centimetres. It was found that the maximum effect was obtained with a length of 1·8 metres. The quantitative results of these experiments are shown in Fig. 5, in which the abscissæ of the curve are the double lengths of the rectangles, and the ordinates represent the corre

* *See* Oberbeck, Wiedemann's *Annalen*, Vol. XXVI., p. 345, 1885.

sponding maximum sparking distances. The sparking distances could not be determined with great exactness, but the errors were not sufficient to mask the general nature of the result.

In a second series of experiments the sides $a c$ and $b d$ were formed of loose coils of wire which were gradually pulled out, and the result is shown in Fig. 6. It will be seen that the maximum sparking distance was attained for a somewhat greater length of side, which is explained by the fact that in the latter experiments the self-induction only was increased by increase of length, while in the former series the capacity was increased as well. Varying the resistance of the micrometer circuit by using copper and German silver wires of various diameters was found to have no effect on the period of oscillation, and extremely little on the sparking distance.

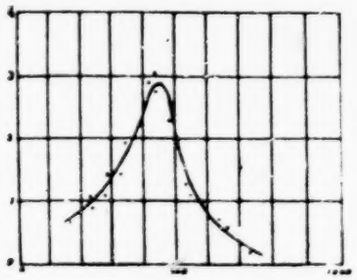

Fig. 5.

Curve showing relation between length of side of rectangle (taken as abscissa) and maximum sparking distance (taken as ordinate), the sides consisting of straight wires of varying lengths.

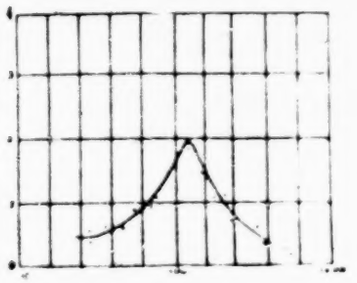

Fig. 6.

Curve showing relation between length of side of rectangle (taken as abscissa) and maximum sparking distance (taken as ordinate), the sides consisting of spirals gradually drawn out.

When the wire $c d$ was surrounded by an iron tube, or when it was replaced by an iron wire, no perceptible effect was obtained, confirming the conclusion previously arrived at that the magnetism of the iron is unable to follow such rapid oscillations, and therefore exerts no appreciable effect.

(To be continued.)

DYNAMOS WITHOUT COMMUTATORS OR BRUSHES.

BY TH. MARCHER (OF MÜLHEIM).

The first recorded attempt to construct a continuous-current dynamo without the impediments of commutator and brushes is due to M. A. F. Gravier, who took out a patent in France for a dynamo of this class. In 1882 a Mr. E. Newton obtained a similar patent in England. In 1883 L. Hajnis, of Prague, took out a patent in Germany for a dynamo on this principle; but in which some of the defects of the Gravier machine were avoided. In 1887 the Cronstadt Electrical Manufacturing Company also designed a dynamo without commutators. Since then but little seems to have been done in this direction.

I will, in the first place, briefly describe the original Gravier machine, from which he subsequently developed the non-commutator type. In Fig. 1 N and S are the field magnets; $a a a$ and $b b b$ are the armature coils, which are mounted on radial cores, as in the Lontin type; and $+f$ and $-f$ are the brushes. When the armature revolves in the direction shown by the large arrow currents are induced in the coils in the direction shown by the small arrows. The armature poles $a a a$, therefore, become S magnetised, and the poles $b b b$ N magnetised. Now imagine a second armature of the ring type, interposed between the above mentioned armature and the poles N S, this second armature having no coils at A A and B B (Fig. 2). The magnets $a a a$ will produce in this armature a current flowing in the direction $c c$, and the magnets

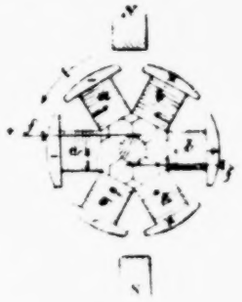

Fig. 1.

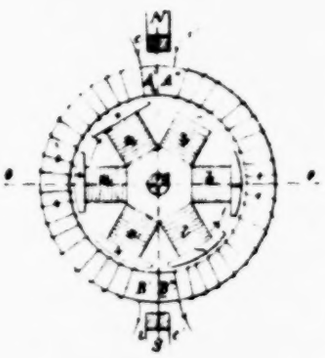

Fig. 2.

$b b b$ will produce a current flowing in the reverse direction, $f f$. Now, these two currents induce poles at A A and B B similar to those of the field-magnets, N S, at the adjacent points. If, therefore, sufficient residual magnetism was present, the magnet N S could be dispensed with, and the pole A A and B B would suffice. Gravier, however, was unable to get any good results from this form of machine, and subsequently designed one without commutator, collector, or brushes. In this dynamo (Fig. 3) Gravier had a revolving armature i, a revolving system of magnetisation, N S, a fixed armature I I, and a fixed system of magnetisation $a a$. The theoretical outcome of this arrangement is as follows:—The magnets $a a$ induce currents in i, which excite the magnets N S, which in turn induce currents in I I; the current thus obtained passes into the external circuit, and also round the magnets $a a$. One method of winding is shown in Fig. 4. The Hajnis machine consists of the same four essential parts, namely, fixed armature and field-magnets, and revolving armature and field magnets, the revolving parts being mounted on the same shaft. This arrangement is shown diagrammatically in Fig. 5. M M M M are fixed magnets, A A are revolving armature coils, B B B B are revolving magnets, and P P is the fixed ring armature. From each individual coil of the revolving armature connections are made to the corresponding magnet coil, each armature coil being one behind the

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[illegible] to the *static hysteresis* experiments by Prof. [illegible] and others also indicate the existence of *viscous* [illegible]. There is evidence of a true *time lag* in magnetisation, especially in the earlier stages of magnetisation. Iron requires time for a given magnetising force to produce its full effect, and this sluggishness does not appear explicable as due either of induction in the iron or to self induction in the magnetising circuit. The result of this magnetic viscosity is to augment the value of $-\int \mathrm{I}\,d\mathrm{H}$ in any rapidly performed cycle, and, consequently, to increase the dissipation of energy per cycle. When we come to consider the question of induction-transformers it will be seen that this viscous hysteresis has to be taken into account in establishing the full theory.

With respect to this *time lag* of magnetisation Prof. Ewing says:* "I repeatedly observed that when the magnetising current was applied to long wires of soft iron there was a distinct *creep up* of the magnetometer deflection after the current had attained a steady value."†

If this is so it would seem that a sufficiently rapid reversal of magnetising force would render such force inoperative in magnetising the iron. Just as the self induction of a circuit operates to make a certain delay in the appearance of the current corresponding to the application of a given electromotive force, and hence renders a circuit apparently a worse conductor for rapidly reversed electromotive forces, so the magnetic lag would introduce a sort of *magnetic self-induction* or retardation in the appearance of the magnetisation corresponding to a given magnetising force.

This time lag appears to be most manifest in the softest iron, and to be especially noticeable near the beginning of the steep part of the magnetisation curve.

In an investigation on the magnetisation of iron under feeble magnetic forces, Lord Rayleigh has also drawn attention to the fact that the settling down of iron when very soft or annealed into a new magnetic state is far from instantaneous;‡ the strength of the earth's horizontal magnetic field is called *h*, and Lord Rayleigh has shown that for unannealed iron and steel magnetising forces ranging from $\frac{1}{3}h$ to $\frac{1}{10800}h$ call forth proportional magnetisation. In other words, the susceptibility is constant over this range, and the value of the corresponding permeability is from 90 to 100, and that this small proportional magnetisation takes place independently of what may be the actual magnetisation of the iron provided it is not very near the condition usually called saturation.

The moment, however, that the magnetising force is pushed beyond these limits the phenomena of hysteresis and retentiveness make their appearance. According to Prof. Ewing (*loc. cit.*) the following group or constellation of hypotheses has to be made in order to approximate to a mechanical explanation of the magnetisation of iron:

1. An elastic tendency on the part of the magnetic molecules to recover their primitive position when displaced.
2. A static frictional resistance to their displacement and to their return removable largely by vibration.
3. A limit for each such that if the displacement of the molecule exceeds it a permanent displacement not removable by vibration results.
4. Probably a viscous resistance to the displacement and return of the molecules.
5. An unequal distribution amongst the molecules of the frictional resistance, such that in some of the molecules it is, perhaps, very small.

Aided by these suppositions we might proceed to build up, in imagination, a mechanical model, which should imitate, under the application of certain stresses, the behaviour of iron under magnetising force, but it is certain that the result would not be practically of much value; and it must still be left to future research to collect and analyse the necessary facts before the mystery of the magnetisation of iron is fully unraveled.

* *Phil. Trans.*, Part II., 1885, p. 523.

† See also Mr. T. Blakesley "On Magnetic Lag," *Phil. Mag.*, July, 1888, p. 34, in which it is shown that, by means of three dynamometers, the lag due to viscous hysteresis may be measured.

‡ Lord Rayleigh "On the Behaviour of Iron and Steel under the Operation of Feeble Magnetic Forces," *Phil. Mag.*, March, 1887, p. 225.

HERTZ'S RESEARCHES ON ELECTRICAL OSCILLATIONS.

BY G. W. DE TUNZELMANN, B.Sc.

H. Hertz has been engaged for some time past in a series of researches on electrical oscillations, which have led to results of very exceptional interest, as was pointed out by Prof. Fitzgerald in his inaugural address to Section A of the British Association last week; and as these results throw considerable light on the nature of electrical action, it will be of interest to readers of *The Electrician* to have a connected account of the investigations, to which I therefore propose to devote a short series of papers.

In Hertz's first Paper on the subject, viz., "On Very Rapid Electrical Oscillations" (Wied. *Ann.*, Vol. XXXI., page [illegible], 1887), he refers to a Paper by Colley, "On some New Methods for Observing Electrical Oscillations, with Applications" (*ibid.*, Vol. XXVI., page 432), who calls attention to the fact that Sir William Thomson in 1853 first showed the possibility of producing electrical oscillations by the discharge of a charged conductor, and gives references to all the investigations in the same direction which were known to him.

For the benefit of readers who may wish to pursue the subject further the list is reproduced below:—

Sir W. Thomson, "Mathematical and Physical Papers," Vol. I., page 540.

Feddersen, Poggendorff's *Annalen*, Vol. CIII., page 69, 1858; Vol. CVIII., page 497, 1859; Vol. CXII., page 452, 1861; Vol. CXIII., page 437, 1861; Vol. CXV., page 336, 1862; Vol. CXVI., page 132, 1862.

Kirchhoff, "Gesammelte Abhandlungen," page 168, containing remarks on, and corrections of some of Feddersen's results.

von Helmholtz, "Gesammelte Abhandlungen," Vol. I., page 531.

von Oettingen, Poggendorff's *Annalen*, Vol. CXV., page 115, 1862; and Jubelband, page 269, 1874.

Bernstein, Poggendorff's *Annalen*, Vol. XIII., page 142, 1878.

Schiller, Poggendorff's *Annalen*, Vol. CLII., page 535, 1874.

L. Lorenz, Wiedemann's *Annalen*, Vol. VII., page 161, 1879.

Mouton, Thèse, Paris, 1876. *Journal des Physique*, Vol. VI., pages 5 and 46, 1876.

Kolaček, Beiblatter zu Wiedemann's *Annalen*, Vol. VII., p. 541, 1883 (Abstract of a Paper published in the reports of the Bohemian Scientific Society in 1882).

Olearsky, Verhandlungen der Academie von Krakau, Vol. VII., p. 141, 1882.

Oberbeck, Wiedemann's *Annalen*, Vol. XVII., pp. 816 and 1,040, 1882; Vol. XIX., pp. 213 and 295, 1883.

Bichat et Blondlot, *Comptes Rendus*, Vol. XCIV., p. 1,720, 1882.

According to these investigations, the electrical oscillations produced in an open circuit by means of an induction coil are measured by ten thousandths of a second, while in the case of the oscillatory discharge of a Leyden jar they are about a hundred times as rapid, as was shown by Feddersen.

According to theory, still more rapid oscillations should be possible in an open circuit of wire of good conducting material, provided its ends are not connected with conductors of any considerable capacity; but it is not possible to determine from theory whether measurable oscillations are actually produced. Some observations of Hertz's led him to believe that under certain circumstances oscillations of this kind were produced, and his researches show that this is so, and that the oscillations are about a hundred times as rapid as those observed by Feddersen; so that their periods are measured by hundred millionths of a second, and, therefore, they occupy a position intermediate between acoustic and luminous vibrations.

Preliminary Experiments.—It is known that if in the secondary circuit of an induction coil there be inserted, in addition to the ordinary air space, across which sparks pass, a Riess spark micrometer, with its poles joined by a long wire,

the discharge will pass across the air space of the micrometer in preference to following the path of least resistance through the wire, provided this air space does not exceed a certain limit, and it is upon this principle that lightning protectors for telegraph lines are constructed. It might be expected that the sparks could be made to disappear by diminishing the length and resistance of the connecting wire; but Hertz finds that though the length of the sparks can be diminished in this way, it is almost impossible to get rid of them entirely, and they can still be observed when the balls of the micrometer are connected by a thick copper wire only a few centimetres in length.

This shows that there must be variations in the potential measureable in hundredths of a volt in a portion of the circuit only a few centimetres in length, and it also gives an indirect proof of the enormous rapidity of the discharge, for the difference of potential between the micrometer knobs can only be due to self-induction in the connecting wire. Now the time occupied by variations in the potential of one of the knobs must be of the same order as that in which these variations can be transmitted through a short length of a good conductor to the second knob. The resistance of the wire connecting the knobs is found to be without sensible effect on the results.

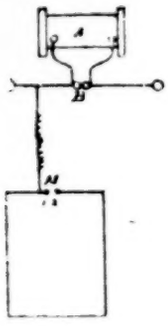

FIG. 1.

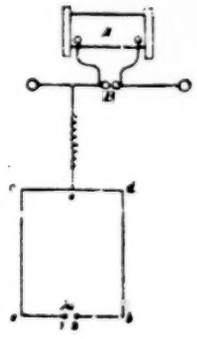

FIG. 2.

In Fig. 1, A is an induction coil and B a discharger. The wire connecting the knobs 1 and 2 of the spark micrometer M, consists of a rectangle, half a metre in length, of copper wire 2 millimetres in diameter. This rectangle is connected with the secondary circuit of the coil in the manner shown in the diagram, and when the coil is in action sparks, sometimes several millimetres in length, are seen to pass between the knobs 1 and 2, showing that there are violent electrical oscillations, not only in the secondary circuit itself, but in any conductor in contact with it. This experiment shows even more clearly than the previous one that the rapidity of the oscillations is comparable with the velocity of transmission of electrical disturbances through the copper wire, which according to all the evidence at our disposal is nearly equal to the velocity of light.

In order to obtain micrometer sparks some millimetres in length, a powerful induction coil is required, and the one used by Hertz was 52 centimetres in length and 20 centimetres in diameter, provided with a mercury contact breaker, and excited by six large Bunsen cells. The discharger terminals consisted of brass knobs 3 centimetres in diameter. The experiments showed that the phenomenon depends to a very great extent on the nature of the sparks at the discharger, the micrometer sparks being found to be much weaker when the discharge in the secondary circuit took place between two points, or between a point and a plate, than when knobs were used. The micrometer sparks were also found to be greatly enfeebled when the secondary discharge took place in a rarefied gas, and also when the sparks in the secondary were less than half a centimetre in length, while, on the other hand, if they exceeded 1½ centimetres the sparks could no longer be observed between the micrometer knobs. The length of secondary spark which was found to give the best results, and which was, therefore, employed in the further observations, was about three quarters of a centimetre.

Very slight differences in the nature of the secondary sparks were found to have great effect on those at the micrometer, and Hertz states that after some practice he was able to determine at once from the sound and appearance of the secondary spark whether it was of a kind to give the most powerful effects at the micrometer. The sparks which gave the best results were of a brilliant white colour, only slightly jagged, and accompanied by a sharp crack.

The influence of the spark is readily shown by increasing the distance between the discharger knobs beyond the striking distance, when the micrometer sparks disappear entirely, although the variations of potential are now greater than before. The length of the micrometer circuit has naturally an important influence on the length of the spark, as the greater its length the greater will be the retardation of the electrical wave in its passage through it from one knob of the micrometer to the other.

The material, the resistance, and the diameter of the wire of which the micrometer circuit is formed have very little influence on the spark. The potential variations cannot, therefore, be due to the resistance, and this was to be expected, for the rate of propagation of an electrical disturbance along a conductor depends mainly on its capacity and coefficient of self-induction, and only to a very small extent on its resistance. The length of the wire connecting the micrometer circuit with the secondary circuit of the coil is also found to have very little influence, provided it does not exceed a few metres in length. The electrical disturbances must therefore traverse it without undergoing any appreciable change. The position of the point of the micrometer circuit which is joined to the secondary circuit is, on the other hand, of the greatest importance, as would be expected, for if the point is placed symmetrically with respect to the two micrometer knobs the variations of potential will reach the latter in the same phase, and there will be no effect, as is verified by observation. If the two branches of the micrometer circuit on each side of the point of contact of the connection with the secondary are not symmetrical, the spark cannot be made to disappear entirely; but a minimum effect is obtained when the point of contact is about half-way between the micrometer knobs. This point may be called the null point.

Fig. 2 shows the arrangement employed, *e* being the null point of the rectangular circuit, which is 125 centimetres long by 80 centimetres broad. When the point of contact is at *a* or *b*, sparks of from 3 to 4 milimetres in length are observed; when it is at *e* no sparks are seen; but they can be made to reappear by shifting the point of contact a few centimetres to the right or left of the null point. It should be noted that sparks only a few hundredths of a milimetre in length can be observed. If when the point of contact is at *e* another conductor is placed in contact with one of the micrometer knobs the sparks reappear.

Now, the addition of this conductor cannot produce any alteration in the time taken by the disturbances proceeding from *e* to reach the knobs, and, therefore, the phenomenon cannot be due simply to single waves in the directions *ea* and *eb* respectively, but must be due to repeated reflection of the waves until a condition of stationary vibration is attained, and the addition of the conductor to one of the knobs must diminish or prevent the reflection of the waves from that terminal. It must be assumed, then, that definite oscillations are set up in the micrometer circuit just as an elastic bar is thrown into definite vibrations by blows from a hammer. If this assumption is correct, the condition for the disappearance of the sparks at M will be that the vibration periods of the two branches *e*1 and *e*2 shall be equal. These periods are determined by the products of the coefficients of self induction of these conductors into the capacities of their terminals, and are practically independent of their resistances.

In confirmation of this, it is found that if when the point of contact is at *e* and the sparks have been made to reappear by connecting a conductor with one of the knobs, this conductor is replaced by one of greater capacity, the sparking is greatly increased. If a conductor of equal capacity, is connected with

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...other micrometer knob the sparks disappear again; the ... of the first conductor can also be counteracted by shifting the point of contact towards it, thereby diminishing the ... in that branch. The conclusions were further confirmed by the results obtained when coils of copper wire were inserted into one or other, and then into both of the ... of the micrometer circuit.

... supposed that as the self induction of iron wires is, for ... alternations, from eight to ten times that of copper wires, ... short iron wire would balance a long copper one; ... was not found to be the case, and he concludes that, ... the great rapidity of the alternations, the magnetism of ... is unable to follow them, and therefore has no effect on ... self induction.

(To be continued.)

MANUFACTURE OF LIGHT.*

BY DR. OLIVER LODGE, F.R.S.

The conclusions at which we have arrived, that light is an ... disturbance, and that light waves are excited by ... oscillations, must ultimately, and very shortly, have a ... import.

Our present systems of making light artificially are wasteful and ineffective. We want a certain range of oscillation, be... 7,000 and 4,000 billion vibrations per second; no other ... to us, because no other has any effect on our retina. ... we do not know how to produce vibrations of this rate. We can produce a definite vibration of one or two hundred ... thousand per second, in other words, we can excite a ... tone of definite pitch, and we can command any de... ... range of such tones continuously by means of bellows ... a key board. We can also (though the fact is less well ... we) excite momentarily definite ethereal vibrations of some ... millions per second, as I have at length explained; but we ... not at present seem to know how to maintain this rate quite ... To get much faster rates of vibration than this ... have to fall back upon atoms. We know how to make ... vibrate; it is done by what we call "heating" the sub..., and if we could deal with individual atoms unhampered ... others, it is possible that we might get a pure and simple ... of vibration from them. It is possible, but unlikely, for ... even when isolated, have a multitude of modes of vibra... ... to themselves, of which only a few are of practical ... to us, and we do not know how to excite some without also ... others. However, we do not at present even deal with in... ... atoms; we treat them crowded together in a compact ... so that their modes of vibration are really infinite.

... a lump of matter, say a carbon filament or a piece ... stone, and by raising its temperature we impress upon ... higher and higher modes of vibration, not trans... the lower into the higher, but superposing the higher ... the lower, until at length we get such rates of vibration ... retina is constructed for, and we are satisfied. But how ... and indirect and empirical is the process. We want ... range of rapid vibrations, and we know no better than ... the whole series leading up to them. It is as though, ... order to sound some little shrill octave of pipes in an organ, ... were obliged to depress every key and every pedal, and to ... a young hurricane.

I have purposely selected as examples the more perfect ... of obtaining artificial light, wherein the waste radia... ... only useless, and not noxious. But the old fashioned ... was cruder even than this; it consisted simply in setting ... burning, whereby not only the fuel but the air ... consumed, whereby also a most powerful radiation was ... in the waste waves of which we were content to sit ... for the sake of the minute, almost infinitesimal, frac... ... of it which enabled us to see.

Everyone knows now, however, that combustion is not a ... or healthy mode of obtaining light; but everybody does not realise that neither is incandescence a satisfactory and unwasteful method which is likely to be practised for more than a few decades, or perhaps a century.

Look at the furnaces and boilers of a great steam engine driving a group of dynamos, and estimate the energy expended; and then look at the incandescent filaments of the lamps excited by them, and estimate how much of their radiated energy is of real service to the eye. It will be as the energy of a pitch pipe to an entire orchestra.

It is not too much to say that a boy turning a handle could, if his energy were properly directed, produce quite as much real light as is produced by all this mass of mechanism and consumption of material.

There might, perhaps, be something contrary to the laws of Nature in thus hoping to get and utilise some specific kind of radiation without the rest; but Lord Rayleigh has shown in a short communication to the British Association at York* that it is not so, and that therefore we have a right to try to do it.

We do not yet know how it is true, but it is one of the things we have got to learn.

Anyone looking at a common glow worm must be struck with the fact that not by ordinary combustion, nor yet on the steam engine and dynamo principle, is that easy light produced. Very little waste radiation is there from phosphorescent things in general. Light of the kind able to affect the retina is directly emitted, and for this, for even a large supply of this, a modicum of energy suffices.

Solar radiation consists of waves of all sizes, it is true, but then solar radiation has innumerable things to do besides making things visible. The whole of its energy is useful. In artificial lighting nothing but light is desired. When heat is wanted it is best obtained separately, by combustion. And so soon as we clearly recognise that light is an electrical vibration, so soon shall we begin to look about for some mode of exciting and maintaining an electrical vibration of any required degree of rapidity. When this has been accomplished, the problem of artificial lighting will have been solved.

ON RECENT DEVELOPMENTS OF THE COWLES' ALUMINIUM PROCESS.†

BY R. E. CROMPTON.

It is unnecessary to again describe the earlier stages of the Brothers Cowles invention of the electric furnace. I confine myself to a description of such parts of the new plant which has been recently put down at Milton, near Stoke upon Trent, that I think will be of general scientific interest.

The experience in America at the works at Lockport, Ohio, showed conclusively that great economies were to be expected from increasing the size of the furnaces and the strength of the electric currents employed to work them; but no current larger than 3,000 amperes had been used up to the time that the Milton Works were planned.

Mr. Eugene Cowles came over to England to ascertain whether English makers of dynamo machines were prepared to supply one 60 per cent. larger than Mr. Brush's "Colossus," which had been made specially for them in America, and which was then the largest direct current machine in the world. He prepared his specification for a dynamo to give a current of 5,000 amperes at 60 volts, and eventually Messrs. Crompton's designs and tender were accepted.

The works were built near the Milton Station on the North Staffordshire Railway, the boilers for generating the steam required are of the Babcock-Wilcox type, and are provided with mechanical stokers; the steam engine is of 600 horse-power, and is a compound condensing horizontal tandem, made by Messrs. Pollit and Wigzel, of Sowerby Bridge; it is furnished with an exceedingly perfect centrifugal governor, which maintains the speed accurately at seventy six revolutions in spite of very great fluctuations in the load. The electrical

* Extract from "Modern Views of Electricity," *Nature*, August 30th, by kind permission of the author.

* B. A. Report, 1891, p. 526.

† Paper read before the British Association meeting (Section G), at Bath, September, 1888.

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DEFENDANT'S EXHIBIT No. 2

Loftin Sketch F

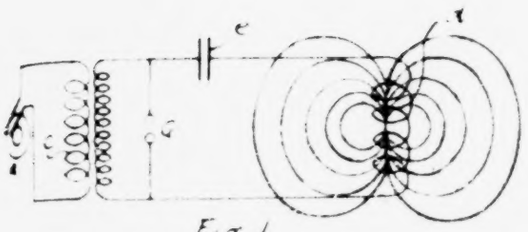


Fig 1

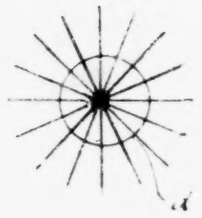


Fig. 1a

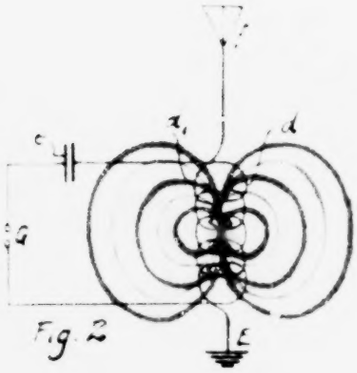


Fig 2

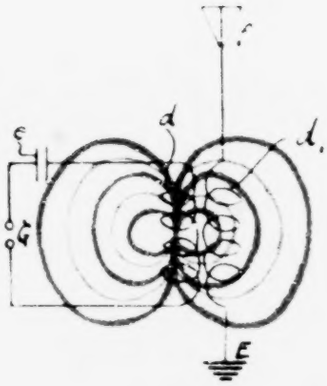


Fig 3

Fig 2a

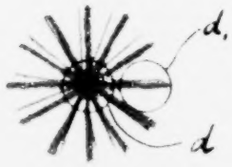


Fig. 3a

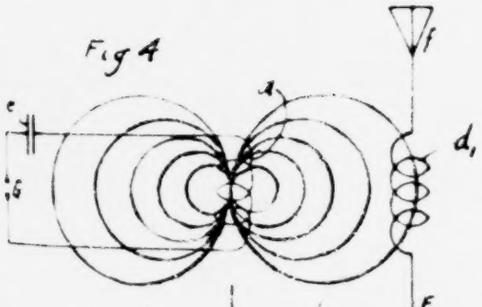


Fig 4

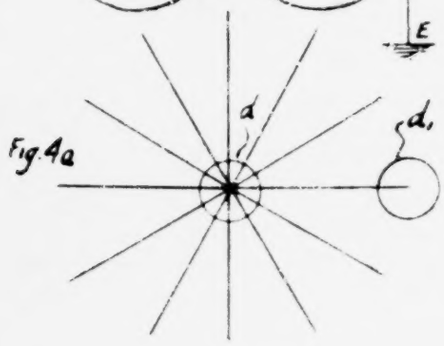


Fig. 4a

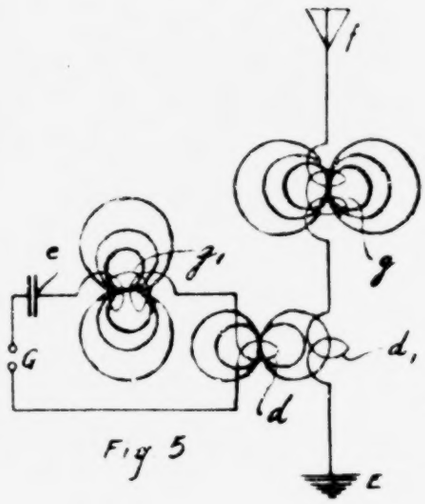


Fig 5

Loftin Sketch G DEFENDANT'S EXHIBIT O-2

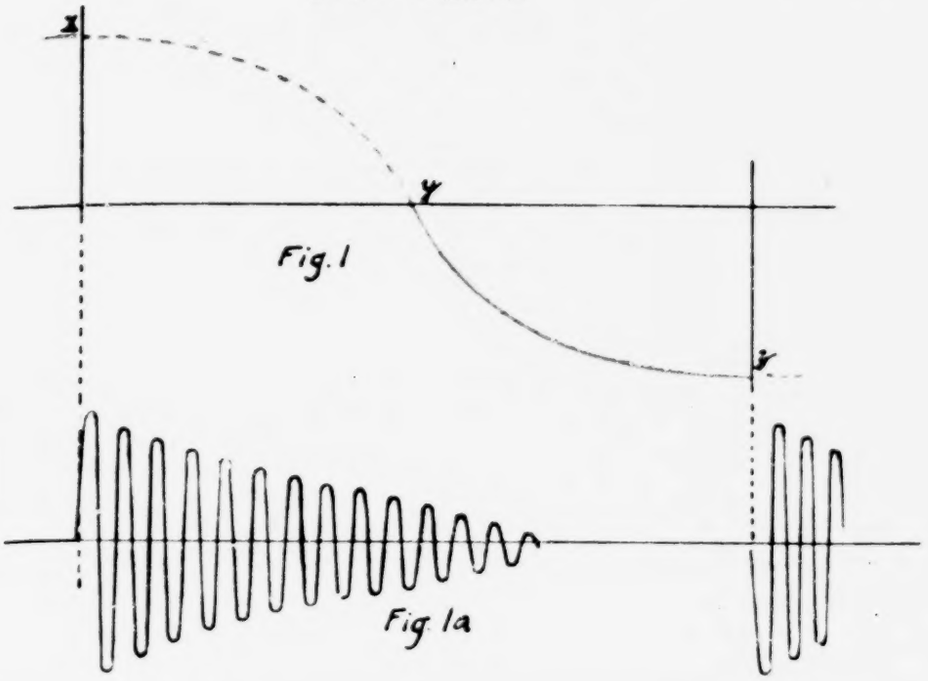


Fig. 1

Fig. 1a

Tight Coupling
Plain gap
LC - LC

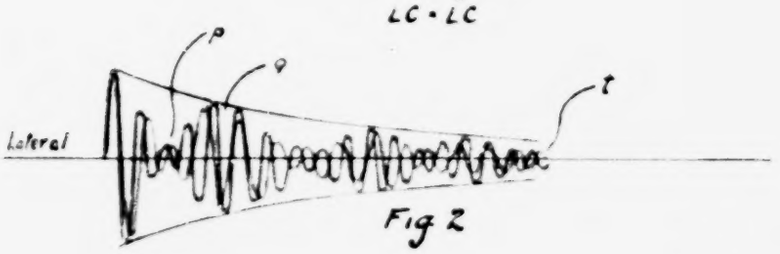


Fig. 2

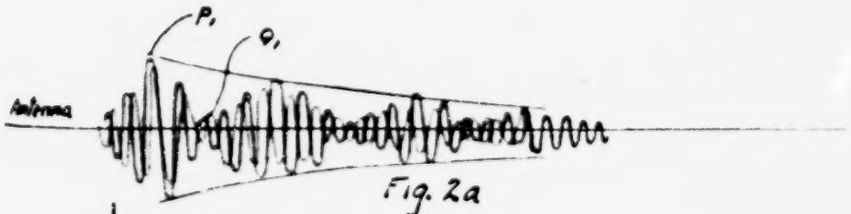


Fig. 2a

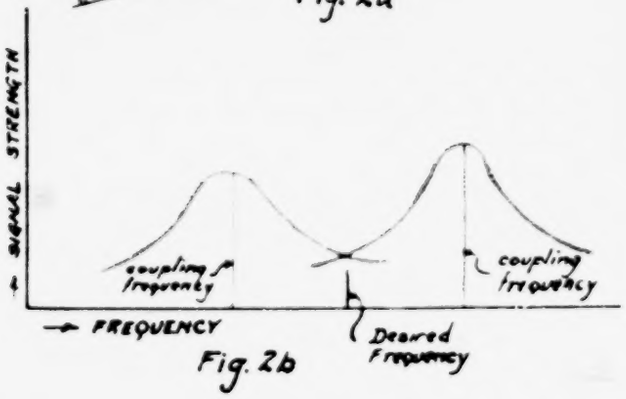


Fig. 2b

Loftin Sketch H

DEFENDANT'S EXHIBIT P-2

Loose Coupling Plain gap.

Antennae LC less than lateral LC

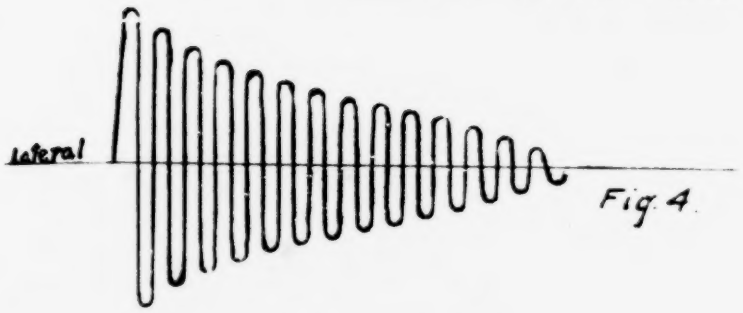
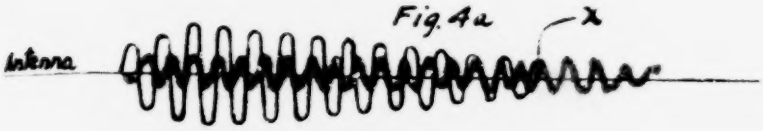


Fig. 4

Fig. 4a



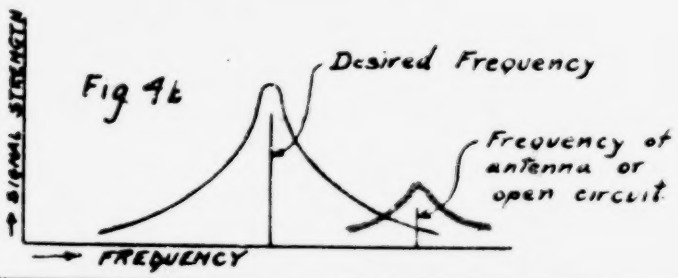


Fig 4b

Loose coupling Plain gap

LC = LC

Fig 5

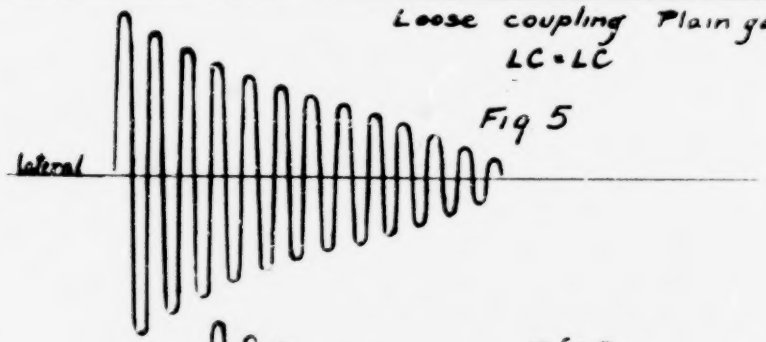
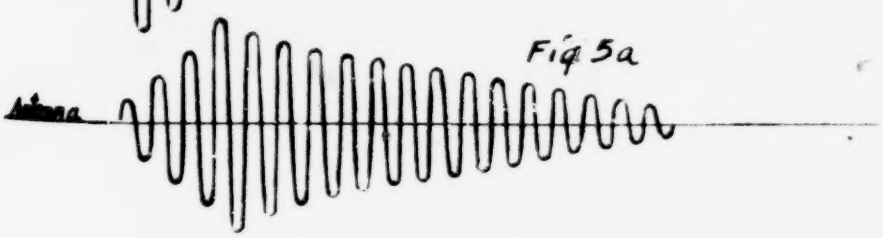


Fig 5a



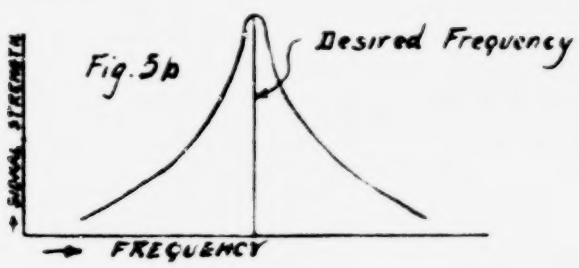
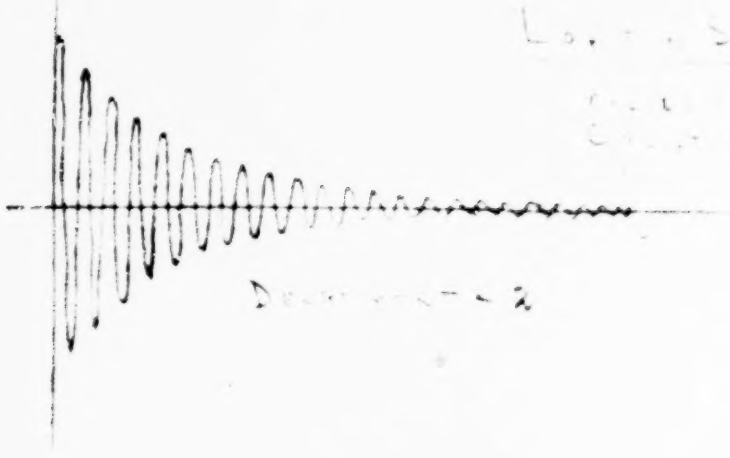


Fig. 5b

DEFENDANT'S EXHIBIT Q-2



No. 640,516. Patented Jan. 2, 1900

M. I. PUPIN.

ELECTRICAL TRANSMISSION BY RESONANCE CIRCUITS

Application filed May 20, 1895. Renewed Oct. 14, 1899.

(No Model.)

Fig. 1.

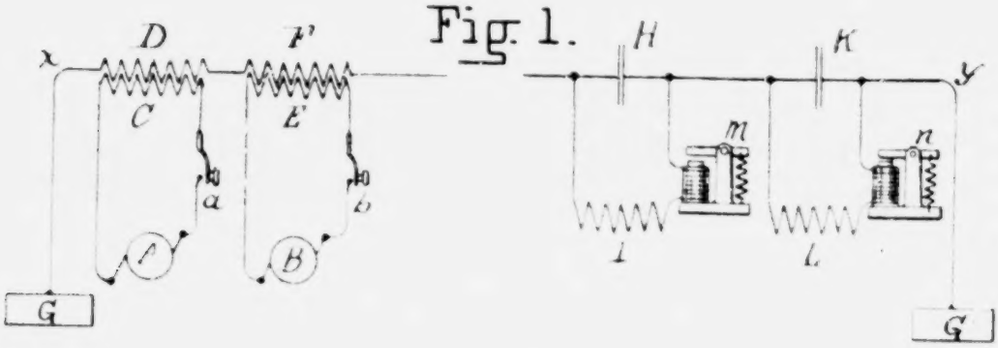


Fig. 2.

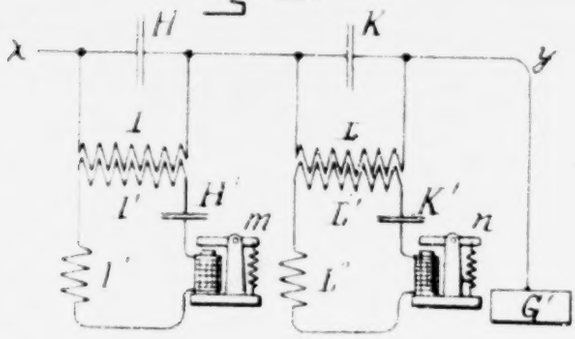
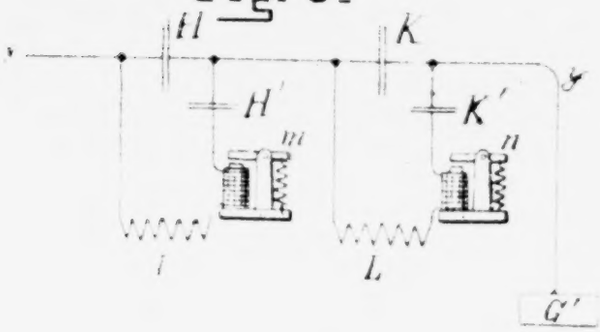


Fig. 3.



Witnesses:

Samuel W. Baldwin

Thomas B. Kinnicutt

Inventor,

Michael I. Pupin,

by Thomas Living Jr

Attorney.

UNITED STATES PATENT OFFICE.

MICHAEL I. PUPIN, OF NEW YORK, N. Y.

ELECTRICAL TRANSMISSION BY RESONANCE-CIRCUITS.

SPECIFICATION forming part of Letters Patent No. 640,516, dated January 2, 1900.

Application filed May 28, 1895. Renewed October 14, 1899. Serial No. 733,890. (No model.)

To all whom it may concern:

Be it known that I, MICHAEL I. PUPIN, a citizen of the United States of America, residing in the city, county, and State of New York, have invented certain new and useful Improvements in Electrical Transmission by Resonance-Circuits, of which the following is a specification.

If a condenser be inserted in a line and a self-induction coil be connected in shunt with this condenser, then an alternating current impressed upon the line will under certain conditions be greater in the shunt-circuit than in the line itself. The shunt-circuit in this case may be considered as a step-up transformer of the line-current. This subject has been discussed at considerable length in Vol. I of Fleming's treatise on the alternate-current transformer and also in Blakesley's book on alternating currents. There have been, however, no experimental data to guide one in determining the exact limitations within which the results of pure theory are applicable. Such limitations exist, and unless they are clearly understood this method of step-up transformation indicated by the theory fails completely. I have studied experimentally this method of step-up current transformation and have discovered the necessary and sufficient conditions under which such a shunt-circuit is resonant. These conditions may be stated briefly, as follows:

First. The capacity of the condenser and the self-induction of the shunt-coil must be so related as to bring the shunt-circuit in resonance with the line-current.

Second. The shunt-coil should either contain no iron at all, or if it contains iron the quantity of it should be very small, and it should be well laminated and should not form a closed magnetic circuit. This is true of resonance-circuits of every form, it being a general principle and not one limited to shunt-circuits that the use of iron should be avoided in such circuits.

Third. The ohmic resistance of the shunt-circuit should be as small as possible and certainly smaller than the resistance of the line.

By employing a well-constructed condenser and a low-resistance self-induction coil without iron I have succeeded in obtaining from a given line-current a resonant current that is twenty times as large as the line-current. I believe that I am the first to investigate experimentally the behavior of such resonant shunt-circuits and to discover the conditions under which they will operate in a manner indicated by the theory. At any rate I consider myself to be the first to apply such circuits to the solution of the practical problem solved by the following invention.

In multiple telegraphy by resonance-circuit it is necessary to employ selective circuits at the receiving end of the line. The employment of resonance shunt-circuits for selective receiving-circuits offers many important advantages.

By a "resonance-circuit" is meant one which has self-induction and capacity and therefore a natural period. When the self-induction and capacity are properly adjusted so as to give it the period of the impressed electromotive force, the resonance-circuit becomes resonant to this electromotive force.

The arrangement of resonance shunt-circuits herein shown gives less self-induction at the receiving end of the line than any other form of resonance-circuit. They are also under all circumstances step-up transformers of the line-current and are less apt when rendered resonant to interfere with each other than resonance-circuits of any other form.

In the accompanying drawings, which form a part of this specification, Figure 1 is a diagrammatic view of the transmitter and receiver stations, the line-wire being broken away. Fig. 2 is a diagrammatic view of the receiver-station in a somewhat-modified system. Fig. 3 is another diagrammatic view of the receiver-station in another modified system.

Referring now more particularly to Fig. 1, $x\ y$ is a telegraph line grounded at its ends G and G'. At the sending end of the line two alternators A and B impress in the line $x\ y$ by means of the coils C D and E F two electromotive forces of different frequencies, say of one hundred and fifty and two hundred and fifty vibrations per second, respectively. The keys a and b serve to open and close the inducing alternator-circuits, and thus impart to the line alternating-current waves.

With a long line, such as is usually employed in telegraph systems of the general

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type here described, the two circuits A a C and B b E are practically independent of each other. They may be varied in arrangement and still retain essential independence. Two circuits forming parts of a system of electric conductors are independent of each other when the energy generated in one by the action of an electromotive force acting in the other is small in comparison with the energy generated in the whole system by the action of this same electromotive force. In order to secure this mutual independence in the transmitter-circuits, it is important that they should act upon the main line through elements which, like the coils D and F, are connected in the main line in series. In practice it is found advantageous to throw the currents onto the line at the transmitting end through transformers. And in case of lines that are short in comparison with the wave length of the current transmitted the selectivity of the receiving resonance-circuits is more pronounced and independent of what is going on at the transmitting end of the line when the secondary coils of the transformers at the transmitting end are all placed in series in the line than when they are placed in multiple. At the receiving end it is important to have condensers with shunts around them containing self-induction coils forming parts of the main line. It is obvious that the coils I and L are just as much in series in the main line as are the condensers H and K.

By the term "transmitter-circuits" I do not mean to designate transmitter branches connected to a line-wire in multiple with each other. Such branches, of course, cannot be independent of each other, since changes in the resistance and self-induction of one will appreciably affect the others.

At the receiving end condensers H and K, of adjustable capacity, are inserted in the line in series, and each condenser is shunted by a coil of adjustable self-induction containing no iron. These coils are indicated in Fig. 1 by the letters I and L. The capacity of the condenser H and the self-induction of the coil I being such that the natural period or frequency of the shunt or resonance circuit H I is the same as the period of one of the electromotive forces which produce the current coming over the line—say that having a periodicity of one hundred and fifty per second—this circuit H I will be in resonance with the current and therefore will act selectively with respect to it. In the same manner by adjusting the electromagnetic constants of the resonant shunt-circuit, which contains coil L, this resonance-circuit is made to act selectively with respect to the other current on the line. These resonance receiving-circuits are, like the transmitting-circuits, mutually independent, a current flowing in one generating no appreciable current in another. If, therefore, the periodicity of the electromotive force impressed by circuit A C a be one hundred and fifty and that of B E b be two hundred and fifty, we shall have, whenever the key a closes the circuit A C a, a resonant current of one hundred and fifty periods in the resonant shunt-circuit H I. Similarly when the key b closes the circuit B E b there will be a resonant current of two hundred and fifty periods in the local circuit K L. If both keys are closed simultaneously and therefore both alternators are acting simultaneously upon the line, there will be a resonant current with the frequency of one hundred and fifty in the circuit H I and there will be a resonant current with a frequency of two hundred and fifty in the circuit K L.

It is evident that theoretically any number of resonance shunt-circuits may be employed at the receiving end of the line, each made resonant (by a proper adjustment of its electromagnetic constants) to one of the periodic currents impressed on the line at the transmitting end.

Referring now more particularly to Fig. 2, which represents the receiving end of the line and can be attached onto the transmitting end shown in Fig. 1 instead of the receiving end shown in that figure, I show a resonance-circuit H I and K L. The condensers H and K, as in Fig. 1, are in series in the line; but I control the frequency of H I by means of a circuit H I I', which contains the secondary coil of the induction-coil I I and the supplemental condenser H and a self-induction coil I'. This system is in its practical operation the same as that of Fig. 1. In each the supplemental condenser H and K and the self-induction coil affect the constants of the resonant shunt-circuits, and by adjusting one or both the natural periods of the resonant shunt-circuits H I and K L can be adjusted until they equal the desired frequencies; but instead of indirectly affecting the constants of the resonant shunt-circuits by means of the supplemental condenser and induction-coils, as in Fig. 2, I can put the supplemental condensers directly in the resonant shunt-circuits. This is shown in Fig. 3, which, like Fig. 2, represents a modification of the receiving end shown in Fig. 1. The periodicities or frequencies of the induction-circuits H H' I and K k' L can be adjusted by adjusting the capacity of the supplemental condensers H and K and the self-induction coils I and L. The forms shown in Figs. 2 and 3 are preferable to the form shown in Fig. 1.

Each resonant shunt-circuit contains an electromagnet m or n, which may be taken as representing generically a translation device operated by the energy of the current which traverses the resonant shunt-circuit. It may be operated by this current either directly or indirectly. It is shown in Fig. 1 as operated directly since the translating device is included directly in the resonant shunt-circuit.

The disposition of the coils and condensers as shown in Figs. 2 and 3 does not differ in principle from that shown in Fig. 1, yet it

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should be noted here that my experience shows these dispositions to be more effective under certain conditions than that of Fig. 1. The dispositions give the resonant shunt-circuits a greater selectivity, and therefore I find these preferable in cases where a large number of resonant receiving-circuits are to be employed whose periods are near each other.

I do not claim in this application the method of distributing the electrical energy of periodic currents, which consists in throwing a number of such currents of different frequencies upon a single line and conveying the several energies of these currents each selectively to a separate electrical translating device; nor do I claim herein a system of distribution of electrical energy comprising a main line, means for impressing multiperiodic electromotive forces thereon, branch lines connected with the main line each having its self-induction and capacity so related as to be permeable to alternating currents of a given frequency, and an electrical receiving device in each branch line; nor do I broadly claim any method of or apparatus for distributing electromotive forces of different frequencies, each selectively, to a separate electrical translating device by the proper proportioning of the electromagnetic constants of the parts of the electrical system to be made selective and by which the translating devices are controlled either with or without any method of or arrangement of apparatus for developing upon a main line the electromotive forces of different desired frequencies independently of each other and simultaneously or otherwise, because these broad inventions are claimed substantially in my other application, Serial No. 501,092, filed February 23, 1894, for multiple telegraphy and which application is now involved in interference; nor do I broadly claim the combination, in an electric circuit, of means for imposing upon said circuit one or more electromotive forces of previously-selected periodicities, one or more circuits in inductive relation to said first-named circuit, and means for tuning the said inductively-related circuit or circuits each in resonance with one of said periodic electromotive forces and independently of the rest of the system, with or without additional means for also tuning separate branches connected to the first-named circuit, with which branches the other circuits named are inductively related, these being claimed in my other application for improvements in telegraphy, filed January 28, 1895, Serial No. 536,488, and at the transmitting-stations I prefer to use the arrangement shown and claimed in my other application for improvements in distributing electrical energy, filed May 21, 1895, Serial No. 550,058, renewed December 4, 1899, as Serial No. 739,207.

Where in the claims I specify the combination of a line-wire or a line with one or more resonant circuits without indicating that there are both receiving and transmitting circuits connected by a line-wire, I wish it to be distinctly understood that I do not limit myself to any specific means or method of transmitting from one station to another nor to any specific connection between the transmitting and receiving stations; nor do I intend, except where it is specified in the claims, to indicate definitely the arrangement which should be employed at the transmitting-station or to limit the claims with respect thereto.

It is obvious that many modifications may be made in my arrangement without departing from the spirit of my invention.

Having now fully described my invention, what I claim, and desire to secure by Letters Patent of the United States, is—

1. In an electric system the combination of a main line, mutually-independent exciting-circuits, which act upon the main line through elements placed therein in series, independent means for impressing an electromotive force of desired frequency upon the main line at each exciting circuit, mutually-independent receiving-circuits, means for tuning each receiving circuit to resonance with one of the impressed electromotive forces, and translating devices operated by the currents in the receiving circuits, substantially as described.

2. In an electric system the combination of a main line, mutually-independent exciting-circuits which act upon the main line through elements placed therein in series, independent means for impressing an electromotive force of desired frequency upon the main line at each exciting-circuit, mutually-independent receiving circuits which are acted upon from the main line through elements connected therein in series, means for tuning each receiving-circuit to resonance with one of the impressed electromotive forces, and translating devices operated by the currents in the receiving circuits, substantially as described.

3. In an electric system the combination of a main line, mutually independent exciting-circuits which act upon the main line through transformers the secondary coils of which are placed in the main line in series, independent means for impressing an electromotive force of desired frequency upon the main line at each exciting-circuit, condensers in series in the main line, a shunt around each condenser containing a self induction coil, thus forming mutually-independent receiving circuits, means for tuning each receiving-circuit to one of the impressed electromotive forces, and translating devices operated by the currents in the receiving-circuits, substantially as described.

4. In an electrical system, the combination of a line-wire, a condenser therein, a shunt around the condenser containing a self-induction coil without an iron core thus forming a resonance circuit and means for adjusting the electromagnetic constants of the resonance-circuit so as to give it a desired periodicity, substantially as described.

5. In a multiplex signaling system the com-

bination of line-wire, means for impressing thereon, independently of each other, electromotive forces of two or more distinct periodicities, two or more condensers in series in the line; a shunt around each condenser containing a self-induction coil, each condenser with its shunt-coil forming an independent resonance-circuit, receiving instruments therein, and means for adjusting the electromagnetic constants of these resonance-circuits, so as to give to each such circuit a periodicity corresponding to one of the impressed electromotive forces, substantially as described.

6. In an electrical system, the combination of a line-wire, means for impressing thereon a current of a given frequency, a condenser in the line, a shunt around the condenser containing a self-induction coil without an iron core thus forming a resonance-circuit, and means for adjusting the electromagnetic constants of the resonance-circuit so as to give it a periodicity corresponding with the frequency of the current to be impressed upon the line, substantially as described.

7. In an electrical system, the combination of the line, means for impressing thereon a current produced by two or more electromotive forces of different frequencies which are independent of each other, two or more condensers in the line in series, a shunt around each condenser containing a self-induction coil, thus forming resonance-circuits, circuits in inductive relation thereto and containing condensers and self-induction coils supplemental to those of the resonance-circuits, receiving instruments, and means for adjusting the electromagnetic constants of these resonance-circuits so as to give each such circuit a periodicity corresponding to the frequency of one of the electromotive forces impressed upon the line, substantially as described.

8. In an electrical system, the combination of a line-wire, two or more condensers connected in series therein, a shunt around each condenser containing a self-induction coil, thus forming resonance-circuits, receiving instruments therein, a supplemental condenser in each of the resonance-circuits, and means for adjusting the constants of each resonance-circuit, so as to give it a desired periodicity, substantially as described.

9. In an electrical system, the combination of a line-wire, means for impressing thereon a current produced by two or more electromotive forces of different desired frequencies, two or more condensers in the line in series, a shunt around each condenser containing a self-induction coil, thus forming resonance-circuits, means for adjusting the constants of each resonance-circuit so as to give each a periodicity corresponding to the frequency of one of the electromotive forces, and translating devices each operated by the energy of the current traversing one of the resonance-circuits, substantially as described.

10. A resonance-circuit in which the self-induction coil employed to give the circuit a definite periodicity contains no iron, substantially as described.

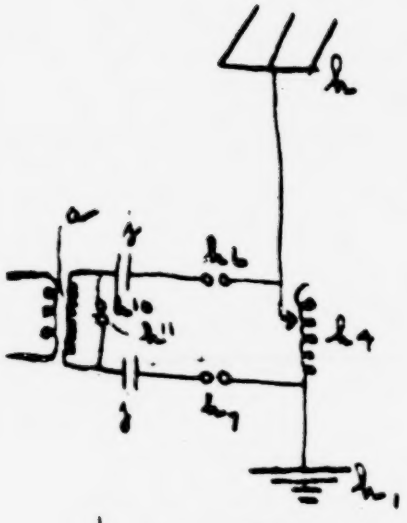
Signed in New York this 25th day of May, 1895.

MICHAEL I. PUPIN.

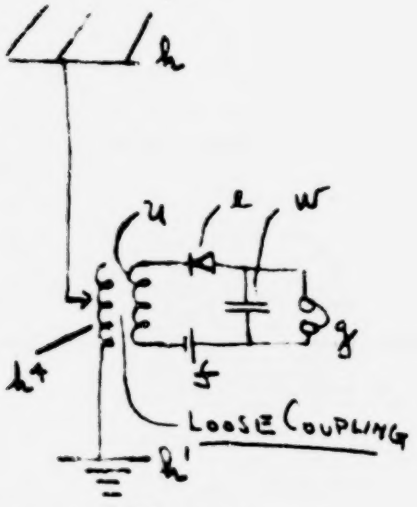
Witnesses:
S. KATHARINE PUPIN,
HY. H. WHITCOMB.

DEFENDANT'S EXHIBIT V-2

LOFTIN SKETCH L



LODGE TRANSMITTER
FIG 4 and DESCRIPTION

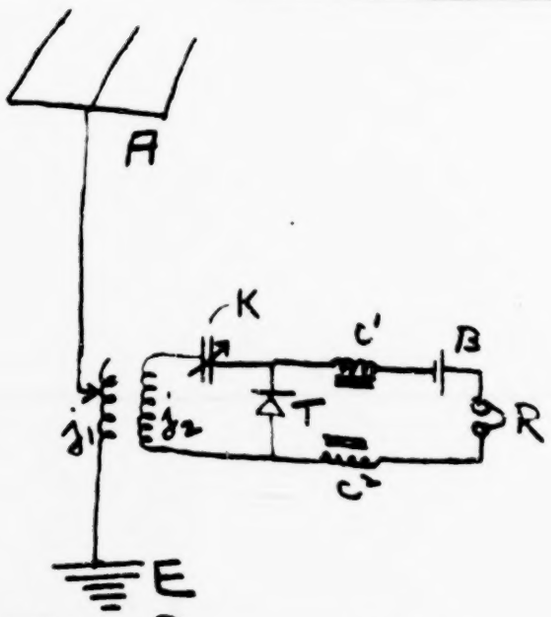


LODGE RECEIVER
FIG 13 and DESCRIPTION

LODGE PATENT 609,154
Aug 16, 1898

DEFENDANT'S EXHIBIT W-2

LOFTIN SKETCH M



MARCONI Receiver 1899
Patent 627,650 of June 27-1899
FIG 1 and DESCRIPTION

No. 645,576 Patented Mar. 20, 1900.

N. TESLA.

SYSTEM OF TRANSMISSION OF ELECTRICAL ENERGY.

Application filed Sept. 2, 1897.

No Model.

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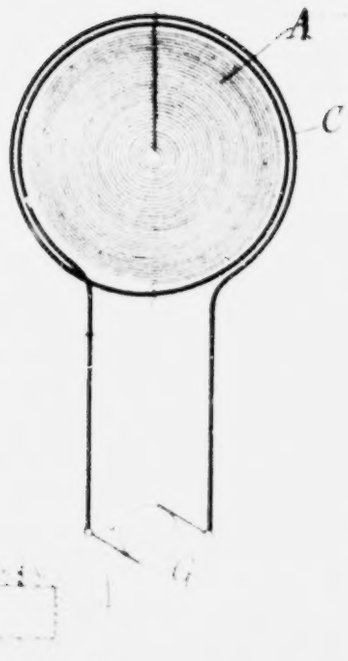

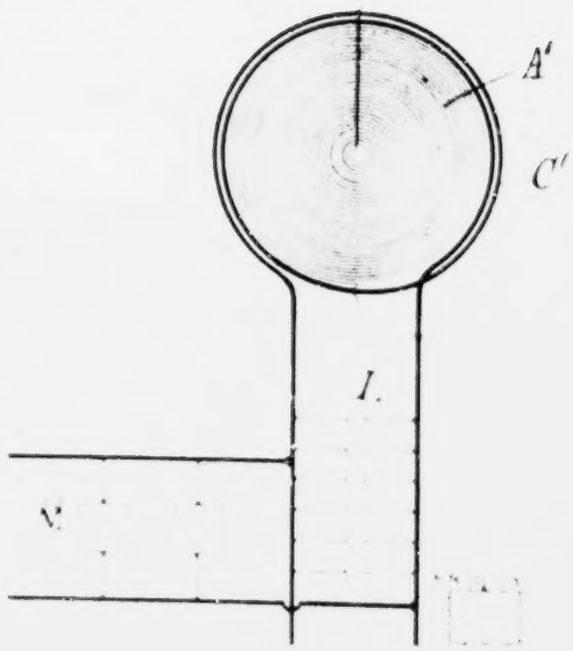

WITNESSES

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INVENTOR

Nikola Tesla

BY

Kerr, Curtis & Page

ATTORNEYS.

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UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

SYSTEM OF TRANSMISSION OF ELECTRICAL ENERGY.

SPECIFICATION forming part of Letters Patent No. 645,576, dated March 20, 1900

Application filed September 2, 1897. Serial No. 650,343. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at New York, in the county and State of New York, have invented certain new and useful Improvements in Systems of Transmission of Electrical Energy, of which the following is a specification, reference being had to the drawing accompanying and forming a part of the same.

It has been well known heretofore that by rarefying the air inclosed in a vessel its insulating properties are impaired to such an extent that it becomes what may be considered as a true conductor, although one of admittedly very high resistance. The practical information in this regard has been derived from observations necessarily limited in their scope by the character of the apparatus or means heretofore known and the quality of the electrical effects producible thereby. Thus it has been shown by William Crookes in his classical researches, which have so far served as the chief source of knowledge of this subject, that all gases behave as excellent insulators until rarefied to a point corresponding to a barometric pressure of about seventy-five millimeters, and even at this very low pressure the discharge of a high-tension induction-coil passes through only a part of the attenuated gas in the form of a luminous thread or arc, a still further and considerable diminution of the pressure being required to render the entire mass of the gas inclosed in a vessel conducting. While this is true in every particular so long as electromotive or current impulses such as are obtainable with ordinary forms of apparatus are employed, I have found that neither the general behavior of the gases nor the known relations between electrical conductivity and barometric pressure are in conformity with these observations when impulses are used such as are producible by methods and apparatus devised by me and which have peculiar and hitherto unobserved properties and are of effective electromotive forces, measuring many hundred thousands or millions of volts. Through the continuous perfection of these methods and apparatus and the investigation of the actions of these current impulses I have been led to the discovery of certain highly-important and useful facts which have hitherto been unknown. Among these and bearing directly upon the subject of my present application are the following: First, that atmospheric or other gases, even under normal pressure, when they are known to behave as perfect insulators, are in a large measure deprived of their dielectric properties by being subjected to the influence of electromotive impulses of the character and magnitude I have referred to and assume conducting and other qualities which have been so far observed only in gases greatly attenuated or heated to a high temperature, and, second, that the conductivity imparted to the air or gases increases very rapidly both with the augmentation of the applied electrical pressure and with the degree of rarefaction, the law in this latter respect being, however, quite different from that heretofore established. In illustration of these facts a few observations, which I have made with apparatus devised for the purposes here contemplated, may be cited. For example, a conductor or terminal, to which impulses such as these here considered are supplied, but which is otherwise insulated in space and is remote from any conducting-bodies, is surrounded by a luminous flame-like brush or discharge often covering many hundreds or even as much as several thousands of square feet of surface, this striking phenomenon clearly attesting the high degree of conductivity which the atmosphere attains under the influence of the immence electrical stresses to which it is subjected. This influence is, however, not confined to that portion of the atmosphere which is discernible by the eye as luminous and which, as has been the case in some instances actually observed, may fill the space within a spherical or cylindrical envelop of a diameter of sixty feet or more, but reaches out to far remote regions, the insulating qualities of the air being, as I have ascertained, still sensibly impaired at a distance many hundred times that through which the luminous discharge projects from the terminal and in all probability much farther. The distance extends with the increase of the electromotive force of the impulses, with the diminution of the density of the atmosphere, with the elevation of the active terminal above the ground, and also, apparently, in a slight measure, with the degree of moisture contained in

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the air. I have likewise observed that this region of decidedly noticeable influence continuously enlarges as time goes on, and the discharge is allowed to pass not unlike a conflagration which slowly spreads, this being possibly due to the gradual electrification or ionization of the air or to the formation of less insulating gaseous compounds. It is, furthermore, a fact that such discharges of extreme tensions approximating those of lightning, manifest a marked tendency to pass upward freely from the ground, which may be due to electrostatic repulsion, or possibly to slight heating and consequent rising of the electrified or ionized air. These latter observations make it appear probable that a discharge of this character allowed to escape into the atmosphere from a terminal maintained at a great height will gradually leak through and establish a good conducting path to more elevated and better conducting air strata, a process which possibly takes place in silent lightning discharges frequently witnessed on hot and sultry days. It will be apparent to what an extent the conductivity imparted to the air is enhanced by the increase of the electromotive force of the impulses when it is stated that in some instances the area covered by the flame discharge mentioned was enlarged more than sixfold by an augmentation of the electrical pressure, amounting scarcely to more than fifty per cent. As to the influence of rarefaction upon the electric conductivity imparted to the gases it is noteworthy that, whereas the atmospheric or other gases begin ordinarily to manifest this quality at something like seventy-five millimeters barometric pressure with the impulses of excessive electromotive force to which I have referred, the conductivity, as already pointed out, begins even at normal pressure and continuously increases with the degree of tenuity of the gas, so that at, say, one hundred and thirty millimeters pressure, when the gases are known to be still nearly perfect insulators for ordinary electromotive forces, they behave toward electromotive impulses of several millions of volts like excellent conductors, as though they were rarefied to a much higher degree. By the discovery of these facts and the perfection of means for producing in a safe, economical, and thoroughly practicable manner current impulses of the character described it becomes possible to transmit through easily-accessible and only moderately rarefied strata of the atmosphere electrical energy not merely in insignificant quantities, such as are suitable for the operation of delicate instruments and like purposes, but also in quantities suitable for industrial uses on a large scale up to practically any amount and, according to all the experimental evidence I have obtained, to any terrestrial distance. To conduce to a better understanding of this method of transmission of energy and to distinguish it clearly, both in its theoretical aspect and in its practical bearing, from other known modes of transmission, it is useful to state that all previous efforts made by myself and others for transmitting electrical energy to a distance without the use of metallic conductors, chiefly with the object of actuating sensitive receivers, have been based, in so far as the atmosphere is concerned, upon those qualities which it possesses by virtue of its being an excellent insulator, and all these attempts would have been obviously recognized as ineffective if not entirely futile in the presence of a conducting atmosphere or medium. The utilization of any conducting properties of the air for purposes of transmission of energy has been hitherto out of the question in the absence of apparatus suitable for meeting the many and difficult requirements, although it has long been known or surmised that atmospheric strata at great altitudes—say fifteen or more miles above sea-level—are, or should be, in a measure, conducting, but assuming even that the indispensable means should have been produced then still a difficulty, which in the present state of the mechanical arts must be considered as insuperable, would remain—namely, that of maintaining terminals at elevations of fifteen miles or more above the level of the sea. Through my discoveries before mentioned and the production of adequate means the necessity of maintaining terminals at such inaccessible altitudes is obviated and a practical method and system of transmission of energy through the natural media is afforded essentially different from all those available up to the present time and possessing, moreover, this important practical advantage, that whereas in all such methods or systems heretofore used or proposed but a minute fraction of the total energy expended by the generator or transmitter was recoverable in a distant receiving apparatus by my method and appliances it is possible to utilize by far the greater portion of the energy of the source and in any locality however remote from the same.

Expressed briefly, my present invention, based upon these discoveries, consists then in producing at one point an electrical pressure of such character and magnitude as to cause thereby a current to traverse elevated strata of the air between the point of generation and a distant point at which the energy is to be received and utilized.

In the accompanying drawing a general arrangement of apparatus is diagrammatically illustrated such as I contemplate employing in the carrying out of my invention on an industrial scale—as, for instance, for lighting distant cities or districts from places where cheap power is obtainable.

Referring to the drawing, A is a coil, generally of many turns and of a very large diameter, wound in spiral form either about a magnetic core or not, as may be found necessary. C is a second coil, formed of a conductor of much larger section and smaller

length, wound around and in proximity to the coil A. In the transmitting apparatus the coil A constitutes the high-tension secondary and the coil C the primary, of much lower tension of a transformer. In the circuit of the primary C is included a suitable source of current G. One terminal of the secondary A is at the center of the spiral coil, and from this terminal the current is led by a conductor B to a terminal D, preferably of large surface, formed or maintained by such means as a balloon at an elevation suitable for the purposes of transmission, as before described. The other terminal of the secondary A is connected to earth and, if desired, also to the primary in order that the latter may be at substantially the same potential as the adjacent portions of the secondary, thus insuring safety. At the receiving-station a transformer of similar construction is employed, but in this case the coil A, of relatively thin wire, constitutes the primary and the coil C, of thick wire or cable, the secondary of the transformer. In the circuit of the latter are included lamps L, motors M, or other devices for utilizing the current. The elevated terminal D is connected with the center of the coil A, and the other terminal of said coil is connected to earth and preferably, also, to the coil C for the reasons above stated.

It will be observed that in coils of the character described the potential gradually increases with the number of turns toward the center, and the difference of potential between the adjacent turns being comparatively small a very high potential, impracticable with ordinary coils, may be successfully obtained. It will be, furthermore, noted that no matter to what an extent the coils may be modified in design and construction, owing to their general arrangement and manner of connection, as illustrated, those portions of the wire or apparatus which are highly charged will be out of reach, while those parts of the same which are liable to be approached, touched, or handled will be at or nearly the same potential as the adjacent portions of the ground, this insuring, both in the transmitting and receiving apparatus and regardless of the magnitude of the electrical pressure used, perfect personal safety, which is best evidenced by the fact that although such extreme pressures of many millions of volts have been for a number of years continuously experimented with no injury has been sustained neither by myself or any of my assistants.

The length of the thin-wire coil in each transformer should be approximately one-quarter of the wave length of the electric disturbance in the circuit, this estimate being based on the velocity of propagation of the disturbance through the coil itself and the circuit with which it is designed to be used. By way of illustration if the rate at which the current traverses the circuit, including the coil, be one hundred and eighty-five thousand miles per second then a frequency of nine hundred and twenty-five per second would maintain nine hundred and twenty-five stationary waves in a circuit one hundred and eighty-five thousand miles long and each wave would be two hundred miles in length. For such a low frequency, to which I shall resort only when it is indispensable to operate motors of the ordinary kind under the conditions above assumed, I would use a secondary of fifty miles in length. By such an adjustment or proportioning of the length of wire in the secondary coil or coils the points of highest potential are made to coincide with the elevated terminals D D, and it should be understood that whatever length be given to the wires this condition should be complied with in order to attain the best results.

As the main requirement in carrying out my invention is to produce currents of an excessively high potential, this object will be facilitated by using a primary current of very considerable frequency, since the electromotive force obtainable with a given length of conductors is proportionate to the frequency; but the frequency of the current is in a large measure arbitrary, for if the potential be sufficiently high and if the terminals of the coils be maintained at the proper altitudes the action described will take place, and a current will be transmitted through the elevated air strata, which will encounter little and possibly even less resistance than if conveyed through a copper wire of a practicable size. Accordingly the construction of the apparatus may be in many details greatly varied, but in order to enable any person skilled in the mechanical and electrical arts to utilize to advantage in the practical applications of my system the experience I have so far gained the following particulars of a model plant which has been long in use and which was constructed for the purpose of obtaining further data to be used in the carrying out of my invention on a large scale are given. The transmitting apparatus was in this case one of my electrical oscillators, which are transformers of a special type, now well known and characterized by the passage of oscillatory discharges of a condenser through the primary. The source G, forming one of the elements of the transmitter, was a condenser of a capacity of about four one-hundredths of a microfarad and was charged from a generator of alternating currents of fifty thousand volts pressure and discharged by means of a mechanically-operated break five thousand times per second through the primary C. The latter consisted of a single turn of stout stranded cable of inappreciable resistance and of an inductance of about eight thousand centimeters, the diameter of the loop being very nearly two hundred and forty-four centimeters. The total inductance of the primary circuit was approximately ten thousand centimeters, so that the primary circuit vibrated generally according to adjustment,

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from two hundred and thirty thousand to two hundred and fifty thousand times per second. The high tension coil A in the form of a flat spiral was composed of fifty turns of heavily-insulated cable No. 8 wound in one single layer, the turns beginning close to the primary loop and ending near its center. The outer end of the secondary or high-tension coil A was connected to the ground, as illustrated, while the free end was led to a terminal placed in the rarefied air stratum through which the energy was to be transmitted, which was contained in an insulating tube of a length of fifty feet or more, within which a barometric pressure varying from about one hundred and twenty to one hundred and fifty millimeters was maintained by means of a mechanical suction-pump. The receiving-transformer was similarly proportioned, the ratio of conversion being the reciprocal of that of the transmitter, and the primary high-tension coil A was connected, as illustrated, with the end near the low-tension coil C to the ground and with the free end to a wire or plate likewise placed in the rarefied air stratum and at the distance named from the transmitting-terminal. The primary and secondary circuits in the transmitting apparatus being carefully synchronized, an electromotive force from two to four million volts and more was obtainable at the terminals of the secondary coil A, the discharge passing freely through the attenuated air stratum maintained at the above barometric pressures, and it was easy under these conditions to transmit with fair economy considerable amounts of energy, such as are of industrial moment, to the receiving apparatus for supplying from the secondary coil C lamps L or kindred devices. The results were particularly satisfactory when the primary coil or system A, with its secondary C, was carefully adjusted, so as to vibrate in synchronism with the transmitting coil or system A C. I have, however, found no difficulty in producing with apparatus of substantially the same design and construction electromotive forces exceeding three or four times those before mentioned and have ascertained that by their means current impulses can be transmitted through much denser air strata. By the use of these I have also found it practicable to transmit notable amounts of energy through air strata not in direct contact with the transmitting and receiving terminals, but remote from them, the action of the impulses, in rendering conducting air of a density at which it normally behaves as an insulator, extending, as before remarked, to a considerable distance. The high electromotive force obtained at the terminals of coil or conductor A was, as will be seen, in the preceding instance, not so much due to a large ratio of transformation as to the joint effect of the capacities and inductances in the synchronized circuits, which effect is enhanced by a high frequency, and it will be obvious that if the latter be reduced to a moderate number the ratio of transformation should be increased, especially in cases in which it may be deemed of advantage to suppress as much as possible, and particularly in the transmitting coil A, the rise of pressure due to the above effects and to obtain the necessary electromotive force solely by a large transformation.

While electromotive forces such as are produced by the apparatus just described may be sufficient for many purposes to which my system will or may be applied, I wish to state that I contemplate using in an industrial undertaking of this kind forces greatly in excess of these, and with my present knowledge and experience in this novel field I would estimate them to range from twenty to fifty million volts and possibly more. By the use of these much greater forces large amounts of energy may be conveyed through the atmosphere to remote places or regions, and the distance of transmission may be thus extended practically without limit.

As to the elevation of the terminals I do not it is obvious that it will be determined by a number of things, as by the amount and quality of the work to be performed, by the local density and other conditions of the atmosphere, by the character of the surrounding country, and such considerations as may present themselves in individual instances. Thus if there be high mountains in the vicinity the terminals should be at a greater height, and generally they should always be, if practicable, at altitudes much greater than those of the highest objects near them in order to avoid as much as possible the loss by leakage. In some cases when small amounts of energy are required the high elevation of the terminals, and more particularly of the receiving-terminal D, may not be necessary, since, especially when the frequency of the currents is very high, a sufficient amount of energy may be collected at that terminal by electrostatic induction from the upper strata, which are rendered conducting by the active terminal of the transmitter or through which the currents from the same are conveyed.

With reference to the facts which have been pointed out above it will be seen that the altitudes required for the transmission of considerable amounts of electrical energy in accordance with this method are such as are easily accessible and at which terminals can be safely maintained, as by the aid of captive balloons supplied continuously with gas from reservoirs and held in position securely by steel wires or by any other means, devices or expedients, such as may be contrived and perfected by ingenious and skilled engineers. From my experiments and observations I conclude that with electromotive forces greatly exceeding fifteen or twenty million volts the energy of many thousands of horse-power may be transmitted over great distances, measured by many hundreds of

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even thousands of miles, with terminals not more than thirty to thirty-five thousand feet above the level of the sea, and even this comparatively-small elevation will be required chiefly for reasons of economy, and, if desired, it may be considerably reduced, since by such means as have been described practically any potential that is desired may be obtained, the currents through the air strata may be rendered very small, whereby the loss in the transmission may be reduced.

It will be understood that the transmitting as well as the receiving coils, transformers, or other apparatus may be in some cases movable—as, for example, when they are carried by vessels floating in the air or by ships at sea. In such a case, or generally, the connection of one of the terminals of the high-tension coil or coils to the ground may not be permanent, but may be intermittently or inductively established, and any such or similar modifications I shall consider as within the scope of my invention.

While the description here given contemplates chiefly a method and system of energy transmission to a distance through the natural media for industrial purposes, the principles which I have herein disclosed and the apparatus which I have shown will obviously have many other valuable uses—as, for instance, when it is desired to transmit intelligible messages to great distances, or to illuminate upper strata of the air, or to produce, designedly, any useful changes in the condition of the atmosphere, or to manufacture from the gases of the same products, as nitric acid, fertilizing compounds, or the like, by the action of such current impulses, for all of which and for many other valuable purposes they are eminently suitable, and I do not wish to limit myself in this respect. Obviously, also, certain features of my invention here disclosed will be useful as disconnected from the method itself—as, for example, in other systems of energy transmission, for whatever purpose they may be intended, the transmitting and receiving transformers arranged and connected as illustrated, the feature of a transmitting and receiving coil or conductor, both connected to the ground and to an elevated terminal and adjusted so as to vibrate in synchronism, the proportioning of such conductors or coils, as above specified, the feature of a receiving-transformer with its primary connected to earth and to an elevated terminal and having the operative devices in its secondary, and other features or particulars such as have been described in this specification or will readily suggest themselves to a perusal of the same. I do not claim in this application a transformer for developing or converting currents of high potential in the form herewith shown and described, and with the two coils connected together as and for the purpose set forth, having made these improvements the subject of a patent granted to me November 2, 1897, No. 593,138, nor do I claim herein the apparatus employed in carrying out the method of this application when such apparatus is specially constructed and arranged for securing the particular object sought in the present invention, as these last-named features are made the subject of an application filed as a division of this application on February 19, 1900, Serial No. 5,780.

What I now claim is—

1. The method hereinbefore described of transmitting electrical energy through the natural media, which consists in producing at a generating-station a very high electrical pressure, causing thereby a propagation or flow of electrical energy, by conduction, through the earth and the air strata, and collecting or receiving at a distant point the electrical energy so propagated or caused to flow.

2. The method hereinbefore described of transmitting electrical energy, which consists in producing at a generating station a very high electrical pressure, conducting the current caused thereby to earth and to a terminal at an elevation at which the atmosphere serves as a conductor therefor, and collecting the current by a second elevated terminal at a distance from the first.

3. The method hereinbefore described of transmitting electrical energy through the natural media, which consists in producing between the earth and a generator-terminal elevated above the same, at a generating-station, a sufficiently-high electromotive force to render elevated air strata conducting, causing thereby a propagation or flow of electrical energy, by conduction, through the air strata, and collecting or receiving at a point distant from the generating-station the electrical energy so propagated or caused to flow.

4. The method hereinbefore described of transmitting electrical energy through the natural media, which consists in producing between the earth and a generator terminal elevated above the same, at a generating-station, a sufficiently-high electromotive force to render the air strata at or near the elevated terminal conducting, causing thereby a propagation or flow of electrical energy, by conduction, through the air strata, and collecting or receiving at a point distant from the generating station the electrical energy so propagated or caused to flow.

5. The method hereinbefore described of transmitting electrical energy through the natural media, which consists in producing between the earth and a generator-terminal elevated above the same, at a generating-station, electrical impulses of a sufficiently-high electromotive force to render elevated air strata conducting, causing thereby current impulses to pass, by conduction, through the air strata, and collecting or receiving at a point distant from the generating-station, the energy of the current impulses by means of a circuit synchronized with the impulses.

6. The method hereinbefore described of

DEFENDANT'S EXHIBIT Y-2

N° 20,981 A.D. 1896

Date of Application, 22nd Sept., 1896—Accepted, 21st Nov., 1896

COMPLETE SPECIFICATION.

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[Communicated from abroad by NIKOLA TESLA, of 46 East Houston Street, New York, United States of America, Electrician.]

Improvements relating to the Production, Regulation, and Utilization of Electric Currents of High Frequency, and to Apparatus therefor.

I, HENRY HARRIS LAKE, of the Firm of Haseltine, Lake & Co., Patent Agents, 45 Southampton Buildings, in the County of Middlesex, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention, subject of the present application, is embodied in certain improvements in methods of and apparatus for producing, regulating and utilizing electric currents of high frequency heretofore invented by Nikola Tesla, and described in British Letters Patent No. 8575, dated May 19, 1891. The method and apparatus referred to in said patent were devised for the purpose of converting, supplying and utilizing electrical energy in a form suited for the production of certain novel electrical phenomena which require currents of high potential and a higher frequency than can readily or even possibly, be developed by generators of the ordinary types or by such mechanical appliances as were theretofore known. The invention referred to was based upon the principle of charging a condenser or a circuit possessing capacity and discharging the same, generally through the primary of a transformer, the secondary of which constituted the source of working current, and under such conditions as to yield a vibratory or rapidly intermittent discharge current.

The present invention, while aiming to simplify and render more efficient the apparatus heretofore used, has for its object, primarily, to provide a means for converting such currents as are generally and most readily obtainable from the mains of ordinary systems of municipal distribution, into currents of the special character referred to, and to regulate or control and utilize such currents in a simple, economical and efficient manner. The improvements are illustrated herein in forms of apparatus adapted for use with existing circuits or systems, and which while constructed and operating on the same general principles are modified only as may be required by a direct or an alternating source of supply.

The apparatus by which the present improvements are carried out may be described in general terms as comprising a circuit from a given source of supply, in which is included or with which is connected any suitable device for making and breaking such circuit in the manner desired, a condenser arranged so as to be periodically charged by the said circuit through the instrumentality of the circuit controller, and a circuit, through which the condenser discharges, of such character that the discharge will take place in a series of rapidly recurring or intermittent impulses.

In the drawings which illustrate the invention,

Fig. 1 is a diagram of circuits and apparatus employed with a source of direct currents. Figs. 2 and 3 are modifications of the same.

Figs. 4, 5 and 6 illustrate the apparatus and circuit connections employed with a source of alternating current. Figs. 7, 8, 9, 10 are similar views illustrating the method of and apparatus for regulating the system.

[*Price 8d.*]

to raise the self induction therein, the motor may be connected in other ways, that is to say, its armature only may be connected with the circuit, or its field and armature coils may be in series and both connected with such circuit. This latter arrangement is illustrated in Figure 3, in which a terminal of the circuit A^{11} is connected to one of the binding posts of the motor [illegible] which the circuit is led through one field coil M, the brushes and commutator C^1 and the other field coil M^1, and thence to a brush F which rests upon the controller disk or cylinder C. The other terminal of the circuit connects with a second brush F^1 bearing on the controller, so that the current which passes through and operates the motor is periodically interrupted.

As an illustration of the various uses to which the apparatus may be put, the secondary L is shown in this figure as connected to two plates P, P, of any suitable character between which a current of air is maintained by a fan on the shaft of the motor G, for developing ozone or for similar purposes.

When the potential of the source of current periodically rises and falls, whether with reversals or not is immaterial, it is essential to economical operation that the intervals of interruption of the charging circuit should bear a definite time relation to the period of the current, in order that the effective potential of the impulses charging the condenser may be as high as possible. In case, therefore, an alternating or equivalent electromotive force be employed as the source of supply, a circuit controller is used which will interrupt the charging circuit at instants predetermined with reference to the variations of potential therein.

A convenient, and probably the most practicable means for accomplishing this is a synchronous motor connected with the source of supply and operating a circuit controller which first interrupts the charging current at or about the instant of highest intensity of each wave and then permits the condenser to discharge the energy stored in it, through its appropriate circuit. Such apparatus, which may be regarded as typical of the means for accomplishing this purpose, is illustrated in Figures 4, 5 and 6.

In Fig. 4, A^{11} A^{11} are the conductors taken from the mains of any alternating current generator A, and for raising the potential of such current a transformer is employed represented by the primary B and secondary B^1.

The circuit of the secondary includes the energizing coils of a synchronous motor G, and a circuit controller C fixed to the shaft of the motor.

An insulating arm O, stationary with respect to the motor shaft and adjustable with reference to the poles of the fixed magnets, carries two brushes F F^1 which bear upon the periphery of the disk C. With the parts thus arranged, the secondary circuit is completed through the coils of the motor whenever the two brushes rest upon the uninsulated segments of the disk, and interrupted through the motor at other times.

Such a motor, if properly constructed, in well understood ways, maintains very exact synchronism with the alternations of the source, and the arm O may, therefore, be adjusted to interrupt the current at any determined point of its waves. By the proper relations of insulated and conducting segments, and the motor poles, the current may be interrupted twice in each complete wave at or about the points of highest intensity.

In order that the energy stored in the motor circuit may be utilized at each break to charge the condenser H, the terminals of the latter are connected to the two brushes F F^1 or to points of the circuit adjacent thereto, so that when the circuit through the motor is interrupted the terminals of the motor circuit will be connected with the condenser. The discharge of the condenser takes place through the primary K, the circuit of which is completed simultaneously with the motor circuit and interrupted while the motor circuit is broken and the condenser being charged. The secondary impulses of high potential and great frequency are available for the operation of vacuum tubes P, single terminal lamps R, and other novel and useful purposes.

It is obvious that the supply current need not be alternating, provided it be

converted or transformed into an alternating current, before reaching the controller. For example, the present improvements are applicable to various forms of rotary transformers as is illustrated in Figs. 5 and 6.

G^1 designates a continuous current motor, here represented as having four field poles wound with coils E^{11} in shunt to the armature. The line wires A^{11} A^{11} connect with the brushes *b b* bearing on the usual commutator.

On an extension of the motor shaft is a circuit controller composed of a cylinder, the surface of which is divided into four conducting segments *c*, and four insulating segments *d*, the former being diametrically connected in pairs as shown in Fig. 6.

Through the shaft run two insulated conductors *e e* from any two commutator segments ninety degrees apart, and these connect with the two pairs of segments *c*, respectively. With such arrangement, it is evident that any two adjacent segments *c c* become the terminals of an alternating current source, so that if two brushes F F^1 be applied to the periphery of the cylinder they will take off current during such portion of the wave as the width of segment and position of the brushes may determine. By adjusting the position of the brushes relatively to the cylinder, therefore, the alternating current delivered to the segments *c c* may be interrupted at any point of its waves.

While the brushes F F^1 are on the conducting segments the current which they collect stores energy in a circuit of high self-induction formed by the wires *f f*, self-induction coils S S, the conductors A^{11} A^{11}, the brushes and commutator. When this circuit is interrupted by the brushes F F^1, passing onto the insulating segments of the controller, the high potential discharge of this circuit stores energy in the condensers H H which then discharge through the circuit of low self-induction containing the primary K. The secondary circuit contains any devices as P, R, for utilizing the current.

In some cases the energy delivered by the system may be readily and economically regulated. It is well known that every electric circuit, provided its ohmic resistance does not exceed certain definite limits, has a period of vibration of its own analogous to the period of vibration of a weighted spring. In order to alternately charge a given circuit of this character by periodic impulses impressed upon it and to discharge it most effectively, the frequency of the impressed impulses should bear a definite relation to the frequency of vibration possessed by the circuit itself. Moreover, for like reasons, the period of vibration of the discharge circuit should bear a similar relation to the impressed impulses or the period of the charging circuit. When the conditions are such that the general law of harmonic vibrations is followed, the circuits are said to be in resonance or in electro-magnetic synchronism, and this condition of the system is found to be highly advantageous.

In carrying out the invention, therefore, the electrical constants should be so adjusted that in normal operation the condition of resonance is approximately attained. To accomplish this, the number of impulses of current directed into the charging circuit per unit time is made equal to the period of the charging circuit itself, or, generally, to a harmonic thereof, and the same relations are maintained between the charging and discharge circuit. Any departure from this condition will result in a decreased output, and this fact is taken advantage of in regulating such output by varying the frequencies of the impulses or vibrations in the several circuits.

Inasmuch as the period of any given circuit depends upon the relations of its resistance, self-induction and capacity, a variation of any one or more of these may result in a variation in its period. There are, therefore, various ways in which the frequencies of vibration of the several circuits in the system may be varied, but the most practicable and efficient ways of accomplishing the desired result are the following:

(a) Varying the rate of the impressed impulses or those which are directed from the source of supply into the charging circuit, as by varying the speed of the commutator or other circuit controller.

(*b*) Varying the self-induction of the charging circuit.

(*c*) Varying the self-induction or capacity of the discharge circuit.

To regulate the output of a single circuit which has no vibration of its own, by merely varying its period would evidently require, for any extended range of regulation, a very wide range of variation of period. But in the system described, a very wide range of regulation of the output may be obtained by a very slight change of the frequency of one of the circuits when the above mentioned rules are observed.

Figs. 7, 8, 9 and 10 illustrate some of the more practicable means for effecting the regulation, as applied to a system deriving its energy from a source of direct currents.

In each of the figures A^{11} A^{11} designate the conductors of a supply circuit of continuous current, G a motor connected therewith in any of the usual ways, and operating a current controller C which serves to alternately close the supply circuit through the motor or through a self-induction coil, and to connect such motor circuit with a condenser H, the circuit of which contains a primary coil K, in proximity to which is a secondary coil L serving as the source of supply to the working circuit or that in which are connected up the devices P R for utilizing the current.

In order to secure the greatest efficiency in a system of this kind, it is essential, as before stated, that the circuits, which mainly as a matter of convenience are designated as the charging and the discharge circuits, should be approximately in resonance or electro-magnetic synchronism. Moreover, in order to obtain the greatest output from a given apparatus of this kind it is desirable to maintain as high a frequency as possible.

The electrical conditions, which are now well understood, having been adjusted to secure, as far as practical considerations will permit, these results, the regulation of the system is effected by adjusting its elements so as to depart in a greater or less degree from the above conditions with a corresponding variation of output. For example, as in Figure 7 the speed of the motor, and consequently of the controller, may be varied in any suitable manner, as by means of a rheostat R^1 in a shunt to such motor, or by shifting the position of the brushes on the main commutator of the motor or otherwise. A very slight variation in this respect by disturbing the relations between the rate of impressed impulses and the vibration of the circuit of high self-induction into which they are directed, causes a marked departure from the condition of resonance and a corresponding reduction in the amount of energy delivered by the impressed impulses to the apparatus.

A similar result may be secured by modifying any of the constants of the local circuits as above indicated. For example, in Figure 8 the choking coil B is shown as provided with an adjustable core N^1, by the movement of which into and out of the coil the self-induction, and consequently the period of the circuit containing such coil, may be varied.

As an example of the way in which the discharge circuit or that into which the condenser discharges, may be modified to produce the same result, there is shown in Figure 9 an adjustable self-induction coil R^{11} in the circuit with the condenser, by the adjustment of which coil the period of vibration of such circuit may be changed.

The same result would be secured by varying the capacity of the condenser, but if the condenser were of relatively large capacity this might be an objectionable plan, and a more practicable method is to employ a variable condenser in the secondary or working circuit, as shown in Figure 10. As the potential in this circuit is raised to a high degree, a condenser of very small capacity may be employed, and if the two circuits, primary and secondary, are very intimately and closely connected, the variation of capacity in the secondary is similar in its effects to the variation of the capacity of the condenser in the primary. As a means well adapted for this purpose two metallic plates S^1 S^1 adjustable to and from each other and constituting the two armatures of the condenser are shown.

The description of the means of regulation is confined herein to a source of supply of direct current, for to such it more particularly applies, but it will be understood that if the system be supplied by periodic impulses from any source which will effect the same results, the regulation of the system may be effected by the method herein described.

The circuit controller or the device which ensures the proper charging and discharging of the condenser may be of any construction that will perform the functions required of it. In illustration of the principle of construction and mode of operation, reference has been made only to forms of mechanism that make and break metallic contacts, but there need be no actual metallic contact, if provision be made for the passage of a spark between separated conductors. Such a device is illustrated in Figs. 11 to 15.

A designates, in Fig. 11, a generator having a commutator a^1 and brushes a^{11} bearing thereon, and also collecting rings b^{11}, b^{11}, from which an alternating current is taken by brushes b^1 in the well understood manner.

The circuit controller is mounted, in part, on an extension of the shaft c^1 of the generator, and in part on the frame of the same, or on a stationary sleeve surrounding the shaft. Its construction, in detail, is as follows:—

e^1 is a metal plate with a central hub e^{11} which is keyed or clamped to the shaft c^1. The plate is formed with segmental extensions corresponding in number to the waves of current which the generator delivers. These segments are preferably cut away, leaving only rims or frames, to one of the radial sides of which are secured bent metal plates i which serve as vanes to maintain a circulation of air when the device is in operation.

The segmental disk and vanes are contained within a close insulated box or case f mounted on the bearing of the generator, or in some other proper way, but so as to be capable of angular adjustment around the shaft. To facilitate such adjustment, a screw rod f^1, provided with a knob or handle, is shown as passing through the wall of the box. The latter may be adjusted by this rod, and when in proper position may be held therein by screwing the rod down into a depression in the sleeve or bearing as shown in Fig. 11.

Air passages g g are provided at opposite ends of the box through which air is maintained in circulation by the action of the vanes.

Through the sides of the box f, and through insulating gaskets h, when the material of the box is not a sufficiently good insulator, extend metallic terminal plugs l, l, with their ends in the plane of the conducting segmental disk e^1 and adjustable radially towards and from the edges of the segments.

Devices of this character are employed in the manner illustrated in Fig. 13.

A, in this figure, represents any source of alternating current, the potential of which is raised by a transformer of which B is the primary and B^1 the secondary.

The ends of the secondary circuit s are connected to the terminal plugs l, l, of an apparatus similar to that of Figures 11 and 12, and having segments rotating in synchronism with the alternations of the current source, preferably, as above described, by being mounted on the shaft of the generator, when the conditions so permit.

The plugs l, l, are then adjusted radially so as to approach more or less the path of the outer edges of the segmental disk, and so that during the passage of each segment in front of a plug a spark will pass between them, which completes the secondary circuit, s. The box, or the support for the plugs l, is adjusted angularly so as to bring the plugs and segments into proximity at the desired instants with reference to any phase of the current wave in the secondary circuit, and fixed in position in any proper manner.

To the plugs l, l, are also connected the terminals of a condenser or condensers, so that at the instant of the rupture of the secondary circuit s by the cessation of the sparks the energy accumulated in such circuit will rush into, and charge, the condenser.

A path of low self-induction and resistance, including a primary K of a few

turns, is provided to receive the discharge of the condenser, when the circuit s is again completed by the passage of sparks, the discharge being manifested as a succession of extremely rapid impulses.

By means of this apparatus effects of a novel and useful character are obtainable, but to still further increase the efficiency of the discharge or working current, there may be in some instances provided a means for further breaking up the individual sparks themselves. A device for this purpose is shown in Figures 14 and 15.

The box or case f in these figures is fixedly secured to the frame or bearing of the generator or motor which rotates the circuit controller in synchronism with the alternating source. Within said box is a disk e^1 fixed to the shaft e with projections d^1 extending from its edge parallel with the axis of the shaft. A similar disk e^1 on a spindle d^{11} in face of the first is mounted in a bearing in the end of the box f with a capability of rotary adjustment.

The ends of the projections d^1 are deeply serrated or several pins or narrow projections placed side by side, as shown in Fig. 14, so that as those of the opposite disks pass each other a rapid succession of sparks will pass from the projections of one disk to those of the other.

The invention is not limited to the precise devices or forms of the devices shown and described. For example, when the source of supply is a circuit of high self-induction no special choking coils or the like need be employed. So, too, the condenser as a distinctive apparatus may be dispensed with when the capacity of its circuit is sufficiently great to accomplish the desired result. The circuit controller may, as already explained, be very greatly modified and varied in construction and principle of operation without departure from the invention.

In the illustrations given of the circuit controller, the contacts and insulating spaces are arranged for charging and discharging a single condenser, but it is obvious that a single motor and circuit controller may be used to operate more than one condenser, by charging one while discharging the other or others.

Having now particularly described and ascertained the nature of the said invention and in what manner the same is to be performed, as communicated to me by my foreign correspondent, I declare that what I claim is:—

1. The apparatus herein described for converting electric currents of the kind generally obtainable from municipal systems of electric distribution, into currents of high frequency, comprising in combination a circuit of high self-induction, a circuit controller adapted to make and break such circuit, a condenser into which the said circuit discharges when interrupted, and a transformer through the primary of which the condenser discharges, as set forth.

2. The combination with a circuit of high self-induction and means for making and breaking the same, of a condenser around the point of interruption in the said circuit, and a transformer the primary of which is in the condenser circuit, as described.

3. The combination with a circuit having a high self-induction, of a circuit controller for making and breaking said circuit, a motor for driving the controller, a condenser in a circuit connected with the first around the point of interruption therein, and a transformer the primary of which is in circuit with the condenser, as set forth.

4. The combination with an electric circuit of a controller for making and breaking the same, a motor included in or connected with said circuit so as to increase its self-induction and driving the said controller, a condenser in a circuit around the controller, and a transformer through the primary of which the condenser discharges, as set forth.

5. The combination with a circuit of direct current, of a controller for making and breaking the same, a motor having its field or armature coils or both included in said circuit and driving said controller, a condenser connected

with the circuit around the point of interruption therein, and a transformer, the primary of which is in the discharge circuit of the condenser, as set forth.

6. The method herein described of converting alternating currents of relatively low frequency into currents of high frequency, which consists in charging a condenser by such currents of low frequency during determinate intervals of each wave of said current, and discharging the condenser through a circuit of such character as to produce therein a rapid succession of impulses, as set forth.

7. The combination with a source of alternating current, a condenser, a circuit controller adapted to direct the current during determinate intervals of each wave into the condenser for charging the same, and a circuit into which the condenser discharges, as set forth.

8. The combination with a source of alternating current, a synchronous motor operated thereby, a circuit controller operated by the motor and adapted to interrupt the circuit through the motor at determinate points in each wave, a condenser connected with the motor circuit and adapted on the interruption of the same to receive the energy stored therein, and a circuit into which the condenser discharges, as set forth.

9. The combination with a source of alternating current, a charging circuit in which the energy of said current is stored, a circuit controller adapted to interrupt the charging circuit at determinate points in each wave, a condenser for receiving, on the interruption of the charging circuit, the energy accumulated therein, and a circuit into which the condenser discharges when connected therewith by the circuit controller, as set forth.

10. The method of regulating the energy delivered by a system for the production of high frequency currents, and comprising a supply circuit, a condenser, a circuit through which the same discharges, and means for controlling the charging of the condenser by the supply circuit and the discharging of the same, the said method consisting in varying the relations of the frequencies of the impulses in the circuits comprising the system, as set forth.

11. The method of regulating the energy delivered by a system for the production of high frequency currents comprising a supply circuit of direct currents, a condenser adapted to be charged by the supply circuit and to discharge through another circuit, the said method consisting in varying the frequency of the impulses of current from the supply circuit, as set forth.

12. The method of producing and regulating electric currents of high frequency which consists in directing impulses from a supply circuit into a charging circuit of high self-induction, charging a condenser by the accumulated energy of such charging circuit, discharging the condenser through a circuit of low self-induction, raising the potential of the condenser discharge and varying the relations of the frequencies of the electrical impulses in the said circuits, as set forth.

13. The combination with a source of current, of a condenser adapted to be charged thereby, a circuit into which the condenser discharges in a series of rapid impulses, and a circuit controller for effecting the charging and discharge of said condenser, composed of conductors movable into and out of proximity with each other, whereby a spark may be maintained between them and the circuit closed thereby during determined intervals, as set forth.

14. The combination with a source of alternating current, of a condenser adapted to be charged thereby, a circuit into which the condenser discharges in a series of rapid impulses, and a circuit controller for effecting the charging and discharge of said condenser composed of conductors movable into and out of proximity with each other in synchronism with the alternations of the source, as set forth.

15. A circuit controller for systems of the kind described, comprising in combination a pair of angularly adjustable terminals and two or more rotating conductors mounted to pass in proximity to the said terminals, as set forth.

16. A circuit controller for systems of the kind described, comprising in

combination two sets of conductors, one capable of rotation and the other of angular adjustment whereby they may be brought into and out of proximity to each other at determinate points and one or both being subdivided so as to present a group of conducting points, as set forth.

Dated this 22nd day of September 1896.

HASELTINE, LAKE & Co.,
45 Southampton Buildings, London, W.C., Agents for the Applicant.

London: Printed for Her Majesty's Stationery Office, by Darling & Son, Ltd.—1896

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SHEET 1

Fig. 1

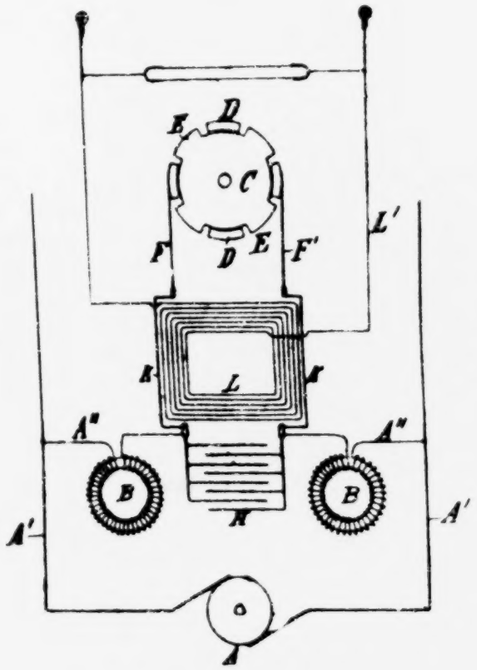


Fig. 2

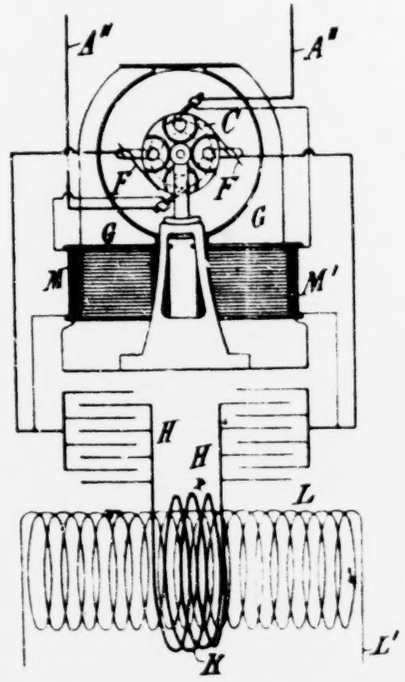


Fig. 3

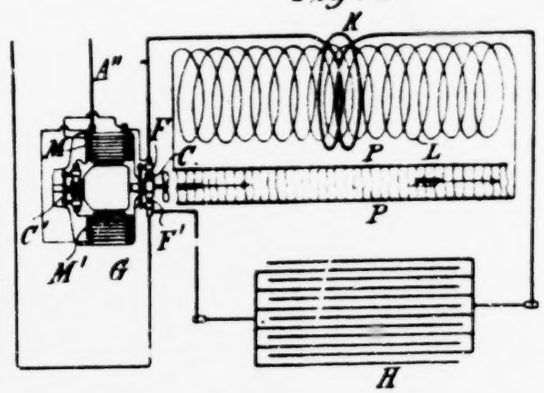


Fig. 9

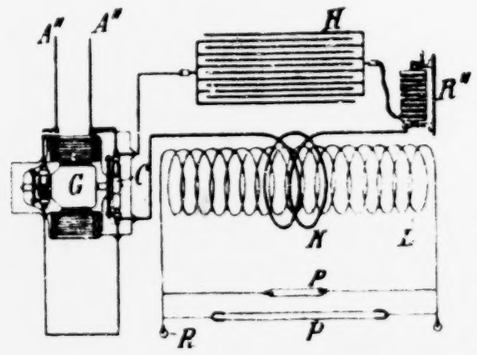


Fig. 7

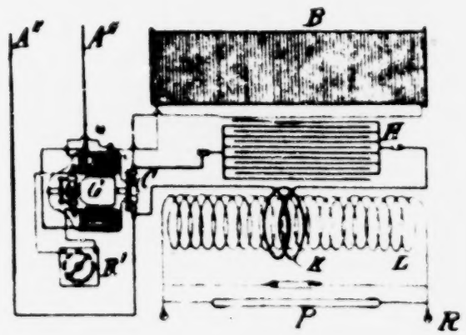


Fig. 8

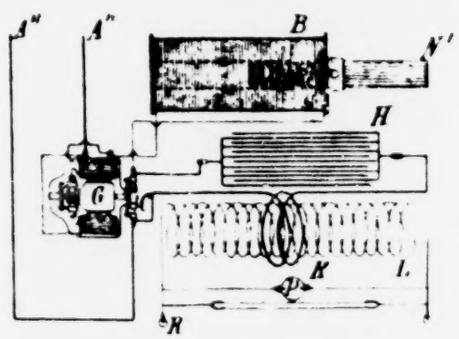
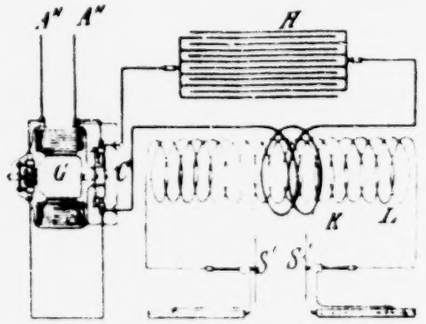


Fig. 10



[This Drawing is a reproduction of the Original on a reduced scale.]

A.D. 1896 SEP. 22. N° 20,981
LAKE'S COMPLETE SPECIFICATION

Fig. 4

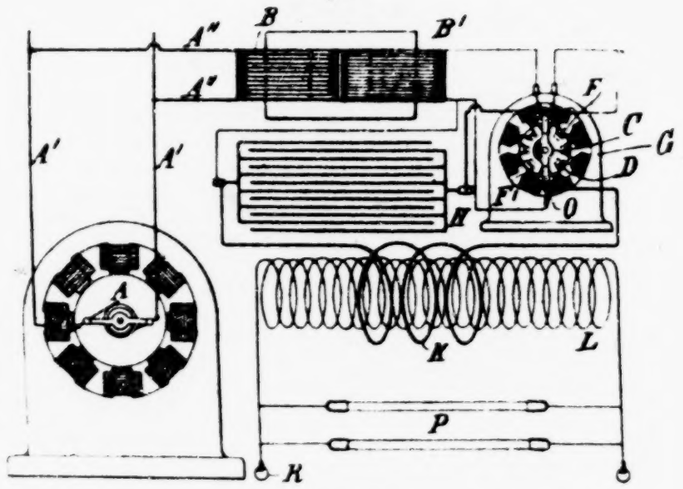


Fig. 5

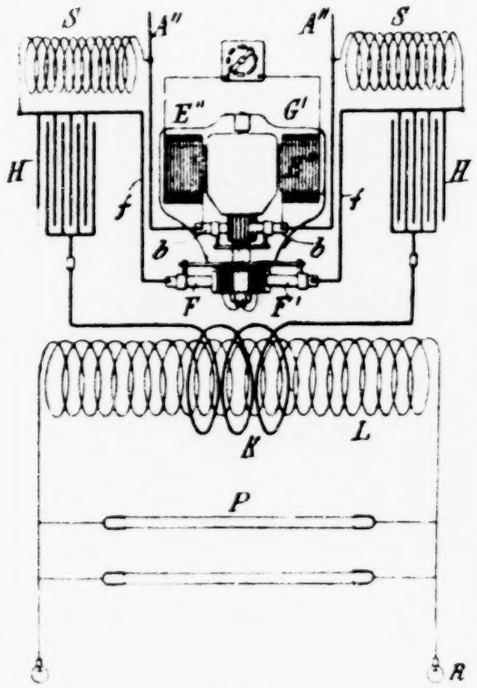


Fig. 6

Fig. 11

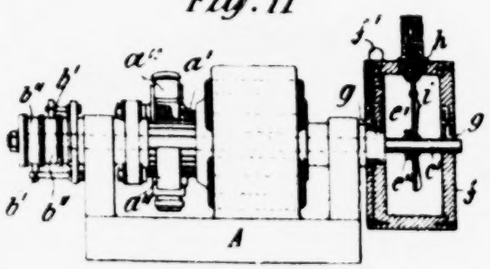


Fig. 12

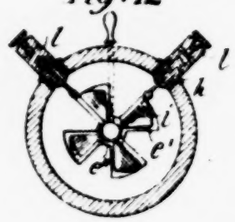


Fig. 13

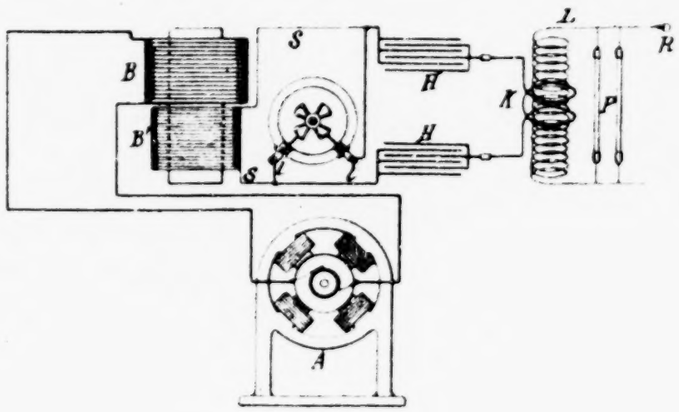


Fig. 14

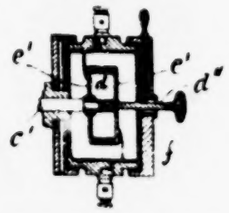


Fig. 15

[This Drawing is a reproduction of the Original on a reduced scale.]

London: Printed by Darling and Son, Ltd.
for Her Majesty's Stationery Office. 1896.

vibrations is that their potential and amplitude, and thereby the energy transmitted is more easily increased. When the Hertzian waves are used there is a certain length of spark which must not be exceeded if the circuit is required to excite vibrations; otherwise the vibrations would be damped too much, the constraint of the system giving way gradually instead of suddenly, but this means that the effective potential is limited, which if lower oscillations are used either does not occur, or can be very easily avoided.

I have found by experiments that the oscillations produced by the discharge of Leyden jars of usual size in a circuit having moderate self-induction, are very convenient for the purpose of transmitting signals, and the experiments also shew that with an equal expenditure of energy in the transmitting circuit it is preferable to use the slower vibrations.

Dated this 26th day of January 1899.

W. P. THOMPSON & Co.,
322, High Holborn, London, W.C. Patent Agents for the Applicant.

COMPLETE SPECIFICATION.

Improvements relating to the Transmission of Electric Telegraph Signals without Connecting Wires.

I, FERDINAND BRAUN, Professor and Doctor of Philosophy, of No. 1, Universität Strasse, Strassburg, in the Province of Alsace, German Empire, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

My invention relates to the transmission of electric signals without connecting wires, and comprises the improvements hereinafter indicated.

The electrical vibrations may be classified into three groups.

The first group includes vibrations which are created by the relative mechanical movement of magnets and coils. These may be called electromagnetic vibrations, and are exemplified in the well known ordinary alternating currents, as used for electric light and transmission of power. Their frequency will obviously be limited by the physical conditions of machinery.

A second group of electrical vibrations has been investigated by Feddersen, and others, and these vibrations consist of oscillations which are produced by the discharge of Leyden jars with or without induction coils in circuit. The frequency of these oscillations is considerably higher than the frequency of the electromagnetic vibrations above referred to.

Third group of vibrations is that first studied by the late Dr. Hertz, and known now as Hertzian waves, and in the production of these the capacity in the circuit is not produced by means of Leyden jars and special induction coils but the capacity and induction of ordinary conductors are used.

Hitherto the attention of inventors has been principally confined to Hertzian waves for the transmission of signals between two circuits without the use of connecting wires and one object has been to increase the frequency of these waves as much as possible in order to obtain propagation in a line as straight as possible. This is exemplified by the use of the Righi transmitter. For the transmission of signals in this manner it is essential, however, that the transmitting and receiving circuits should be, so to speak, visible to each other as stated by Dr. Hertz in one of his earlier papers concerning the transmission of electric waves, and by Professor Slaby's experiments it has been shewn that various material

objects, such as sails, smoke, trees, buildings and the like, interposed between the circuits, weaken or in some cases entirely prevent communication between the same.

My invention is partially intended to obviate this inconvenience, and I do this by making use of electrical oscillations belonging to the second group above mentioned, and which have only a small frequency compared with the frequencies hitherto adopted. By this means, owing to the length of the waves, these latter are able to pass through conductors of these are of moderate thickness only. Furthermore, obstacles in the path of the waves will not project such sharply defined shadows, the waves passing round them in a manner similar to that in which sound waves pass round obstacles. Another and perhaps even more important advantage in using slower vibrations is that their potential and amplitude, and thereby the energy transmitted, is more easily increased. When the Hertzian waves are used there is a certain length of spark which must not be exceeded if the circuit is required to excite vibrations, otherwise the vibrations would be damped too much, the constraint of the system giving way gradually instead of suddenly, but this means that the effective potential is limited, which if slower oscillations are used either does not occur or can be very easily avoided.

I have found by experiments that the oscillations produced by the discharge of Leyden jars of usual size in a circuit having moderate self-induction, are very convenient for the purpose of transmitting signals, and the experiments also shew that with an equal expenditure of energy in the transmitting circuit it is preferable to use the slower vibrations.

The Leyden jar or whatever other apparatus used for the production of the electric impulses is connected with the spark gap of a Rhumkorff apparatus or a Wimshurst influence machine and provided with the well known vertical sending wire preferably of considerable length. In the receiving station the ordinary arrangement may also be used for the vertical receiving wire, the coherer, local battery and signalling device, such as Morse or the like.

In order that the invention may be clearly understood I have shown in the accompanying drawings by way of example some arrangements of circuits for transmitting signals by means of the electric oscillations above described.

In Figure 1 a Leyden jar indicated at F has its inner and outer coatings connected through the air gap σ, a coil P of small self-induction being included in the circuit. The inner coating is connected to the transmitting wire M. The jar is charged in the usual manner by means of an influence machine, inductorium or other suitable means.

In Figure 2 a secondary coil S is provided communicating with the transmitting wire M so that the oscillatory currents in the coil P are transformed into currents at an increased potential.

In place of one jar two or more can be used connected in parallel or in series. Figure 3 for example shews two jars arranged in series, or as commonly called in "cascade".

Figure 4 shows an arrangement similar to Figure 3, but in which the current is transformed, a secondary coil S being connected with the transmitting wire M.

The invention is not limited to the precise arrangements or circuits shown in the drawings, as these can be varied very considerably, and electrical oscillations of a low frequency suitable for transmitting signals according to my invention can be produced in various other ways.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is

1. The improvement in the transmission of electrical signals without connecting wires, which consists in using electrical vibrations of comparatively low frequency such as are produced by the discharge of Leyden jars, either with or without induction coils in circuit, substantially as described.

2. For the system of wireless transmission of electrical signals the combination with a transmitting device, consisting of a spark producer, condensers and vertical sending wire, of a receiving device, consisting of a receiving wire, local battery, coherer and signalling apparatus, substantially as described.

Dated the 23rd day of October 1899.

W. P. THOMPSON & Co.,
Of London, Liverpool, Manchester, and Birmingham.

Redhill: Printed for Her Majesty's Stationery Office, by Malcomson & Co., Ltd.—1900.

A.D. 1899. Jan 26. N° 1862.

BRAUN'S Complete Specification. 1 SHEET

Fig. 1.

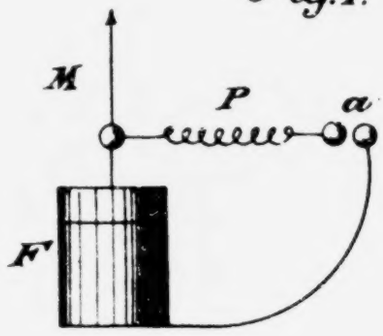


Fig. 2.

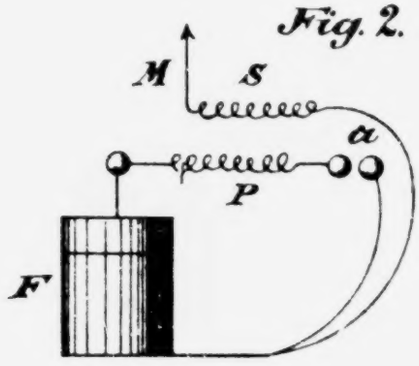


Fig. 3.

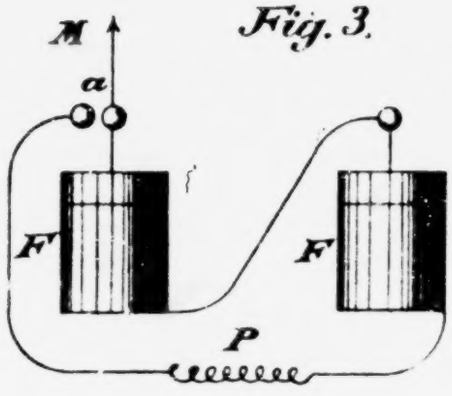
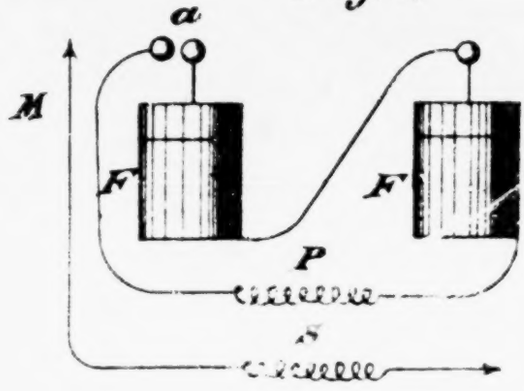


Fig. 4.



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3184-3185

intercepting wires a length of wire or a device acting by induction or capacity, or both, in such a way that it produces a difference of path of half a wave length.

Both arrangements may also be combined.

It is also possible to make the transmitter out of two crossed systems insulated from each other and to form the receiver in the same way taking care of favourable conditions of capacity. The horizontally polarised waves pass through the vertical wires or rods and *vice versa*. The advantage lies in being able to regulate the capacity and in the symmetry of arrangement and compactness within a small space which renders possible a metallic protection against unexpected interruptions.

The current collected from the frame can also be conveyed to a small primary coil and transformed in a secondary coil to greater potential, and then the coherer be excited thereby.

Moreover two metal balls, which are in so intimate contact with each other as the particles of a coherer can be inserted in the intercepting wire the quick oscillations produced thereby are conducted to the coherer. This may be of advantage in dealing with very slow waves.

The transmitter and receiver, or one of them, can also consist of plate coils or of solenoids of the usual form.

Dated the 14th day of June 1899.

W. P. THOMPSON & Co.,
322, High Holborn, London, W.C., Patent Agents for the Applicant.

COMPLETE SPECIFICATION.

Improvements in Wireless Telegraphy.

I, FERDINAND BRAUN, Professor and Doctor of Philosophy, of No. 1, Universitat Strasse, Strasburg, in the Alsace, German Empire, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

It has already been proposed in wireless telegraphy to attach a large metal plate to the receiving wire with the object of strengthening the action thereby. But in the same degree as (under the most favourable conditions) the absolute quantity of electricity intercepted is increased, the surface to be charged is also correspondingly increased, so that the increase of potential on which the excitation of the coherer specially depends is not thereby arrived at. In conformity with this conclusion experiments have shown that this arrangement is practically useless.

The following arrangement is intended to obviate this defect.

This invention is shown by the figures (1—10), which are diagrams of the arrangements and the electrical connections, similar reference letters being provided for similar parts.

A number of parallel wires, as thin as possible, a^1, a^2, a^3 and so forth are stretched as to form a grating parallel to the direction of the electric vibrations of the transmitter; they are connected to the coherer C by means of a common connecting wire. Herein use is made of the discovery that the electro-static lines of force as well as the dielectric displacement currents when in the neighbourhood of conductors tend to come nearer to one another. In this manner practically the entire electric energy of the induction falling on the surface, is intercepted, whilst the capacity is very small. The potentials

are therefore high and the reaction favourable, as proved by experiment. The wire can of course be distributed as on a cylindrical surface.

Fig. 2 shows a symmetrical arrangement, K is a condenser, C the coherer, the action of these elements being so well known as to need no further description.

The electrodynamic reactions which occur in the single wires are hereby obviously increased only with regard to the free charges thus produced and as soon as their quantity is sufficient for the capacity of the coherer and the neighbouring surface to be charged, then practically the limit of the reaction is reached.

In order also to sum up the induced electro-motive forces, the wires must be connected in series. But doing so, as indicated in Fig. 3, then one would come to no result because, if in the front wires a^1, a^3, a^5 and so forth turned towards the transmitter, currents in the upward direction were induced then the same amount of potential would be produced in the wires a^1, a^3, a^5 and so forth, on the other side of the grating but in the opposite sense, and therefore the windings would neutralise one another. The following arrangement (Fig. 4) avoids this defect. Between the front and back wires and insulated from them a sheet of metal is inserted. This protects the back wires from direct induction so as to make them serve essentially only as conducting wires in order to sum up the electro-motive forces induced in the front side. The same object can be attained by protecting the leading off wires by surrounding metal (say in the shape of a tube).

The metal sheet may in practise be replaced by wire gauze and there is even some action if it is quite absent as the front wires themselves partially screen the back ones if suitably placed.

Finally the same object may be attained as indicated in Fig. 5. When between front and back intercepting wires a length of wire is operatively connected by means of induction or capacity or both, which wire is of such a length as to produce a difference of course of half a wave length.

Fig. 6 shows a combination of the two arrangements.

Fig. 7 a symmetrical arrangement; K is a condenser C the corresponding tube.

It is also possible to make the transmitter out of two systems of grating arranged crosswise and insulated from each other (Fig. 8) and to form the receiver in the same way having regard to favourable conditions of capacity. The horizontally polarised waves pass through the vertical wires or rods and vice versâ. The advantage lies in the possibility of regulating the capacity and the symmetry of arrangement and compactness within a small space which renders possible a metallic protection against unexpected disturbance.

The current collected from the frame can also be conveyed to a small primary coil I and transformed in a secondary coil II to greater potential, and then the coherer be excited thereby.

Moreover two metal balls S^1, S^2 can be inserted in the intercepting wire especially in dealing with the interior of a coherer, and the quick oscillations produced thereby are conducted to the coherer.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. An intercepting apparatus for telegraphy by electrical waves consisting of a system of parallel wires for the incoming electrical vibrations, which wires may be connected either in parallel or in series substantially as described.

2. The special arrangement of arranging the wires in two planes lying one behind the other between which planes is placed a metal plate or a lattice, substantially as described.

3. Connections between the wires devised by means of resistance, capacity or

self induction to displace the phase of the front set of wires half a wave length against the back set substantially as described

4 Two gratings of wire crossing each other at right angles and one lying behind the other, substantially as described.

Dated the 13th day of March 1900.

W. P. THOMPSON & Co.,
Of London, Liverpool, Manchester and Birmingham.

Redhill: Printed for Her Majesty's Stationery Office, by Malcomson & Co., Ltd.—1900.

Fig. 1.

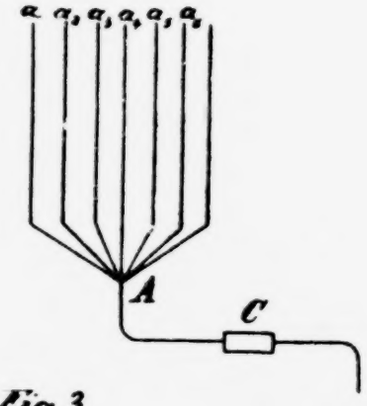


Fig. 2.

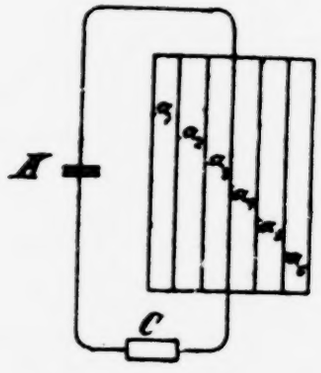


Fig. 3.

Fig. 4.

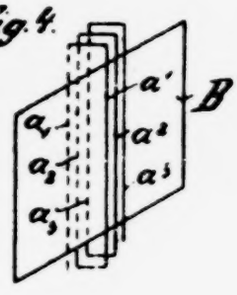


Fig. 5.

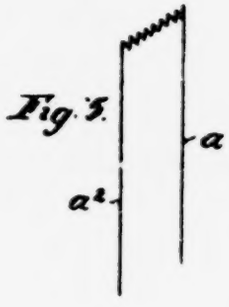


Fig. 6.

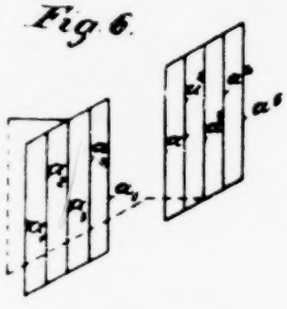


Fig. 7.

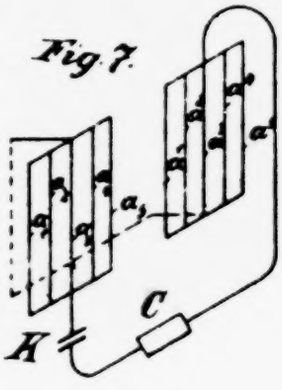


Fig. 8.

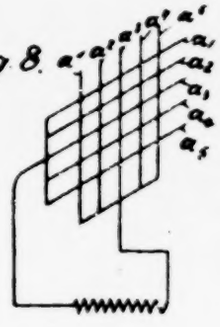


Fig. 9.

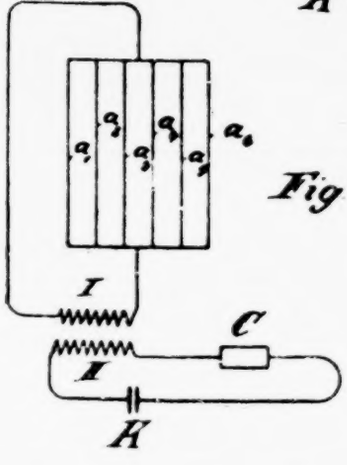


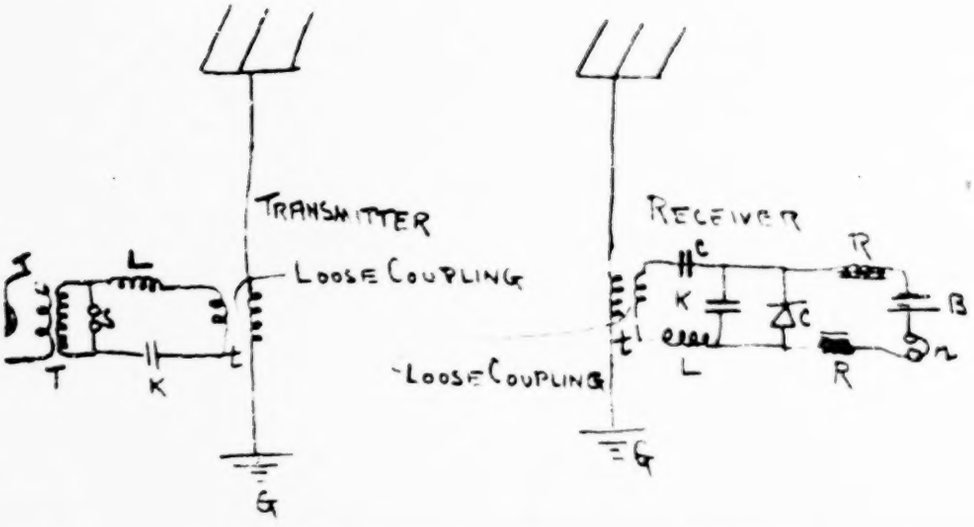
Fig. 10.

[This Drawing is a reproduction of the Original on a reduced scale.]

Malby & Sons Photo-Litho

DEFENDANT'S EXHIBIT B-3

LOFTIN SKETCH N



STONE 4-TUNED CIRCUIT SYSTEM
STONE-BAKER LETTERS 1891
STONE PATENT 714,756

Loftin Sketch O

Quenched Gap System.

Fig 6

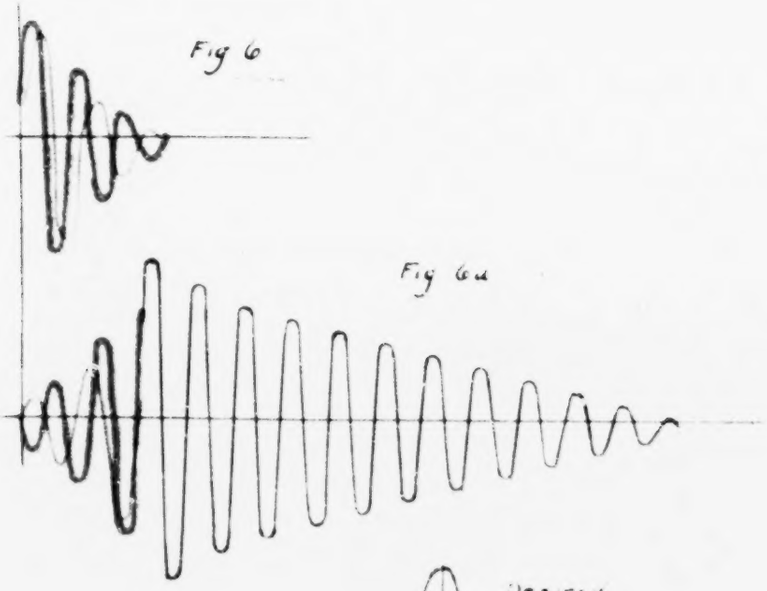


Fig 6a

Fig 6b

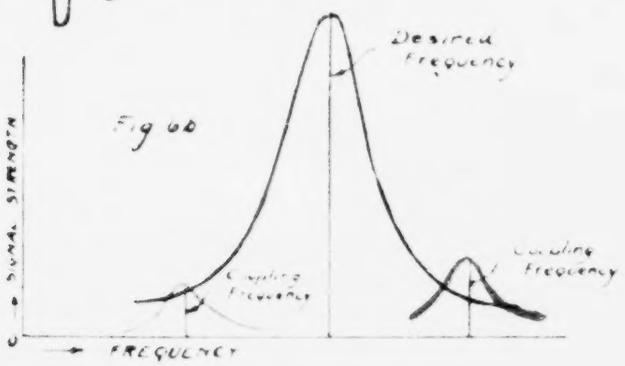
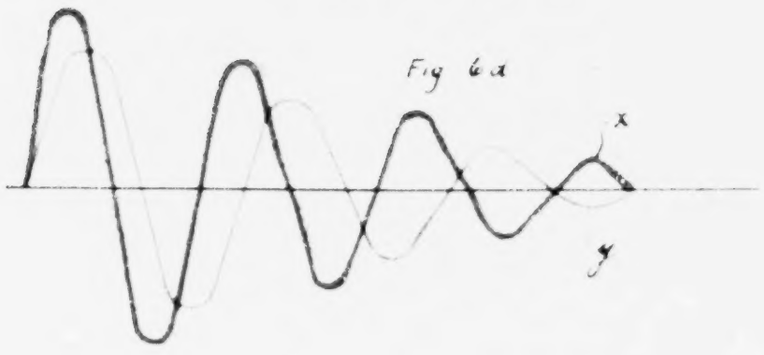


Fig 6c



DEFENDANT'S EXHIBIT E-3

(Defendant's Exhibit No. 2, Baker deposition)

Boston, July 22, 1893.

Mr. John Stone Stone,
Phillips Building,
Boston, Mass.

My dear Stone:- June 20th

Your letters of July 18th and ~~20th~~ last were received in due course, and have been read with great interest. The "selective" methods of space telegraphy therein described I believe I understand sufficiently to set up and operate them.

Allow me to add that this specialization of the work which Marconi's experiments to date leave in rather primitive condition, is very important, and should be prosecuted without delay by way of further development, and protection by letters-patent.

Yours very cordially,

Luther B. Baker

June 30th 1919

My dear Bryan:-

One other limitation to the utility of the vertical wire open telegraphy system is that the radiations emanate in all directions from the transmitting wire so that within the sphere of influence of one vertical wire, all other vertical wire stations, in effect, get the signals sent from this wire and may not only pick the signals sent from it, but will be interfered with if it is the purpose of receiving signals from any other vertical wire station from which they may be attempting to receive a communication.

This difficulty may be overcome by using transmitting wires giving forth simple harmonic signal waves and receiving station signal waves or stations only capable of receiving simple harmonic signal waves.

In the existing vertical wire stations, the waves sent out and the waves received are complex harmonic waves owing to the fact that the vertical wires are not simple resonators but are capable, upon having their electrical equilibrium abruptly disturbed, of developing oscillations of a

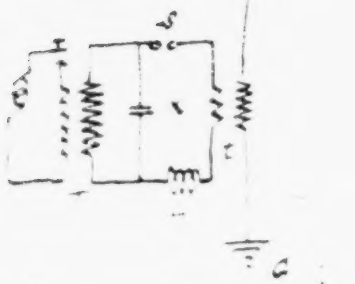
considerable number of different frequencies and also an capable of responding more or less powerfully to a correspondingly large number of different frequencies.

Instead of utilizing the vertical wire itself at the transmitting station as the oscillator, I propose to impress upon this vertical wire, oscillations from an oscillator, which oscillations shall be of a frequency corresponding to the fundamental of the wire. Similarly at the receiving station, I shall draw from the vertical wire, only that component of the complex wave which is of lower frequency.

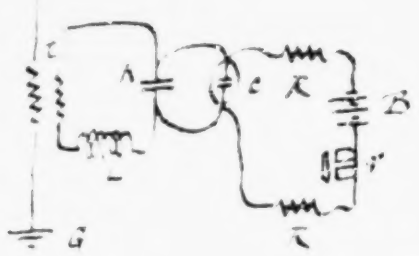
If now the fundamental of the wire at the receiving station be the same as that of the wire at the transmitting station, then the receiving station may receive signals from the transmitting station, but if it be different from that of the transmitting station, it may not receive those signals.

By such an arrangement it is obvious we shall be enabled to have a large number of vertical wire stations or numbers

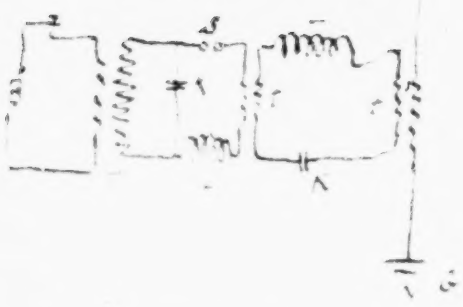
distinct from each other and receiving
stations capable of only receiving the signals
sent from the transmitting station
or stations from which it is adjusted to
receive signals and the transmitting and
receiving stations may not then interfere
with the operation of neighbouring stations.
An arrangement of the apparatus is shown
below.



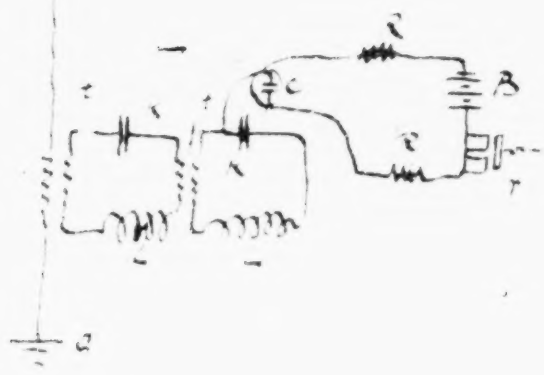
Transmitting Station



Receiving Station



Transmitting Station



Receiving Station

In these sketches, G is ground, X is condenser, C is
coil, L is inductance coil without iron,
T is step up transformer, t is transformer
with iron core, R is potentiometer coil, B is battery,
V is relay.

The tuning of these circuits one to another
and all to the same frequency will probably
be best accomplished empirically, though
the basic general proportions may be de-
termined mathematically.

Please let me know if the description I
have given in this letter is sufficient to give
you an intelligent understanding of the in-
vention and ~~to enable you~~ in your belief to
enable you to set up and operate the in-
vention without more experimental work
than that preparing to place the circuits.

Cordially yours

John Stone Stone

3653-1

Subject: Spark Telegraphy

July 15 1899

My dear Baker

As few men there who have made a special study of the subject are familiar with some of the theoretical considerations which are involved in spark telegraphy by the so called Hertzian or vortex wire system, I send you a brief description of the phenomena and of the theory.

In the usual arrangement, the essential apparatus is that shown diagrammatically in Fig 1 below in which A is the transmitting station and A' is the receiving station.

a = battery

b = key

c = inductance

d = circuit breaker

e = to primary of the spark coil I

f = secondary " " " I'

g = a spark gap

h = vertical wire

i = ground connection

k = balance

Fig. 1

When the key K is depressed the primary circuit becomes a high potential difference coil necessary which proceeds to charge the vertical wire to a high potential relative to the earth. This potential difference increases till it is sufficient to break down the air gap e whereupon the vertical wire discharges to earth through the spark gap the resistance of which is now insignificant relative to the impedance of the secondary S. The discharge of the vertical wire is oscillatory in character owing to the electro

at the capacity and inductance coefficients of self induction of the vertical wire, but owing to the fact that the electro-static capacity is distributed along the wire and is measured not uniformly distributed the different points along the wire (being at different distances from the earth) the oscillations are not simple harmonic in character but may be represented by a Fourier Series,

$A_0 + A_1 \sin pt + A_2 \sin 2pt + A_3 \sin 3pt + \&c$

$+ B_0 + B_1 \cos pt + B_2 \cos 2pt + B_3 \cos 3pt + \&c.$

The oscillatory discharge of the vertical wire sets up corresponding electro-magnetic waves surrounding it, part of which are radiated with the velocity of light.

These electro magnetic radiations, upon passing the vertical wire at the receiving station set up corresponding electro-motive forces in it. You may, if you please, regard the electro-motive forces as due to the lines of magnetic force cutting the vertical wire at the receiving station.

The electro-motive forces as set up may similarly be represented by a corresponding

Fourier's series:

$A_1' \sin p\theta + A_2' \sin 2p\theta + A_3' \sin 3p\theta + \&c$

$B_0 + B_1' \cos p\theta + B_2' \cos 2p\theta + B_3' \cos 3p\theta + \&c.$

Then since $\frac{1}{R}$ of the secondary electricity being sent to the bridges of these slight electro-motive forces and the impedance of the coils R being very great to such high frequency electro-motive forces they act in full force upon the coherer & which is surrounded by very high resistance but which when acted upon by these rapidly varying electro-motive forces is broken down as coherers and its resistance enormously diminished.

The diminution in the resistance of the coherer permits a current from the battery E of the secondary station to pass through the coherer and this current operates the secondary instrument B.

Such in brief is the general system.

In my arrangement the vibratory current overlapped in the patent wire is not due to the oscillatory discharge of the wire but is due to a simple harmonic electro-

motive force impressed upon it which electro-
motive force produces forced current
vibrations in the wire which forced vi-
brations as is well known depend for
their period and form only upon the
period and form of the impressed force
and not upon the electro-magnetic con-
stants of the circuit in which they are
enveloped as is the case with free or
natural vibrations of a system.
The current in the vertical wire in
any system may therefore be repre-
sented by a simple harmonic

$A_2 \sin pt$

and if the period of the impressed force
be the same as that of the fundamental
of the vertical wire, then it may be
represented by

$A_a \sin pt$.

The radiations will also be simple har-
monic and of the same period $\frac{1}{p}$
and will develop in the vertical wire
at the receiving station a corresponding
simple harmonic electro-motive force

of periodicity of
I mean the existence of the preceding
station a permanent circuit time to
the periodicity of. Under these circum-
stances the existence will be effected
by the sufficient from the preceding
station disturbance, but if a second
preceding station develops radiations of
periodicity of, materially different from
that the preceding apparatus will
not be affected by these radiations
even the circuit in which the existence
is created is practically effective to these
radiations as are in perfect synchronism &
the current which these radiations are
capable of exciting.
The prior transmitting circuit shown in
my letter to you of June 30th is practically
the same as that employed by Tesla for
the production of high frequency currents
except that I place an inductance coil L
in the circuit to give additional means of
tuning and to overcome by its greater in-
fluence the reaction from the induction

current developed at the transmitting station. Again the inductance of the coil L should be made large compared to the inductance of the secondary of the inductive coil t at the receiving station in order to obtain well defined resonance to a single frequency.

I believe that I was the first to discover that it was convenient to place an auxiliary inductance coil of large inductance in a secondary circuit in order to render it resonant to a definite frequency. I have also shown that it accomplishes this purpose.

In the second use of transmitting and receiving stations shown in my letter to you of June 30 ultimo, everything is the same as that shown in the first two diagrams except that an additional resonant circuit attuned to the same frequency as the others, is interposed between the vertical wire and the transmitting and receiving apparatus for the purpose of additionally sifting out the undesired harmonics..

A modification of the receiving circuit shown in my previous letter to you and a modification which I believe would be useful consist in interchanging the position of the condenser K and spark gap S in the transmitting circuit as shown in Fig 2 below.

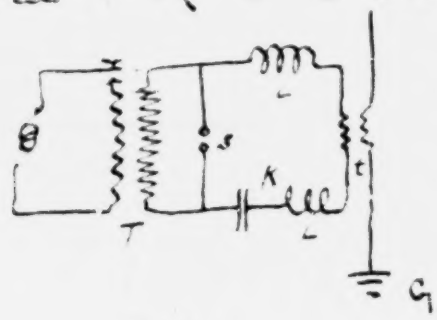


Fig 2.

A secondary effect of compensating low inductance coupling between the antenna circuit and the transformer T which has its advantages and others is due likelihood to the derived circuit through the secondary of T producing a disturbance in the periodicity of the current developed in the primary circuit B - S. K -

Cordially yours

John Stone Stone

[fol. 3207] Answer. I think so.

34. Dedirect question. Does that apply to any other part of this article?

Answer. I am afraid I do not understand your question.

35. Redirect question. Was any other part of this article as here copied written then for the first time?

Answer. The article in the book?

36. Redirect question. By "article" I mean these notes?

Answer. That is the only thing; yes, sir.

37. Redirect question. Do you now remember how you came to make this addition to the notes?

Answer. After having reread the article referred to in the lecture, I probably jotted that down to indicate the particular bearing on the subject in question.

DEFENDANT'S EXHIBIT E-3

(Defendant's Exhibit No. 1, Baker deposition)

Boston, July 22, 1899.

MR. JOHN STONE STONE,
Phillips Building, Boston, Mass.

MY DEAR STONE:

Your letters of July 18th and June 20th last were received in due course, and have been read with great interest. The "selective" methods of space telegraphy therein described I believe I understand sufficiently to set up and operate them.

Allow me to add that this speculation of the work which Marconi's experiments to date leave in rather primitive condition is very important and should be prosecuted without delay by way of further development and protection by letters patent.

Yours very cordially, Joseph B. Baker.

DEFENDANT'S EXHIBIT H-3

(Defendant's Exhibit No. 4, Baker deposition)

In The United States Patent Office. Serial No. 44384. Room No. 91. Application of JOHN STONE STONE, for Apparatus for Selective Electric Signaling. Filed January 23, 1901

Affidavit of Joseph B. Baker

JOSEPH B. BAKER, of lawful age, being duly sworn, deposes and says as follows:

I am well acquainted with Mr. John Stone Stone, the applicant in the above-entitled case, having been associated with him for several years at the laboratory of the American Bell Telephone Co. at Boston, where I was engaged in electrical experimentation for that company.

I am a graduate of the Massachusetts Institute of Technology with the degree of electrical engineer, and for some [fol. 3208] years acted as electrician for the American Telephone and Telegraph Company at Boston.

I have carefully examined a copy of the specification and drawings in the above-entitled case. Prior to November, 1899, Mr. Stone, the applicant, sent to me at Newton, Mass., by mail, a full and complete written description with drawings of the invention described and claimed in this case, which I duly received and read and fully understood. Also, prior to the time above named, I wrote and mailed to Mr. Stone a letter in which I stated that I had received his description and understood it and believed myself capable of putting the same in practice.

Joseph B. Baker.

Boston, Mass., March 18, 1901.

Subscribed and sworn to before me. Charles C. Kurtz, *Notary Public.*

Defendant's Exhibit 1-3

(Defendant's Exhibit No. 5, Baker deposition)

In the United States Patent Office. Room 109. Application of John Stone Stone for patent for improvement in space telegraphy. Serial number 182544. (Case F.) Filed November 24, 1903

State of Massachusetts,
County of Suffolk, ss:

Joseph E. Baker, of lawful age, being first duly sworn, deposes and says, as follows:

I reside at Wellesley Hills, in the county of Norfolk and State of Massachusetts.

I am well acquainted with Mr. John Stone Stone, the applicant named in the above-entitled case, having been associated with him for several years at the laboratory of the American Bell Telephone Company at Boston, where I was engaged in electrical experimentation for that company.

I am a graduate of the Massachusetts Institute of Technology with the degree of electrical engineer and for some years acted as electrician for the American Telephone and Telegraph Company at Boston.

Prior to December 15, 1899, I received from Mr. Stone two letters containing a full and complete written description with drawings of a system of selective electric signaling by simple harmonic electromagnetic waves.

Also prior to December 15, 1899, I wrote and mailed to Mr. Stone a letter in which I stated that I had received his description and understood it and believed myself capable of putting the same in practice.

The photolithographic copies of the letters annexed hereto and marked "Exhibit A" and "Exhibit B" are facsimiles of the letters received by me from Mr. Stone as aforesaid. [fol. 3299] The photolithographic copy of the letter annexed hereto and marked "Exhibit C" is a facsimile of the letter sent by me to Mr. Stone in acknowledgment of his letters, as aforesaid.

I am the same Joseph B. Baker who executed an affidavit to substantially the same facts set forth above on March 18, 1901, which affidavit I am informed and believe now forms a

part of the record of patent No. 714831 in the archives of the United States Patent Office.

The letter referred to by me in said affidavit is the same letter referred to herein, a copy of which is hereunto annexed as "Exhibit A."

(Signed) Joseph B. Baker.

Sworn and subscribed before me this 29th day of January, 1904. (Signed) Benj. F. Haines, *Notary Public.*

DEFENDANT'S EXHIBIT K-3

(Defendant's Exhibit No. 7, Stone deposition)

Joseph B. Baker, consulting electrical engineer. Office and laboratory, 40 Lincoln St., Boston. Telephone 1293 Oxford.

Boston, June 3, 1902.

ALEXANDER P. BROWNE, ESQ.,
31 *State Street*, Boston, Mass.

MY DEAR BROWNE:

In accordance with your letter of May 28th, I have hunted up three letters written me by Stone in the summer of 1899. I hope one or more of these will be useful to you.

The letters herewith are of date June 23, 1899, June 30, 1899, and July 18, 1899.

Very truly yours, Joseph B. Baker.

DEFENDANT'S EXHIBIT N-3

(Defendant's Exhibit No. 10, Stone deposition)

Boston, July 22, 1899.

MR. JOHN STONE STONE:
Phillips Building, Boston, Mass.

MY DEAR STONE: Your letters of July 18th and June 20 last were received in due course and have been read with great interest. The "selective" methods of space telegraphy

therein described I believe I understand sufficiently to set up and operate them.

Allow me to add that this specialization of the work, which Marconi's experiments to date leave in rather primitive condition, is very important, and should be prosecuted without delay by way of further development, and protection by letters.

Yours very cordially, Joseph B. Baker.

[fol. 3210] As it was necessary to send the original to Heliotype Printing Co., 211 Tremont St., on January 4th, 1904, the above copy was made by me on that date, and I hereby state it to be a true copy of the original document.

G. A. Higgins. (Seal.)

Then personally appeared before me the said G. A. Higgins and made oath that the foregoing statements by her are true.

George Lemist Clarke, *Notary Public.* (Seal.)

I hereby certify that I have compared the original letter from Joseph B. Baker to Mr. John Stone Stone, dated Boston, July 22d, 1899, with the above copy and find the above to be a true copy of the original letter before mentioned.

George Lemist Clarke, *Notary Public.*

DEFENDANT'S EXHIBIT P-3 3648

UNITED STATES PATENT OFFICE.

JOHN STONE STONE, OF BOSTON, MASSACHUSETTS, ASSIGNOR TO LOUIS E. WHICHER, ALEXANDER P. BROWNE, AND BRAINARD T. JUDKINS, TRUSTEES.

METHOD OF SELECTIVE ELECTRIC SIGNALING.

SPECIFICATION forming part of Letters Patent No. 714,756, dated December 2, 1902

Application filed February 8, 1900. Serial No. 4,505. (No model.)

To all whom it may concern:

Be it known that I, JOHN STONE STONE, a citizen of the United States, residing at Boston, in the county of Suffolk and State of Massachusetts, have invented certain new and useful Improvements in Methods of Selective Electric Signaling, of which the following is a specification.

My invention relates to the art of transmitting intelligence from one station to another by means of electromagnetic waves without the use of wires to guide the waves to their destination; and it relates more particularly to the system of such transmission in which the electromagnetic waves are developed by producing electric vibrations in an elevated conductor preferably vertically elevated.

Heretofore in signaling between two stations by means of electromagnetic waves when the stations are not connected by a conducting-wire certain disadvantageous limitations have been observed which greatly militated against the commercial value of the methods employed. When the electromagnetic waves are developed by producing natural or forced electric vibrations in a horizontal conductor, the attenuation of the waves so developed as they travel away from the conducter is found to be so great as to very seriously limit the distance to which they may be transmitted and effectively received, the chief cause of this observed phenomenon probably being that owing to the horizontal position of the conductor the plane of polarization of the waves is such as to cause the rapid absorption of the energy of the waves by the conducting-surface of the earth or water over which they travel. This difficulty has been overcome by a method of developing the waves which consists in producing natural electric vibrations in a vertically elevated conductor, in which case the plane of polarization of the wave so produced is at quadrature with that of the waves which may be developed by a horizontal wire, and in case of the vertical conductor the attenuation of the waves is observed to be very much less than in the case of the horizontal conductor, so that these waves may be transmitted to and effectively received at much greater distances. A limitation of the commercial utility of this system is, however, observed, which depends upon the fact that it has not heretofore been found possible, so far as I am aware, to direct signals sent out from a transmitting-station to the particular receiving-station with which it is desired to communicate to the exclusion of other receiving-stations equipped with equally or more sensitive receiving apparatus and located within the radius of influence of the sending-station. Electromagnetic waves have also been developed by producing natural or forced electric oscillations in loops or coils of wire at the transmitting-station and also by means of the discharge of electricity between two conducting spheres, cylinders, or cones; but in such cases the sphere of influence is so limited as to greatly restrict the commercial utility of these two methods of developing the signal-waves. In fine, the method of signaling by means of electromagnetic waves between stations not connected by a conducting-wire, in which method the electromagnetic waves are developed by electric vibrations in an elevated conductor, has great advantages over the other existing or proposed methods for accomplishing this purpose in which the electromagnetic waves are developed by other means, since in the case of the waves developed by the elevated-conductor method the waves may be transmitted to and effectively received at greater distances than by the other systems; but whereas in the systems employing the other methods of generating the waves the signals developed may, at least theoretically, be directed to the particular receiving-station with which it is desired to communicate to the exclusion of other similar receiving-stations in the neighborhood. It has heretofore been found impossible, so far as I know, to accomplish this purpose in the system employing an elevated conductor or wire as the source of the electromagnetic waves.

The object of this invention is to overcome the hereinbefore-described limitation to the system in which the waves emanate from vertical conductors, so that in such systems the transmitting-stations may selectively trans-

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mit their signals each to a particular receiving-station simultaneously or otherwise without mutual interference.

It is also the object of the invention to provide means whereby each of a plurality of transmitting and receiving stations in such a system may be enabled to selectively place itself in communication with any other station to the exclusion of all the remaining stations.

It is further the object of the present invention to enable the vertical or elevated conductor in such a system to be made the source of simple harmonic electromagnetic waves of any desired frequency independent of its length and other geometrical constants. Thus the frequency impressed upon the elevated conductor may or may not be the same as the natural period or fundamental of such conductor; but, as will be hereinafter explained, an elevated conductor that is aperiodic may be employed and is best adapted for use when the apparatus is to be used successively for different frequencies, and such aperiodic elevated conductor is likewise the preferred form of elevated conductor when two or more frequencies are to be simultaneously impressed upon or received by a single elevated conductor; but forced simple harmonic electrical vibrations of different periodicities may each be separately impressed upon a different elevated conductor, and the several energies of the resulting electromagnetic waves may be selectively conveyed each to a separate translating device.

Before proceeding to describe the invention certain fundamental principles relative to electrical vibrations should be stated, as these principles are involved in the art of signaling by means of what may be called "unguided electromagnetic waves."

If the electrical equilibrium of a conductor be abruptly disturbed and the conductor thereafter be left to itself, electric currents will flow in the conductor, which tend to ultimately restore the condition of electrical equilibrium. These currents may be either unidirectional or oscillatory in character, depending upon the relation between the principal electromagnetic constants of the conductor—*i. e.*, upon its electromagnetic and electrostatic capacities and its resistance. These phenomena are analogous to the mechanical phenomena which are observed when the mechanical equilibrium of a system is abruptly disturbed and the system is thereafter left to itself. In the case of a mechanical system motions result which tend to restore the mechanical equilibrium of the system. These motions may consist either of a unidirectional displacement or of to and fro vibrations of the system or parts of the system, depending upon the relations which subsist between the principal mechanical constants of the system—*i. e.*, its moments of mass and elasticity and its friction coefficients. In general the determination of the relations which must subsist in order that an oscillatory restoration of equilibrium shall take place, either in an electric or in a mechanical system, and the determination of the period of these oscillations is very difficult; but in certain simple cases both the determination of the conditions for an oscillatory restoration of equilibrium and of the period of these oscillations is quite simple.

An example of a simple mechanical system capable of an oscillatory restoration of equilibrium is to be found in the torsional pendulum, which consists of a highly elastic wire fixed at one end and supporting at its other extremity a heavy mass called the "bob." If a torsional stress be imparted to the wire of this pendulum by turning the bob about the axis of the wire and the bob be then abruptly released, the pendulum will in general execute isochronous oscillations about the axis of the suspending-wire in the process of restoration of equilibrium. An example of a simple electrical system capable of an oscillatory restoration of equilibrium is to be found in the case of a circuit consisting simply of a condenser and a coil without iron in its core, as shown in Figure 1 of the accompanying drawings, in which C is a condenser and I is a coil without iron in its core. If a charge of electricity be imparted to the condenser and if its electrodes be then connected to the coil, as shown in Fig. 1, an isochronous oscillatory current will in general be developed in the circuit in the process of restoration of its electrical equilibrium. Such a simple circuit as that shown in Fig. 1 is known as a system with a single degree of freedom, and the electric oscillations which it supports when its equilibrium is abruptly disturbed and it is then left to itself are known as the natural vibrations or oscillations of the system. These vibrations begin with a maximum of amplitude and gradually die away in accordance with what is known as an "exponential" law and are what are known as "simple harmonic vibrations." They may be represented graphically as in Fig. 2, in which A is a curve drawn to rectangular coordinates, in which the ordinates represent instantaneous values of current strength and the abscissæ represent times. When two such simple circuits are associated together inductively, as shown in Fig. 3, the system so formed is known as a system of two degrees of freedom, and in the oscillatory restorations of equilibrium of such a system the vibrations in such circuits—the currents—are in general not simple harmonic in character, but in general consist of the superposition of two simple harmonic currents, as shown in Fig. 4. In general, if a simple circuit, as shown in Fig. 1, be associated together in a system either by conductive or by inductive connections a system of at least [illegible] of freedom results, and the natural oscillations of such a system will therefore consist of the superposition of at least [illegible] currents. It is, moreover, a fact that the

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ent simple harmonic components of the oscillations which together constitute the oscillatory restoration of equilibrium of a complex system are in general not the same as those of the separate simple circuits when these circuits are isolated from one another; but the presence of each simple circuit modifies the natural period of each of the other circuits with which it is associated. Thus in a particular case if there be two simple circuits, the first with a natural period of .004 of a second when isolated, and the second with a period of .0025 of a second when isolated; these circuits when inductively connected, as shown in Fig. 3, may have an oscillatory restoration of equilibrium of which the simple harmonic components are .00444 of a second, and .00159 of a second, showing that the inductive association of the circuits together has increased the natural period of the high-period circuit, and decreased the natural period of the low-period circuit. It is, moreover, to be remembered that during the restoration of electric equilibrium currents of each of the periods are found in each of the circuits of the connected system.

So far we have considered the natural vibrations of electric systems—*i. e.*, the electric vibrations, by means of which the electric equilibrium of circuits is restored after it has been abruptly destroyed and the circuits are left to themselves—and we have compared the simple case of such natural electric vibrations with the corresponding natural mechanical vibrations of mechanical systems. We have seen that simple circuits may have simple harmonic natural electric oscillations and that complex circuits will in general have complex electric oscillations. We have, moreover, seen that the natural period of oscillations depended upon the electromagnetic constants of the circuit in the case of a simple circuit and that each of the periods of oscillation in the case of a complex or of interrelated circuits depended upon the electromagnetic constants of each of the interrelated circuits; but, besides the ability to execute natural vibrations or oscillations both electric and mechanical systems are capable of supporting what are termed "forced vibrations," and in the case of forced vibrations the period of the vibration is independent of the electromagnetic constants of the circuit, on the one hand, and the mechanical constants of the mechanical system, on the other hand, and depends only upon the period of the impressed force. Thus if a simple harmonic electromotive force be impressed upon a circuit free from hysteresis, whether it be a simple circuit or a complex of simple circuits, the forced vibrations or currents resulting from this impressed force will also be simple harmonic and of the same period as that of the impressed force.

In the present system of signaling by means of electromagnetic waves, in which a vertical conductor is employed as the source of electromagnetic radiations, the electric oscillations are of the kind hereinbefore described as natural vibrations, the vertical conductor being charged to a high potential relative to the surrounding earth and permitted to abruptly discharge to earth by means of an electric spark between two ball-electrodes. In such a method of developing the electromagnetic waves the oscillations are necessarily of a complex character, and therefore the resulting electromagnetic waves are of a complex character and consist of a great variety of superimposed simple harmonic vibrations of different frequencies. The vibrations consist of a simple harmonic vibration of lower period than all the others, known as the "fundamental," with a great variety of simple harmonics of higher periodicity superimposed thereon. Similarly the vertical conductor at the receiving-station is capable of receiving and responding to vibrations of a great variety of frequencies, so that the electromagnetic waves which emanate from one vertical conductor used as a transmitter are capable of exciting vibrations in any other vertical wire as a receiver, and for this reason any transmitting-station in a system of this character will operate any receiving-station within its sphere of influence, and the messages from the transmitting-station will not be selectively received by the particular receiving-station with which it is desired to communicate, but will interfere with the operation of other receiving-stations within its sphere of influence, thereby preventing them from properly responding to the signals of the transmitting-stations from which they are intended to receive their signals.

By my invention the vertical conductor of the transmitting-station is made the source of electromagnetic waves of but a single periodicity, and the translating apparatus at the receiving-station is caused to be selectively responsive to waves of but a single periodicity, so that the transmitting apparatus corresponds to a tuning-fork sending but a single simple musical tone, and the receiving apparatus corresponds to an acoustic resonator capable of absorbing the energy of that single simple musical tone only. When, however, the elevated conductor is aperiodic, it is adapted to receive or transmit all frequencies, and accordingly a single aperiodic elevated conductor may be associated with a plurality of local circuits, each attuned to a different frequency after the manner now well known in the art of multiple telegraphy by wire conductors.

When a single elevated conductor is to be made a source of a plurality of signal-waves of different frequences and when, moreover, these signal-waves are to be simultaneously developed, it is obviously necessary that the trains of waves of different frequencies developed at the elevated conductor shall be

independent of each other—i. e., it is necessary that the electric vibrations of one frequency impressed upon the elevated conductor shall not be affected by the set of signals simultaneously impressing vibrations of another frequency upon the conductor. The manner of developing the individual electric vibrations of a particular frequency described in this specification is such as to insure *per se* the required independence of the vibrations when several different frequencies are simultaneously impressed upon the elevated conductor. Several forms of such arrangements of the apparatus will, nevertheless, be herein after fully described in order to add to the completeness of the specification.

When the apparatus at a particular station is attuned to the same periodicity as that of the electromagnetic waves emanating from a particular transmitting-station, then this receiving-station will respond to and be capable of selectively receiving messages from that particular transmitting-station to the exclusion of messages simultaneously or otherwise sent from other transmitting stations in the neighborhood which generate electromagnetic waves of different periodicities. Moreover, by my invention the operator at the transmitting or receiving station may at will adjust the apparatus at his command in such a way as to place himself in communication with any one of a number of stations in the neighborhood by bringing his apparatus into resonance with the periodicity employed by the station with which communication is desired.

In order that the vertical conductor at the transmitting station shall generate harmonic electromagnetic waves of but a single frequency, I cause the electric vibrations in the conductor to be of a simple harmonic character, and this in turn I accomplish by producing what are substantially forced electric vibrations in the vertical conductor instead of producing natural vibrations in the conductor, as has heretofore been practiced. In order that the electric translating apparatus at the receiving station shall be operated only by electric waves of a single frequency and by no others, I interpose between the vertical conductor at the receiving station and the translating devices a resonant circuit or circuits attuned to the particular frequency of the electromagnetic waves which it is desired to have operate the translating devices.

Having thus described, broadly, the nature and object of the invention and the electrical principles upon which it is based, the details of the invention may best be described by reference to the drawings which accompany and form a part of this specification. The same letters, so far as may be, represent similar parts in all the figures.

Figs. 1 to 4 are diagrams already referred to. Fig. 5 is a diagram illustrating one arrangement of the transmitting-station. Fig. 6 is a diagram illustrating an arrangement of the receiving-station. Fig. 7 is a diagram illustrating another form of the transmitting-station. Fig. 8 is a diagram illustrating another form of the receiving-station. Figs. 9 and 15 are diagrams illustrating a detail of the construction at both transmitting and receiving stations. Figs. 10 and 11 are diagrams illustrative of the connection of the coherer at receiving-stations. Fig. 12 is a diagram illustrating the connection of a condenser-telephone at the receiving-station. Figs. 13 and 16 are diagrams illustrative of forms of transmitter-stations capable of developing signal-waves of two different frequencies. Figs. 14 and 17 are diagrams illustrative of forms of receiving stations capable of receiving selectively signal-waves of two different frequencies.

In the drawings, represents a vertical or virtually vertical conductor grounded in the earth connection E.

M, M', M'', and M''' are induction-coils whose primary and secondary wires are I_1, I_2, and I_3 and I_4, I_5, I_6, I_7, respectively.

L_1, L_2, and L_3 are auxiliary inductance-coils.

C, C', C'', and C''' are electrical condensers.

K and K_1 are coherers.

B is an electric battery.

a is an alternating-current generator.

k and k_1 are circuit-closing keys.

R and R' are telegraphic relays or other suitable electric translating devices.

p and *p'* are automatic circuit-interrupters.

s and *s'* are spark-gaps.

In the organization illustrated in Fig. the generator a develops an alternating electromotive force of moderate frequency, and when the key k is depressed develops a current in the primary circuit of the transformer M. The transformer M is so designed as to transform the electromotive force in the primary circuit to a very high electromotive force in the secondary. As the potential difference at the terminals of the secondary rises, the charge in the condenser C rises until the potential difference is sufficient to break down the dielectric at the spark-gap. When this occurs, the condenser C discharges through the spark s and the primary I_1 and inductance-coil L_1. This discharge is oscillatory in character and of very high frequency, as will be explained hereinafter. The high-frequency current so developed passing through the primary I_1 induces a correspondingly high frequency electromotive force and current in the secondary I_2, and forced electric vibrations result in the vertical conductor, which are practically of a single harmonic character. These simple harmonic vibrations in the conductor A develop electromagnetic waves, which are also practically simple harmonic in character, and these in turn impinging upon the vertical conductor at the receiving-station develop

corresponding simple harmonic vibrations of like frequency.

In the organization illustrated in Fig. 6 the simple harmonic electromagnetic waves of a given frequency or periodicity impinging upon the vertical conductor *r* develop therein corresponding electrical vibrations of like frequency. By means of the induction-coil M a vibratory electromotive force corresponding in frequency to the electric vibrations in the conductor *r* is induced in the secondary circuit I_1 L C C'. If the frequency of this induced electromotive force is that to which the circuit I_1 L C C' is attuned, there will be a maximum potential difference developed at the plates of the condenser C, and this potential will operate the coherer K. When the coherer K operates, the resistance of the circuit B R K is enormously diminished and the battery B develops a current which operates the translating device R. The decoherer (not shown in the drawing) is thereby set in operation and as soon as the impulse passes the coherer is restored to its sensitive condition. If, however, the frequency of the electromagnetic waves which impinge upon the vertical conductor *r* of the receiving-station depicted in Fig. 6 is not the same as that to which the circuit I_1 L C C' is attuned, the electromotive force induced in this circuit will be different from that to which the circuit will respond by virtue of resonance and there will be but a negligible potential difference developed at the plates of the condenser C. Under these circumstances the coherer K will not be operated and the signals will not actuate the translating device R.

When transmitting-stations and a corresponding number of receiving-stations are employed by adjusting the electromagnetic constants of the circuits at the various receiving-stations, these circuits may be so proportioned or tuned that the energy of the electromagnetic waves emanating from any given transmitting-station will be selectively received and absorbed at a given receiving-station.

Before proceeding to a description of the operation of the other two forms of transmitting and receiving stations shown in Figs. 7 and 8 it is to be noted that the condenser C in Fig. 5 discharges through the circuit *s* I_1 L, and its discharge is practically unaffected by its conductive connection with the circuit through I'_2. The reason for this is that the impedance offered by the circuit through I'_2 is enormously greater than that through *s* I_1 L. Also the discharge through the circuit *s* I_1 L is of very great frequency, because the frequency of the oscillations of such discharges of condensers is approximately inversely proportional to the square root of the product of the inductance of the circuit by the capacity of the condenser, and for the purpose of this invention the apparatus is so designed that the product of the capacity of the condenser by the inductance of the circuit is made numerically very small. Moreover, the oscillations in the circuit *s* I_1 L are approximately simple harmonic in character and are practically unaffected by the inductive association with the vertical wire, because of the auxiliary inductance furnished by the coil L, it being capable of demonstration that if by means of the coil L the inductance of the circuit L I_1 *s* is rendered large compared to the mutual inductance between this circuit and the vertical wire the natural oscillations which will take place in the circuit *s* I_1 L will be practically unaffected by the inductive association with the vertical wire and will therefore be practically of a simple harmonic character, as in the case of the isolated simple circuit shown in Fig. 1. The principle may for the present purpose be stated thus—that when two simple oscillators, each such as that shown in Fig. 1, are inductively associated with each other, as in Fig. 3, the system is a system of two degrees of freedom, and the natural period of oscillation of each simple circuit is modified by the presence of the other; but if the proportions of the circuits be such that the product of the inductances of the two circuits is large compared to the mutual inductance between the circuits the natural period of oscillation of each of the circuits becomes practically the same as if the circuits were isolated.

The mathematical expression for the frequency to which a circuit is resonant when it is isolated from all other circuits—*i. e.*, has but a single degree of freedom—is well known and may be stated as follows:

$$n = \frac{1}{2\pi\sqrt{C_1 L_1}}$$

from which

$$L_1 = \frac{1}{C_1 p_1},$$

where n is the frequency, C_1 is the capacity, L_1 is the inductance, and p is the periodicity, which equals $2\pi n$. In the case of a circuit of two degrees of freedom, however, in order to make the component circuits each responsive to the same frequency as when isolated—in other words, to overcome the modifying effect of the mutual inductance of each circuit upon the other—it is necessary to consider, in the case of inductive relation, the expression:

$$\frac{1}{C_1 p_2} = L_1 - \frac{M^2_{12} p \left(L_2 p - \frac{1}{C_2 p}\right)}{R^2_2 + \left(L_2 p - \frac{1}{C_2 p}\right)^2},$$

where C_1 L_1 are the capacity and inductance of the first circuit, C_2 L_2 R_2 are the capacity, inductance, and resistance, respectively, of the second circuit, and M_{12} is the mutual inductance of the circuits. From these expressions careful consideration will show that the ef-

fective inductance of the first circuit has been modified by its inductive relation with the second circuit, and it is

$$L'_1 = L_1 - \frac{M'^2_{12} p \left(L_2 p - \frac{1}{C_2 p}\right)}{R'^2_2 + \left(L_2 p - \frac{1}{C_2 p}\right)^2}$$

Similarly we have to consider the expression

$$\frac{1}{C_2 p'} = L_2 - \frac{M'^2_{12} p \left(L_2 p - \frac{1}{C_2 p}\right)}{R'^2_1 + \left(L_2 p - \frac{1}{C_2 p}\right)^2}$$

from which it will be seen that the effective inductance of the second circuit has been modified by its inductive relation with the first circuit and is

$$L'_2 = L_2 - \frac{M'^2_{12} p \left(L_1 p - \frac{1}{C_1 p}\right)}{R'^2_1 + \left(L_1 p - \frac{1}{C_1 p}\right)^2}$$

These two inductances L'_1 and L'_2 are the apparent inductances which each of these circuits would have if acting as the primary to induce simple harmonic vibrations of frequency s in the other. It is therefore necessary in order to overcome the modifying effect of the mutual inductance on either circuit to add to that circuit an auxiliary inductance-coil of inductance large compared to the term of the form:

$$\frac{M'^2 p \left(L p - \frac{1}{C p}\right)}{R'^2 + \left(L p - \frac{1}{C p}\right)^2},$$

or at least so large that when it is added to the natural inductance of the circuit the sum of their inductances is very large compared to the said term. If, further, the electric equilibrium of the circuit s I, L be abruptly disturbed and the circuit be then left without impressed force, the oscillations which are developed in it induce corresponding oscillations in the vertical wire, which oscillations are virtually forced vibrations, corresponding in frequency with the natural oscillations developed in the circuit s I, L and being practically independent, as regards their frequency, of the constants of the second circuit in which they are induced.

It is to be understood that any suitable device may be employed to develop the simple harmonic force impressed upon the vertical wire. It is sufficient to develop in the vertical wire practically simple harmonic vibrations of a fixed and high frequency.

The vertical wire may with advantage be so constructed as to be highly resonant to a particular frequency, and the harmonic vibrations impressed thereon may with advantage be of that frequency. The construction of such a vertical wire is shown and described in other applications of mine now pending.

At the receiving station shown in Fig. [illegible] the inductance-coil L is introduced in order to supply auxiliary inductance and to permit of the circuit C C' I L being attuned to a particular frequency practically independently of the constants of the vertical wire.

In both the organizations illustrated in Figs. 5 and 6 the inductance-coils L may be made adjustable and serve as a means whereby the operators may adjust the apparatus to the particular frequency which it is intended to employ.

Passing now to the organizations illustrated in Figs. 7 and 8, it is to be noted that they differ, respectively, from those illustrated in Figs. 5 and 6 in that additional resonant circuits $C' I_2 L I_2$ are interposed between the vertical conductor and the generating and translating devices, respectively.

In the transmitter arrangements illustrated in Fig. 7 the circuit $C I'_2 L I_2$ is attuned to the same period as the circuit $C' L I_1 s$ and merely tends to weed out and thereby screen the vertical wire from any harmonics which may exist in the current developed in the circuit $C' L I_1 s$. This screening action of an interposed resonant circuit is due to the well-known property of such circuits by which a resonant circuit favors the development in it of simple harmonic currents of the period to which it is attuned and strongly opposes the development in it of simple harmonic currents of other periodicities. In this organization an ordinary spark-coil, (shown at M'',) equipped in the usual way with an interrupter p and condenser C'', is employed, the current being supplied by the battery B. The operation of this organization is substantially the same as that of the organization shown in Fig. 5, hereinbefore described, except for the screening action of the circuit $C I'_2 L I_2$ and need not therefore be further described. Suffice it to say that when the source of vibratory currents is particularly rich in harmonics any suitable number of resonant circuits, each attuned to the desired frequency, may be connected inductively in series, as shown in Figs. 9 and 10, and interposed between the generating device and the vertical conductor for the purpose of screening the vertical conductor from the undesirable harmonics.

In the organization illustrated in Fig. 8 the electric resonator $C I'_2 L I_2$ interposed between the vertical conductor and the circuit containing the coherer, is attuned to the same period as the circuit L C C' I and acts to screen the coherer-circuit from the effect of all currents developed in the vertical conductor save that of the current of the particular period to which the receiving station is intended to respond. As in the case of the transmitting station, any suitable number of resonant circuits, each attuned to the particular period to which the station is desired to respond, may be

connected, as shown in Figs. 9 and 15, and interposed between the vertical conductor and the coherer-circuit. Such circuits so interposed serve to screen the receiver from the effect of all currents which may be induced in the vertical conductor that are not of the period to which the receiving-station is intended to respond.

The apparatus shown in Figs. 13, 14, 15, 16, and 17 illustrate methods of associating the apparatus hereinbefore described, and illustrated in Figs. 5, 6, 7, 8, and 9, when two or more stations are to be associated with a common elevated conductor. The operation of each individual station is the same as that already described in connection with Figs. 5, 6, 7, 8, and 9. For the sake of clearness only two stations are shown associated with the common elevated conductor V in the drawings; but it is obvious that any desired number of stations may be associated with a common elevated conductor in the same manner.

An inspection of the drawings will show that Figs. 13 and 16 illustrate two transmitting-stations of the type shown in Fig. 7 associated with a common elevated conductor, whereas Figs. 14 and 17 illustrate two receiving-stations of the type shown in Fig. 8 associated with a common elevated conductor.

When a plurality of stations are associated with a common elevated conductor, each of the stations is characterized by being tuned to a different frequency fronf that of any of the other stations so associated.

In Figs. 13, 14, 15, 16, and 17 it will be observed that the two different stations associated with a common elevated conductor have therein been differentiated by attaching a subscript to the letters of reference in the case of one of the stations and not to the letters of reference of the other station.

The operation of each of the transmitting-stations in Figs. 13 and 16 is identical with that of the transmitting-station illustrated in Fig. 7, and the operation of each of the receiving-stations shown in Figs. 14 and 17 is identical with the operation of the receiving-station illustrated in Fig. 8.

To illustrate, the step-up transformer or spark-coil M' in Figs. 13 and 16 is equipped with an interrupter *p* and condenser C'', and the current is supplied by the battery B. When the key *k* is depressed, a high potential is developed in the secondary of M'. As the potential difference at the terminals of the secondary of M' rises, the condenser C'' is charged till the resulting potential difference at *s* is sufficient to break down the spark-gap *s*. When this occurs, the condenser C'' discharges through the spark-gap *s*, the primary of M', and the inductance-coil L''. This circuit is attuned to a given high frequency, and the oscillatory current which results is therefore of that frequency. This current induces a similar current in the interposed resonant circuit L' M C' M, attuned to the same frequency, which current in turn induces a current of corresponding frequency in the conductor V M E.

Passing now to the operation of the receiving-stations shown in Figs. 14 and 17 it may be remarked that since the operation of each of these stations is identical with the operation of the receiving-station shown in Fig. 8, the energy of the waves of one particular frequency will be absorbed by one of the receiving-stations and the energy of the waves of another particular frequency will be absorbed by the other receiving-station. This selective reception of the energy of waves of a particular frequency is independent of the number of waves of different frequencies which may be simultaneously present.

It is to be here noted that the above-described methods of simultaneously transmitting and receiving space-telegraph messages by a common elevated conductor are not described as the preferred methods, since the branch circuits M M_1 in Figs. 16 and 17 are not in themselves selective and since the elevated conductors in Figs. 13 and 14 contain a number of induction-coils in series not essential to the operation of any one of the stations singly, but that any way of associating a plurality of the stations shown in Figs. 5, 6, 7, and 8 with a vertical conductor will result in a system for simultaneously transmitting and receiving space-telegraph signals, owing to the fact that these stations are in themselves innerently selective and are capable of causing the independent development of vibrations of different frequencies in the elevated conductor and of selectively absorbing the energy of waves of different frequencies.

The branch circuits M M_1 of Fig. 17 are not selective, since they contain but one element of a tuned circuit—viz., the inductance of M and M_1. Vibratory currents of whatever frequency they may be communicated by the vertical wire to these circuits will divide among them in simple inverse proportion to their electromagnetic impedances and are not selective except for a slight reaction due to the associated circuits C' M' L' and C'_1 M_1 L'_1. These reactions, so far from tending to make the branches selective to the frequencies to which their associated circuits are intended to respond, will, in fact, cause them to oppose more strongly currents of these frequencies than those to which the associated circuits are not attuned. Again, it is obvious that the inductance of the coil M in Fig. 13 is merely an additional impedance in the elevated conductor, which, to say the least, cannot assist in the development of vibrations in the elevated conductor impressed by circuit C'_1 M'_1 L'_1 M_1. The same is obviously true of the coil M_1 in the elevated conductor with reference to the operation of the circuit C' M' L'. Now passing to the transmitting station shown at Fig. 16 it is obvious that the vibrations communicated by the circuit C' M' L' to the elevated conductor V are sub-

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ject to a shunt due to the coil M in the other branch of the elevated conductor, and conversely the vibrations developed in the elevated conductor by the associated circuit $C_1 M_1 L_1$ are subject to a shunt due to the coil M in the other branch of the elevated conductor. Finally, the coil M in the elevated conductor in Fig. 14 can at best only present an impedance to the waves intended to be received by the circuit $C_1 M_1 L_1$, and conversely the coil M_1 in the elevated conductor can at at best only present an impedance to the vibrations intended to be received by the circuit C' M' L'.

No mention has heretofore been made of the function of the condensers shown at C' in Fig. 6 and at C'' in Fig. 8, as these condensers are not essential to the tuning of the circuits in which they are placed, but merely serve to exclude the current of the batteries B from the resonant circuits. In order that these condensers may not appreciably affect the tuning of the circuits in which they are included, and thereby lower the resonant rise of potential at the plates of the condensers C and C, (shown in Figs. 6 and 8,) they are so constructed as to have large capacities compared to the capacities of C and C' in Figs. 6 and 8, respectively.

In Figs. 6 and 8 the coherers K are shown connected in shunt-circuit to the condensers C and C, respectively; but they may be connected serially in the resonant circuit, as shown in Fig. 10, or they may be connected in shunt-circuit to the coil L and condenser C, as shown in Fig. 11.

Though a coherer has been shown and described in the specification as the means of detecting the presence of oscillations in the receiving resonant circuits, under which circumstances it operates as a telegraphic relay to control a local-battery circuit including an electric translating device, any other suitable electroreceptive device may be employed to receive the signal—as, for example, a condenser-telephone. When a condenser-telephone is employed as a receiver, the receiving resonant circuit may be that illustrated in Fig. 12, in which C is the condenser-telephone and also the capacity by which the circuit L C C' I, is attuned.

In constructing the various parts of the apparatus shown and described in this specification there is great latitude as to the special forms that may be given them; but it must be remembered that when a circuit is to be tuned and it is desired to gain a high degree of resonance both electrostatic and magnetic hysteresis must be carefully excluded from the resonant circuit. For this reason all iron should be excluded from the coils in the resonant circuits and solid dielectrics should not ordinarily be employed in the condensers. These injunctions apply to the construction of resonant circuits attuned to very high frequencies, but not with the same force to the construction of resonant circuits to be tuned to low frequencies. Another precaution to be taken in the construction of the apparatus included in the resonants circuits when very high frequency currents are employed is that conductors between which there exists a considerable potential difference during the operation of the apparatus shall be kept as far apart as practical, because of the excessive displacement currents which tend to flow in the case of high-frequency currents. For this reason it will often be found to be convenient to build the coils in the form of flat spirals instead of long spirals of several layers, as is the usual construction of coils. Flat spirals with the turns well separated in order to minimize the displacement-currents between the turns are, however, by no means the only form of coils adapted to be used in conjunction with air-condensers for the purpose of tuning circuits to high frequencies and may often be neither the best nor most convenient form of coil to employ. Therefore in defining the character of the coils to be employed for this purpose it will be of advantage to first give the general theoretical considerations which lead to a special construction of the coils and to then give a practical guide to the manner of designing the coils for a particular frequency or range of frequencies.

A coil or solenoid as usually constructed consists of many turns of cotton or silk insulated wire wound on an insulating-core, such as a glass or ebonite tube or a wooden spool, the consecutive turns being separated only by the thin insulating coating of the wire. These solenoids, moreover, are in general wound with several layers of wire, the layers also being separated from each other only by the insulating coatings of the wires. Such solenoids are well adapted to be used in conjunction with condensers having solid dielectrics for the purpose of tuning circuits to low frequencies; but neither such coils nor such condensers are available for the purpose of tuning circuits to such high frequencies as are concerned in the present invention. In the case of high frequencies the energy absorbed in the solid dielectric of the condenser, due to dielectric hysteresis, is excessive, and the displacement-currents between the adjacent turns and layers of the coil mask and neutralize the inductance of the coil. Moreover, the solid dielectric forming the core of such coils exerts a deleterious effect, which in some instances is probably partially due to its possessing a small degree of conductivity, but which must in most instances be ascribed to the high specific inductive capacity of the material and to its dielectric hysteresis.

In order to tune a circuit to a predetermined high frequency, so that it shall show a well-defined selectivity for that frequency to the exclusion of other frequencies, even to the exclusion of frequencies differing but slightly from the predetermined frequency, it is necessary not only that the condenser

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shall be free from dielectric hysteresis, but that the coil shall be so constructed as to behave for that frequency practically like a conductor having a fixed resistance and a fixed inductance, but devoid of capacity. Coils constructed in the usual way do not behave for high frequences as if they had a fixed resistance and inductance and no capacity, but partake more of the character of conductors having distributed resistance, inductance, and capacity. In fact, they may in some instances behave with high frequencies more like condensers than like conductors having fixed resistance and inductance and no capacity. Since a coil constructed in the usual way behaves for high frequencies as a conductor having distributed resistance, inductance, and capacity, it follows that such a coil will show for high frequencies the same quasi resonance as is observed with low frequencies in long aerial lines and cables—*i. e.*, that it will *per se* and without the intermediary of a condenser show a slight degree of selectivity for some particular frequency and for certain multiples of that frequency just as a stretched string which has distributed inertia and elasticity will respond to the particular tone called its "fundamental" and to all other tones whose periods are aliquot parts of the periods of that fundamental; but it is not with such quasi resonance that the present invention is carried into effect, and I wish it understood that I here disclaim any system employing distributed inductance and capacity as a means for tuning the resonant circuits described in this specification.

A general criterion which determines the utility of a coil for tuning a circuit to a particular high frequency is that the potential energy of the displacement-currents in the coil shall be small compared to the kinetic energy of the conduction-current flowing through the coil when the coil is traversed by a current of that frequency.

I have found that for a single-layer coil the following procedure is sufficient for practical purposes: Determine the inductance of the coil by formulæ to be found in the text-books and treatises on electricity and magnetism. This will enable the kinetic energy of the coil to be determined for any particular current and will also permit of the determination of what would be the potential gradient along the coil for the current of the frequency to be employed if the coil were devoid of distributed electrostatic capacity. Next calculate the electrostatic capacity between an end turn and each of the remaining turns of the coil. These capacities, together with the potential gradient found, will enable the potential energy to be determened, and if the ratio of the potential energy to the kinetic energy so found be neglible compared to unity the coil will practically satisfy the requirements hereinbefore mentioned. If the coil does not meet the requirements, the design should be so changed as to increase the separation between the turns, or the size of the wire should be diminished or the dimensions of the coil so otherwise altered as to decrease the distributed capacity without proportionately diminishing the inductance. The calculations may be greatly abbreviated and the liability to error greatly reduced if the results of the computations be plotted in curves.

Regarding the effect of a dielectric core in a coil to be used for tuning a circuit to a high frequency it is sufficient to state that the preferred form of support for such a coil is any skeleton frame which will hold the turns of wire in place without exposing much surface of contact to the wires and affording a minimum of opportunity for the development of displacement-currents within itself.

In this specification I have spoken of elevated conductors, vertically-elevated conductors, and vertical conductors. I wish to be understood as including in the term "elevated" conductors disposed at an angle to the earth's surface as distinguished from horizontal conductors disposed parallel to the earth's surface. By the terms "vertically-elevated" and "vertical" I refer to conductors whose disposition with regard to the earth's surface is mainly or wholly at a right angle or vertical thereto, which is the particular form of elevated conductor preferred by me for use in connection with my present improvement.

In this specification I have described the development of free or unguided electromagnetic signal-waves of a given freqhency by employing in association with an elevated conductor a circuit such as to produce therein forced simple harmonic electric vibrations of the frequency desired. I have also described a method of receiving or absorbing the energy of free or unguided simple harmonic electromagnetic waves of one frequency to the exclusion of waves of a different frequency by associating with an elevated conductor a circuit made resonant to the frequency of the waves whose energy is to be absorbed. The circuit whereby forced simple harmonic electric vibrations are produced in the elevated conductor I have shown as a circuit containing a condenser and a self-induction coil so proportioned as to make the natural vibrations of a frequency which is the frequency of the vibrations to be forced or impressed in an elevated conductor. The circuit whereby the energy of the electromagnetic waves of one frequency is absorbed to the exclusion of that of waves of other frequencies is in like manner a circuit containing a condenser and a self-induction coil so proportioned as to make the circuit resonant to a frequency which is the frequency of the waves the energy of which is to be received. Both of the circuits I have spoken of are tuned circuits, and they may be conveniently distinguished with reference to their respective functions by denominating the circuit employed in the development of the vibrations

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as an "oscillating" or "sonorous" circuit and by denominating the circuit employed in the reception or absorption of the vibrations as a "resonant" circuit. I prefer to make this discrimination in nomenclature for the reason that while both the circuits are resonant circuits, yet functionally only that one employed for receiving or absorbing is accurately so described. Except for this distinction in function it is well to note that all oscillating or sonorous circuits are resonant circuits, but only such resonant circuits as have their resistance less than the square foot of the ratio of four times their inductance by their capacity are oscillating or sonorous circuits.

Also throughout this specification I have described the electrical oscillations or vibrations and the free or unguided electromagnetic waves or radiations as simple harmonic. It is the object of my present invention to approach as nearly as possible to the perfect simple harmonic wave, and such object is attained to within such a degree of precision as to preclude any interference with the operation of the system by any possible departure that may exist in the wave from the absolute simple harmonic form. My reason for confining the description of the electrical oscillations or vibrations and the electromagnetic waves or vibrations to the simple harmonic type is that in the operation of the system only the simple harmonic components are effective in carrying out the object of the invention. Though it is impossible to prevent the presence of minute overtones accompanying these simple harmonic waves, such overtones not only do not contribute to the useful operation of the system, but may, in fact, become obstacles to such useful and complete operation unless their amplitude be excessively small, as is the case in the present invention. It is for this reason that I have taken every precaution to approximate as closely as may be to the true or absolute simple harmonic wave form, thereby reducing to a minimum the overtones which cause a departure from the true sine-wave.

Specifically, though it may be possible to employ the purposes of multiple and selective wireless telegraphy, electric vibrations and radiations departing considerably from the simple harmonic type by employing at the receiving end circuits selective to the fundamental of such vibrations and radiations, yet it will only be through the selective reception of that simple harmonic component of the vibrations or radiations which is their fundamental that the system will be operative. The other simple harmonic components of the vibrations or radiations add nothing to the operation of the system. Moreover, if such overtones exist in the waves emanating from a transmitting-station their presence will preclude the possibility of placing receiving-stations in the immediate neighborhood of such transmitting-station for the reception of signal-waves of frequencies corresponding to the frequencies of such overtones.

Whereas in the present specification I have used the term "elevated" conductor to describe the source of radiation of electromagnetic waves developed by forced electric vibrations impressed thereon, yet I deem it proper to point out that this expression should not be confused with the term "conductor" when used in connection with systems wherein that term is employed to denote a wire or other metallically-continuous conductor extending from a transmitting to a receiving station. It is of course obvious that in the art to which the present specification relates such a conductor is wholly absent. The vertical metallically-continuous source of radiant energy is a structure the location and function of which are confined entirely to the transmitting or it may be the receiving end of a system in which the conductor which connects the transmitting and receiving stations is the non-metallic—non-conducting, in fact—dielectric medium, which is commonly called the "ether" and which is by many assumed to be essential to the theory of the propagation of electrical and magnetic force, radiant light, and radiant heat.

Having described my invention, I claim—

1. The method of developing free or unguided simple harmonic electromagnetic waves of a definite frequency, which consists in producing forced simple harmonic electric vibrations of the same frequency in an elevated conductor.

2. The method of absorbing the energy of free or unguided, simple harmonic, electromagnetic signal-waves of one frequency, to the exclusion of the energy of like waves of a different frequency, which consists in associating with an elevated conductor a circuit resonant to the frequency of the waves, the energy of which is to be absorbed.

3. The method of distributing the energy of free or unguided electromagnetic waves which consists in independently developing forced simple harmonic electric vibrations of different frequencies in an elevated conductor and receiving the several energies of the resulting electromagnetic waves of different frequencies, each to the exclusion of the rest, in a separate electric translating device.

4. The method of distributing the energy of free or unguided electromagnetic waves which consists in independently developing a number of forced simple harmonic electric vibrations of different frequencies in an elevated conductor and receiving the several energies of the resulting electromagnetic waves, of different frequencies, each to the exclusion of the rest, in a separate circuit resonant to the same frequency as that of the waves, the energy of which is to be absorbed therein.

5. The method of distributing the energy of free or unguided electromagnetic waves which consists in developing forced simple

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harmonic electric vibrations of different frequencies, each in a different elevated conductor, and receiving the several energies of the resulting electromagnetic waves of different frequencies, each to the exclusion of the rest, in a separate electric translating device.

6. The method of distributing the energy of free or unguided electromagnetic waves which consists in developing a number of forced simple harmonic electric vibrations of different frequencies, each in a different elevated conductor, and receiving the several energies of the resulting electromagnetic waves of different frequencies, each to the exclusion of the rest, in a separate resonant circuit attuned to the same frequency as that of the waves, the energy of which is to be absorbed therein.

7. The method of rendering a circuit resonant to a given high frequency, which consists in balancing the reactance of an air-condenser by the reactance of a coil, the amplitude of whose potential energy is small compared to the amplitude of its kinetic energy when it is supporting a current of said given high frequency.

8. The method of constructing a coil to be used in a circuit to be made resonant to a given high frequency, which consists in so proportioning the coil that the amplitude of its potential energy shall be small compared to the amplitude of its kinetic energy when supporting a current of given high frequency.

9. The method of developing free or unguided simple harmonic electromagnetic signal-waves, which consists in discharging a condenser through a closed circuit having inductance adapted to produce under such conditions simple harmonic vibrations, and impressing the electrical vibrations so produced upon an open-circuit or elevated conductor substantially as described.

10. The method of developing free or unguided simple harmonic electromagnetic signal-waves which consists in discharging a condenser through a closed circuit having inductance adapted to produce under such conditions simple harmonic vibrations, impressing these vibrations on a resonant circuit or group thereof resonant to the frequency of these vibrations, and impressing the resulting electrical vibrations upon an open-circuit or elevated conductor.

11. The method of selectively receiving the energy of free or unguided simple harmonic electromagnetic signal-waves of different frequencies, each to the exclusion of the rest, which consists in receiving the same in an elevated conductor and translating or conveying the several energies of the resulting electrical oscillations, each to a separate circuit associated with said elevated conductor, and resonant to the frequency of the electromagnetic waves, the energy of which it is to receive.

12. The method of selectively receiving the energy of simple harmonic electromagnetic signal-waves of different frequencies, each to the exclusion of the rest, which consists in receiving the same in an elevated conductor and translating or conveying the several energies of the resulting electrical oscillations, each to a separate group of resonant circuits associated with said elevated conductor and resonant to the frequency of the electromagnetic waves the energy of which it is to receive.

13. The method of selectively receiving the energy of free or unguided simple harmonic electromagnetic signal-waves of different frequencies, each to the exclusion of the rest, which consists in receiving the same in a plurality of elevated conductors, thereby developing in each elevated conductor electrical oscillations corresponding in frequency to the electromagnetic waves received by it and in translating or conveying from each elevated conductor to an associated circuit the energy of the particular electrical oscillation to the frequency of which said associated circuit is made resonant.

14. The method of selectively receiving the energy of simple harmonic electromagnetic signal-waves of different frequencies, each to the exclusion of the rest, which consists in receiving the same in a plurality of elevated conductors, thereby developing in each elevated conductor electrical oscillations corresponding in frequency to the electromagnetic waves received by it and in translating or conveying from each elevated conductor to a group of resonant circuits associated therewith the energy of the particular electrical oscillations to the frequency of which said group of associated circuits is resonant.

15. The method of absorbing the energy of free or unguided simple harmonic electromagnetic signal-waves of one frequency to the exclusion of the energy of like waves of different frequencies which consists in associating with an elevated conductor a group of circuits, each resonant to the frequency of the waves, the energy of which is to be absorbed.

16. The method of receiving the energy of simple harmonic electromagnetic signal-waves, which consists in receiving the same in an elevated conductor and translating or conveying the energy of the resulting electrical oscillations to an electrical translating device shunted around the terminals of one of the elements of a resonant circuit associated with said elevated conductor and resonant to the frequency of the electromagnetic waves

17. The method of distributing the energy of free or unguided electromagnetic waves, which consists in independently developing a number of forced simple harmonic electric vibrations of different frequencies in an elevated conductor and receiving the several energies of the resulting electromagnetic waves of different frequencies, each to the exclusion

of the rest, in a group of circuits resonant to the same frequency as that of the waves the energy of which is to be absorbed therein.

19. The method of distributing the energy of free or unguided electromagnetic waves, which consists in developing a number of forced simple harmonic electric vibrations of different frequencies each in a different elevated conductor, and receiving the several energies of the resulting electromagnetic waves of different frequencies each to the exclusion of the rest, in a separate group of circuits resonant to the same frequency as that of the waves the energy of which is to be absorbed.

20. The method of developing free or unguided simple harmonic electromagnetic signal waves, which consists in disturbing the electrical equilibrium of a circuit comprising a condenser, and a coil having inductance adapted to produce under such conditions simple harmonic vibrations, and impressing the electrical vibrations so produced upon an open circuit or elevated conductor, substantially as described.

20. The method of developing free or unguided simple harmonic electromagnetic signal-waves, which consists in disturbing the electrical equilibrium of a circuit comprising a condenser and a coil having inductance adapted to produce under such conditions simple harmonic vibrations, impressing these vibrations on a resonant circuit or group thereof attuned to the frequency of these vibrations, and impressing the resulting electrical vibrations upon an open circuit or elevated conductor.

21. The method of receiving the energy of simple harmonic electromagnetic signal waves, which consists in receiving the same in an elevated conductor and translating or conveying the energy of the resulting electrical oscillations to an electrical translating device forming one of the elements of a resonant circuit associated with said elevated conductor and resonant to the frequency of the electromagnetic waves.

22. The method of developing free or unguided simple harmonic electromagnetic signal waves or [illegible] which consists in disturbing the electrical equilibrium of a closed oscillating circuit associated with an elevated conductor and possessing sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and the elevated conductor.

23. The method of [illegible] guided simple harmonic electromagnetic signal waves or [illegible] which consists in disturbing the electrical equilibrium of a closed oscillating circuit forming part of a group of resonant [illegible] associated with an elevated conductor [illegible] possessing sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and the [illegible] between it and the elevated conductor.

24. The method of developing free or unguided simple harmonic electromagnetic signal waves or radiations of different frequencies independently in a single elevated conductor, which consists in disturbing the electrical equilibrium of closed oscillating circuits associated with said elevated conductor, each being attuned to a different one of the frequencies to be developed, and each of said oscillating circuits having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and the other oscillating circuits and the said elevated conductor.

25. The method of receiving the energy of simple harmonic electromagnetic waves of a given frequency, to the exclusion of other waves of different frequencies, which consists in receiving the same in an elevated conductor and conveying the energy of the resulting electrical oscillations to a circuit associated with the elevated electrical conductor and made resonant to the frequency of the electromagnetic waves the energy of which is to be received by a condenser and an auxiliary inductance coil whose inductance is sufficient to swamp the effect of the mutual inductance between the associated circuit and the elevated conductor.

26. The method of selectively receiving the energy of simple harmonic electromagnetic signal waves of one frequency, to the exclusion of like waves of different frequencies, which consists in receiving the same upon an elevated conductor and translating or conveying the energies of the resulting electrical oscillations each to a separate circuit associated with said elevated conductor and resonant to the frequency of the electromagnetic waves the energy of which is to be received, and each having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and the other associated circuits and between it and the elevated conductor.

27. The method of developing [illegible] simple harmonic electromagnetic signal waves of a given frequency, which consists in impressing upon a [illegible] vertical conductor forced simple harmonic electrical oscillations of the same frequency.

28. The method of [illegible] simple harmonic electromagnetic [illegible] which consists in [illegible]

effect of the mutual inductance between it and the elevated conductor.

30. The method of distributing the energy of free or unguided, electromagnetic waves, which consists in independently developing a number of forced, simple harmonic, electric vibrations of different frequencies in an elevated conductor, and receiving the several energies of the resulting electromagnetic waves of different frequencies, each to the exclusion of the rest in a separate circuit resonant to the same frequency as that of the waves, the energy of which is to be absorbed, and having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and all of the circuits with which it is associated.

31. The method of distributing the energy of free or unguided, electromagnetic waves, which consists in developing a number of forced, simple harmonic, electric vibrations of different frequencies, each in a different elevated conductor, and receiving the several energies of the resulting electromagnetic waves of different frequencies, each to the exclusion of the rest, in a separate resonant circuit attuned to the same frequency as that of the waves, the energy of which is to be absorbed therein, and having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and all circuits with which it is associated.

32. The method of developing free or unguided, simple harmonic, electromagnetic signal-waves, which consists in discharging a condenser through a closed circuit having inductance adapted to produce under such conditions simple harmonic vibrations and sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and an elevated conductor with which it is associated, and impressing the electrical vibrations so produced upon the said elevated conductor.

33. The method of developing free or unguided, simple harmonic, electromagnetic, signal-waves, which consists in discharging a condenser through a closed circuit having inductance adapted to produce under such conditions simple harmonic vibrations, impressing these vibrations on a resonant circuit or group thereof resonant to the frequency of these vibrations, each circuit having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and all circuits with which it is associated, and impressing the resulting electrical vibrations upon an open circuit or elevated conductor.

34. The method of selectively receiving the energy of free or unguided, simple harmonic, electromagnetic, signal-waves of different frequencies, each to the exclusion of the rest, which consists in receiving the same in an elevated conductor and translating or conveying the several energies of the resulting electrical oscillations, each to a separate circuit associated with said elevated conductor, and resonant to the frequency of the electromagnetic waves, the energy of which it is to receive, each circuit having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and all circuits with which it is associated.

35. The method of selectively receiving the energy of simple harmonic, electromagnetic, signal-waves of different frequencies, each to the exclusion of the rest, which consists in receiving the same in an elevated conductor and translating or conveying the several energies of the resulting electrical oscillations, each to a separate group of resonant circuits associated with said elevated conductor and resonant to the frequency of the electromagnetic waves, the energy of which it is to receive, each circuit having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and all circuits with which it is associated.

36. The method of selectively receiving the energy of free or unguided, simple harmonic, electromagnetic signal-waves of different frequencies, each to the exclusion of the rest, which consists in receiving the same in a plurality of elevated conductors, thereby developing in each elevated conductor electrical oscillations corresponding in frequency to the electromagnetic waves received by it and in translating or conveying from each elevated conductor to an associated circuit the energy of the particular electrical oscillations to the frequency of which said associated circuit is made resonant, each of said circuits having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and the elevated conductor and all circuits with which it is associated.

37. The method of selectively receiving the energy of simple harmonic, electromagnetic, signal-waves of different frequencies, each to the exclusion of the rest, which consists in receiving the same in a plurality of elevated conductors, thereby developing in each elevated conductor electrical oscillations corresponding in frequency to the electromagnetic waves received by it and in translating or conveying from each elevated conductor to a group of resonant circuits associated therewith the energy of the particular electrical oscillations to the frequency of which said group of associated circuits is resonant, each of said circuits having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and the elevated conductor and all circuits with which it is associated.

38. The method of absorbing the energy of free or unguided, simple harmonic, electromagnetic, signal-waves of one frequency to the exclusion of the energy of like waves of different frequencies, which consists in associating with an elevated conductor a group of circuits, each resonant to the frequency of the waves, the energy of which is to be absorbed, each circuit having sufficient auxiliary inductance to swamp the effect of the

mutual inductance between it and all circuits with which it is associated.

39. The method of receiving the energy of simple harmonic, electromagnetic signal-waves, which consists in receiving the same in an elevated conductor and translating or conveying the energy of the resulting electrical oscillations to an electrical translating device shunted around the terminals of one of the elements of a resonant circuit associated with said elevated conductor and resonant to the frequency of the electromagnetic waves, each circuit having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and all circuits with which it is associated.

40. The method of distributing the energy of free or unguided electromagnetic waves, which consists in independently developing a number of forced, simple harmonic, electric vibrations of different frequencies in an elevated conductor and receiving the several energies of the resulting electromagnetic waves of different frequencies, each to the exclusion of the rest, in a group of circuits resonant to the same frequency as that of the waves, the energy of which is to be absorbed therein, each circuit having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and all circuits with which it is associated.

41. The method of distributing the energy of free or unguided electromagnetic waves, which consists in developing a number of forced, simple harmonic, electric vibrations of different frequencies, each in a different elevated conductor, and receiving the several energies of the resulting electromagnetic waves of different frequencies, each to the exclusion of the rest, in a separate group of circuits resonant to the same frequency as that of the waves the energy of which is to be absorbed, each of said circuits having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and the elevated conductor and all circuits with which it is associated.

42. The method of developing free or unguided, simple harmonic, electromagnetic signal-waves, which consists in disturbing the electrical equilibrium of a circuit comprising a condenser, and a coil having inductance adapted to produce under such conditions simple harmonic vibrations, and impressing the electrical vibrations so produced upon an elevated conductor, each circuit having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and all circuits with which it is associated.

43. The method of developing free or unguided, simple harmonic, electromagnetic signal-waves, which consists in disturbing the electrical equilibrium of a circuit comprising a condenser and a coil having inductance adapted to produce under such conditions simple harmonic vibrations, impressing these vibrations on a resonant circuit or group thereof attuned to the frequency of these vibrations, and impressing the resulting electrical vibrations upon an elevated conductor each circuit having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and all circuits with which it is associated.

44. The method of receiving the energy of simple harmonic, electromagnetic signal-waves, which consists in receiving the same in an elevated conductor and translating or conveying the energy of the resulting electrical oscillations to an electrical translating device forming one of the elements of a resonant circuit associated with said elevated conductor and resonant to the frequency of the electromagnetic waves, each circuit having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and all circuits with which it is associated.

45. The method of absorbing the energy of free or unguided simple harmonic electromagnetic signal-waves of one frequency, to the exclusion of the energy of like waves of different frequency, which consists in receiving the same in an elevated conductor and translating or conveying the resulting electric vibrations to a circuit associated with said elevated conductor, and resonant to the frequency of the waves, the energy of which is to be received.

In testimony whereof I have hereunto subscribed my hand this 6th day of February, 1900.

JOHN STONE STONE.

Witnesses:
E. D. CHADWICK,
ALEX. P. BROWNE.

No. 714,758. Patented Dec. 2, 1902.

J. S. STONE.

METHOD OF SELECTIVE ELECTRIC SIGNALING.

(Application filed Feb. 8, 1900.)

(No Model.) 5 Sheets—Sheet 1.

Fig. 1.

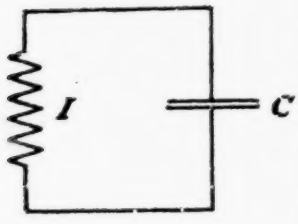
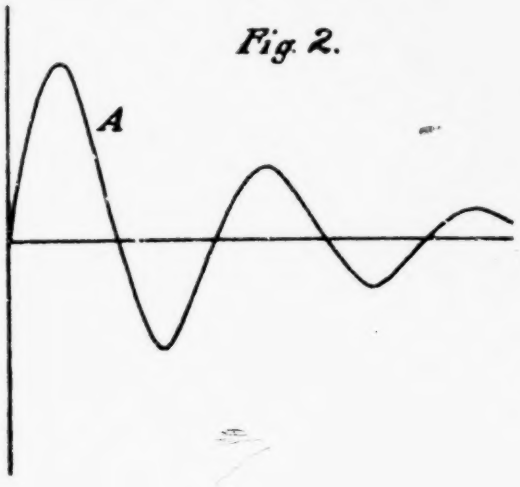


Fig. 2.



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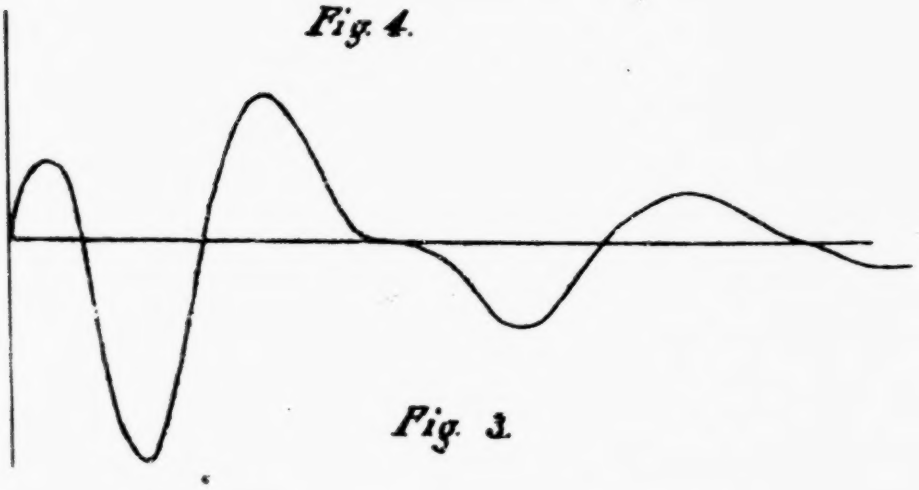
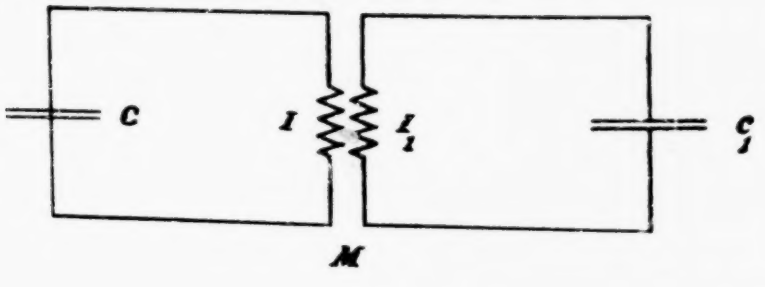


Fig. 3.



WITNESSES:

E. G. Chadwick.

E. B. Tomlinson

INVENTOR

John Stone Stone

BY

Alex P. Browne

ATTORNEY.

No. 714,756. Patented Dec. 2, 1902.

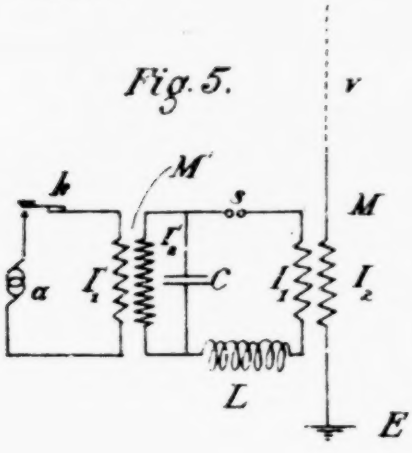
J. S. STONE.

METHOD OF SELECTIVE ELECTRIC SIGNALING.

Application filed Feb. 8, 1900.

(No Model.) 5 Sheets—Sheet 2.

Fig. 5.



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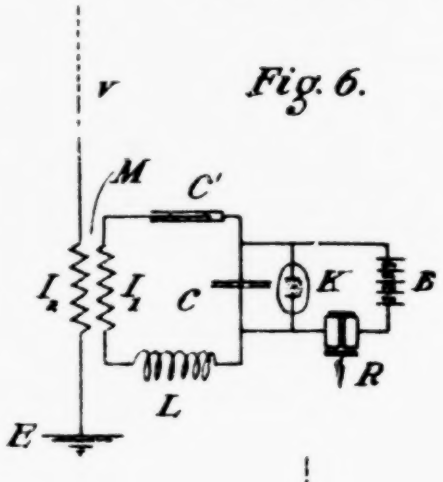

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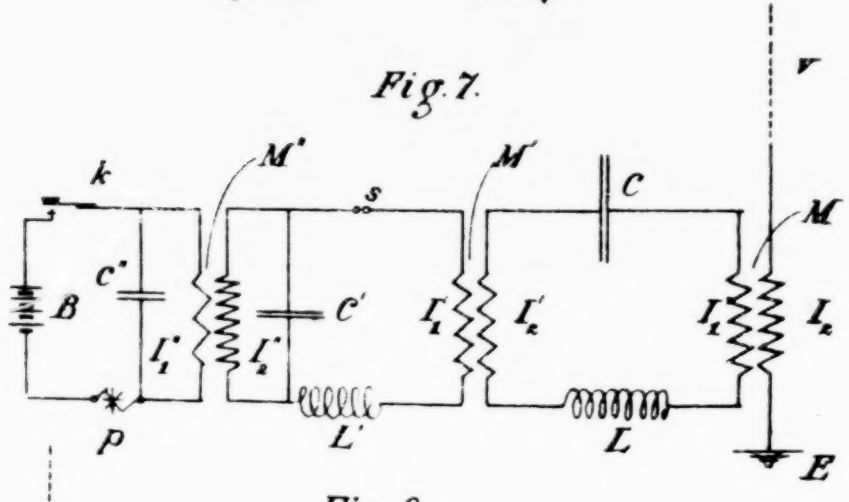
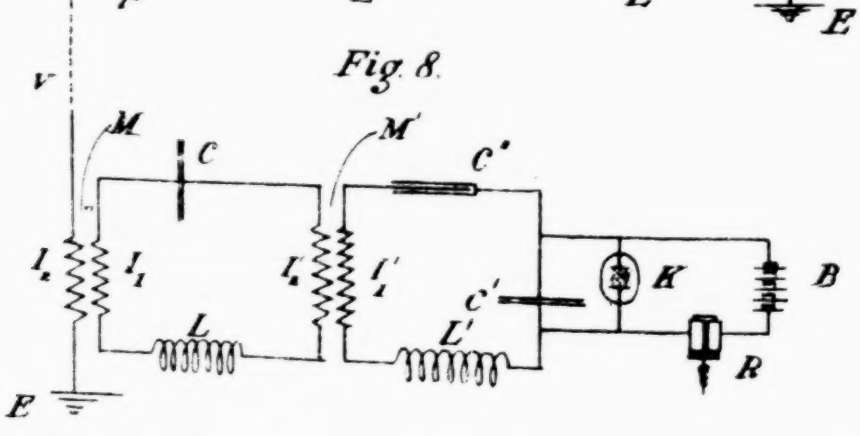


Fig. 8.



WITNESSES:

E. D. Chadwick

E. B. Tomlinson

INVENTOR

John Stone Stone

BY

Alex P. Browne

ATTORNEY

No. 714,758. Patented Dec. 2, 1902.

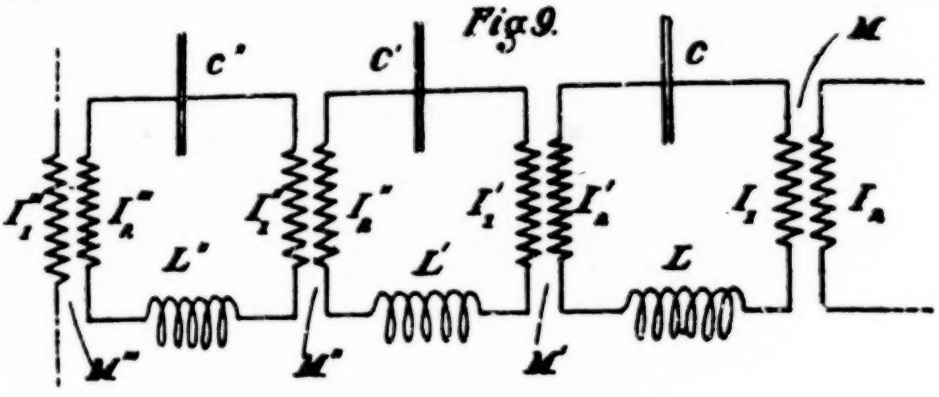
J. S. STONE.

METHOD OF SELECTIVE ELECTRIC SIGNALING.

(Application filed Feb. 8, 1900.)

(No Model.) 5 Sheets—Sheet 3.

Fig. 9.



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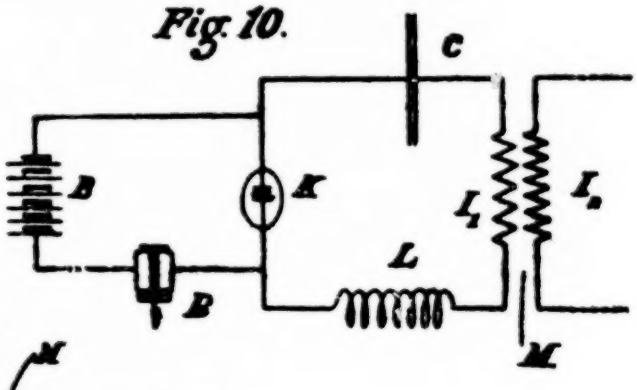

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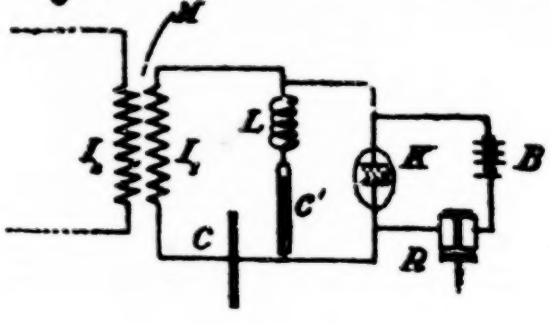
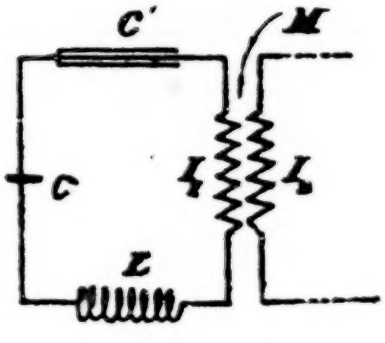


Fig. 12.



WITNESSES:

E. G. Chadwick.
E. B. Tomlinson.

INVENTOR

John Stone Stone

BY

Alex P. Browne

ATTORNEY.

3665

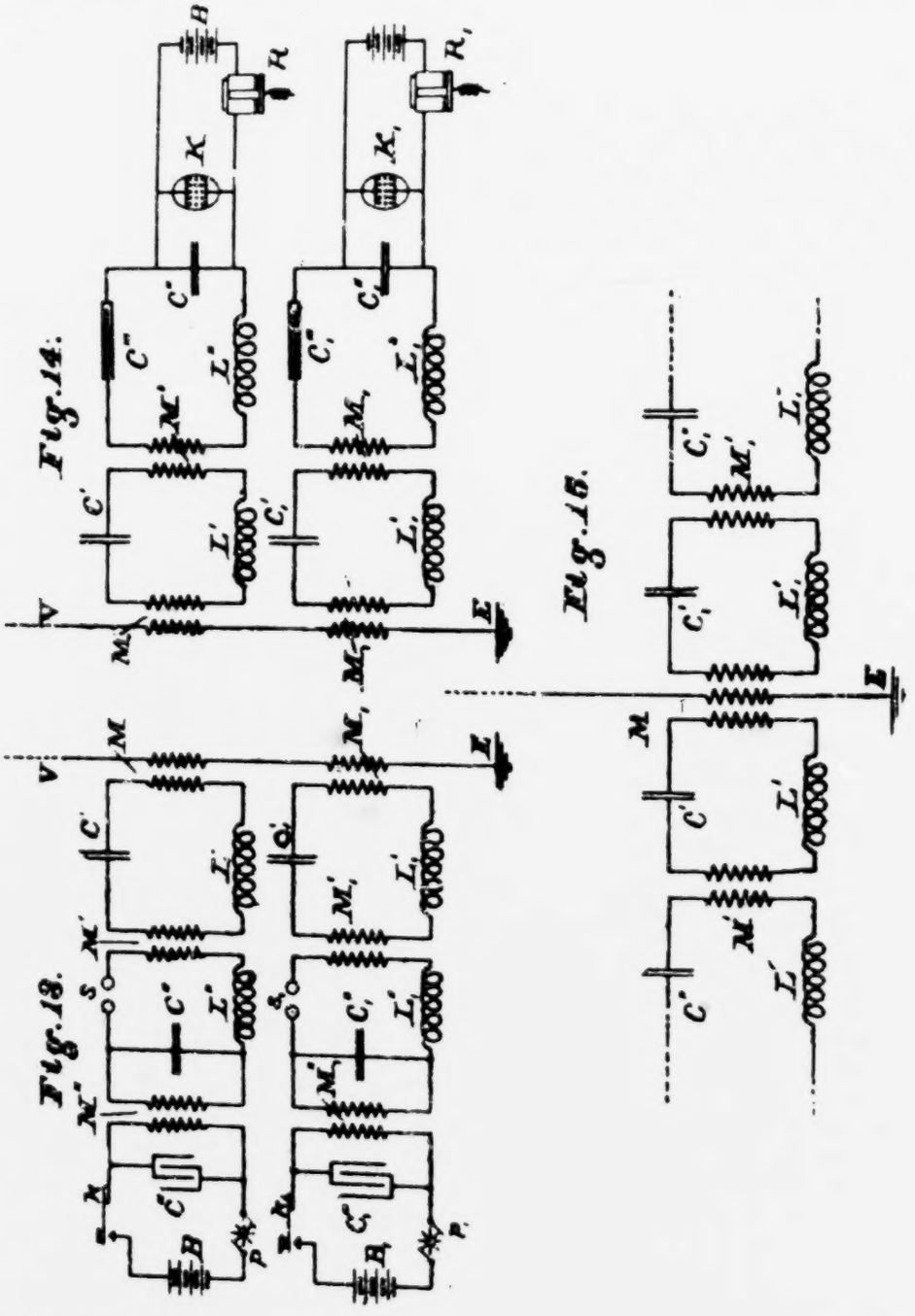
No. 714,756. Patented Dec. 2, 1902.

J. S. STONE.

METHOD OF SELECTIVE ELECTRIC SIGNALING.

(Application filed Feb. 8, 1900.)

(No Model.) 5 Sheets—Sheet 4.



WITNESSES
Ellen B. Tomlinson.
Jeremiah Toomey

INVENTOR
John Stone Stone
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attorney

3228

No. 714,758. Patented Dec. 2, 1902.

J. S. STONE.

METHOD OF SELECTIVE ELECTRIC SIGNALING.

(Application filed Feb. 8, 1900.)

(No Model.) 5 Sheets—Sheet 5.

Fig. 16.

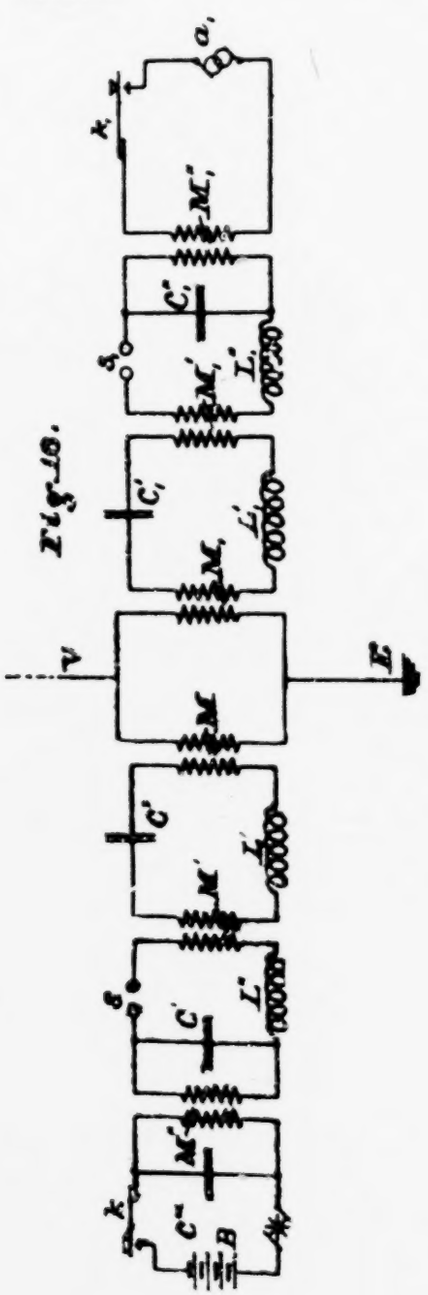
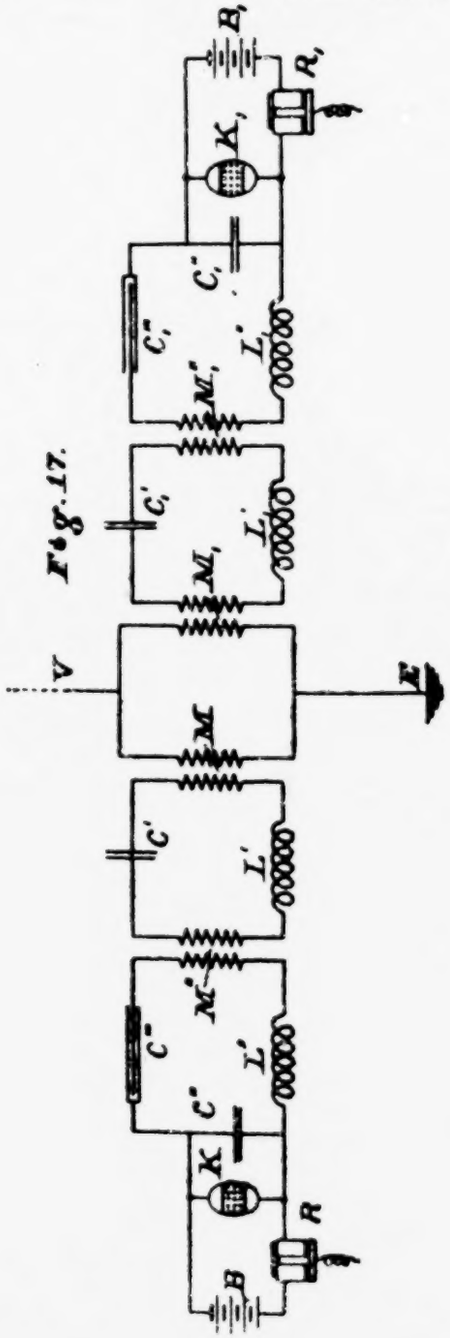


Fig. 17.



WITNESSES.

Ellen P. Tomlinson

Jeremiah Toomey

INVENTOR

John Stone Stone

by Alex P. Browne, attorney

3229–3230

DEFENDANT'S EXHIBIT Q-3

3667

No. 714,831. Patented Dec. 2, 1902.

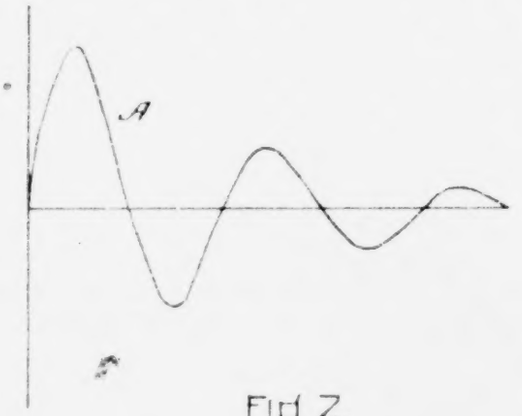
J. S. STONE.

APPARATUS FOR SELECTIVE ELECTRIC SIGNALING.

Application filed Jan. 28, 1901.

(No Model.) 5 Sheets—Sheet 1.

Fig 1.



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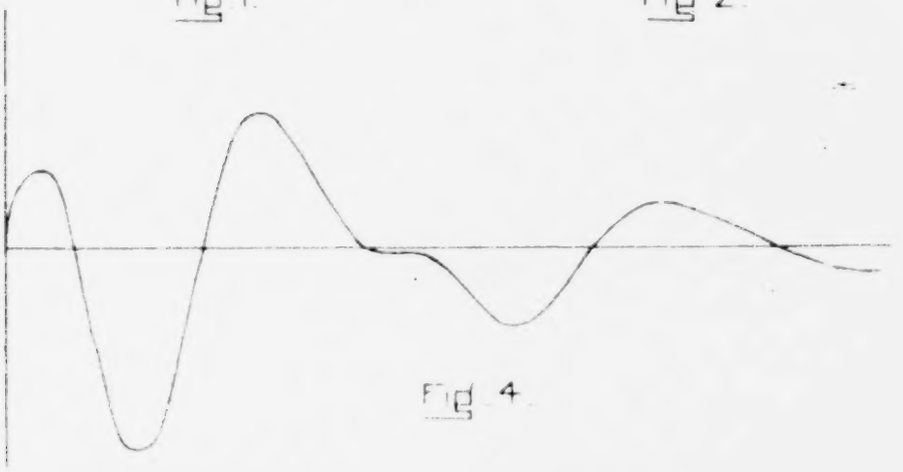

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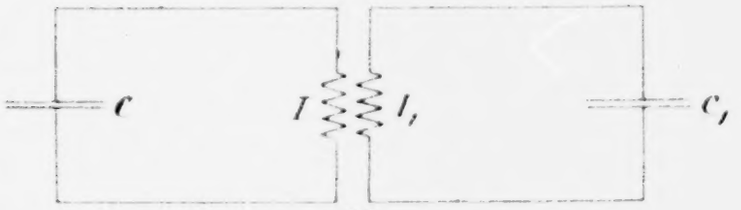


Fig 3.

WITNESSES:

Philip J. Doherty

INVENTOR

John Stone Stone

by Albert G. Davis

Attorney

3231-3232

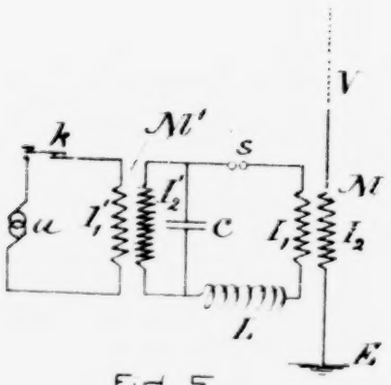
No. 714,831. Patented Dec. 2, 1902.

J. S. STONE.

APPARATUS FOR SELECTIVE ELECTRIC SIGNALING.

Application filed Jan. 23, 1901.

(No Model.) 5 Sheets—Sheet 2



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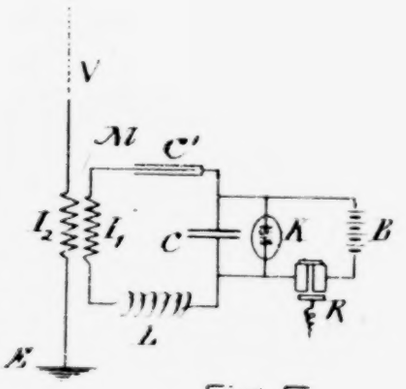

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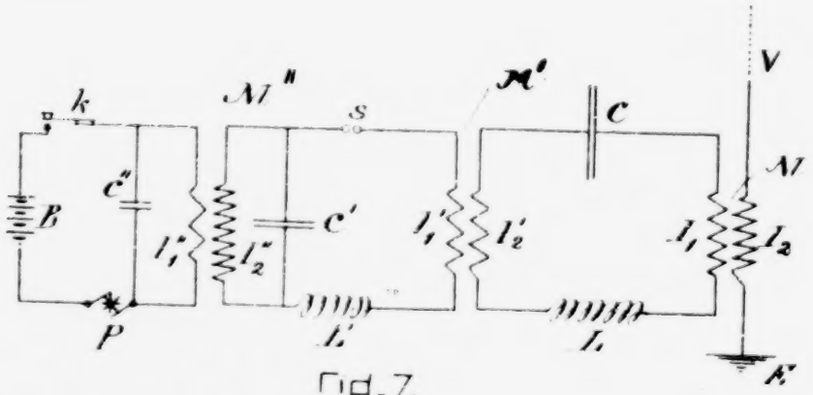

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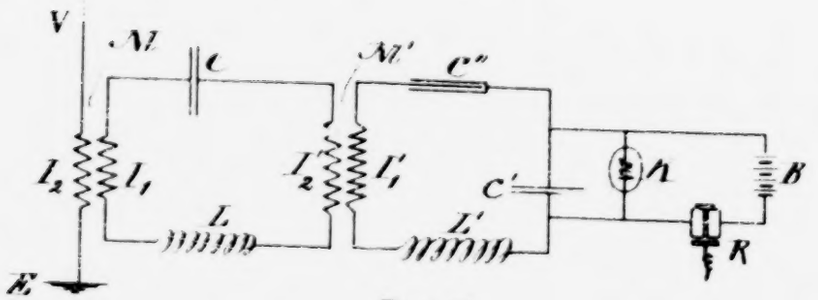


Fig. 8.

WITNESSES:
Edwin B Tomlinson
Philip J Doherty

INVENTOR:
John Stone Stone
by Alex P Browne
attorney

No. 714,831 Patented Dec. 2, 1902.

J. S. STONE.

APPARATUS FOR SELECTIVE ELECTRIC SIGNALING.

Application filed Jan. 23, 1901.

(No Model.) 5 Sheets—Sheet 3.

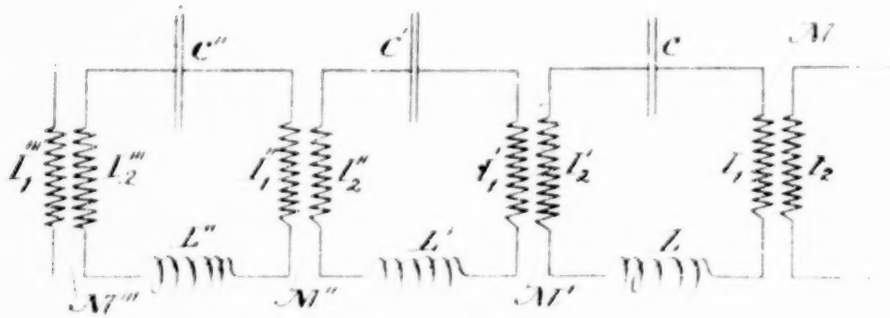
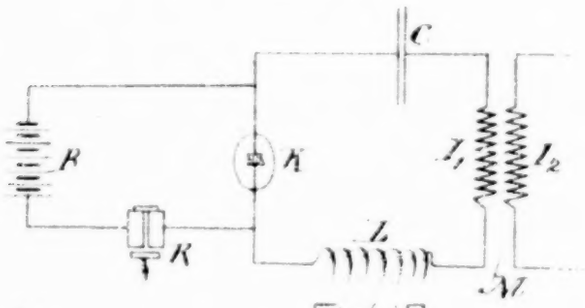


Fig. 9.



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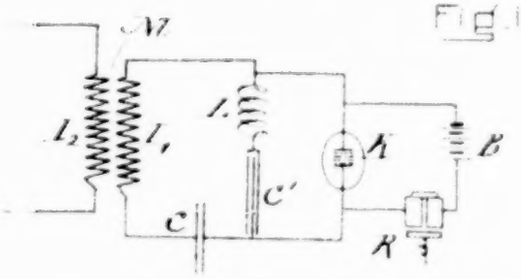

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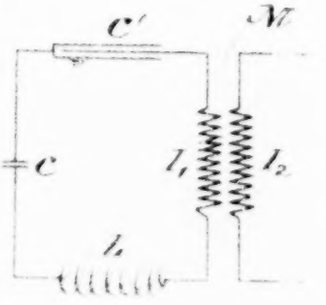


Fig. 12.

WITNESSES:

INVENTOR:

36670

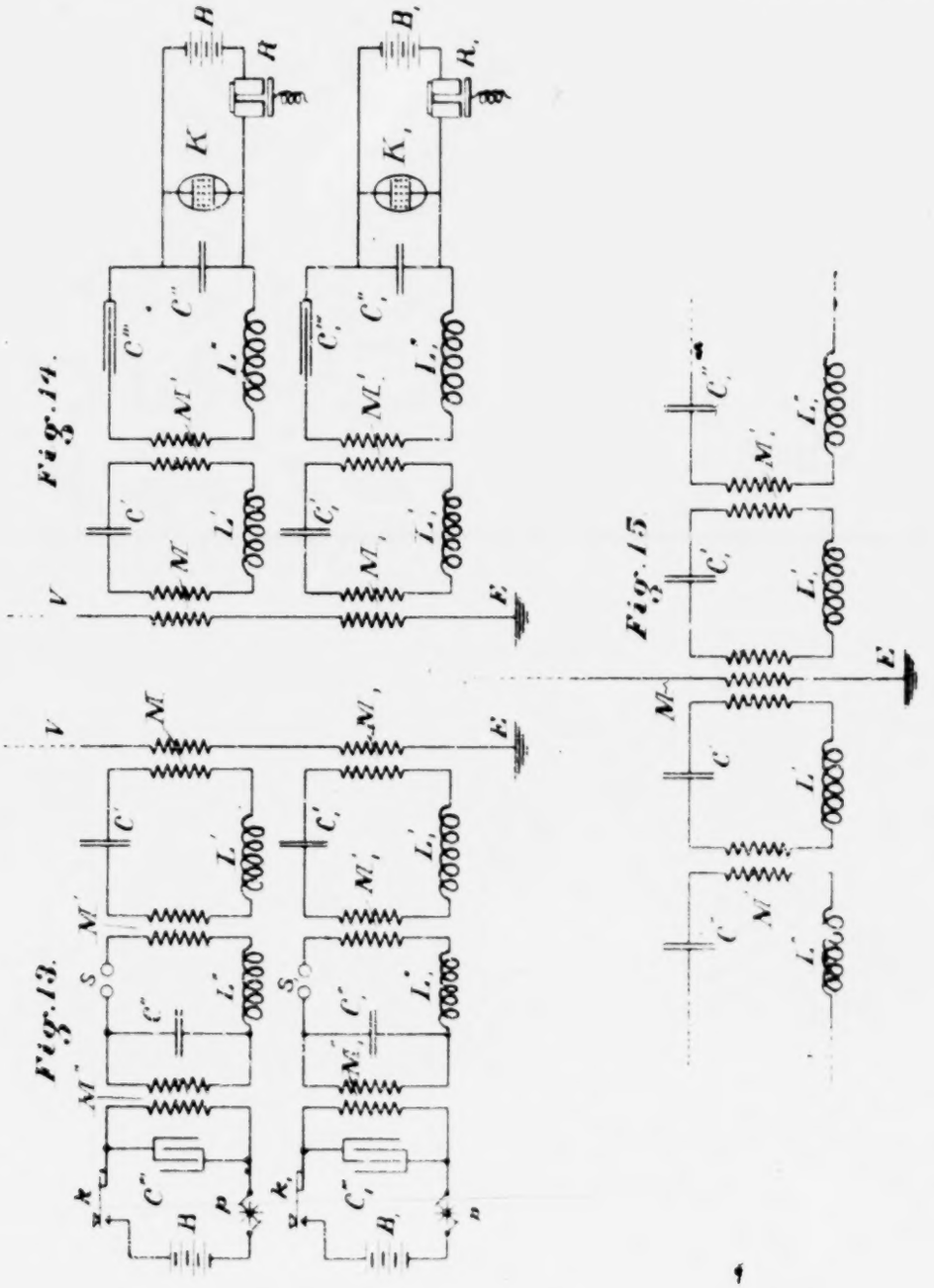
No. 714,831. Patented Dec. 2, 1902.

J. S. STONE.

APPARATUS FOR SELECTIVE ELECTRIC SIGNALING.

Application filed Jan. 23, 1901.

(No Model.) 5 Sheets—Sheet 4.



WITNESSES
M. C. Goodrich
L. A. Jones

INVENTOR
John Stone Stone
by Alex P. Browne,
Attorney

3235

No. 714,831. Patented Dec. 2, 1902.

J. S. STONE.

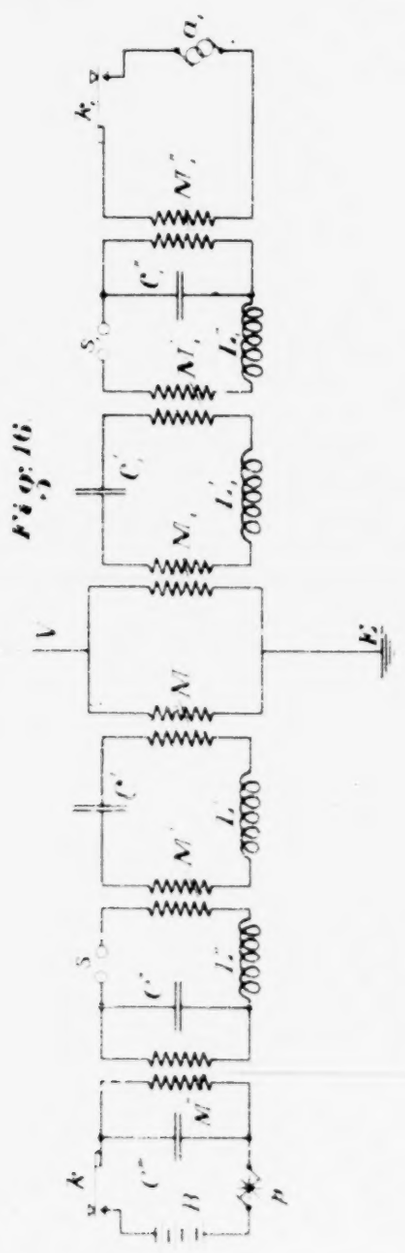
APPARATUS FOR SELECTIVE ELECTRIC SIGNALING.

Application filed Jan. 23, 1901.

No Model.

5 Sheets—Sheet 5.

Fig. 16.



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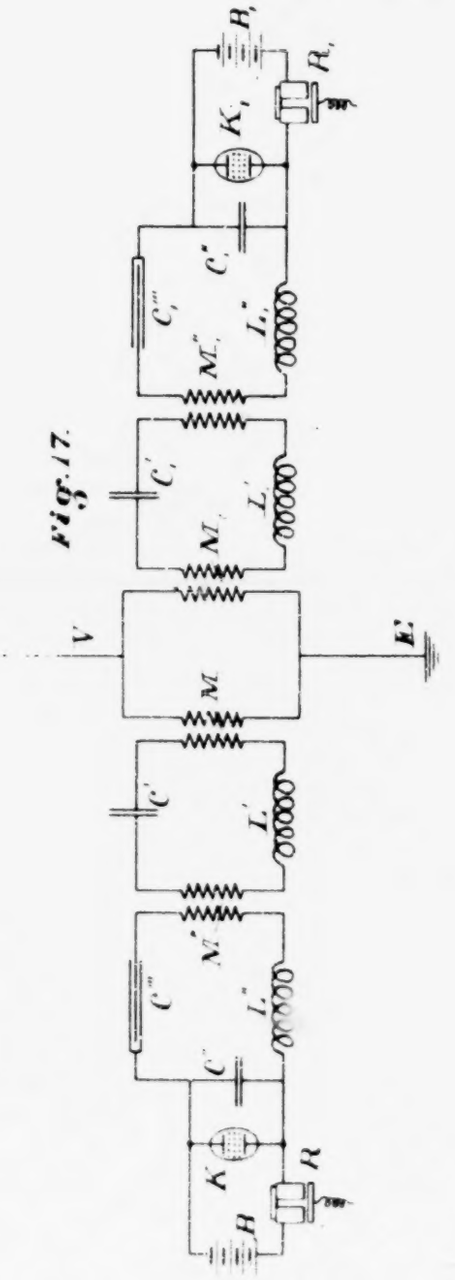

WITNESSES.

INVENTOR.

John Stone Stone

by Alex P. Browne, attorney

UNITED STATES PATENT OFFICE.

JOHN STONE STONE, OF BOSTON, MASSACHUSETTS, ASSIGNOR TO LOUIS E. WHICHER, ALEXANDER P. BROWNE, AND BRAINERD T. JUDKINS, TRUSTEES.

APPARATUS FOR SELECTIVE ELECTRIC SIGNALING.

SPECIFICATION forming part of Letters Patent No. 714,831, dated December 2, 1902.

Original application filed February 8, 1900, Serial No. 4,505. Divided and this application filed January 23, 1901. Serial No. 44,384. (No model.)

To all whom it may concern:

Be it known that I, JOHN STONE STONE, a citizen of the United States, residing at Boston, in the county of Suffolk and State of Massachusetts, have invented certain new and useful Improvements in Apparatus for Selective Electric Signaling, of which the following is a specification.

My invention relates to the art of transmitting intelligence from one station to another by means of electromagnetic waves without the use of wires to guide the waves to their destination, and it relates more particularly to the system of such transmission in which the electromagnetic waves are developed by producing electric vibrations in an elevated conductor, preferably vertically elevated.

Heretofore in signaling between two stations by means of electromagnetic waves when the stations are not connected by a conducting-wire certain disadvantageous limitations have been observed which greatly militated against the commercial value of the methods employed. When the electromagnetic waves are developed by producing natural or forced electric vibrations in a horizontal conductor, the attenuation of the waves so developed as they travel away from the conductor is found to be so great as to very seriously limit the distance to which they may be transmitted and effectively received, the chief cause of this observed phenomenon probably being that owing to the horizontal position of the conductor the plane of polarization of the waves is such as to cause the rapid absorption of the energy of the waves by the conducting surface of the earth or water over which they travel. This difficulty has been overcome by a method of developing the waves which consists in producing natural electric vibrations in a vertically-elevated conductor, in which case the plane of polarization of the wave so produced is at quadrature with that of the waves which may be developed in a horizontal wire, and in case of the vertical conductor the attenuation of the waves is observed to be very much less than in the case of the horizontal conductor, so that these waves may be transmitted to and effectively received at much greater distances. A limitation of the commercial utility of this system is, however, observed, which depends upon the fact that it has not heretofore been found possible, so far as I am aware, to direct signals sent out from a transmitter-station to the particular receiving-station with which it is desired to communicate to the exclusion of other receiving-stations equipped with equally or more sensitive receiving apparatus and located within the radius of influence of the sending-station. Electromagnetic waves have also been developed by producing natural or forced electric oscillations in loops or coils of wire at the transmitting-station and also by means of the discharge of electricity between two conducting spheres, cylinders, or cones; but in such cases the sphere of influence is so limited as to greatly restrict the commercial utility of these two methods of developing the signal-waves. In fine, the method of signaling by means of electromagnetic waves between stations not connected by a conducting-wire, in which method the electromagnetic waves are developed by electric vibrations in an elevated conductor, has great advantages over the other existing or proposed methods for accomplishing this purpose in which the electromagnetic waves are developed by other means, since in the case of the waves developed by the elevated conductor method the waves may be transmitted to and effectively received at greater distances than by the other systems, but whereas in the systems employing the other methods of generating the waves the signals developed may at least theoretically be directed to the particular receiving-station with which it is desired to communicate to the exclusion of other similar receiving-stations in the neighborhood, it has heretofore been found impossible, so far as I know, to accomplish this purpose in the system employing an elevated conductor or wire as the source of the electromagnetic waves.

The object of this invention is to overcome

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the hereinbefore-described limitation to the system in which the waves emanate from vertical conductors, so that in such systems the transmitting-stations may selectively transmit their signals each to a particular receiving station simultaneously or otherwise without mutual interference.

It is also the object of the invention to provide means whereby each of a plurality of transmitting and receiving stations in such a system may be enabled to selectively place itself in communication with any other station to the exclusion of all the remaining stations.

It is further the object of the present invention to enable the vertical or elevated conductor in such a system to be made the source of simple harmonic electromagnetic waves of any desired frequency independent of its length and other geometrical constants. Thus the frequency impressed upon the elevated conductor may or may not be the same as the natural period or fundamental of such conductor; but, as will be hereinafter explained, an elevated conductor that is aperiodic may be employed and is best adapted for use when the apparatus is to be used successively for different frequencies, and such aperiodic elevated conductor is likewise the preferred form of elevated conductor when two or more frequencies are to be simultaneously impressed upon or received by a single elevated conductor; but forced simple harmonic electric vibrations of different periodicities may each be separately impressed upon a different elevated conductor, and the several energies of the resulting electromagnetic waves may be selectively conveyed each to a separate translating device.

Before proceeding to describe the invention certain fundamental principles relative to electrical vibrations should be stated, as these principles are involved in the art of signaling by means of what may be called "unguided electromagnetic waves."

If the electrical equilibrium of a conductor be abruptly disturbed and the conductor thereafter be left to itself, electric currents will flow in the conductor, which tend to ultimately restore the condition of electrical equilibrium. These currents may be either unidirectional or oscillatory in character, depending upon the relation between the principal electromagnetic constants of the conductor—i. e., upon its electromagnetic and electrostatic capacities and its resistance. These phenomena are analogous to the mechanical phenomena which are observed when the mechanical equilibrium of a system is abruptly disturbed and the system is thereafter left to itself. In the case of a mechanical system motions result which tend to restore the mechanical equilibrium of the system. These motions may consist either of a unidirectional displacement or of to-and-fro vibrations of the system or parts of the system, depending upon the relations which subsist between the principal mechanical constants of the system—i. e., its moments of mass and elasticity and its friction coefficients. In general the determination of the relations which must subsist in order that an oscillatory restoration of equilibrium shall take place either in an electric or in a mechanical system and the determination of the period of these oscillations is very difficult; but in certain simple cases both the determination of the conditions for an oscillatory restoration of equilibrium and of the period of these oscillations is quite simple.

An example of a simple mechanical system capable of an oscillatory restoration of equilibrium is to be found in the torsional pendulum, which consists of a highly-elastic wire fixed at one end and supporting at its other extremity a heavy mass called the "bob." If a torsional stress be imparted to the wire of this pendulum by turning the bob about the axis of the wire and the bob be then abruptly released, the pendulum will in general execute isochronous oscillations about the axis of the suspending-wire in the process of restoration of equilibrium. An example of a simple electrical system capable of an oscillatory restoration of equilibrium is to be found in the case of a circuit consisting simply of a condenser and a coil without iron in its core, as shown in Figure 1 of the accompanying drawings, in which C is a condenser, and I is a coil without iron in its core. If a charge of electricity be imparted to the condenser and if its electrodes be then connected to the coil, as shown in Fig. 1, an isochronous oscillatory current will in general be developed in the circuit in the process of restoration of its electrical equilibrium. Such a simple circuit as that shown in Fig. 1 is known as a system with a "single degree of freedom," and the electric oscillations which it supports when its equilibrium is abruptly disturbed and it is then left to itself are known as the "natural" vibrations or oscillations of the system. These vibrations begin with a maximum of amplitude and gradually die away in accordance with what is known as an "exponential" law and are what are known as "simple harmonic vibrations." They may be represented graphically, as in Fig. 2, in which A is a curve drawn to rectangular coordinates, in which the ordinates represent instantaneous values of current strength and the abscissæ represent times. When two such simple circuits are associated together inductively, as shown in Fig. 3, the system so formed is known as a system of "two degrees of freedom," and in the oscillatory restorations of equilibrium—i. e., in the natural vibrations in such circuits—the currents are in general not simple harmonic in character, but in general consist of the superposition of the simple harmonic currents, as shown in Fig. 4. In general if n simple circuits, as shown in Fig. 5, be asso-

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ciated together in a system either by conductive or by inductive connections a system of at least *n* degrees of freedom results, and the natural oscillations of such a system will therefore consist of the superposition of at least *n* currents. It is, moreover, a fact that the different simple harmonic components of the oscillations which together constitute the oscillatory restoration of equilibrium of a complex system are in general not the same as those of the separate simple circuits when these circuits are isolated from one another; but the presence of each simple circuit modifies the natural period of each of the other circuits with which it is associated. Thus in a particular case if there be two simple circuits, the first with a natural period of .004 of a second when isolated and the second with a period of .0025 of a second when isolated, these circuits when inductively connected, as shown in Fig. 3, may have an oscillatory restoration of equilibrium, of which the simple harmonic components are .00444 of a second and .00159 of a second, showing that the inductive association of the circuits together has increased the natural period of the high-period circuit and decreased the natural period of the low-period circuit. It is, moreover, to be remembered that during the restoration of electric equilibrium currents of each of the periods are found in each of the circuits of the connected system.

So far we have considered the natural vibrations of electric systems—*i. e.*, the electric vibrations by means of which the electric equilibrium of circuits is restored after it has been abruptly destroyed and the circuits are left to themselves—and we have compared the simple case of such natural vibrations with the corresponding natural mechanical vibrations of mechanical systems. We have seen that simple circuits may have simple harmonic natural electric oscillations and that complex circuits will in general have complex electric oscillations. We have, moreover, seen that the natural period of oscillations depended upon the electromagnetic constants of the circuit in the case of a simple circuit and that each of the periods of oscillation in the case of a complex or of interrelated circuits depended upon the electromagnetic constants of each of the interrelated circuits; but besides the ability to execute natural vibrations or oscillations both electric and mechanical systems are capable of supporting what are termed "forced vibrations," and in the case of forced vibrations the period of the vibration is independent of the electromagnetic constants of the circuit on the one hand and the mechanical constants of the mechanical system on the other hand and depends only upon the period of the impressed force. Thus if a simple harmonic electromotive force be impressed upon a circuit free from hysteresis, whether it be a simple circuit or a complex of simple circuits, the forced vibrations or currents resulting from this impressed force will also be simple harmonic and of the same period as that of the impressed force.

In present systems of signaling by means of electromagnetic waves in which a vertical conductor is employed as the source of electromagnetic radiations the electric oscillations are of the kind hereinbefore described as "natural vibrations," the vertical conductor being charged to a high potential relative to the surrounding earth and permitted to abruptly discharge to earth by means of an electric spark between two ball-electrodes. In such a method of developing the electromagnetic waves the oscillations are necessarily of a complex character, and therefore the resulting electromagnetic waves are of a complex character and consist of a great variety of superimposed simple harmonic vibrations of different frequencies. The vibrations consist of a simple harmonic vibration of lower period than all the others, known as the "fundamental," with a great variety of simple harmonics of higher periodicity superimposed thereon. Similarly the vertical conductor at the receiving station is capable of receiving and responding to vibrations of a great variety of frequencies, so that the electromagnetic waves which emanate from one vertical conductor used as a transmitter are capable of exciting vibrations in any other vertical wire as a receiver, and for this reason any transmitting-station in a system of this character will operate any receiving station within its sphere of influence, and the messages from the transmitting station will not be selectively received by the particular receiving station with which it is desired to communicate, but will interfere with the operation of other receiving stations within its sphere of influence, thereby preventing them from properly responding to the signals of the transmitting-stations from which they are intended to receive their signals.

By my invention the vertical conductor of the transmitting-station is made the source of electromagnetic waves of but a single periodicity, and the translating apparatus at the receiving station is caused to be selectively responsive to waves of but a single periodicity, so that the transmitting apparatus corresponds to a tuning-fork, sending but a single simple musical tone, and the receiving apparatus corresponds to an acoustic resonator capable of absorbing the energy of that single simple musical tone only. When, however, the elevated conductor is aperiodic, it is adapted to receive or transmit all frequencies, and accordingly a single aperiodic elevated conductor may be associated with a plurality of local circuits each attuned to a different frequency after the manner now well known in the art of multiple telegraphy by wire conductors.

When a single elevated conductor is to be made a source of a plurality of single waves

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of different frequencies and when, moreover, these signal-waves are to be simultaneously developed, it is obviously necessary that the trains of waves of different frequencies developed in the elevated conductor shall be independent of each other—*i. e.*, it is necessary that the electric vibrations of one frequency impressed upon the elevated conductor shall not be affected by the act of simultaneously impressing vibrations of another frequency upon the conductor. The manner of developing the individual electric vibrations of a particular frequency described in this specification is such as to insure *per se* the required independence of the vibrations when several different frequencies are simultaneously impressed upon the elevated conductor. Several forms of such arrangements of the apparatus will nevertheless be hereinafter fully described in order to add to the completeness of the specification.

When the apparatus at a particular station is attuned to the same periodicity as that of the electromagnetic waves emanating from a particular transmitting-station, then this receiving-station will respond to and be capable of selectively receiving messages from that particular transmitting-station to the exclusion of messages simultaneously or otherwise sent from other transmitting-stations in the neighborhood which generate electromagnetic waves of different periodicities. Moreover, by my invention the operator at the transmitting or receiving station may at will adjust the apparatus at his command in such a way as to place himself in communication with any one of a number of stations in the neighborhood by bringing his apparatus into resonance with the periodicity employed by the station with which intercommunication is desired.

In order that the vertical conductor at the transmitting-station shall generate harmonic electromagnetic waves of but a single frequency, I cause the electric vibrations in the conductor to be of a simple harmonic character, and this in turn I accomplish by producing what are substantially forced electric vibrations in the vertical conductor in lieu of producing natural vibrations in the conductor, as has heretofore been practiced. In order that the electric translating apparatus at the receiving-station shall be operated only by electric waves of a single frequency and by no others, I interpose between the vertical conductor at the receiving-station and the translating devices a resonant circuit or circuits attuned to the particular frequency of the electromagnetic waves which it is desired to have operate the translating devices.

Having thus described, broadly, the nature and object of the invention and the electrical principles upon which it is based, the details of the invention may best be described by having reference to the drawings which accompany and form a part of this specification.

The same letters, so far as may be, represent similar parts in all the figures.

Figures 1 to 4 are diagrams already referred to. Fig. 5 is a diagram illustrating one arrangement of the transmitting-station. Fig. 6 is a diagram illustrating an arrangement of the receiving station. Fig. 7 is a diagram illustrating another form of the transmitting-station. Fig. 8 is a diagram illustrating another form of the receiving-station. Figs. 9 and 15 are diagrams illustrating a detail of the construction at both transmitting and receiving stations. Figs. 10 and 11 are diagrams illustrative of the connection of the coherer at the receiving-stations. Fig. 12 is a diagram illustrating the connection of a condenser-telephone at the receiving-station. Figs. 13 and 16 are diagrams illustrative of forms of transmitter-stations capable of developing signal-waves of two different frequencies. Figs. 14 and 17 are diagrams illustrative of forms of receiving-stations capable of receiving selectively signal-waves of two different frequencies.

In the drawings, V represents a vertical or virtually vertical conductor grounded by the earth connection E.

M, M′, M″, and M‴ are induction-coils whose primary and secondary wires are I_1, I'_1, I''_1 and I'''_1 and I_2 I'_2 I''_2, respectively.

L, L′, and L″ are auxiliary inductance-coils.

C, C′, C″, and C‴ are electrical condensers.

K and K_1 are coherers.

B is an electric battery.

a is an alternating-current generator.

k and k_1 are circuit-closing keys.

R and R_1 are telegraphic relays or other suitable electric translating devices.

p and p_1 are automatic circuit-interrupters.

s and s_1 are spark-gaps.

In the organization illustrated in Fig. 5 the generator *a* develops an alternating electromotive force of moderate frequency, which when the key *k* is depressed develops a current in the primary circuit of the transformer M. The transformer M′ is so designed as to transform the electromotive force in the primary circuit to a very high electromotive force in the secondary. As the potential difference at the terminals of the secondary I'_2 rises the charge in the condenser C increases till the potential difference is sufficient to break down the dielectric at the spark-gap *s*. When this occurs, the condenser C discharges through the spark at *s*, the primary I_1, and the inductance-coil L. This discharge is oscillatory in character and of very high frequency, as will be explained hereinafter. The high-frequency current so developed passing through the primary I_1 induces a corresponding high-frequency electromotive force and current in the secondary I_2, and forced electric vibrations result in the vertical conductor V, which are practically of a simple har-

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monic character. These simple harmonic vibrations in the conductor V develop electromagnetic waves, which are also practically simple harmonic in character, and these, in turn, on impinging upon the vertical conductor at the receiving-station develop therein corresponding simple harmonic vibrations of like frequency.

In the organization illustrated in Fig. 6 the simple harmonic electromagnetic waves of a given frequency or periodicity impinging upon the vertical conductor V develop therein corresponding electrical vibrations of like frequency. By means of the induction-coil M a vibratory electromotive force corresponding in frequency to the electric vibrations in the conductor V is induced in the secondary circuit I_1 L C C'. If the frequency of this induced electromotive force is that to which the circuit I_1 L C C' is attuned, there will be a maximum potential difference developed at the plates of the condenser C, and this potential will operate the coherer K. When the coherer K operates, the resistance of the circuit B R K is enormously diminished and the battery B develops a current which operates the translating device R. The decoherer (not shown in the drawings) is thereby set in operation, and as soon as the impulse passes the coherer is restored to its sensitive condition. If, however, the frequency of the electromagnetic waves which impinge upon the vertical conductor V of the receiving-station depicted in Fig. 6 is not the same as that to which the circuit I_1 L C C' is attuned, the electromotive force induced in this circuit will be different from that to which the circuit will respond by virtue of resonance, and there will be but a negligible potential difference developed at the plates of the condenser C. Under these circumstance the coherer K will not be operated and the signals will not actuate the translating device R.

When transmitting-stations and a corresponding number of receiving-stations are employed, by adjusting the electromagnetic constants of the circuits at the various stations these circuits may be so proportioned or tuned that the energy of the electromagnetic waves emanating from any given transmitting-station will be selectively received and absorbed at a given receiving-station.

Before proceeding to a description of the operation of the other two forms of transmitting and receiving stations (shown in Figs. 7 and 8) it is to be noted that the condenser C in Fig. 5 discharges through the circuit s I_1 L, and its discharge is practically unaffected by its conductive connection with the circuit through I_2. The reason for this is that the impedance offered by the circuit through I_2 is enormously greater than that through s I L. Also the discharge through the circuit s I_1 L is of very great frequency, because the frequency of the oscillations of such discharges of condensers is approximately inversely proportional to the square root of the product of the inductance of the circuit by the capacity of the condenser, and for the purpose of this invention the apparatus is so designed that the product of the capacity of the condenser by the inductance of the circuit is made numerically very small. Moreover, the oscillations in the circuit s I_1 L are approximately simple harmonic in character and are practically unaffected by the inductive association with the vertical wire because of the auxiliary inductance furnished by the coil I_1, it being capable of demonstration that if by means of the coil L the inductance of the circuit L I_1 s is rendered large compared to the mutual inductance between the circuit and the vertical wire the natural oscillations which will take place in the circuit s I_1 L will be practically unaffected by the inductive association with the vertical wire and will therefore be practically of a simple harmonic character, as in the case of the isolated simple circuit shown in Fig. 1. The principle may for the present purpose be stated thus: that when two simple oscillators, each such as that shown in Fig. 1, are inductively associated with each other, as in Fig. 3, the system is a system of two degrees of freedom, and the natural period of oscillation of each simple circuit is modified by the presence of the other; but if the proportions of the circuits be such that the product of the inductance of the two circuits is large compared to the mutual inductance between the circuits the natural period of oscillation of each of the circuits becomes practically the same as if the circuits were isolated. If, further, the electric equilibrium of the circuit s I_1 L be abruptly disturbed and the circuit be then left without impressed force, the oscillations which are developed in it induce corresponding oscillations in the vertical wire, which oscillations are virtually forced vibrations corresponding in frequency with the natural oscillations developed in the circuit s I_1 L and being practically independent as regards their frequency of the constants of the second circuit in which they are induced.

The mathematical expression for the frequency to which a circuit is resonant when it is isolated from all other circuits—*i. e.*, has but a single degree of freedom—is well known and may be stated as follows:

$$n = \frac{1}{2\pi\sqrt{C_1 L_1}}$$

from which

$$L_1 = \frac{1}{C_1 p^2}$$

where n is the frequency, C_1 is the capacity, L_1 is the inductance, and p is the periodicity which equals $2\pi n$. In the case of a circuit of two degrees of freedom, however, in order to make the component circuits each responsive

to the same frequency as when isolated—in other words, to overcome the modifying effect of the mutual inductance of each circuit upon the other—it is necessary to consider in the case of inductive relation the expression:

$$\frac{1}{C_1 p^2} = L_1 - \frac{M^2_{12} p \left(L_2 p - \frac{1}{C_2 p}\right)}{R^2_2 + \left(L_2 p - \frac{1}{C_2 p}\right)^2},$$

where C_1 L_1 are the capacity and inductance of the first circuit C_2 L_2 R_2 are the capacity, inductance, and resistance, respectively, of the second circuit and M_{12} is the mutual inductance of the circuits. From these expressions careful consideration will show that the effective inductance of the first circuit has been modified by its inductive relation with the second circuit, and it is:

$$L'_1 = L_1 - \frac{M^2_{12} p \left(L_2 p - \frac{1}{C_2 p}\right)}{R^2_2 + \left(L_2 p - \frac{1}{C_2 p}\right)^2}.$$

Similarly we have to consider the expression:

$$\frac{1}{C_2 p^2} = L_2 - \frac{M^2_{12} p \left(L_1 p - \frac{1}{C_1 p}\right)}{R^2_1 + \left(L_1 p - \frac{1}{C_1 p}\right)^2}$$

from which it will be seen that the effective inductance of the second circuit has been modified by its inductive relation with the first circuit and is

$$L'_2 = L_2 - \frac{M^2_{12} p \left(L_1 p - \frac{1}{C_1 p}\right)}{R^2_1 + \left(L_1 p - \frac{1}{C_1 p}\right)^2}.$$

These two inductances L'_1 and L'_2 are the apparent inductances which each of these circuits would have if acting as a primary to induce simple harmonic vibrations of frequency n in the other. It is therefore necessary in order to overcome the modifying effect of the mutual inductance on either circuit to add to that circuit an auxiliary inductance-coil of inductance large compared to the term of the form

$$\frac{M^2 p \left(L p - \frac{1}{C p}\right)}{R^2 + \left(L p - \frac{1}{C p}\right)^2}$$

or at least so large that when it is added to the natural inductance of the circuit the sum of their inductances is very large compared to the said term.

It is to be understood that any suitable device may be employed to develop the simple harmonic force impressed upon the vertical wire. It is sufficient to develop in the vertical wire practically simple harmonic vibrations of a fixed and high frequency.

The vertical wire may with advantage be so constructed as to be highly resonant to a particular frequency, and the harmonic vibrations impressed thereon may with advantage be of that frequency. The construction of such a vertical wire is shown and described in other applications of mine now pending.

At the receiving-station shown in Fig. 6 the inductance-coil L is introduced in order to supply auxiliary inductance and to permit of the circuit C C' I_1 L being attuned to a particular frequency practically independently of the constants of the vertical wire.

In both the organizations illustrated in Figs. 5 and 6 the inductance-coils L may be made adjustable and serve as a means whereby the operators may adjust the apparatus to the particular frequency which it is intended to employ.

Passing now to the organizations illustrated in Figs. 7 and 8, it is to be noted that they differ, respectively, from those illustrated in Figs. 5 and 6 in that additional resonant circuits C I'_1 L_1 are interposed between the vertical conductor and the generating and translating devices, respectively.

In the transmitter arrangements illustrated in Fig. 7 the circuit C I'_1 L_1 is attuned to the same period as the circuit C' L' I'_1, and merely tends to weed out and thereby screen the vertical wire from any harmonics which may exist in the current developed in the circuit C' L' I'_1. This screening action of an interposed resonance-circuit is due to the well-known property of such circuits by which a resonant circuit favors the development in it of simple harmonic currents of the period to which it is attuned and strongly opposes the development in it of simple harmonic currents of other periodicities. In this organization an ordinary spark-coil, (shown at M",) equipped in the usual way with an interrupter and condenser C", is employed, the current being supplied by the battery B. The operation of this organization is substantially the same as that of the organization shown in Fig. 5, hereinbefore described, except for the screening action of the circuit C I'_1 L_1 and need not, therefore, be further described. Suffice it to say that when the source of vibratory currents is particularly rich in harmonics any suitable number of resonant circuits each attuned to the desired frequency may be connected inductively in series, as shown in Figs. 9 and 15, and interposed between the generating device and the vertical conductor for the purpose of screening the vertical conductor from the undesirable harmonics.

In the organization illustrated in Fig. 8 the electric resonator C I_2 L_2, interposed between the vertical conductor and the circuit containing the coherer, is attuned to the same period as the circuit L C C' I_1 and acts to screen the coherer-circuit from the effect of all currents developed in the vertical conductor save that of the current of the particular period to which the receiving-station is

intended to respond. As in the case of the transmitting-station, any suitable number of resonant circuits, each attuned to the particular period to which the station is desired to respond, may be connected, as shown in Figs. 9 and 15, and interposed between the vertical conductor and the coherer circuit. Such circuits so interposed serve to screen the receiver from the effects of all currents which may be induced in the vertical conductor that are not of the period to which the receiving-station is intended to respond.

No mention has heretofore been made of the function of the condensers shown at C in Fig. 6 and at C in Fig. 8, as those condensers are not essential to the tuning of the circuits in which they are placed, but merely serve to exclude the current of the batteries B from the resonant circuits. In order that these condensers may not appreciably affect the tuning of the circuits in which they are included, and thereby lower the resonant rise of potential at the plates of the condensers C and C, (shown in Figs. 6 and 8,) they are so constructed as to have large capacities compared to the capacities of C and C in Figs. 6 and 8, respectively.

In Figs. 6 and 8 the coherers K are shown connected in shunt-circuit to the condensers C and C, respectively; but they may be connected serially in the resonant circuit, as shown in Fig. 10, or they may be connected in shunt-circuit to the coil L and condenser C, as shown in Fig. 11.

Though a coherer has been shown and described in the specification as the means of detecting the presence of oscillations in the receiving resonant circuits, under which circumstances it operates as a telegraphic relay to control a local battery circuit including an electric translating device, any other suitable electroreceptive device may be employed to receive the signal—as, for example, a condenser telephone. When a condenser telephone is employed as a receiver, the receiving resonant circuit may be that illustrated in Fig. 12, in which C is the condenser-telephone and also the capacity by which the circuit L C C' I, is attuned.

The apparatus shown in Figs. 13, 14, 15, 16, and 17 illustrates methods of associating the apparatus hereinbefore described, and illustrated in Figs. 5, 6, 7, 8, and 9, when two or more stations are to be associated with a common elevated conductor. The operation of each individual station is the same as that already described in connection with Figs. 5, 6, 7, 8, and 9. For the sake of clearness only two stations are shown associated with the common elevated conductor V in the drawings, but it is obvious that any desired number of stations may be associated with a common elevated conductor in the same manner.

An inspection of the drawings will show that Figs. 13 and 16 illustrate two transmitting-stations of the type shown in Fig. 7 associated with a common elevated conductor, whereas Figs. 14 and 17 illustrate two receiving-stations of the type shown in Fig. 8 associated with a common elevated conductor.

When a plurality of stations are associated with a common elevated conductor, each of the stations is characterized by being tuned to a different frequency from that of any of the other stations so associated. In Figs. 13, 14, 15, 16, and 17 it will be observed that the two different stations associated with a common elevated conductor have therein been differentiated by attaching a subscript to the letters of reference in the case of one of the stations and not to the letters of reference of the other station.

The operation of each of the transmitting-stations in Figs. 13 and 16 is identical with that of the transmitting-station illustrated in Fig. 7, and the operation of each of the receiving-stations shown in Figs. 14 and 17 is identical with the operation of the receiving-station illustrated in Fig. 8.

To illustrate, the step-up transformer or spark-coil M in Figs. 13 and 16 is equipped with an interrupter p and condenser C'', and the current is supplied by the battery B. When the key k is depressed, a high potential is developed in the secondary of M''. As the potential difference at the terminals of the secondary of M rises the condenser C'' is charged till the resulting potential difference at s is sufficient to break down the spark-gap s. When this occurs, the condenser C'' discharges through the spark at s, the primary of M, and the inductance-coil L. This circuit is attuned to a given high frequency, and the oscillatory current which results is therefore of that frequency. This current induces a similar current in the interposed resonant circuit L' M' C M attuned to the same frequency, which current in turn induces a current of corresponding frequency in the conductor V M E.

Passing now to the operation of the receiving stations shown in Figs. 14 and 17, it may be remarked that since the operation of each of these stations is identical with the operation of the receiving-station shown in Fig. 8 the energy of the waves of one particular frequency will be absorbed by one of the receiving stations and the energy of the waves of another particular frequency will be absorbed by the other receiving-station. This selective reception of the energy of waves of a particular frequency is independent of the number of waves of different frequencies which may be simultaneously present.

It is to be here noted that the above-described methods of simultaneously transmitting and receiving space-telegraph messages by a common elevated conductor are not described as the preferred methods, but that any way of associating a plurality of the stations shown in Figs. 5, 6, 7, and 8 with a vertical conductor will result in a system for simultaneously transmitting and receiving space-telegraph signals, owing to the fact that these sta-

tions are in themselves inherently selective and are capable of causing the independent development of vibrations of different frequencies in the elevated conductor and of selectively absorbing the energy of different frequencies, since the branch circuits M M in Figs. 16 and 17 are not in themselves selective and since the elevated conductors in Figs. 13 and 14 contain a number of induction-coils in series not essential to the operation of any one of the stations singly.

The branch circuits M M of Fig. 17 are not selective, since they contain but one element of a tuned circuit—viz., the inductance of M and M. Vibratory currents, of whatever frequency they may be, communicated by the vertical wire to these circuits will divide among them in single inverse proportion to their electromagnetic impedances and are not selective except for a slight reaction due to the associated circuits C M L and C M L. These reactions, so far from tending to make the branches selective to the frequencies to which their associated circuits are intended to respond, will, in fact, cause them to oppose more strongly currents of these frequencies than those to which the associated circuits are not attuned. Again, it is obvious that the inductance of the coil M in Fig. 13 is merely an additional impedance in the elevated conductor, which, to say the least, cannot assist in the development of vibrations in the elevated conductor impressed by circuit C_1 M_1 L_1 M_2. The same is obviously true of the coil M_1 in the elevated conductor with reference to the operation of the circuit C M L. Now passing to the transmitting station shown at Fig. 16, it is obvious that the vibrations communicated by the circuit C M L to the elevated conductor V are subject to a shunt due to the coil M_1 in the other branch of the elevated conductor, and, conversely, the vibrations developed in the elevated conductor by the associated circuit C_1 M_1 L_1 are subject to a shunt due to the coil M in the other branch of the elevated conductor. Finally, the coil M in the elevated conductor in Fig. 14 can at best only present an impedance to the waves intended to be received by the circuit C_1 M_1 L_1, and, conversely, the coil M_1 in the elevated conductor can at best only present an impedance to the vibrations intended to be received by the circuit C M L.

In constructing the various parts of the apparatus shown and described in this specification there is great latitude as to the special forms that may be given them; but it must be remembered that when a circuit is to be tuned and it is desired to gain a high degree of resonance both electrostatic and magnetic hysteresis must be carefully excluded from the resonant circuit. For this reason all iron should be excluded from the coils in the resonant circuits, and solid dielectrics should not ordinarily be employed in the condensers. These injunctions apply to the construction of resonant circuits attuned to very high frequencies, but not with the same force to the construction of resonant circuits to be tuned to low frequencies. Another precaution to be taken in the construction of the apparatus included in the resonant circuits when very high-frequency currents are employed is that conductors between which there exists a considerable potential difference during the operation of the apparatus shall be kept as far apart as practical, because of the excessive displacement-currents which tend to flow in the case of high-frequency currents. For this reason it will often be found to be convenient to build the coils the form of flat spirals instead of long spirals of several layers, as is the usual construction of coils. Flat spirals with the turns well separated in order to minimize the displacement currents between the turns are, however, by no means the only forms of coils adapted to be used in conjunction with air-condensers for the purpose of tuning circuits to high frequencies and may often be neither the best nor most convenient form of coil to employ. Therefore in defining the character of the coils to be employed for this purpose it will be of advantage to first give the general theoretical considerations which lead to a special construction of the coils and to then give a practical guide to the manner of designing the coils for a particular frequency or range of frequencies.

A coil or solenoid as usually constructed consists of many turns of cotton or silk insulated wire wound on an insulating-core, such as a glass or ebonite tube or a wooden spool, the consecutive turns being separated only by the thin insulating coating of the wire. These solenoids, moreover, are in general wound with several layers of wire, the layers also being separated from each other only by the insulating coatings of the wires. Such solenoids are well adapted to be used in conjunction with condensers having solid dielectrics for the purpose of tuning circuits to low frequencies; but neither such coils nor such condensers are available for the purpose of tuning circuits to such high frequencies as are concerned in the present invention. In the case of high frequencies the energy absorbed in the solid dielectric of the condenser due to dielectric hysteresis is excessive and the displacement-currents between the adjacent turns and layers of the coil mask and neutralize the inductance of the coil. Moreover, the solid dielectric forming the core of such coils exerts a deleterious effect, which in some instances is probably partially due to its possessing a small degree of conductivity, but which must in most instances be ascribed to the high specific inductive capacity of the material and to its dielectric hysteresis.

In order to tune a circuit to a predetermined high frequency, so that it shall show a well-defined selectivity for that frequency to the exclusion of other frequencies, even to the exclusion of frequencies differing but slightly from the predetermined frequency, it is nec-

essary not only that the condenser shall be free from dielectric hysteresis, but that the coil shall be so constructed as to behave for that frequency practically like a conductor having a fixed resistance and a fixed inductance, but devoid of capacity. Coils constructed in the usual way do not behave for high frequencies as if they had a fixed resistance and inductance and no capacity, but partake more of the character of conductors having distributed resistance, inductance, and capacity. In fact, they may in some instances behave with high frequencies more like condensers than like conductors having fixed resistance and inductance and no capacity. Since a coil constructed in the usual way behaves for high frequencies as a conductor having distributed resistance, inductance, and capacity, it follows that such a coil will show for high frequencies the same quasi-resonance as is observed with low frequencies in long aerial lines and cables—*i. e.*, that it will *per se* and without the intermediary of a condenser show a slight degree of selectivity for some particular frequency and for certain multiples of that frequency just as a stretched string which has distributed inertia and elasticity will respond to a particular tone called its "fundamental" and to all other tones whose periods are aliquot parts of the periods of that fundamental; but it is not with such quasi-resonance that the present invention is carried into effect, and I wish it understood that I here disclaim any system employing distributed inductance and capacity as a means of tuning the resonant circuits described in this specification.

A general criterion which determines the utility of a coil for tuning a circuit to a particular high frequency is that the potential energy of the displacement-currents in the coil shall be small compared to the kinetic energy of the conduction-current flowing through the coil when the coil is traversed by a current of that frequency.

I have found that for a single-layer coil the following procedure is sufficient for practical purposes. Determine the inductance of the coil by formulæ to be found in the text-books and treatises on electricity and magnetism. This will enable the kinetic energy of the coil to be determined for any particular current and will also permit of the determination of what would be the potential gradient along the coil for the current of the frequency to be employed if the coil were devoid of distributed electrostatic capacity. Next calculate the electrostatic capacity between an end turn and each of the remaining turns of the coil. These capacities, together with the potential gradient found, will enable the potential energy to be determined, and if the ratio of the potential energy to the kinetic energy so found be negligible compared to unity the coil will practically satisfy the requirements hereinbefore mentioned. If the coil does not meet the requirements, the design should be so changed as to increase the separation between the turns or the size of the wire should be diminished or the dimensions of the coil so otherwise altered as to decrease the distributed capacity without proportionately diminishing the inductance. The calculations may be greatly abbreviated and the liability to error greatly reduced if the results of the computations be plotted in curves.

Regarding the effect of a dielectric core in a coil to be used for tuning a circuit to a high frequency, it is sufficient to state that the preferred form of support for such a coil is any skeleton frame which will hold the turns of wire in place without exposing much surface of contact to the wires and affording a minimum of opportunity for the development of displacement-currents within itself.

In this specification I have spoken of elevated conductors, vertically-elevated conductors, and vertical conductors. I wish to be understood as including in the term "elevated" conductors disposed at an angle to the earth's surface as distinguished from horizontal conductors disposed parallel to the earth's surface. By the terms "vertically elevated" and "vertical" I refer to conductors whose disposition with regard to the earth's surface is mainly or wholly at a right angle or vertical thereto, which is the particular form of elevated conductor preferred by me for use in connection with my present improvement.

In this specification I have described the development of free or unguided electromagnetic signal-waves of a given frequency by employing in association with an elevated conductor a circuit such as to produce therein forced simple harmonic electric vibrations of the frequency desired. I have also described a method of receiving or absorbing the energy of free or unguided simple harmonic electromagnetic waves of one frequency to the exclusion of waves of a different frequency by associating with an elevated conductor a circuit made resonant to the frequency of the waves whose energy is to be absorbed. The circuit whereby forced simple harmonic electric vibrations are produced in the elevated conductor I have shown as a circuit containing a condenser and a self-induction coil so proportioned as to make the natural vibrations of a frequency which is the frequency of the vibrations to be forced or impressed in an elevated conductor. The circuit whereby the energy of the electromagnetic waves of one frequency is absorbed to the exclusion of that of waves of another frequency is in like manner a circuit containing a condenser and a self-induction coil so proportioned as to make the circuit resonant to a frequency which is the frequency of the waves the energy of which is to be received. Both of the circuits I have spoken of are tuned circuits, and they may be conveniently distinguished with reference to their respec-

tive functions by denominating the circuit employed in the development of the vibrations as an "oscillating" or "sonorous" circuit and by denominating the circuit employed in the reception or absorption of the vibrations as a "resonant" circuit. I prefer to make this discrimination in nomenclature for the reason that while both the circuits are resonant circuits, yet time only only that one employed for receiving or absorbing is accurately so described. Except for this distinction in function it is well to note that all oscillating or sonorous circuits are resonant circuits, but only such resonant circuits as have their resistance less than the square root of the ratio of four times their inductance by their capacity are oscillating or sonorous circuits.

Also throughout this specification I have described the electrical oscillations or vibrations and the free or unguided electromagnetic waves or radiations as simple harmonic. It is the object of my present invention to approach as nearly as possible to the perfect simple harmonic wave and such object is attained to within such a degree of precision as to preclude any possible interference with the operation of the system by any departure that can exist in the wave from the absolute simple harmonic form. My reason for confining the description of the electrical oscillations or vibrations and the electromagnetic waves or radiations to the simple harmonic type is that in the operation of the system only simple harmonic waves and vibrations are effective in carrying out the object of the invention. If in any similar system of selective space telegraphy there be frequent, even minute, overtones accompanying the simple harmonic signal waves, such overtones will not only not contribute to the useful operation of the system, but may, in fact, become obstacles to such useful and complete operation. It is for this reason that I have taken every precaution to obtain a true or absolute simple harmonic wave form.

Specifically, though it may be possible to employ for the purpose of multiple and selective wireless telegraphy electric vibrations and radiations departing considerably from the simple harmonic type by employing at the receiving end circuits selective to the fundamental of such vibrations and radiations, yet it will only be through the selective reception of that simple harmonic component of the vibrations or radiations which is their fundamental that the system will be operative. The other simple harmonic components of the vibrations or radiations add nothing to the operation of the system. Moreover, if such overtones exist in the waves emanating from a transmitting station their presence will preclude the possibility of placing receiving stations in the immediate neighborhood of such transmitting station for the reception of signal waves of frequencies corresponding to the frequencies of such overtones.

Whereas in the present specification I have used the term "elevated" conductor to describe the source of radiation of electromagnetic waves developed by forced electric vibrations impressed thereon, yet I deem it proper to point out that this expression should not be confused with the term "conductor" when used in connection with systems wherein that term is employed to denote a wire or other metallically continuous conductor extending from a transmitting to a receiving station. It is of course obvious that in the art to which the present specification relates such a conductor is wholly absent. The vertical metallically continuous source of radiant energy is a structure the location and function of which are confined entirely to the transmitting, or it may be to the receiving, end of a system in which the conductor which connects the transmitting and receiving stations is the non-metallic non-conducting—in fact, dielectric—medium, which is commonly called the "ether" and which is by many assumed to be essential to the theory of the propagation of electrical and magnetic forces, radiant light, and radiant heat.

Having described my invention, I claim—

1. In a system for developing free or unguided simple harmonic electromagnetic signal waves of a definite frequency, an elevated conductor and means for developing therein forced simple harmonic electric vibrations of corresponding frequency.

2. In a system for receiving the energy of free or unguided simple harmonic electromagnetic signal waves of a definite frequency, to the exclusion of the energy of signal waves of other frequencies, an elevated conductor and a resonant circuit associated with said conductor and attuned to the frequency of the waves, the energy of which is to be received.

3. In a system for independently developing free or unguided simple harmonic electromagnetic signal waves of different frequencies, an elevated conductor and means for independently developing therein forced, simple harmonic, electric vibrations of different and corresponding frequencies.

4. In a system for selectively receiving the energy of free or unguided, simple harmonic, electromagnetic signal waves of different frequencies, each to the exclusion of the rest, an elevated conductor, and resonant circuits associated with said conductor and each attuned to the frequency of a different one of the trains of waves, the energy of which is to be received.

5. In a system for independently developing free or unguided simple harmonic, electromagnetic signal waves of different frequencies, a plurality of elevated conductors corresponding to the number of said different frequencies, and means for impressing upon each

of said conductors forced simple harmonic electric vibrations corresponding to a different one of the said frequencies.

6. In a system for selectively receiving the energy of free or unguided simple harmonic, electromagnetic signal-waves of different frequencies, a plurality of elevated conductors corresponding in number to the number of different frequencies to be received, and resonant circuits each associated with a different elevated conductor, and each attuned to a different one of the said frequencies.

7. In a system for producing free and unguided electromagnetic signal-waves of a definite frequency, an elevated conductor, a source of electrical energy and a group of resonant circuits interposed between said elevated conductor and said source of electrical energy, said circuits being attuned to the frequency of the waves to be developed.

8. In a system for receiving the energy of free or unguided simple harmonic, electromagnetic signal-waves of one frequency to the exclusion of the energy of those of other frequencies, an elevated conductor, an electric translating device, and a group of resonant circuits interposed between said elevated conductor and said electric translating device, said circuits being resonant to the frequency of the waves, the energy of which is to be received.

9. In a system for developing free or unguided simple harmonic, electromagnetic signal-waves, a condenser, means for charging and discharging said condenser through a closed circuit having inductance adapted to produce under such conditions simple harmonic electric vibrations, and means for communicating the vibrations so produced to an open circuit or elevated conductor.

10. In a system for developing free or unguided, simple harmonic, electromagnetic signal-waves, a condenser, means for charging and discharging said condenser through a closed circuit having inductance adapted to produce under such conditions simple harmonic electric vibrations, means for communicating said vibrations to a resonant circuit or group thereof attuned to the frequency of these vibrations and means of communicating the resulting electrical vibrations in said resonant circuit or group thereof to an open circuit or elevated conductor.

11. A circuit resonant to a given high frequency comprising a coil having the amplitude of its potential energy small compared to the amplitude of its kinetic energy when it is supporting a current of said given high frequency, and a condenser adapted to balance by its reactance, the reactance of said coil for said given high frequency.

12. In a circuit resonant to a given high frequency, a coil having the amplitude of its potential energy small compared to the amplitude of its kinetic energy when supporting a current of said given high frequency.

13. In a system for selectively receiving the energy of free or unguided simple harmonic electromagnetic signal-waves of different frequencies, an elevated conductor, and a plurality of resonant circuits associated with said elevated conductor, each resonant to the particular frequency of the electromagnetic waves, the energy of which it is to receive.

14. In a system for selectively receiving the energy of free or unguided simple harmonic, electromagnetic, signal-waves of different frequencies, a plurality of elevated conductors, each associated with a circuit resonant to the particular frequency of the electromagnetic waves, the energy of which it is to receive.

15. In a system for selectively receiving the energy of free or unguided simple harmonic, electromagnetic, signal-waves of different frequencies, a plurality of elevated conductors, each associated with a group of circuits resonant to the particular frequency of the electromagnetic waves the energy of which it is to receive.

16. In a system for selectively receiving the energy of free or unguided simple harmonic, electromagnetic signal-waves of different frequencies, an elevated conductor and a plurality of groups of resonant circuits associated with said elevated conductor, each of said groups of circuits being resonant to the particular frequencies of the electromagnetic waves, the energy of which it is to receive.

17. In a system for receiving the energy of free or unguided, simple harmonic, electromagnetic signal-waves of a definite frequency to the exclusion of energy of signal-waves of other frequencies, an elevated conductor and a group of resonant circuits associated with said conductor and attuned to the frequency of the waves, the energy of which is to be received.

18. In a system for selectively receiving the energy of free or unguided, simple harmonic, electromagnetic signal-waves of different frequencies, each to the exclusion of the rest, an elevated conductor and a plurality of resonant circuits associated with said conductor and each attuned to the frequency of a different one of the trains of waves, the energy of which is to be received.

19. In a system for selectively receiving the energy of free or unguided simple harmonic, electromagnetic signal-waves of different frequencies, a plurality of elevated conductors corresponding in number to the number of different frequencies to be received, and groups of resonant circuits each associated with a different elevated conductor, and each attuned to a different one of the said frequencies.

20. In a system for developing free or unguided simple harmonic, electromagnetic signal-waves or radiations, an elevated conductor, associated closed oscillating circuits, means for disturbing the electrical equilibrium of said oscillating circuits, and means for swamping the effect of the mutual inductance between said circuit and the elevated conductor.

21. In a system for independently developing free or unguided electromagnetic signal-waves or radiations of different frequencies, an elevated conductor, associated closed oscillating circuits each attuned to a different one of the frequencies to be developed, and each of said oscillating circuits having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and the other oscillating circuits and between it and the elevated conductor.

22. In a system for receiving the energy of simple harmonic, electromagnetic waves of a given frequency, to the exclusion of like waves of different frequencies, an elevated conductor, a circuit associated with said elevated conductor and made resonant to the frequency of the electromagnetic waves, the energy of which is to be received, by the condenser and an auxiliary inductance-coil whose inductance is sufficient to swamp the effect of the mutual inductance between the associated circuit and the elevated conductor.

23. In a system for receiving the energy of simple harmonic, electromagnetic waves of one frequency, to the exclusion of like waves of different frequencies, an elevated conductor, associated circuits each resonant to the frequency of the electromagnetic waves to be received, and each having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and the other associated circuits and between it and the elevated conductor.

24. In a system for developing simple harmonic, electromagnetic signal-waves or radiations of a given frequency, a metallically-continuous vertical oscillator and means for impressing thereon simple harmonic, electrical, oscillations of the same frequency.

25. In a system for simultaneously developing simple harmonic, electromagnetic, signal waves of different frequencies, a metallically-continuous vertical oscillator, and means for impressing thereon simple harmonic, electrical oscillations of the same frequencies.

26. In a system for receiving the energy of free or unguided, simple harmonic, electromagnetic waves, an elevated conductor, a circuit associated with said elevated conductor and resonant to the frequency of the electromagnetic waves, and an electric translating device shunted around the terminals of one of the elements of said resonant circuit.

27. In a system for receiving the energy of free or unguided, simple harmonic, electromagnetic waves, an elevated conductor, a group of resonant circuits associated with said resonant conductor, resonant to the frequency of the electromagnetic waves, and an electric translating device shunted around terminals of that one of said resonant circuits which is farthest removed from the elevated conductor.

28. In a system for receiving the energy of free or unguided, simple harmonic, electromagnetic waves, an elevated conductor and an electric translating device forming one of the elements of a resonant circuit associated with said elevated conductor and resonant to the frequency of the electromagnetic waves.

29. In a system for receiving the energy of simple harmonic, electromagnetic waves of a given frequency, to the exclusion of like waves of different frequencies, an elevated conductor, a circuit associated with said elevated conductor and made resonant to the frequency of the electromagnetic waves, the energy of which is to be received, and means for swamping the effect of the mutual inductance between said circuit and the elevated conductor.

30. In a system for receiving the energy of simple harmonic, electromagnetic waves of one frequency, to the exclusion of like waves of different frequencies, an elevated conductor, associated circuits each resonant to the frequency of the electromagnetic waves to be received, and means in each of said circuits for swamping the effect of the mutual inductance between it and the other circuits and between it and the elevated conductor.

31. In a system for receiving the energy of free or unguided, simple harmonic, electromagnetic signal waves of a definite frequency, to the exclusion of the energy of signal-waves of other frequencies, an elevated conductor, a resonant circuit associated with said conductor and attuned to the frequency of the waves, the energy of which is to be received, and means for swamping the effect of the mutual inductance between said circuit and the elevated conductor.

32. In a system for selectively receiving the energy of free or unguided, simple harmonic, electromagnetic signal-waves of different frequencies, each to the exclusion of the rest, an elevated conductor, resonant circuits associated with said conductor and each attuned to the frequency of a different one of the trains of waves, the energy of which is to be received, and means for swamping the effect of the mutual inductance between said circuit and the elevated conductor.

33. In a system for selectively receiving the energy of free or unguided, simple harmonic electromagnetic signal-waves of different frequencies, a plurality of elevated conductors corresponding in number to the number of different frequencies to be received, resonant circuits each associated with a different elevated conductor and each attuned to a different one of the said frequencies, and means in each of said circuits for swamping the effect of the mutual inductance between it and the other circuits and between it and the elevated conductor.

34. In a system for producing free and unguided electromagnetic signal-waves of a definite frequency, an elevated conductor, a source of electric energy, a group of resonant circuits interposed between said elevated conductor and said source of electric energy, said circuits being attuned to the frequency

of the waves to be developed, and means in each of said circuits for swamping the effect of the mutual inductance between it and the other circuits and between it and the elevated conductor.

35. In a system for receiving the energy of free or unguided, simple harmonic, electromagnetic signal-waves of one frequency, to the exclusion of the energy of those of other frequencies, an elevated conductor, an electric translating device, a group of resonant circuits interposed between said elevated conductor and said electric translating device, said circuits being resonant to the frequency of the waves, the energy of which is to be received, and means in each of said circuits for swamping the effect of the mutual inductance between it and the other circuits and between it and the elevated conductor.

36. In a system for developing free or unguided, simple harmonic, electromagnetic signal-waves, a condenser, means for charging and discharging said condenser through a closed circuit having inductance adapted to produce under such conditions simple harmonic, electric vibrations, means for communicating the vibrations so produced to an elevated conductor, and means for swamping the effect of the mutual inductance between said circuit and the elevated conductor.

37. In a system for developing free or unguided, simple harmonic, electromagnetic signal-waves, a condenser, means for charging and discharging said condenser through a closed circuit having inductance adapted to produce under such conditions simple harmonic, electric vibrations, means for communicating said vibrations to a resonant circuit or group thereof attuned to the frequency of these vibrations, means of communicating the resulting electrical vibrations in said resonant circuit or group thereof to an elevated conductor, and means in each of said circuits for swamping the effect of the mutual inductance between it and the other circuits and between it and the elevated conductor.

38. In a system for selectively receiving the energy of free or unguided, simple harmonic, electromagnetic signal-waves of different frequencies, an elevated conductor, a plurality of resonant circuits associated with said elevated conductor, each resonant to the particular frequency of the electromagnetic waves, the energy of which it is to receive, and means in each of said circuits for swamping the effect of the mutual inductance between it and the other circuits and between it and the elevated conductor.

39. In a system for selectively receiving the energy of free or unguided, simple harmonic, electromagnetic signal-waves of different frequencies, a plurality of elevated conductors, each associated with a circuit resonant to the particular frequency of the electromagnetic waves, the energy of which it is to receive, and means in each of said circuits for swamping the effect of the mutual inductance between it and the other circuits and between it and the elevated conductor.

40. In a system for selectively receiving the energy of free or unguided, simple harmonic, electromagnetic signal-waves of different frequencies, a plurality of elevated conductors, each associated with a group of circuits resonant to the particular frequency of the electromagnetic waves the energy of which it is to receive, and means in each of said circuits for swamping the effect of the mutual inductance between it and the other circuits and between it and the elevated conductor.

41. In a system for selectively receiving the energy of free or unguided, simple harmonic, electromagnetic signal-waves of different frequencies, an elevated conductor, a plurality of groups of resonant circuits associated with said elevated conductor, each of said groups of circuits being resonant to the particular frequencies of the electromagnetic waves, the energy of which it is to receive, and means in each of said circuits for swamping the effect of the mutual inductance between it and the other circuits and between it and the elevated conductor.

42. In a system for receiving the energy of free or unguided, simple harmonic, electromagnetic signal-waves of a definite frequency, to the exclusion of energy of signal-waves of other frequencies, an elevated conductor, a group of resonant circuits associated with said conductor attuned to the frequency of the waves, the energy of which is to be received, and means in each of said circuits for swamping the effect of the mutual inductance between it and the other circuits and between it and the elevated conductor.

43. In a system for selectively receiving the energy of free or unguided, simple harmonic, electromagnetic signal-waves of different frequencies, each to the exclusion of the rest, an elevated conductor, a plurality of resonant circuits associated with said conductors and each attuned to the frequency of a different one of the trains of waves, the energy of which is to be received, and means in each of said circuits for swamping the effect of the mutual inductance between it and the other circuits and between it and the elevated conductor.

44. In a system for selectively receiving the energy of free or unguided, simple harmonic, electromagnetic signal-waves of different frequencies, a plurality of elevated conductors corresponding in number to the number of different frequencies to be received, groups of resonant circuits each associated with a different elevated conductor, and each attuned to a different one of the said frequencies, and means in each of said circuits for swamping the effect of the mutual inductance between it and the other circuits and between it and the elevated conductor.

JOHN STONE STONE.

In presence of—
ALEX. P. BROWNE,
ELLEN B. TOMLINSON.

2-390

DEFENDANT'S EXHIBIT R-3

3685

DEPARTMENT OF THE INTERIOR,

UNITED STATES PATENT OFFICE.

To all persons to whom these presents shall come, Greeting:

THIS IS TO CERTIFY that the annexed is a true copy from the records of this office of the File Wrapper and Contents, in the matter of the

Letters Patent of

John Stone Stone, Assignor to Louis E. Whicher, Alexander P. Browne, and Brainerd T. Judkins, Trustees,

Number 714,756, Granted December 2, 1902,

for

Improvement in Methods of Selective Electric Signaling.

IN TESTIMONY WHEREOF I have hereunto set my hand and caused the seal of the Patent Office to be affixed, at the City of Washington, this twentieth day of October, in the year of our Lord, one thousand nine hundred and twenty-four and of the Independence of the United States of America the one hundred and forty-ninth.

W. A. Kinnan

Acting Commissioner of Patents.

3250

36886

NUMBER (SERIES OF 1900)

4505

PATENT No. 711475

Name of [illegible] Stone & Stone
Assignees of Lewis B. Macher, Alexander D. Brown
and Daniel S. Judkins, Trustees
Brainerd & [illegible]

of Boston

County of

State of Massachusetts

Invention Method of Selective Electric Signaling

	ORIGINAL		RENEWED	
Petition	[illegible]	1900		190
Affidavit	[illegible]	1900		190
Specification	[illegible]	1900		190
Drawing	[illegible]	1900		190
Model or Specimen	none	190		190
First Fee, Cash	$15	1900		190
" " Cert		190		190
App. filed complete	7/18	1900		190
Examined	[illegible] June 20	1902		190
Countersigned	[illegible]			190
Notice of Allowance	[illegible]	190		190
Final Fee Cash	$20 Nov 8	1902		190
" " Cert		190		190
Patented	December 2	1902		190

Filed Division of Apr. 11, 1901 PARTS OF APPLICATION FILED

Certificate & Correction December 6 1902

Associate Attorney Watson & Watson, Wash. D.C.

Attorney Celest P. Brown 31 State St. Boston Mass

Name

Serial Number

Patent No.

Date of Patent

4505.

36887

Div.

Serial Number. 1,100 Class Subs.

4565

Patent No. 711,786

Fan stone stove.

Of Boston

County of

State of Massachusetts

Location

Method & ~~and Apparatus for~~ electric electric lighting -

Parts of Application filed.

Petition Feb. 1. 1900.

Affidavit " "

Specification " "

Drawing " "

Model

Specimen

First Fee Cash $15. Feb. 5. 1900.

" Cert.

Appl. filed complete -

Examined

Countersigned

Notice of allowance , 190

Final Fee Cash , 190

" " Cert , 190

Patented , 190

3252

36838

IN THE UNI[redacted] OFFICE.

Room No. -- SERIAL NO. ----

Application of John Sigua[illegible],

For Patent for Improvement in [illegible] for Selective Electric Signalling,

Filed ---------- Allowed ----------

In reply to Office Letter of ----------

[illegible] STREET, BOSTON, Feb. 7, 1900.

To the Commissioner of Patents, Washington, D.C.

SIR

[illegible] petition and power of attorney, [illegible], [illegible] sheets of drawings, and check for fif- [illegible], [illegible] filing the above appli- [illegible].

[illegible],

Alex. P. [illegible],

Attorneys.

[illegible].

32563

136839

APPLICATION FOR LETTERS PATENT.

PETITION.

To the Commissioner of Patents:

Your Petitioner

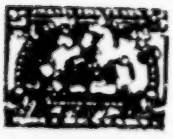
residing

P. O. address, 2 Newbury St. Boston, Mass.

prays that Letters Patent may be granted to him

for the set forth in the annexed specifications and hereby appoints as his authorized attorney ALEX P. BROWNE, of No. 31 State Street, Boston, Mass.,

with full power of substitution and revocation to prosecute this application, to make alterations and amendments therein, to receive the patent and to transact all business in the Patent Office connected therewith.



John Stow Shaw

SPECIFICATION.

TO ALL WHOM IT MAY CONCERN:

Be it known that

My invention relates to the art of transmitting intelligence from one station to another by means of electro-magnetic waves without the use of wires to guide the waves to their destination, and it relates more particularly to the system of transmission in which the electro-magnetic waves are developed by producing electric vibrations in an elevated conductor, preferably vertically elevated.

In practice in signalling between two stations by means of electro-magnetic waves, when the stations are not connected by a conducting wire, certain disadvantageous limitations have been observed which greatly militated against the commercial value of the methods employed. When the electro-magnetic waves are developed by producing natural or forced electric vibrations in a horizontal conductor, the attenuation of the waves so developed as they travel away from the conductor, is found to be so great as to very seriously limit the distance to which they may be transmitted and effectively received, the chief cause of this observed phenomenon probably being that owing to the horizontal position of the conductor, the plane of polarization of the waves is such as to cause the rapid absorption of the energy of the waves by the conducting surface of the earth or water over which they travel. This difficulty has been overcome by a method of developing the waves which consists in producing natural electric vibrations in a vertically elevated conductor, in which case the plane of polarization of the wave so produced is at quadrature with that of the waves which may be developed by a horizontal wire, and in case of the vertical conductor the attenuation of the waves is observed

be very much less than in the case of the horizontal conductor so that these waves may be transmitted to, and effectively received at much greater distances.

A limitation of the commercial utility of this system is however observed which depends upon the fact that it has not heretofore been found possible, so far as I am aware, to direct signals sent out from a transmitter station to the particular receiving station with which it is desired to communicate to the exclusion of other receiving stations equipped with equally or more sensitive receiving apparatus and located within the radius of influence of the sending station.

Electro-magnetic waves have also been developed by producing natural or forced electric oscillations in loops or coils of wire at the transmitting station and also by means of the discharge of electricity between two conducting spheres, cylinders, or cones, but in such cases, the sphere of influence is so limited as to greatly restrict the commercial utility these two methods of developing the signal waves.

In fine, the method of signalling by means of electro-magnetic waves between stations not connected by a conducting wire, in which method the electro-magnetic waves are developed by electric vibrations in an elevated conductor, has great advantages over the other existing or proposed methods for accomplishing this purpose in which the electro-magnetic waves are developed by other means since in the case of the waves developed by the elevated conductor method, the waves may be transmitted to and effectively received at greater distances than by the other systems. But whereas in the systems employing the other methods of generating the waves, the signals de-

veloped may, at least theoretically, be directed to the particular receiving station with which it is desired to communicate to the exclusion of other similar receiving stations in the neighborhood; it has been proposed, for example, that as I know, to accomplish this purpose in the system of the above-mentioned character, the electrical oscillations are caused to be propagated in the form of electromagnetic waves.

The object of this invention is to overcome the above-mentioned limitation to the [illegible] waves [illegible]

[illegible]

[illegible]

[

mately restore the condition of electrical equilibrium. These currents may be either unidirectional or oscillatory in character, depending upon the relation between the principal electro-magnetic constants of the conductor, i.e., upon its electromagnetic and electro-static capacities and its resistance. These phenomena are analogous to the mechanical pehnomena which are observed when the mechanical equilibrium of a system is abruptly disturbed and the system is thereafter left to itself. In the case of a mechanical system, motions result which tend to restore the mechanical equilibrium of the system. These motions may consist either of a unidirectional displacement or of to and fro vibrations of the system or parts of the system, depending upon the relations which subsist between the principal mechanical constants of the system, i.e., its moments of mass and elasticity and its friction coefficients. In general, the determination of the relations which must subsist in order that an oscillatory restoration of equilibrium shall take place, either in an electric or in a mechanical system, the determination of the period of these oscillations is very difficult, but in certain simple cases both the determination of the conditions for an oscillatory restoration of equilibrium, and of the period of these oscillations is quite simple.

An example of a simple mechanical system capable of oscillatory restoration of equilibrium is to be found in the torsional pendulum, which consists of a highly elastic wire fixed at one end and supporting at its other extremity a mass called the bob. If a torsional stress be impressed upon the wire of this pendulum by turning the bob about the axis of the wire and the bob be then abruptly released, the pen-

in general execute isochronous oscillations about the axis of the suspending wire in the process of restoration of equilibrium. An example of a simple electrical system capable of an oscillatory restoration of equilibrium is to be found in the case of a circuit consisting simply of a condenser and a coil without iron in its core as shown in Fig.1 of the accompanying drawings in which C is a condenser and I is a coil without iron in its core. If a charge of electricity be imparted to the condenser and if its electrodes be then connected to the coil as shown in Fig.1, an isochronous oscillatory current will in general be developed in the circuit in the process of restoration of its electrical equilibrium. Such a simple circuit as that shown in Fig.1 is known as a system with a single degree of freedom, and the electric oscillations which it supports when its equilibrium is abruptly disturbed and it is then left to itself are known as the natural vibrations or oscillations of the system. These vibrations begin with a maximum of amplitude and gradually die away in accordance with what is known as an exponential law, and are what are known as simple harmonic vibrations. They may be represented graphically as in Fig.2, in which A is a curve drawn to rectangular coordinates in which the ordinates represent instantaneous values of current strength and the abscissae represent times.

When two such simple circuits are associated together, inductively as shown in Fig.3, the system so formed is known as a system of two degrees of freedom and in the oscillatory restorations of equilibrium, i.e., in the natural vibrations in such circuits, the currents are in general not simple harmonic in character but in general consist of the superposition of

two simple harmonic currents as shown in Fig.4.

In general, if n simple circuits as shown in Fig.1 be associated together in a system either by conductive or by inductive connections, a system of at least n degrees of freedom results and the natural oscillations of such a system will therefore consist of the superposition of at least n currents. It is moreover a fact that the different simple harmonic components of the oscillations which together constitute the oscillatory restoration of equilibrium of a complex system are in general not the same as those of the separate simple circuits when these circuits are isolated from one another, but the presence of each simple circuit modifies the natural period of each of the other circuits with which it is associated. Thus in a particular case if there be two simple circuits, the first with a natural period of .004 of a second when isolated and the second with a period of .0025 of a second when isolated; these circuits when inductively connected as shown in Fig. 4 will have an oscillatory restoration of equilibrium of which the simple harmonic components are .0044 of a second, and .0014 of a second, showing that the inductive association of the circuits together has increased the natural period of the higher frequency circuit, and decreased the natural period of the lower frequency circuit. It is moreover to be remembered that during the restoration of electric equilibrium currents of each of the periods are found in each of the circuits of the connected system.

So far we have considered the natural vibrations of electric systems, i.e., the electric vibrations by means of which the electric equilibrium of circuits is restored after it has been abruptly destroyed and the circuits are left to themselves and we have compared the simple case of mechanical electric

vibrations with the corresponding natural mechanical vibrations or mechanical systems. We have seen that simple circuits may have simple harmonic natural electric oscillations, and that complex circuits will in general, have complex oscillations. We have moreover seen that the natural oscillations depended upon the electro-magnetic constants of the circuit in the case of a simple circuit and that the periods of oscillation in the case of a complex or interrelated circuits depended upon the electro-magnetic constants of each of the interrelated circuits. But besides the power to execute natural vibrations or oscillations, both electrical and mechanical systems are capable of supporting what are called forced vibrations and in the case of forced vibrations the period of the vibration is independent of the electrical constants of the circuit on the one hand, and the mechanical constants of the mechanical system on the other hand, and depends only upon the period of the impressed force. Thus if a simple harmonic electro-motive force be impressed upon a circuit free from hysteresis, whether it be a simple circuit or a complex of simple circuits, the forced vibrations or currents resulting from this impressed force will also be simple harmonic, and of the same period as that of the impressed force.

In the present system of signalling by means of electro-magnetic waves in which a vertical conductor is employed as the source of electro-magnetic radiations, the electric oscillations hereinbefore described as natural vibrations of the conductor being charged to a high potential and the surrounding earth and permitted to absorb the energy of an electric spark be-

tween two ball electrodes.

In such a method of developing the electro-magnetic waves, the oscillations are necessarily of a complex character and therefore the resulting electro-magnetic waves are of a complex character and consist of a great variety of superimposed simple harmonic vibrations of different frequencies. The vibrations consist of a simple harmonic vibration of lower period than all the others, known as the fundamental with a great variety of simple harmonics of higher periodicity superimposed thereon. Similarly the vertical conductor at the receiving station is capable of receiving and responding to vibrations of a great variety of frequencies so that the electro-magnetic waves which emanate from one vertical conductor used as a transmitter are capable of exciting vibrations in any other vertical wire as a receiver and for this reason, any transmitting station in a system of this character will operate any receiving-station within its sphere of influence and the messages from the transmitting station will not be selectively received by the particular receiving station with which it is desired to communicate but will interfere with the operation of other receiving stations within its sphere of influence, thereby preventing them from properly responding to the signals of the transmitting stations from which they are in order to receive their signals.

By my invention the vertical conductor of the transmitting station is made the source of electro-magnetic waves of a single periodicity, and the translating apparatus of the receiving station is caused to be selectively responsive to waves of but a single period to the exclusion

apparatus corresponds to a tuning fork sending but a single simple musical tone, and the receiving apparatus corresponds to an acoustic resonator capable of absorbing the energy of that single, simple musical tone only.

When the apparatus at a particular station is attuned to the same periodicity as that of the electro-magnetic waves emanating from a particular transmitting station, then this receiving station will respond to and be capable of selectively receiving messages from that particular transmitting station, to the exclusion of messages simultaneously or otherwise sent from other transmitting stations in the neighborhood which generate electro-magnetic waves of different periodicities. Moreover, by my invention the operator at the transmitting or receiving station may at will adjust the apparatus at his command in such a way as to place himself in communication with any one of a number of stations in the neighborhood, by bringing his apparatus into resonance with the periodicity employed at the station with which intercommunication is desired.

In order that the vertical conductor at the transmitting station shall generate harmonic electro-magnetic waves of but one frequency, I cause the electric vibrations in the conductor to be of a simple harmonic character and this in turn I effect by producing what are substantially forced electric vibrations in the vertical conductor in lieu of producing natural vibrations in the conductor as has heretofore been practiced. In the electric transmitting apparatus at the receiving station which is to be operated only by electric waves of a certain periodicity and by no others, I interpose between the

vertical conductor at the receiving station and the translating devices, resonant circuits attuned to the particular frequency of the electro-magnetic waves which it is desired to have operate the translating devices.

Having thus described broadly, the nature and object of the invention and the electrical principles upon which it is based, the details of the invention may best be described by having reference to the drawings which accompany and form a part of this specification. The same letters, so far as may be, represent similar parts in all the figures.

Figures 1 to 4 are diagrams already referred to.

Fig. 5 is a diagram illustrating one arrangement of transmitting station.

Fig. 6 is a diagram illustrating an arrangement of receiving station.

Fig. 7 is a diagram illustrating another form of transmitting station.

Fig. 8 is a diagram illustrating another form of receiving station.

Figs. 9 and 13 are diagrams illustrating a detail of tion at both transmitting and receiving stations.

Figs. 10 and 11 are diagrams illustrative of tion of the coherer at receiving stations.

Fig. 12 is a diagram illustrating the telephone at the receiving station.

In the drawings V represents vertical conductor grounded at

M, M' and M'' are induction coils, the primary coils are I, I' and I'' and

L, L' and L'' are auxiliary inductance coils.

C, C' and C'' are electrical condensers.

K is a coherer.

B is an electric battery.

a is an alternating current generator

T is a circuit closing key.

R is a telegraphic relay or other suitable electric translating device.

B is an automatic circuit interrupter.

s is a spark gap

In the organization illustrated in Fig. 5 the generator a develops an alternating electro-motive force of moderate frequency which when the key k is depressed develops a current in the primary circuit of the transformer M'. The transformer M' is so designed as to transform the electro-motive force in the primary circuit to a very high electro-motive force in the secondary. As the potential difference at the terminals of the secondary L' rises, the charge in the condenser C increases till the potential difference is sufficient to break down the dielectric at the spark gap s. When this occurs, the condenser C discharges through the spark at s the primary I, and the inductance coil L. This discharge is oscillatory in character and of very high frequency as will be explained hereafter. The high frequency current so developed passing through the primary I, induces a corresponding high frequency electro-motive force and current in the secondary I, and forced electric vibrations result in the vertical conductor v, which are practically of a simple harmonic character. These simple harmonic [illegible] in the conductor v develop electro-magnetic waves,

which are also practically simple harmonic in character and these in turn on impinging upon the vertical conductor at the receiving station develop therein corresponding simple harmonic vibrations of like frequency.

In the organization illustrated in Fig. 8 [redacted] monic electro-magnetic waves of a given frequency or periodicity impinging upon the vertical conductor v develop [redacted] corresponding electrical vibrations of like frequency. By means of the induction coil H, a vibratory electro-motive force corresponding in frequency to the electric vibrations in the conductor v is induced in the secondary circuit I, L, C, C', If the frequency of this induced electro-motive force is that to which the circuit I, L C C' is attuned, there will be a maximum potential difference developed at the plates of the condenser C, and this potential will operate the coherer K. When the coherer K operates, the resistance of the circuit B R K is enormously diminished and the battery B develops a current which operates the translating device R. The decoherer, not shown in the drawing, is thereby set in operation and as soon as the impulse passes, the coherer is restored to its sensitive condition. If however the frequency of the electro-magnetic waves which impinge upon the vertical conductor v of the receiving station depicted in Fig. 8 is not the same as that to which the circuit I, L C C' is attuned, the electro-motive force induced in this circuit will be different from that to which the circuit will respond by virtue of resonance, and there will be but a negligible potential difference developed at the plates of the condenser C. Under these circumstances the coherer K will not be operated and the signals will not actuate the translating device R.

When transmitting stations and a corresponding number of receiving stations are employed, by adjusting the electro-magnetic constants of the circuits at the various receiving stations, these circuits may be so proportioned or tuned that the energy of the electro-magnetic waves emanating from any given transmitting station will be selectively received and absorbed at a given receiving station.

Before proceeding to a description of the operation of the other two forms of transmitting and receiving stations shown in Figs. 7 and 8, it is to be noted that the condenser C in Fig. 5 discharges through the circuit s I, L, and its discharge is practically unaffected by its conductive connection with the circuit through I'_2. The reason for this is that the impedance offered by the circuit through I'_2 is enormously greater than that through s I, L. Also the discharge through the circuit s I, L is of very great frequency because the frequency of the oscillations of such discharges of condensers is approximately inversely proportional to the square root of the product of the inductance of the circuit by the capacity of the condenser and for the purpose of this invention the apparatus is so designed that the product of the capacity of the condenser by the inductance of the circuit is made numerically very small. Moreover the oscillations in the circuit s I, L are approximately simple harmonic in character and are practically unaffected by the inductive association with the vertical wire because of the auxiliary inductance furnished by the coil I, it being capable of demonstration that if by means of the coil L, the inductance of the circuit L I, s is rendered large compared the mutual inductance between the circuit and the vertical

wire, the natural oscillations which will take place in the circuit s I, L will be practically unaffected by the inductive association with the vertical wire and will therefore be practically of a simple harmonic character as in the case of the isolated simple circuit shown in Fig.1. The principle may, for the present purpose, be stated thus:- That when two simple oscillators, each such as that shown in Fig.1, are inductively associated with each other as in Fig.3, the system is a system of two degrees of freedom, and the natural period of oscillation of each simple circuit is modified by the presence of the other, but if the proportions of the circuits be such that the product of the inductances of the two circuits is large compared to the mutual inductance between the circuits, the natural period of oscillation of each of the circuits becomes practically the same as if the circuits were isolated. If further, the electric equilibrium of the circuit s I, L be abruptly disturbed and the circuit be then left without impressed force, the oscillations which are developed in it induce corresponding oscillations in the vertical wire, which oscillations are virtually forced vibrations, corresponding in frequency with the natural oscillations developed in the circuit s I, L and being practically independent, as regards their frequency, of the constants of the second circuit in which they are induced.

It is to be understood that any suitable device may be employed to develop the simple harmonic force impressed upon the vertical wire. It is sufficient to develop in the vertical wire practically simple harmonic vibrations of a fixed and high frequency.

At the receiving station shown in Fig.6 the inductance coil L is introduced in order to supply auxiliary inductance and to permit of the ~~current~~ circuit C C' I, L being attuned to a particular frequency practically independently of the constants of the vertical wire.

In both the organizations illustrated in Figs.5 and 6, the inductance coils L may be made adjustable and serve as a means whereby the operators may adjust the apparatus to the particular frequency which it is intended to employ.

Passing now to the organizations illustrated in Figs.7 and 8, it is to be noted that they differ respectively from those illustrated in Figs.5 and 6 in that additional resonant circuits C I' L I, are interposed between the vertical conductor and the generating and translating devices respectively.

In the transmitter arrangements illustrated in Fig.7, the circuit C I' L I, is attuned to the same period as the circuit C' L' I', s and merely tends to weed out and thereby screen the vertical wire from any harmonics which may exist in the current developed in the circuit C' L' I', s. This screening action of an interposed resonant circuit is due to the well known property of such circuits by which a resonant circuit favors the development in it of simple harmonic currents of the period to which it is attuned and strongly opposes the development in it of simple harmonic currents of other periodicities. In this organization an ordinary spark coil, shown at M', equipped in the usual way with an interrupter p and condenser C' is employed, the current being supplied by the battery B. The operation of this organization is substantially the same as that of the organization shown in Fig.5, hereinbefore described, except for the screening action

of the circuit C I' L I, and need not therefore be further described. Suffice it to say that when the source of vibratory currents is particularly rich in harmonics any suitable number of resonant circuits, each attuned to the desired frequency may be connected inductively in series, as shown in Figs. 9 and 10, and interposed between the generating device and the vertical conductor for the purpose of screening the vertical conductor from the undesirable harmonics.

In the organization illustrated in Fig.8, the electric resonator C I' L I, interposed between the vertical conductor and the circuit containing the coherer is attuned to the same period as the circuit L' C' C" I', and acts to screen the coherer circuit from the effect of all currents developed in the vertical conductor save that of the current of the particular period to which the receiving station is intended to respond. As in the case of the transmitting station, any suitable number of resonant circuits, each attuned to the particular period to which the station is desired to respond may be connected as shown in Figs. 9 and 10, and interposed between the vertical conductor and the coherer circuit. Such circuits so interposed serve to screen the receiver from the effect of all currents which may be induced in the vertical conductor that are not of the period to which the receiving station is intended to respond.

No mention has heretofore been made of the function of the condensers shown at C' in Fig.6 and at C" in Fig.8, as those condensers are not essential to the tuning of the circuits in which they are placed, but merely serve to exclude the current of the batteries B from the resonant circuits. In or-

der that these condensers may not appreciably affect the tuning of the circuits in which they are included and thereby lower the resonant rise of potential at the plates of the condensers C and C', shown in Figs. 6 and 8, they are so constructed as to have large capacities compared to the capacities of C and C' in Figs. 6 and 8 respectively.

In Figs. 6 and 8, the coherers K are shown connected in shunt circuit to the condensers C and C' respectively, but they may be connected serially in the resonant circuit as shown in Fig. 10, or they may be connected in shunt circuit to the coil L and condenser C' as shown in Fig. 11.

Though a coherer has been shown and described in the specification as the means of detecting the presence of oscillations in the receiving resonant circuits, under which circumstances it operates as a telegraphic relay to control a local battery circuit including an electric translating device, any other suitable electro-receptive device may be employed to receive the signal, as for example, a condenser telephone. When a condenser telephone is employed as a receiver, the receiving resonant circuit may be that illustrated in Fig. 12, in which C is the condenser telephone and also the capacity by which the circuit L C C' I, is attuned.

In Fig. 12 R' is a coil of very great impedence employed to prevent the passage of the electrical oscillations from the resonant circuit L C C' I into the battery circuit and the consequent disturbance of the resonance. The battery B should be of very high potential and it serves to maintain a permanent charge in the condenser telephone C. Such a charge greatly enhances the sensitiveness of the telephone and causes the attraction between its plates to vary more nearly in proper-

tion to the variations of electro-motive force at its terminals. As it is inconvenient to attain very high potentials by means of primary galvanic batteries, it will be found convenient in practice to employ either a Plante battery of very small capacity but of a large number of cells connected in series or else a condenser charged from time to time to a high potential.

In constructing the various parts of the apparatus shown and described in this specification there is great latitude as to the special forms that may be given them, but it must be remembered that when a circuit is to be tuned and it is desired to gain a high degree of resonance both electro-static and magnetic hysteresis must be carefully excluded from the resonant circuit. For this reason all iron should be excluded from the coils in the resonant circuits and solid dielectrics should not ordinarily be employed in the condensers. These injunctions apply to the construction of resonant circuits attuned to very high frequencies, but not with the same force to the construction of resonant circuits to be tuned to low frequencies. Another precaution to be taken in the construction of the apparatus included in the resonant circuits when very high frequency currents are employed is that conductors between which there exists a considerable potential difference during the operation of the apparatus shall be kept as far apart as practical, because of the excessive displacement currents which tend to flow in the case of high frequency currents. For this reason it will often be found to be convenient to build the coils in the form of flat spirals instead of long spirals of several layers as is the usual construction of coils.

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In this specification I have spoken of elevated conductors, vertically elevated conductors, and vertical conductors. I wish to be understood as including in the term "elevated", conductors disposed at an angle to the earth's surface as distinguished from horizontal conductors, disposed parallel to the earth's surface. By the terms "vertically elevated" and "vertical", I refer to conductors whose disposition with regard to the earth's surface is mainly or wholly at a right angle or vertical thereto, which is the particular form of elevated conductor preferred by me for use in connection with my present improvement.

Having described my invention, I claim:

1. The method of developing simple harmonic electro-magnetic waves of a definite periodicity, which consists in producing forced simple harmonic electric vibrations of the same periodicity in an elevated conductor.

2. The method of absorbing the energy of simple harmonic electro-magnetic waves of one periodicity to the exclusion of the energy of electro-magnetic waves of different periodicity which consists in associating with an elevated conductor a resonant circuit or a group thereof attuned to the same period as that of the waves the energy of which is to be absorbed.

3. The method of distributing the energy of electro-magnetic waves which consists in independently developing forced simple harmonic electric vibrations of different periodicities in elevated conductors and conveying the several components of the resulting electro-magnetic waves, each selectively, to separate electric translating devices.

4. The method of distributing the energy of electro-mag-

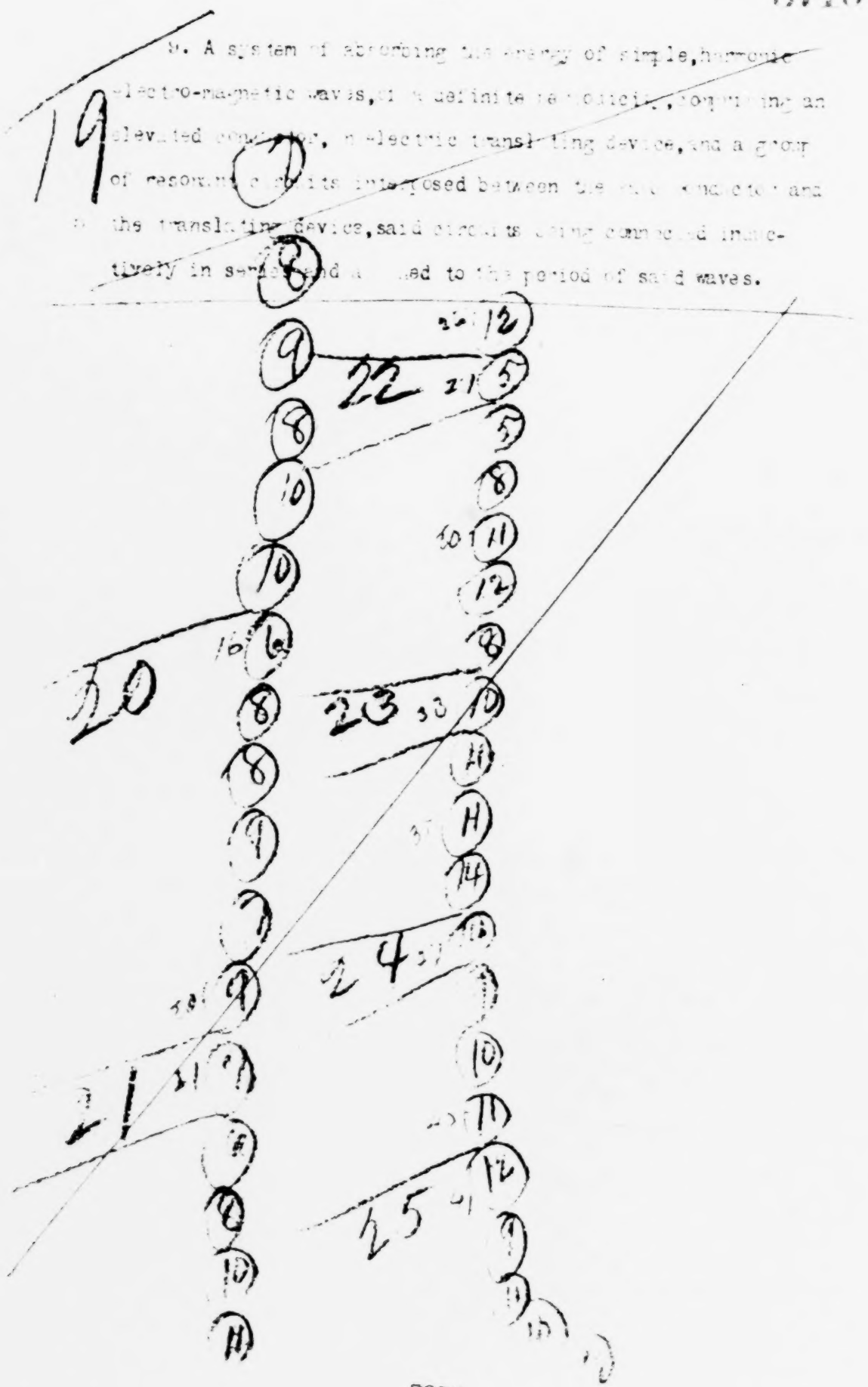
netic waves which consists in independently developing a number of forced simple harmonic electric vibrations of different periodicity, [illegible] electro-magnetic waves, each selective, [illegible] or group thereof attuned to [illegible] waves, the energy of which is to be absorbed [illegible].

6. A system of utilizing the energy of electro-magnetic waves, comprising an elevated conductor, means of independently developing therein forced, simple, harmonic electric vibrations of a definite periodicity, a resonant circuit or group of circuits, associated with a second elevated conductor attuned to the said definite periodicity, and an electric translating device [illegible].

7. A system for the absorption of energy of electro-magnetic waves, comprising an elevated conductor, means independently developing therein forced simple harmonic electric vibrations of different definite periodicities, and a number of resonant circuits or groups of circuits, each one elevated conductor attuned to one of said periodicities, and an electric translating device associated with each resonant circuit or group thereof.

8. A system for developing simple harmonic electro-magnetic waves of a definite periodicity, comprising an elevated conductor, a generator of vibratory electric currents, and a number of resonant circuits, connected inductively in series and interposed between the said conductor and the generator.

9. A system of absorbing the energy of simple, harmonic electro-magnetic waves, of a definite period, comprising an elevated conductor, a electric translating device, and a group of resonant circuits interposed between the conductor and the translating device, said circuits being connected inductively in series and adapted to the period of said waves.



In testimony [illegible] I have hereunto subscribed my hand this 6th day of February, 1900.

Witnesses:

E. E. Bradwick. John Sloan Sloan.

Allen P. Brocway Jr.

[illegible].

State of [illegible], County of Suffolk, ss.

John Sloan Sloan,

the above named petitioner, being duly sworn, deposes and says that he is a citizen of the United States and resident of Boston, in the County of Suffolk and State of Massachusetts, and that he verily believes himself to be the original, first and sole inventor of the improvement in Methods of [illegible] for Selective Electric Signalling, described and claimed in the foregoing letters patent; that he does not know and does not believe that the same was ever before known or used in any country foreign to the United States; that he does not believe that the same was ever before known or used in any foreign country [illegible] years prior to the application for this patent; that he does not know and does not believe that the same was ever patented or described in any printed publication in this or any foreign country [illegible] years prior to his invention thereof.

John Sloan Sloan.

Subscribed and sworn to before me this 6th day of February A.D. 1900.

Everett D. Bradwick

Notary Public.

3712

2-946.

Room No. 21.

All communications should be addressed to "The Commissioner of Patents, Washington, D. C."

All communications respecting this application should give the serial number, date of filing, and title of invention.

DEPARTMENT OF THE INTERIOR,

UNITED STATES PATENT OFFICE,

WASHINGTON, D. C., March 10, 1900.

John Shane Stone,

Care, Alexander P. Browne,

31 State St.,

Boston, Mass.

U. S. PATENT OFFICE
MAR 10 1900

Please find below a communication from the **EXAMINER** *in charge of your application.*

Filed Feb. 6, 1900. Ser. No. 4505, for Method of and Apparatus for Selective Electric Signaling.

C. H. Duell
Commissioner of Patents.

There appear in this case four claims for methods and four claims for systems, there being no claim 5 in the case. The applicant is not allowed claims on separate and independent inventions, as set out in Rule 41 of the amended Rules of Practice of July 15, 1899. The applicant will elect which claimshe will prosecute in this application, when action on the merits will be had.

For the state of the art see the following patents:

Pupin, 540,515, June 2, 1895,
" 540,516, " " "
Telegraphy, Telegraphs, Multiplex,
Baltzar, 530,228, Oct. 2, 1894,
Wilson, 443,871, Dec. 29, 1891,
Pitsee, 550,510, Nov. 26, 1895,
Lodge, 602,154, Apr. 12, 1898,
Marconi, 627,650. June 27, 1899,
British
Lodge, 29,069 and 29,605 of 1897,
Thompson, 528 of 1898,

Telegraphy,
Telegraphs,
Circuits and Systems.

Fred O. Fish

RULE 77. In every amendments the exact word or words to be stricken out or inserted in the application must be specified and the precise point indicated where the erasure or insertion is to be made. All such amendments must be on sheets of paper separate from the papers previously filed, and written on but one side of the paper.

3277

IN THE UNITED STATES PATENT OFFICE. 3713 2

Room No. 51, SERIAL No. [illegible].

Application of John Stone Stone,

for Patent for Improvement in Method of and Apparatus for Selective Electric Signaling,

filed Feb 27, 1900, allowed ---

In reply to Office Letter of March 10, 1900.

21 State
~~31~~ WATER STREET, BOSTON, [illegible], 1901

To the Commissioner of Patents, Washington, D.C.

SIR:

Pursuant to the requirements of the Examiner, the present case is amended by cancelling claims 1, 2, 3, and 4, as the same form the subject matter of another application sworn to and filed; also by amending the title of the invention as set forth in the petition and at page 1, line 4 of the specification, by erasing the words "and apparatus for."

Also by erasing from the specification the paragraph beginning at line 11, page 15.

Amend Fig. 1 of the drawing by erasing the box F, impedance coil R', and the connections between the same and the resonant circuit I, C, C', I'. The portions of the specifications and drawings desired to be erased by the foregoing amendments are inadvertently inserted by inadvertence.

Respectfully,

Alex. P. Browne,
atty for applt

3278 6

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#3

Room No. 21. 11

(All communications should be addressed to "The Commissioner of Patents, Washington, D. C.")

All communications respecting this application should give the serial number, date of filing, and title of invention.

286

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE,

WASHINGTON, D. C. Feb. 12, 1901.

John Stone Stone,

Care, Alexander P. Browne,

31 State St.,

Boston, Mass.

Please find below a communication from the **EXAMINER** *in charge of your application.*

Filed Feb. 3, 1900, Ser. No. 4505, for Method of and Apparatus for Selective Electric Signaling.

C. H. Duell

Commissioner of Patents.

This application has been considered in connection with the amendment of Jan. 23, 1901.

It is thought that applicant intended to refer to figure 3 instead of figure 2 in line 18 of page 7 of his specification.

Claim 1 covers a method for developing simple harmonic electromagnetic waves of a definite periodicity by setting up simple harmonic electric vibrations of the same periodicity of an elevated conductor. The nature or disposition of the conductor in which such electric vibrations are set up in no way affect the method per se. The claim is accordingly rejected upon the patent to Pupin, 640,515, Jan. 2, 1900, Telegraphy, Multiplex.

Claim 2 is rejected upon the patent to Tesla, 627,650, June 27, 1899, Telegraphy, Circuits and Systems, particular reference

In every amendment the exact word or words to be stricken out or inserted in the application must be specified and the precise point indicated where the erasure or insertion is to be made. All such amendments must be on sheets of paper separate from other papers previously filed, and written on but one side of the paper.

In every application for a patent filed subsequent to December 31, 1897, responsive action must be made by the inventor within one year after the last official action or the case will become abandoned.

being had to figure 1.

Claims 3 and 4 are not understood for the reason that it is not clear whether one or several conductors are implied, that is, whether the independent frequencies are impressed upon one or different conductors. However this may be claims 3 and 4 are deemed to be met in the patent to Pupin, 640,316, cited above, and for the reasons stated in connection with claim 1. Attention is also called to the system found in the British patent to Lodge, 29,505 of 1897, of record.

G. C. Maue

Examiner. Div. 16.

3 00

(1) (6) 3716 4

In the United States Patent Office.

Room No.61, Serial No.4906,

Application of John Stone Stone,

For Patent for Improvement in Method of and Apparatus for Selective Electric Signaling,

Filed February 8,1900,

In reply to Office letter of February 13,1901.

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31 State street, Boston,

March 23,1901.

To the Commissioner of Patents,

Washington, D.C.

Sir,

Amend the title by striking out the words 'and Apparatus therefor.'

Amend the specification by striking out '2' in line 18 of page 1 and replacing it by '1'.

Amend claim 1 by inserting the words 'free or unguided' in line 13,page 20,after the word 'developing.'

Amend claim 2 by inserting the words 'free or unguided' in line 17,page 20,after the words 'energy of' and by inserting the words 'free or unguided' in line 18,page 20,after the words 'energy of.'

Amend claim 3 by inserting the words 'free or unguided' at line 23,page 20,after the words 'energy of.' Also by erasing the word 'conductors' at line 24,same page,and substituting the word 'conductor,'also in the same line by inserting the word 'an' after the word 'in',and by inserting at line 27,

same page, the word "a" after the word "to."

Amend claim 4 by inserting the words "free or unguided" in line 24, page 20, after the words "energy of"; also by erasing the word "conductors" and substituting the word "conductor" at line 3, page 21. Also in the same line by inserting the word "an" after the word "in."

Add two claims 5 and 6 respectively, as follows:

"5. The method of distributing the energy of free or unguided electro-magnetic waves which consists in developing forced simple harmonic electric vibrations of different periodicities, each in a different elevated conductor, and ~~conducting~~ the several energies of the resulting electro-magnetic waves, each selectively, to a separate electric translating device.

"6. The method of distributing the energy of free or unguided electro-magnetic waves which consists in developing a number of forced simple harmonic electric vibrations of different frequencies, each in a different elevated conductor, and ~~conducting~~ the several energies of the resulting electro-magnetic waves, each selectively, to a separate resonant circuit, or group thereof, attuned to the same period as that of the waves, the energy of which is to be absorbed therein."

Argument upon the pertinency of the [illegible] in reference is made for convenience in a separate paper filed herewith.

Respectfully,

Alex P Browne
atty for applt

4505-3

In the United States Patent Office.

Room No.81, Serial No.4505,

Application of John Stone Stone,

For Patent for Improvement in Method of and Apparatus for Selective Electric Signaling,

Filed February 8,1900,

In reply to Office letter of February 12,1901.

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31 State street, Boston,

March 23,1901.

To the Commissioner of Patents,

Washington, D.C.

Sir,

A r g u m e n t .

Applicant does not understand that the Examiner in rejecting claim 1 of the application upon Pupin's patent No. 640,918 contends that there is no novelty in using in a system of space telegraphy, free or unguided simple harmonic electro-magnetic waves which are developed by producing forced simple harmonic electric vibrations in elevated conductors. He understands that claim 1 is rejected because it is by the Examiner construed to be in terms broad enough to cover a method of developing guided simple harmonic electro-magnetic waves which are developed by producing forced simple harmonic waves in an elevated horizontal conductor or main line, since this is the nature of the disclosure contained in the patent to Pupin referred to by the Examiner.

Such a construction of claim 1 is deemed by the applicant to be too broad since the claim must be construed with refer-

ence to the specification of which it forms a part, in which the meaning attached by the applicant to the term 'elevated conductor' is explicitly stated (see lines 1 to 11 inclusive, p. 20 of the application.) The paragraph in the specification above referred to forbids the interpretation of the term 'elevated conductor' in claim 1 as meaning an elevated horizontal conductor in a straight line, and it also by virtue of the accompanying lines covering the phenomena involved, precludes the interpretation of the term 'simple harmonic electro-magnetic waves' in the claim as including guided simple harmonic electro-magnetic waves.

Electro-magnetic waves emanating from an elevated conductor, if the term elevated conductor be used in the sense in which the applicant has applied it in his specification, are not intended except in so far as the earth or water over which they travel may be considered to exert a guiding influence.

Applicant's attorney contends that the claim in its original form is not susceptible of a construction which would make it read on anything in the art. The invention as claimed is [illegible] and the claim is not indefinite.

Nevertheless the application for the purpose of eliminating the question will be amended in the manner set forth above, and the claim will be rejected as thus amended.

Respectfully,

Geo. P. Brown
Asst. Examiner

91.

DEPARTMENT OF THE INTERIOR

UNITED STATES PATENT OFFICE,

WASHINGTON, D. C. April 10, 1901.

John Stone Stone,

Care, Alex. P. Browne,

31 State St.,

Boston, Mass.

Please find below communication from the **EXAMINER** *in charge of your application.*

Filed Feb. 8, 1900. Ser. No. 4,505. For Method of and Apparatus for Selective Electric Signaling.

Fig. 1 of the drawings will be changed as requested by the applicant, on the filing of proper prints.

Claim 1 is again rejected upon the patent to Lupin of record. So far as the method of developing the waves is concerned, it is immaterial whether they be guided or free and unguided, and the fact that they are to be used in the wireless system is immaterial. Attention is called to the statement of invention in the Lupin patent.

Claim 2 is again rejected upon the patent to Marconi 697,040 of record. Claims 3 and 4 are each rejected upon Swiss patent to Braun, 18,377, taken in view of Lupin of record.

The application of the Lupin method of developing simple or onic waves as applied to the Braun system is [illegible].

Claims 3 and 4 are drawn to separate species of inventions as described in claims 5 and 6, and the drawings does not appear a sufficient showing of a proper basis for any of the claims 3, 4, 5 and 6.

Said claims 5 and 6 amount simply to aggregations. There is no patentable cooperation between independent telegraphic systems which operate with a definite periodicity for its waves.

Examiner, Div. 10.

37722

IN THE UNITED STATES PATENT OFFICE.

To the Commissioner of Patents.

Sir:

In the matter of the application of

John Stone Stone

for Letters Patent for an improvement in Method of and Apparatus for Selective Electric Signaling

Serial No. 4505, filed Feb. 8, 1900

please recognize the firm of WATSON & WATSON, (consisting of James A. Watson, Robert Watson and John Watson, Jr.,) of Washington, D. C., and Baltimore, Md. as my associates.

Respectfully,

Chas P Brown
atty for applt

37723

IN THE UNITED STATES PATENT OFFICE.

Room No.91. Serial No.4505.

Application of John Stone Stone,

For Patent for Improvement in ~~Apparatus for~~ Selective Electric Signaling.

Filed ~~January 23, 1902.~~ Feb 8 1902

In reply to office letter of April 16,1901.

31 State Street, Boston.

April 8,1902.

To the Commissioner of Patents,

Washington,D.C.

Sir:

The case is amended as follows:

Insert in the specification, after the paragraph ending page 4, line 22:

"Thus the frequency impressed upon the elevated conductor may or may not be the same as the natural period or fundamental of such conductor, but as will be hereinafter explained, an elevated conductor that is aperiodic may be employed, and is well adapted for use when the apparatus is to be used successively for different frequencies, and such aperiodic elevated conductor is likewise a preferred form of elevated conductor when two or more frequencies are to be simultaneously impressed upon or received by a single elevated conductor.

"But forced simple harmonic electric vibrations of different periodicities may each be separately impressed upon a different elevated conductor, and the several energies of the resulting electromagnetic waves may be selectively conveyed each to a separate [illegible]

After the [illegible] line 4 insert:

"When, however, the elevated conductor is aperiodic it is [illegible] receive or transmit [illegible] frequencies, and accordingly

a single aperiodic elevated conductor may be associated with a plurality of local circuits, each attuned to a different frequency by the means now well known in the art of multiple telegraphy by wire conductors.

"Where a single elevated conductor is to be made a source of a plurality of signal waves of different frequencies, and when ... desirable, these signal waves are to be simultaneously developed, it is ... necessary that the trains of waves of different frequencies ... upon the elevated conductor shall be ... it is necessary that the electric vibrations ... upon the elevated conductor shall not ... simultaneously impinging vibrations of ... frequencies. The manner of developing the ... in this ... to the receiving ... different frequencies ... simultaneously impressed upon the elevated conductor ... preferred form of apparatus for transmitting the apparatus will never ... that is necessary, or fully described in order to add to it, or complement of the specification."

Page 10, line 26, erase the word "transmitting" and substitute the word "translating."

Page 11, line 20, insert:

"C and C' are diagrams illustrative of forms of transmitting ... capable of developing signal waves of two different ...

... and R' are diagrams illustrative of forms of receiving stations capable of receiving selectively signal waves of two different frequencies."

Page 12, line 2, erase the word "and"; introduce after "C''" the words "and C'''".

Page 12, line 3, erase all after "K" and substitute "and K are ... coherers."

Page 12,line 6,insert [illegible] for "battery"

and P and S are Plants batteries

Page 12,line 6,erase "is" and [illegible]

"key" and substitute "keys"

Page 12,line 7,erase "a" and [illegible]

erase "relay" and substitute "relays"

Page 12,line 8,erase "device" and substitute "parts"

Page 12,line 9,erase "is an" and [illegible]

erase "interrupter" and substitute "interrupters"

Page 12,line 10,[illegible]

erase "cap" and substitute "caps"

At the end of page 12 insert

"The terminal wire may be made of [illegible] to be highly resistant to [illegible] but the [illegible] resistance increased [illegible] of the wire. The construction of such a radial wire is [illegible] other applications of wire [illegible]"

The following amendment and [illegible] added by amendment are presented in reference to [illegible] contained in the Office letter of April 16, 1928, that there is not sufficient showing in the drawings to form a proper basis for the claims 3,4, and 5.

The amendment applicant deems to meet the requirements of the Office so far as they relate to claims 3 and 4. As regards the bearing of the Office action in connection with claims 5 and 8, applicant respectfully submits that the drawings marked Figs. 1 to 8, inclusive, are sufficient as for these claims, also if he were to show in his drawings a [illegible] comprising [illegible] transmitting stations and more than one receiving station, associated with a separate circuited [illegible], it would result merely in reduplicating Figs. 1, 2, 7 and 8. This is not [illegible] that the several transmitting stations would be identical in construction

and the various receiving stations identical in construction, but because the difference in frequency employed at these stations is not susceptible of being readily shown in the diagrams, or what amounts to the same thing the differences in the inductances of the coils and the capacities of the condensers are not readily [illegible] diagrams of the type used.

[illegible] cannot agree with the Examiner that there is no [illegible] feature in the organization covered by claims 5 and 6. It [illegible] sufficient to note that ever since the art of wireless [illegible] been practised, the great need for commercial purposes [illegible] system as is sought to be covered in claims 5 and 6 has been fully recognised. Ever since the art of wireless or space telegraphy has existed, the problem, a solution of which is claimed in claims 5 and 6, has been one of vital importance and the principal commercial value of wireless telegraphy has depended upon its practical solution. Applicant contends that he who solves this problem in a thoroughly practical manner has added more to the commercial value of wireless telegraphy than any one else and is entitled to the protection sought to be secured in claims 5 and 6.

Regarding the amendment in question, applicant farther submits that owing to the fact that his transmitting and receiving stations illustrated in Figs. 5, 6, 7 and 8, are inherently selective by virtue of the auxilliary coils L, L', L'', etc., and that a plurality of such stations can therefore be associated in any desired way with a common vertical wire to form the system sought to be covered by claims 5 and 6, he did not at first consider it necessary to include drawings and a detail description of the organization sought to be covered in these claims. Applicant, however, now concurs with the Examiner, and feels that the present amendment to the specification and the added sheets of drawings increase the completeness with which the invention as a whole is set forth.

The amendment which has been referred to above is as follows:

Page 17, after line 24, insert:

"The apparatus shown in Figs. 13,14,15, and 16 illustrate methods of associating the apparatus hereinbefore described, and illustrated in Figs.5,6,7, and 8, when two or more stations are to be associated with a common elevated conductor. The operation of each individual station is the same as that already described in connection with Figs.5,6,7, and 8. For the sake of clearness only two stations are shown associated with the common elevated conductor V in the drawings, but it is obvious that any desired number of stations may be associated with a common elevated conductor in the same manner.

"An inspection of the drawings will show that Figs.13 and 14 illustrate two transmitting stations of the type shown in Fig.7 associated with a common elevated conductor, whereas Figs.14 and 15 illustrate two receiving stations of the type shown in Fig.8 associated with a common elevated conductor.

"When a plurality of stations are associated with a common elevated conductor, each of the stations is characterized by being tuned to a different frequency from that of any of the other stations so associated. In Figs.13,14,15, and 16, it will be observed that the two different stations associated with a common elevated conductor have therein been differentiated by attaching a subscript to the letters of reference in the case of one of the stations and not to the letters of reference of the other station.

"The operation of each of the transmitting stations in Figs. 13 and 16 is identical with that of the transmitting station illustrated in Fig.7, and the operation of each of the receiving stations shown in Figs.14 and 17 is identical with the operation of the receiving station illustrated in Fig.8.

"To illustrate.- The step up transformer or spark coil M''' in Figs.13 and 16, is equipped with an interrupter p and condenser C''', and the current is supplied by the battery B. When the key is depressed, a high potential is developed in the secondary of M''' As the potential difference at the terminals of the secondary of

rises, the condenser C'' is charged till the resulting potential difference at a is sufficient to break down the spark gap g. When this occurs, the condenser C'' discharges through the spark gap, the primary of M', and the inductance coil L''. This circuit is attuned to a given high frequency and the oscillatory current which results is therefore of that frequency. This current induces a similar current in the interposed resonant circuit L', M', C', M attuned to the same frequency, which current in turn induces a current of corresponding frequency in the conductor V. The branch L M C is attuned to the given high frequency of the oscillation developed in the circuits L'' g C'' M' and L' M' C' M while the branch L C M is attuned to the frequency of the oscillations similarly developed in the circuits L'' g C'' M' and L' M' C' M. Since these two frequencies are different as hereinbefore specified, the energy of the oscillations developed in the one branch will not be materially absorbed in the other. In this way two sets of forced oscillations of different frequencies may be developed in the elevated conductor V without mutual interference.

Passing now to the operation of the receiving stations shown in Figs. 14 and 16, it may be remarked that since the operation of each of these stations is identical with the operation of the receiving station shown in Fig. 8, ~~it only remains to show that~~ the energy of the waves of one particular frequency will be absorbed by ~~communicated only to~~ one of the receiving stations and ~~that~~ the energy of the waves of another particular frequency will be absorbed by ~~communicated only to~~ the other receiving station.

In both Fig. 14 and Fig. 16 the branch circuits L M C and L M C are attuned each respectively to the same particular frequencies as the circuits M L' M' C' M' L'' C'' P and M L' M' C' M' L'' C'' P. When therefore simple harmonic waves of one of these particular frequencies impinge upon the vertical wire V, the energy of these waves is received in that particular branch circuit which is attuned to the frequency of the waves and is practically excluded from the other branch. The energy so received is communicated to the resonant circuits associated with this branch and affects the

receiving translating devices in the usual manner. This selective reception of the energy of waves of a particular frequency is independent of the number of waves of different frequencies which may be simultaneously present.

"It is to be here noted that the above described methods of simultaneously transmitting and receiving space telegraph messages by a common elevated conductor are the preferred methods, but that not discussed as the any way of associating a plurality of the stations shown in Figs. 5,6,7, and 8 with a vertical conductor will result in a system for simultaneously transmitting and receiving space telegraph signals owing to the fact that these stations are, themselves inherently selective and are capable of causing the independent development of vibrations of different frequencies in the elevated conductor and of selectively absorbing the energy of waves of different frequencies, even without employing the tuned branch circuits C - M and G - M." A30

The following amendment is made as the result of a recent interview with the Examiner in charge. Up to the time of that interview applicant had considered it sufficient to point out in his specification 1st, the great necessity of avoiding the effects of magnetic and electro-static hysteresis in the tuned circuits of his invention, and to specify that the coils should be constructed without iron cores and that solid dielectrics should not be employed in the condensers; 3d, to indicate that the usual forms of coils are not adapted for use in these tuned circuits for the reason of the excessive displacement-currents which tend to flow between conductors charged to a considerable difference of potential, and 4th, to suggest a form of coil in which this effect is less pronounced than in the usual form of coil. Applicant now concurs with the Examiner and feels that the following amendment adds to the completeness of the specification, since it is not necessary to indefinitely diminish the displacement currents in the coil, but suffices to reduce them to the point at which the potential energy

(3230)

of these displacement currents is small compared to the kinetic energy of the conduction current in the coil for the particular frequency of current with which the coil is to be used.

Insert after page 10 of the specification the following:

"Flat spirals with the turns well separated in order to minimize the displacement currents between the turns are, however, by no means the only form of coils adapted to be used in conjunction with air condensers for the purpose of tuning circuits to high frequencies, and may often be neither the best nor most convenient form of coil to employ. Therefore in defining the character of the coils to be employed for this purpose it will be advantageous to first give the general theoretical considerations which lead to a special construction of the coils and to then give a practical guide to the manner of designing the coils for any particular frequency or range of frequencies.

"A coil or solenoid as usually constructed consists of many turns of cotton or silk insulated wire wound on an insulating core such as a glass or ebonite tube or a wooden spool, the consecutive turns being separated only by the thin insulating coating [illegible] solenoids moreover are in general wound with several layers of turns, the layers also being separated from each other only by the insulating coatings of the wires. Such solenoids are well adapted to be used in conjunction with condensers having solid dielectrics for the purpose of tuning circuits to low frequencies, but neither such coils nor such condensers are available for the purpose of tuning circuits to such high frequencies as are contemplated with the present invention. In the case of high frequencies the energy absorbed in the solid dielectric of the condenser, due to dielectric hysteresis, is excessive, and the displacement currents between the adjacent turns and layers of the coil mask and neutralize the inductance of the coil. Moreover the solid dielectric forming the core of such coils exerts a deleterious effect which in some instances is probably partially due to its possessing a small degree of conductivity, but which must in most instances be ascribed to the high specific inductive capacity of

the material and to its dielectric hysteresis.

"In order to tune a circuit to a predetermined high frequency so that it shall show well defined selectivity for that frequency to the exclusion of other frequencies, even to the exclusion of frequencies differing but slightly from the predetermined frequency, it is necessary not only that the condenser shall be free from dielectric hysteresis, but that the coil shall be so constructed as to behave for that frequency practically like a conductor having a fixed resistance and a fixed inductance, but devoid of capacity. Coils constructed in the usual way do not behave for high frequencies as if they had a fixed resistance and inductance and no capacity, but partake more of the character of conductors having distributed resistance, inductance and capacity. In fact they may in some instances behave with high frequencies more like condensers than like conductors having fixed resistance and inductance and no capacity. Since a coil constructed in the usual way behaves for high frequencies as a conductor having distributed resistance, inductance and capacity, it follows that such a coil will show for high frequencies the same quasi-resonance as is observed with low frequencies in long aerial lines and cables, i.e., that it will per se, and without the intermediary of a condenser show a slight degree of selectivity for some particular frequency and for certain multiples of that frequency, just as a stretched string which has distributed inertia and elasticity, will respond to the particular tone called its fundamental, and to all other tones whose periods are aliquot parts of the periods of that fundamental. But it is not with such quasi-resonance that the present invention is carried into effect, and I wish it understood that I hereby disclaim any system employing distributed inductance and capacity as a means for tuning the resonant circuits described in this specification.

A general criterion which determines the utility of a coil for tuning a circuit to a particular high frequency is that the

potential energy of the displacement currents in the coil shall be small compared to the kinetic energy of the conduction current flowing through the coil when the coil is traversed by a current of that frequency.

I have found that for a single layer coil the following procedure is sufficient for practical purposes. Determine the inductance of the coil by formulae to be found in the text books and treatises on electricity and magnetism. This will enable the kinetic energy of the coil to be determined for any particular current and will also permit of the determination of what would be the potential gradient along the coil for the current of the frequency to be employed if the coil were devoid of distributed electrostatic capacity. Next calculate the electrostatic capacity between an end turn and each of the remaining turns of the coil. These capacities together with the potential gradient found will enable the potential energy to be determined, and if the ratio of the potential energy to the kinetic energy so found be negligible compared to unity, the coil will practically satisfy the requirements hereinbefore mentioned. If the coil does not meet the requirements the design should be so changed as to increase the separation between the turns, or the size of the wire should be diminished or the dimensions of the coil so otherwise altered as to decrease the distributed capacity without proportionately diminishing the inductance. The calculations may be greatly abbreviated and the liability to error greatly reduced if the results of the computations be plotted in curves.

"Regarding the effect of a dielectric core in a coil to be used for tuning a circuit to a high frequency, it is sufficient to state that the preferred form of support for such a coil is any skeleton frame which will hold the turns of wire in place without exposing much surface of contact to the wires and affording a minimum of opportunity for the development of displacement currents within itself."

4505-45

Claims:

Amend claim 3 by striking out the word conveying",line four thereof,and substituting therefor the word "receiving"; by adding the words "at a distance," after the word "waves" in the fifth line thereof,and by striking out the word "to" in line five and substituting the word "in."

Amend claim 4 by striking out the word "carrying",line four thereof and substituting the word "receiving";by adding the words "at a distance," after the word "waves",in the fifth line thereof; by striking out the word "to" in line six thereof and substituting the word "in" therefor.

Amend claim 5 by striking out the word "conveying" in line four thereof and substituting the word "receiving"; by adding the words "at a distance," after the word "waves" in the fifth line thereof; by striking out the word "to",line six thereof,and substituting the word "in."

Amend claim 6 by striking out the word "carrying",line five thereof,and substituting the word "receiving" therefor; by adding the words "at a distance," after the word "waves" in the sixth line thereof; by striking out the word "to",line six thereof,and substituting the word "in" therefor.

Add the following claims:

"7. The method of tuning a circuit to a given high frequency, which consists in balancing the reactance of an air condenser by the reactance of a coil,the amplitude of whose potential energy is small compared to the amplitude of its kinetic energy when it is supporting a current of said given high frequency.

"8. The method of constructing a coil to be used in a circuit to be tuned to a given high frequency, which consists in so proportioning the coil that the amplitude of its potential energy shall be small compared to the amplitude of its kinetic energy when supporting a current of said given high frequency.

4505-46

"9. The method of developing free or unguided simple harmonic electro-magnetic signal waves, which consists in discharging a condenser through a closed circuit having inductance adapted to produce under such conditions simple harmonic vibrations, and impressing the electrical vibrations so produced upon an open circuit or elevated conductor substantially as described.

"10. The method of developing free or unguided simple harmonic electro-magnetic signal waves which consists in discharging a condenser through a closed circuit having inductance adapted to produce under such conditions simple harmonic vibrations, impressing these vibrations on a resonant circuit or group thereof attuned to the frequency of these vibrations, and impressing the resulting electrical vibrations upon an open circuit or elevated conductor.

"11. The method of selectively receiving the energy of simple harmonic electro-magnetic signal waves of different frequencies, which consists in receiving the same in an elevated conductor and translating or conveying the several energies of the resulting electrical oscillations each to a separate resonant circuit, associated with said elevated conductor and attuned to the frequency of the electro-magnetic waves, the energy of which it is to receive.

"12. The method of selectively receiving the energy of simple harmonic electro-magnetic signal waves of different frequencies which consists in receiving the same in an elevated conductor and translating or conveying the several energies of the resulting electrical oscillations, each to a separate group of resonant circuits, associated with said elevated conductor and attuned to the frequency of the electro-magnetic waves the energy of which it is to receive.

"13. The method of selectively receiving the energy of simple harmonic electro-magnetic signal waves of different frequencies which consists in receiving the same in a plurality of elevated conductors, thereby developing in each elevated conductor electrical oscillations corresponding in frequency to the electro-magnet-

ic waves received by it and in translating o conveying from each elevated conductor to an associated resonant circuit the energy of the particular electrical oscillations to the frequency of which said associated circuit is attuned.

"14. The method of selectively receiving the energy of simple harmonic electro-magnetic signal waves of different frequencies which consists in receiving the same in a plurality of elevated conductors, thereby developing in each elevated conductor electrical oscillations corresponding in frequency to the electro-magnetic waves received by it and in translating or conveying from each elevated conductor to a group of resonant circuits associated therewith the energy of the particular electrical oscillations to the frequency of which said group of associated resonant circuits is attuned."

Reply to the rejections upon references is made for convenience in a separate paper.

Respy
Allen P. Brown
atty for appel

3300

IN THE UNITED STATES PATENT OFFICE.

Room No.31. Serial No.45055.

Application of John Stone Stone,

For Patent for Improvement in ~~Apparatus for~~ Selective Electric Signaling.

Filed ~~June 23,1901~~ Feb 5 1902,

In reply to Office letter of April 10,1901.

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51 State street, Boston,

April 8,1901.

To the Commissioner of Patents,

Washington,D.C.

Sir:

In reply to references cited by the Patent Office.

Claim 1 having been rejected upon the patent to Pupin, No 640,515 of January 2,1900, applicant respectfully submits that the specification of the Pupin patent was written in 1895 as appears on its face and that it is only in the light of the subsequent advance of the art and of the present invention that anything contained in the Pupin patent could possibly have been construed to suggest a system for developing free or unguided forced simple harmonic signal waves emanating from an elevated conductor used as a radiator, and passing out from it to great distances through the surrounding atmosphere in the form of radient energy. The object of the Pupin invention is in fact to develop practically independently in a single line conductor, two currents of different frequencies in order that these two currents may be used for duplex telegraphy by being selectively received in separated branch circuits at the receiving end of the line, each branch circuit being tuned to the frequency of one of said alternating currents

If, however, the apparatus described in Pupin's patent for

developing currents of different frequencies in a line conductor could be employed to develop the electrical vibrations in the elevated conductors or radiators of applicant's present invention, then it might be alleged that Pupin's invention had a double use to which he was entitled even though he did not apprehend it at the time of filing his application, or did not consider it worth claiming or even mentioning in his specification. But the apparatus of the Pupin patent is not, in the present state of the art, capable of being employed for the development of the electro-magnetic signal waves described by applicant in his specification. This is for the reason that the lengths of waves generated by the means described in the Pupin patent are of the order of 10^3 as compared with those which in the present state of the art are available for the purposes of the present invention. In the present state of the art such frequencies as are capable of being developed by the only apparatus described or suggested in the Pupin patent, if impressed upon an elevated conductor of practicable dimensions would produce no appreciable radiation of energy, i.e., the resulting electrical vibrations in the elevated conductor would give rise to practically no free or unguided electro-magnetic waves. There would be but a negligible amount of the energy which would emanate from the oscillator never to return to it. Practically all the energy would be confined to the neighborhood of the oscillator and would flow out and back with each oscillation.

Now if in the immediate future it be shown that by the use of a specially constructed elevated conductor, the apparatus described or implied in the Pupin patent becomes available as a practical means of developing electro-magnetic waves of practical utility in the art of wireless telegraphy, then the method of so specially constructing the elevated conductor may, and in the judgment of the applicant will, itself involve invention, and the specially constructed elevated conductor when used with the apparatus in the Pupin patent in like manner constitute a patentable invention.

Claim 2 having been rejected upon the patent to Marconi No. 627,650 of June 27,1899,applicant respectfully submits that in the first place the object of the Marconi patent was not to selectively receive the energy of electro-magnetic waves of one frequency to the exclusion of the energy of waves of other frequencies.

His object was to overcome certain inherent difficulties in the system which he had previously been employing. In that earlier system the elevated conductor (which in the patent cited as a reference he styles a capacity) was connected to the earth through the coherer,and the static charges,owing to atmospheric electricity,which accumulated upon the elevated conductor discharging through the coherer seriously interfered with the proper operation of the system. In order to overcome this difficulty,Mr. Marconi placed the coherer in a branch or local circuit,not conductively connected with the elevated conductor,and grounded the elevated conductor through a coil. The static charges accumulated by the elevated conductor were thereby permitted to readily pass to earth without interfering with the operation of the coherer.

Mr.Marconi must have been perfectly aware,at the time of filing of his application for the patent now cited as a reference in this case,of the great practical importance of securing a selective system of space telegraphy,and yet we find in this patent no reference to such a system,and it is only by implication and in the light of applicant's specification that a passage in the Marconi patent can be construed to indicate that Marconi had any intention of disclosing in this patent the invention sought to be covered in claim 2 of the present application. But as will hereinafter be fully and clearly shown,the above referred to passage in Marconi's patent has a well defined meaning of its own and any other interpretation of it is wholly unwarranted. Mr.Marconi did not consider the invention of the patent cited as a solution of the problem of selectively receiving the energy of simple harmonic electro-magnetic signal waves of one frequency to the exclusion of those of other frequencies,and therefore did not in this patent

claim to [illegible] important invention. If he had considered his invention a solution of so important a problem,he would not have published the solution in his patent without claiming it,and would not have satisfied himself with the claims he did make.

It may be contended that though Marconi did not at the time of filing his application,know that his apparatus could,or intend that it should,be used for selectively receiving the energy of simple harmonic electro-magnetic waves of one frequency to the exclusion of those of other frequencies,yet the apparatus of his patent is capable of such use,and that therefore his patent constituted a publication of such a system of selectively receiving the energy of simple harmonic waves of one frequency to the exclusion of waves of other frequencies.

The answer to such a contention is that the Marconi patent does not disclose a system which could operate to selectively receive the energy of waves of one frequency to the exclusion of the energy of those of other frequencies. The instructions contained in this patent are sufficiently explicit to forbid such an hypothesis.

These instructions as to the manner of constructing the coil make the apparatus incapable of such use,and furthermore we must note in the specification the absence of any specific instruction as to the proper conditions for the tuning of circuits to such high frequencies as are involved in the present invention. The Marconi specification specifically instructs us,both in text and drawing,to construct the induction coil of fine insulated wire,in very much the same manner as solenoids are usually constructed in practice,with the turns close together; and particular stress is laid upon the importance of having the primary and secondary quite close to each other. This practically instructs us to wind the secondary immediately upon the primary. Owing to the displacement currents which take place in the case of high frequencies,where precautions are not taken to prevent them, such a coil will behave more like a condenser than a [illegible]. It would be absolutely

impossible to balance the reactance of such a coil by the reactance of a condenser for high frequencies.

Furthermore the entire absence from the Marconi specification of any instructions concerning the necessity of avoiding the effects of electrostatic and magnetic hysteresis,and the effects of displacement currents in the apparatus constituting the branch circuit,which includes the coherer,would of itself preclude the Marconi patent from being properly considered as in any way a disclosure of the invention sought to be claimed by applicant.

The passage in the Marconi specification before mentioned,in which there might seem to be some hint of a selective system,is: "It is desirable"(note,not essential) "that the induction coil should be in tune or syntony with the electrical oscillations transmitted,the most appropriate number of turns and the most appropriate thickness of wire varying with the length of wave of the oscillations transmitted."

The true meaning of this passage is that the organization described in the patent is capable of receiving the waves,whatever be their length within practical limits,but that the apparatus will be more efficient for this purpose if the coil is tuned to the frequency of the waves to be received. It has long been known that a circuit may be rendered sensitive to oscillations of a certain limited extent of frequency by the proper adjustment of the coil for certain frequencies both for the fundamental and for the harmonics or overtones of the fundamental as compared with other frequencies. The analogy in sound to this is familiar,namely the stretched string vibrating normally in its fundamental and in notes corresponding to aliquot parts of the period of the fundamental.

In the operation of the organization described in the Marconi patent,it is clear that owing to the manner in which the coherer coil is constructed,it does not operate as a simple inductance,but that electrostatic capacity in the convolutions in the coil and the displacement current through the coherer,but with more or less

combination of a conden[illegible]oil by which the [illegible]
lations in the elevated [illegible]ted through the [illegible]
circuit in passing to the [illegible]tion.

Claims 3 and 4 each [illegible]. the Swiss patent to
Braun,No.18,577 of June [illegible]view of the United [illegible]
patent to Pupin No.[illegible],[illegible]900,and it is implied in
the Office action of [illegible] this action is taken be-
cause the applic[illegible]ethod of developing simple
harmonic waves [illegible]Braun system is unpatentable.
Applicant resp[illegible]s that he has not seen the Braun
Swiss patent cit[illegible]t he has had access to and examined
copy of the Swi[illegible]tent to Braun No.1862 of 1899,which is
later date [illegible]ion he believes to be for the same invention
as the Swiss patent cited. Applicant fails to see what bearing
either of these patents can have upon that part of either claim
or claim 4 which relates to the selective reception [illegible]
of waves of different frequencies,each in a separate receiving
station,since both the Pupin and Braun patents are restricted to
paratus to be used at transmitting stations.

Applicant finds that the object of the Braun invention is to
obtain free or unguided electro-magnetic signal waves of greater
length than those given by a Hertz oscillator,and this he seeks
to accomplish in order that the signals may less easily be ob-
structed in their passage from the transmitting to the receiving
station by intervening obstacles such as houses,hills,etc.

For this purpose it was wholly unnecessary that Braun's sig-
nal waves should be simple harmonic in character,and his specifi-
cation makes no provision that they shall be simple harmonic
in character.

Applicant has already argued in his letter to the Office of
March 23,1901 that the electric vibrations in the apparatus dis-
closed by Braun are the natural vibrations of a system of at least
two degrees of freedom and are in general therefore not of a sim-
ple harmonic character. This point does not seem to be contended
by the Examiner. In view of the fact that the Examiner has again
rejected [illegible] upon the patent to Braun in view of the patent to

Applicant now further points out that there is not even an allusion in the Braun disclosure to the necessity of guarding against the effects of electrostatic and magnetic hysteresis in the associated circuits, and since there is no hint in Braun's disclosure of the importance of so constructing the coils as to avoid the effects of displacement currents, one seeking to practice the invention of the Braun patent would employ the usual forms of coil and condenser. Such apparatus, though it might operate to accomplish the results sought by Braun, would be wholly unsuited to perform the functions of the apparatus of the present application. The apparatus of the Braun patent is simply a combination of the Tesla apparatus for producing high frequency currents with the elevated conductor as radiator of a wireless telegraph station to form a wireless telegraph transmitting station sending out waves if greater length than those theretofore employed in wireless telegraph stations of the elevated conductor type.

Applicant contends that in order to properly tune the circuits described in his application, either the auxilliary coils L,L',L'',etc., must be included in those circuits, or the inductive coils M,M',M'',etc., must be so specially constructed as to furnish the auxilliary inductance which these coils impart to the circuit. Moreover the most strict attention must be given to the exclusion of electrostatic and magnetic hysteresis in these circuits.

Respy
Alex P. Brown
atty for appl't

2600

7600

4-3-00

Amendment

Apr. 12

IN THE UNITED STATES PATENT OFFICE.

Room No.31,

Application of

For Patent for

Filed

In reply to

21 [illegible] street, Boston,

April 11, 1900.

To the Commissioner of Patents,

Washington, D.C.

Sir:

[illegible] drawings re[illegible]

to at page [illegible], [illegible] of amendme.

of the 9th inst.

Respectfully,

Alex. D. Brown

Att'y. for Applicant.

107

2—9611.

Paper No. 91

Address only to the Commissioner of Patents, Washington, D. C.

Please No. 9

All communications respecting this application should give the serial number, date of filing, and title of invention.

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE,

WASHINGTON, D. C. May 13, 1902.

4532

John Stone Stone,

Care, Watson & Watson,

Washington, D.C.

RECEIVED MAY 13 1902 FILED

Paper filed being a communication from the EXAMINER in charge of your application,

Ser. No. 4505, for Method of Selective Electric Signalling, filed Feb. 8, 1900,

F. I. Allen

Commissioner of Patents.

This action is in response to applicant's communication filed Apl. 11 and 12, 1902.

It is evident that the original specification in view of the state of the art would justify the addition of views showing two local circuits tuned to different frequencies inductively connected to a single aperiodic sending or receiving conductor, but it is obvious that the present showing of specifically novel modifications of parallel and series tuned conductively connected branch circuits is specifically new matter for which there was no adequate foundation in the case as originally filed.

Additional illustration should therefore be limited to the unobjectionable form and the present new illustration presented, if at all, in a new application. It seems evident that many specific claims could be drawn to the apparatus now shown that would be clearly patentable over the disclosure in the case as originally presented.

The grounded conductor VR should therefore be shown as a single straight wire broken only by the secondary windings I_2, the induction coils I, I_1 and condensers C, C' being omitted therefrom.

If it should appear that the presence of the two transformer secondaries in the sending and receiving conductors give them a concurrent fundamental or natural period so that the shunt conden-

3309

ser jetts and the inductance coils 11, 12 are necessary to operativeness, then it will be evident that it requires invention to use two locals on one vertical conductor and all reference to such acidification would have to be eliminated. [illegible] thought to be the case, however, and the present requirement is limited to that of the last preceding para raph. In this connection it is pointed out that applicant has shown on the new drawings an arrangement of scherer and translating device in connection with a Planté cell and that he has in the amendment referred to a certain "e ection frame" for re ain ing the dielectric's core of the coil. This matter having no foundation in the original specification must be rejected to as involving a departure from the original disclosure and cancellation is required. The fact that applicant has in a co-pending application filed about one year after the filing of this case stated that the dielectric cell is well known in the art, does not [illegible] disclosure therein a description of the same as filed, cannot be studied by the [illegible] to be later than that of the [illegible] application of what we stated or said in the original specification. The original specification pointed out that old dielectric and electric cylinders must be carefully [illegible]

that can be relied upon for patentability of claims 7 and 8 over the patent to Lodge, 609,154, Aug. 16, 1898, of record, and as that is new to this application it must be objected to as new matter.

Page 16, line 3, "current" should be changed to circuit.

Certain of the claims, such as claim 1, involve an argument the soundness of which the office has no means of testing. Assuming that the simple harmonic wave in a closed vibrator, it does not necessarily follow that such simple harmonic wave can be transferred to the elevated conductor and from the latter to the other without change of form. The fact is that applicant has undoubtedly improved the form of wave by the use of closed tuned circuits having an extra loading coil and the Office is not in a position to affirm or deny anything more than this. Because of the undoubted improvements involved in the apparatus upon which the claim is based it is allowed, and all other claims containing the same implication of novel features will be allowed.

Claim 2 is on a different basis. It can take nothing from the words "simple harmonic" because it has long been understood that a circuit tuned to respond to a given fundamental frequency will always be more efficient when acted upon by a simple harmonic of said frequency. This claim is alternative in substance and objectionable for that reason, the function of one resonant circuit being different from that of a group of resonant circuits in so much as the former lacks the weeding out action of the latter. Considering it as concerning the first alternative it is met in Marconi, 627,650, June 27, 1899, of record. Tuning is never perfect and in order to avoid this reference it is necessary to show affirmatively that there can be no tuning possible with his construction. He gives full particulars and details of construction and there can be no difficulty in proving mathematically whether or not any tuning effect is possible with his apparatus. Claim 3 is also rejected on Lodge aforesaid, in which the waves received

are probably not simple harmonic. In connection with figure 12 a condenser is described as a substitute for the resistance w for connecting the coherer more closely with the receiving apparatus whereby it is stimulated. On page 1 it is stated as to the telegraph instrument that it is associated with a "subsidiary circuit capable of electric oscillations of the same particular frequency" as the sending station.

Claim 7 is rejected on Lodge aforesaid, wherein an open coil balances the capacity of the air condenser in which the area h is one plate and the ground the other.

Claim 8 is also rejected on the same patent, special reference being had to lines 17 to 29 of page 3.

Claim 11 differs from claim 2 only in that it specifies a plurality of resonant circuits associated with one elevated conductor. The latter feature was admitted in the description only because it did not involve invention in view of Pupin's multiplex system of telegraphy described in patent No. 640,515, and the claim which is otherwise the same as said claim 2 must be rejected on the same reference and for the same reasons.

Claims 7 and 8 are also rejected as involving new matter.

Claim 13 is merely for the use of Marconi's apparatus in the art pointed out by Lodge and it is accordingly rejected.

Claims 1, 3, 4, 5, 6, 9, 10, 12 and 14 are capable of an interpretation which would make them definitive of applicant's invention. They are accordingly allowed.

Examiner, Div. 14.

Amended D/
May 31/02

IN THE UNITED STATES PATENT OFFICE.

...No.31, Serial No.4,555,

...plication of John Stone Stone,

...r Patent for Improvement in Method of Selective

Electric Signaling,

...Filed February 9,1900,

In reply to Office letter of May 13,1902.

---

31 State street,Boston,Mass.,

May 28,1902.

...ner of Patents,

...Washington,D.C.

The case is amended as follows:

...11 of the specification,line 20,erase "Fig.2" and sub-

...stitute therefor "Figs.3 and 15."

...ge 10,line 3,change "current" to "circuit."

...12 of the specification,line 5,erase "Fig.9" and sub-

...stitute therefor "Fig.3."

...line 1,erase "Fig.9" and substitute "Figs.3 and 15."

...of the amendment of April 8,1902,lines 17 and 18,

...erase "several" and substitute therefor the word "Several."

...4,erase the number "14" and substitute therefor the

...

...erase the number "16" and substitute therefor the

...

...of the amendment of April 8,1902,erase lines 1 and 2.

...1,change the word "Part" and substitute therefor

a comma (",") [illegible] after the number "8" the word and number "and 17."

Line 3,erase [illegible] and after the number "8" insert "and 9".

Line 7,erase [illegible] and substitute a comma "," after number "9" insert "and 9."

Line 11,erase [illegible] and substitute the number "11."

Line 14,erase [illegible] and substitute the number "12."

Line 23,erase [illegible] and substitute therefor a comma "," [illegible] after the number "10"

Line 26,erase [illegible] and substitute therefor the number "10."

Line 27,erase the number "10" and substitute therefor the number "10."

Line 32, erase [illegible] and substitute the number "10."

[illegible] from the letter [illegible] letters are [illegible] "mail" [illegible] to the end of the paragraph.

Line 2,erase the number "10" and substitute the number "17;

Line 30,erase from the "10" through "that."

Lines 33 and 34,erase "communicates only to" and substitute therefor "is communicated by."

Line 37,erase "that."

[illegible] erase "communicates only to" and substitute therefor "is communicated by"

Line 50,erase from the [illegible] through "and Penner" on [illegible].

[illegible] after the word "are" insert "not identified as [illegible]

[illegible] erase from "ever although [illegible] the [illegible]

[illegible] of the pleading and substitute [illegible] ten [illegible]

For the sake of clearness, claims 2,7,8,11, and 13 are canceled and the following substitute claims are filed:

"2. The method of absorbing the energy of free or unguided, simple harmonic, electro-magnetic signal waves of one frequency, to the exclusion of the energy of like waves of a different frequency, which consists in associating with an elevated conductor a circuit resonant to the frequency of the waves, the energy of which is to be absorbed.

"7. The method of rendering a circuit resonant to a given high frequency, which consists in balancing the reactance of an air condenser by the reactance of a coil, the amplitude of whose potential energy is small compared to the amplitude of its kinetic energy when it is supporting a current of said given high frequency.

"8. The method of constructing a coil to be used in a circuit to be resonant to a given high frequency, which consists in so proportioning the coil that the amplitude of its potential energy shall be small compared to the amplitude of its kinetic energy when supporting a current of given high frequency.

"11. The method of selectively receiving the energy of free or unguided simple harmonic electro-magnetic signal waves of different frequencies, each to the exclusion of the rest, which consists in receiving the same in an elevated conductor and translating or conveying the several energies of the resulting electrical oscillations, each to a separate circuit associated with said elevated conductor, and resonant to the frequency of the electro-magnetic waves, the energy of which it is to receive.

"13. The method of selectively receiving the energy of free or unguided simple-harmonic electro-magnetic signal waves of different frequencies, each to the exclusion of the rest, which consists in receiving the same in a plurality of elevated conductors, thereby developing in each elevated conductor electrical oscillations corresponding in frequency to the electro-magnetic waves received by it and in translating or conveying from each elevated conductor to the associated circuit the energy of the oscillations

electrical oscillation to the frequency of which said associated circuit is made resonant."

Add the following claims:

15 ~~14.~~ The method of absorbing the energy of free or unguided simple harmonic electro-magnetic signal waves of one frequency to the exclusion of the energy of like waves of different frequencies which consists in associating with an elevated conductor a group of circuits, each resonant to the frequency of the waves, the energy of which is to be absorbed.

16 ~~15.~~ The method of receiving the energy of simple harmonic electro-magnetic signal waves, which consists in receiving the same in an elevated conductor and translating or conveying the energy of the resulting electrical oscillations to an electrical translating device shunted around the terminals of one of the elements of a resonant circuit associated with said elevated conductor and attuned to the frequency of the electro-magnetic waves.

IN THE UNITED STATES PATENT OFFICE.

Room No.91, Serial No.4,505,

Application of John Stone Stone,

For Patent for Improvement in Method of Selective Electric Signaling,

Filed February 8,1900,

In reply to Office letter of May 13,1902.

---

31 State street,Boston,Mass.,

May 28,1902.

Commissioner of Patents,

Washington,D.C.

Sir:

With reference to the criticisms of the Examiner as to new matter,it is believed that none of them is well founded. The matter of inductive or conductive connection of circuits as well known alternatives is referred to on page 7 of the original specification in the early part of the paragraph beginning "In general if n simple circuits," etc.

Regarding the use of a Plante battery in lieu of a condenser of large capacity,it is to be observed that the equivalence of t these two devices for such purposes as the exclusion of a battery current from a circuit and the suppression of sparks at contacts was well recognized many years before the date of filing of the present application. The Examiner is respectfully referred to "Alternate Currents of Electricity" by Blakesley,published in 1885,in which the equivalence of a condenser of large but variable capacity and an electro-lytic cell is very closely and interestingly set forth. Moreover,on page 13,lines 2 to 7,inclusive,of the present specification as originally filed,the Examiner will find an instance in which applicant mentions a Plante battery and a condenser of large capacity as alternate forms. 4505-02

However,to facilitate [illegible] examination of the case,applicant has decided to accept the suggestion of the Examiner to cancel Figs.13 to 16 and substitute therefor new figures 13 to 17 sent herewith. To render the specification accurately descriptive of the new drawings,an amendment to it is also made,which for convenience is placed upon a separate paper.

The Examiner refers to the illustrative example of a precaution to be taken set forth in lines 14 to 16 of page 19 as a basis for his objection to the present specific statement that solid dielectrics should be eliminated as far as possible from the coils. Particular attention is called to the fact that the descriptive matter referred to is preceded by the broad unqualified statement that both electrostatic and magnetic hysteresis must be excluded from the resonant circuit.

Properly viewed,the reference to exclusion of solid dielectrics from the coils is merely a specific restatement of the above co-ordinate with and as much justified as the statements in lines 14 to 16,above quoted. There being adequate ground for the statement that solid dielectrics should so far as possible be excluded from the coils,the suggestion of a skeleton frame as an obvious expedient is entirely unimportant and further objection should not be urged.

Applicant cannot conceal the validity of the Examiner's ruling as to the phrase "small as compared to the kinetic energy" introduced into the specification [illegible] application by recent amendment. The Examiner rightly states,however,that the original disclosure of applicant justifies the description of the potential energy of the displacement currents in the coil by the word "small." Now this word "small" involves comparison,and comparison with things of like kind,and it seems clear therefore to applicant that when it is stated that the potential energy is small as compared to the kinetic energy,this is merely a more accurate statement of the fact that the potential energy is small. The [illegible] "Hodges" case,144, does not [illegible]

4 5 [illegible]

which the potential energy of displacement currents shall be small. In fact what is shown in that patent excludes any such idea.

The only passage in the Lodge patent cited which gives particular instruction with regard to the construction of the coils he employs, are as follows:

"Between either capacity area and its knob I place a syntonizing self-inductance coil - that is, a coil of wire or metallic ribbon h', preferably insulated with any solid or fluid insulator, as in Fig. 6, or in air, of shape suitable to attain greatest inductance with a given amount of resistance."

Again:

"In Fig. 7 the syntonizing-coil h' is shown as surrounding a large telegraph-insulator I."

Again:

"The self-inductance-coil represented at h' in all applicable figures is a coil of highly conducting wire or ribbon, well insulated by air or by some other medium, as already described, or else covered to a sufficient thickness with insulating material of such shape as to have maximum self-inductance for a given resistance, and it may be either a flat coil including a considerable plane area or it may be a cylindrical coil wound upon a finely-subdivided iron core, as shown at H in Fig. 3, the wire being either single-lapped or "bunched" or otherwise."

With reference to the examiner's criticism of claims 2, 11 and 13, applicant respectfully suggests that the Examiner must have overlooked the distinction heretofore made in the case between a circuit made resonant by adding a coil and a condenser, and the quasi resonance obtained by efforts to regulate both the capacity and inductance of the coil itself, which is apparently what is sought to be done by Tesla in his patent No. 645,576. The result of such quasi resonance, even if successfully obtained, will not be the absorbing or selective receiving of the energy of waves of one frequency to the exclusion of the energy of [illegible] frequency

quencies,and no method is disclosed in any of the references involving the employment of resonant circuits as distinguished from quasi resonant coils,in the manner and for the purposes disclosed by the applicant.

Applicant has disclaimed such quasi resonance in which distributed electro-static capacity of the coil itself is employed to diminish the impedence of the coil,because such distributed capacity diminishes the impedance of the coil not alone for one frequency,but for a very large number of frequencies,and is therefore not available for the purpose of making a circuit resonant to one frequency to the exclusion of other frequencies.

Applicant does not contend that there is no advantage to be gained by such a construction as that shown in the Marconi patent cited. He only contends that it is not useful for the purpose of selective signaling,where waves of one frequency are received to the exclusion of waves of other frequencies.

The Marconi patent cited does not profess to be for a system of selective signaling and is incapable of use as a selective system.

It does,however disclose a system whereby disturbance from atmospheric electricity is minimized,and is,in the opinion of applicant,adapted to such use.

It is believed that some of the claims may with advantage be amended for the sake of greater clearness,and that certain claims may well be added. These amendments and additions are also for convenience made in the separate paper before referred to.

With reference to the applicant's action in canceling Figs. 15 to 16,he begs to have it understood that he is advised that these Figures may contain certain novel arrangements which may be in themselves patentable to him,and hence that their cancelation in this case is not to be regarded as abandonment. Figs 15 16.

Respectfully,

H505

Fig. 9.

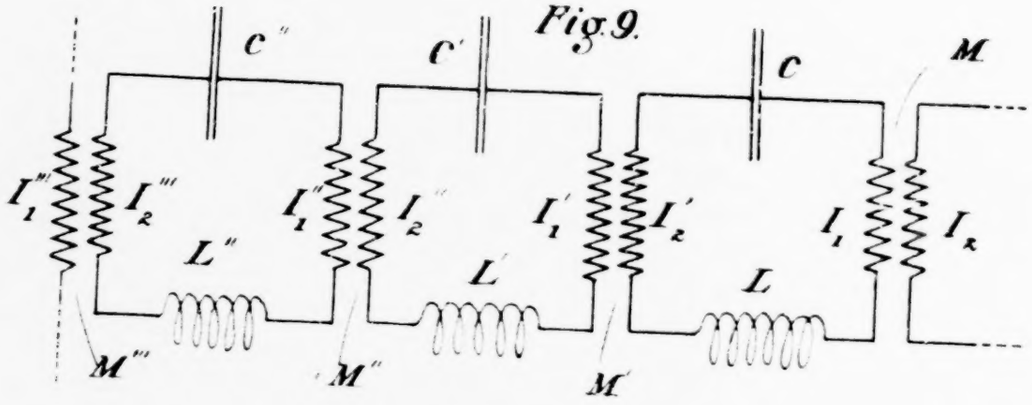


Fig. 10.

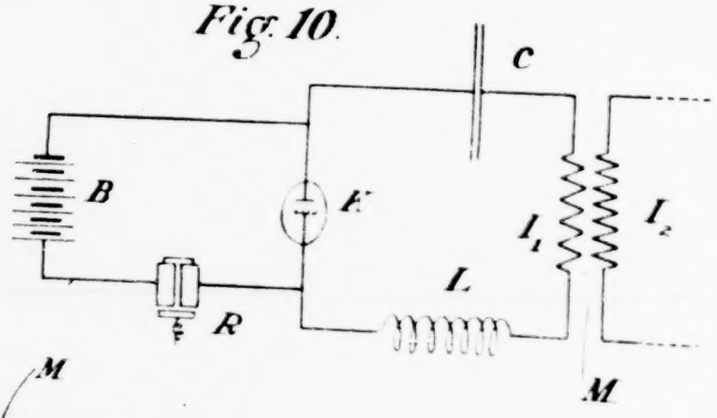


Fig. 11.

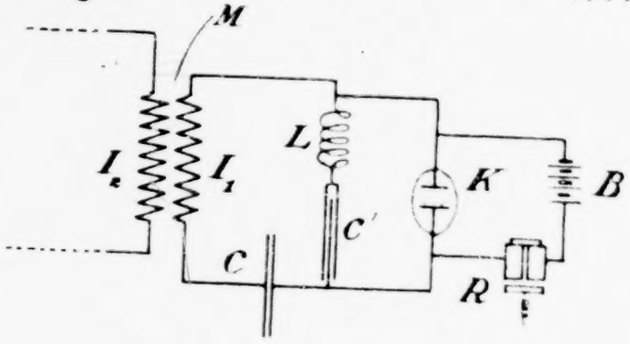
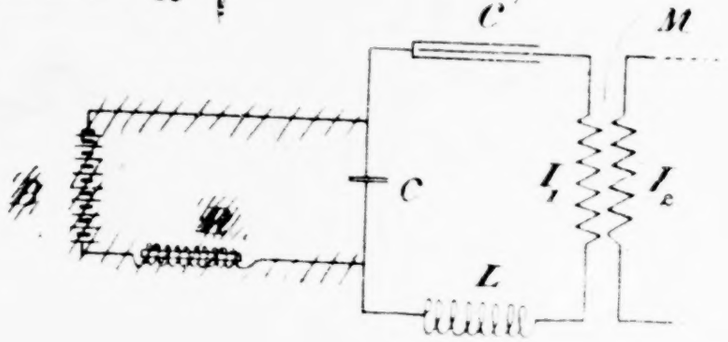


Fig. 12.



WITNESSES:

Argument & Brief
June 9 2

IN THE UNITED STATES PATENT OFFICE.

Room No.31, Serial No.4005,

Application of John Stone Stone,

For Let. Pat. for Improvement in Method of Selective Electric Signaling,

Filed February 3,1900,

In reply to Office letter of May 18,1900.

---

31 State street, Boston,

June 7 ,1900.

To the Commissioner of Patents,

Washington, D.C.

Sir:

Applicant finds that an error has occurred in the typewriting of the amendment of late May 28,1900, an explanatory passage has been omitted after the paragraph ending on line 24, page 3 thereof.

The paragraph thus omitted is explanatory of the bearing of the [illegible] patent to Lodge No.609,154, dated [illegible] of May 28th, and is as follows:

"[illegible] the matter of the inductance of the [illegible] substantially large. He therefore [illegible] displacement [illegible] between the turns entirely. His instructions to use metallic [illegible], to wind [illegible] insulation, to wind [illegible] insulation instead of a skeleton frame, to wind [illegible] upon a finely subdivided iron core, are all [illegible] to fall the use of such coils as are [illegible] lines 7 to 9 of the present specification."

Applicant therefore now submits the above quoted passage as [illegible] bearing of the [illegible] patent of record upon the special [illegible] of said [illegible] by the applicant.

Applicant further notes that in his argument of May 28,1902 he did not meet or more properly speaking, comment upon the following passage in the Office letter of May 13,1902.

"Certain of the claims,such as claim 1,involve an argument, "the soundness of which the Office has no means of testing. Assuming that the simple harmonic wave can be produced in a closed vibrator,it does not necessarily follow that such simple harmonic "wave can be transferred to the elevated conductor and from the "latter to the ether without change of form. The fact is that "applicant has undoubtedly improved the form of wave by the use of "closed tuned circuits having an extra loading coil and the Office "is not in a position to affirm or deny anything more than this. "Because of the undoubted improvement involved in the apparatus "upon which the claim is based,it is allowed,and all other claims "containing the same implication of novel feature will be allowed."

Applicant concurs with the Examiner in his view that if simple harmonic electric vibrations can be developed in a closed,i.e, a persistent,vibrator,it is not obvious that these vibrations can be transferred to the elevated conductor of a wireless telegraph system and thereby develop in the ether free or unguided,electromagnetic waves or radiation,also of a simple harmonic character.

But though such method of developing free or unguided electro magnetic waves or radiation of a simple harmonic character is not obvious,applicant nevertheless contends that he has proved,both by mathematical argument and by experiments,that if forced simple harmonic electric vibrations be impressed upon the elevated conductor of a wireless telegraph system,the resulting radiation of electric and magnetic force will also be simple harmonic and of the same frequency.

So far as the applicant is aware he was the first to discover and make public this fact.

He states that the mere fact that the electric vibrations which take place in the associated persistent oscillator are simple harmonic in character and that the vibations which take place in the elevated conductor are the forced vibrations which result

from impressing these simple harmonic vibrations on the elevated conductor, is enough to insure that the electric vibrations in the elevated conductor are also simple harmonic with respect to time and are of the same frequency as those of the oscillator which developed them. Because it has long been known that if a simple harmonic force act upon a mechanical or electric system, be it ever so complex in structure, the resulting forced vibrations will also be simple harmonic in character and of the same frequency as the force which gave them birth, except in the case where there is hysteresis. But in the case of an aerial conductor of a wireless telegraph system there is no hysteresis present, and the forced electric vibrations of the elevated conductor must therefore be of the same form and frequency as the vibrations of the oscillator which communicated them to the elevated conductor.

In respect to the foregoing, the Examiner is respectfully referred to the definition of forced vibration given in "The Theory of Electricity and Magnetism" by A.G.Webster, Article 248, page 489, which is as follows:

"An oscillation whose period is that of force, as in our "present case, is called a forced oscillation or vibration in "contra-distinction to the case of the previous section, where "no force being applied, the period is governed by the constants of the system, and the oscillation is called a free "oscillation."

Also "The Theory of Sound" by Lord Rayleigh, First Edition, 1877, Article 46, pages 41 and 42, which is as follows:

"The distinction between forced and free vibrations is "very important, and must be clearly understood. The period "of the former is determined wholly by the force which is "supposed to act on the system from without; while that of "the latter depends only on the constitution of the system "itself. Another point of difference is that so long as the "external influence continues to operate, a forced vibration "is maintained, being represented strictly by a harmonic function. The free vibration gradually dies away, becoming "insensible after a time."

Also the present application,page 8,lines 10 to 23:

"But besides the ability to execute natural vibrations "or oscillations,both electric and mechanical systems are "capable of supporting what are termed <u>forced vibrations</u> and "in the case of forced vibrations,the period of the vibration is independent of the electro-magnetic constants of the cir- "cuit on the one hand,and the mechanical constants of the me- "chanical system on the other hand,and depends only upon the "period of the impressed force. Thus if a simple harmonic "electro-motive force be impressed upon a circuit free from "hysteresis,whether it be a simple circuit,or a complex of "simple circuits,the forced vibrations or currents resulting "from the impressed force will also be simple harmonic,and "of the same period as that of the impressed force."

Also present application,page 10,lines 19 to 26:

"In order that the vertical conductor at the transmit- "ting station shall generate harmonic electro-magnetic waves "of definite frequency,I cause the electric vibrations in said conductor to be of a simple harmonic character and "this in turn I accomplish by producing what are substantial- "ly forced electric vibrations in the vertical conductor in "lieu of producing natural vibrations in the conductor as "has heretofore been practised."

Further it may be thus shown that the vibrations of the [illegible] are forced simple harmonic electric vibrations [illegible] frequency as those impressed upon it by the associated [illegible] oscillator,it is still true that the free or un- [illegible] electro-magnetic wave or radiation will also be of a [illegible] and of the same frequency as the elec- [illegible] elevated conductor. Fortunately,however,for [illegible] discussion of the Hertz oscillator,as given by [illegible] can be made available to show that the electro-magnetic [illegible] simple harmonic transaction and of the same [illegible] as the vibrations in the associated conductor. Though the

Though the electric vibrations which Dr.Hertz employed in his experiments with what is known as his dumb bell oscillator,were not forced simple harmonic vibrations,but were the natural vibrations of the oscillator,nevertheless in his mathematical interpretation of his results,he employed a solution strictly applicable only to the case of forced simple harmonic vibrations in the oscillator.

In order not to encumber the case with lengthy mathematical expressions,the Examiner is asked to consult either "Electric Waves," by Dr.Heinrich Hertz,in the original or in the translation by D.E. Jones, Macmillan & Co.,1893; or "The Theory of Light," by Thomas Preston, Second Edition,1895; or "Absolute Measurements in Electricity and Magnetism," by A.Gray,1893,Vol.2,part 2,chap.14,section 3,in each of which Hertz' analysis of the operation of his dumb bell oscillator,when executing simple harmonic electric vibrations,is given. By referring to the equations for the electric and magnetic forces in the medium surrounding the oscillator,the Examiner will find that in the equatorial plane of the oscillator,however far it be extended,the magnetic force is always parallel to the plane,that the electric force is always normal to the plane,and that the potential is zero throughout the plane. It follows directly from these considerations that if a conducting sheet be extended through this equatorial plane,no current will be developed in the sheet and no disturbance of the field of force can result,since no lines of magnetic force will cut the conducting sheet, and there will be no component of electric force parallel to the sheet. If the conducting sheet be infinitely conductive,it follows that all that goes on below the sheet may be eliminated,leaving only a conductor extending vertically from the conducting sheet,and bearing at its extremity a capacity area. Such an arrangement is substantially the same as the vertically elevated conductor of a wireless telegraph system extending vertically from the conductive surface of the earth and terminating in a capacity area at its extremity. It follows,therefore,that the solution given by Dr.Hertz for the radiation emanating from his dumb bell oscillator executing simple harmonic vibrations is directly applicable to the problem of the elevated conductor in a wireless telegraph system.

executing simple harmonic electric vibrations. Now since simple harmonic electric vibrations in the Hertz oscillator give rise to simple harmonic electro magnetic radiation, so also must simple harmonic electric vibrations in the elevated conductor of a wireless telegraph system give rise to simple harmonic electro magnetic radiation.

These considerations show, therefore, that the forced simple harmonic electric vibrations of the elevated conductor would give birth to electro-magnetic waves, also simple harmonic in character, and of the same period as the electric vibrations forced in the elevated conductor

So far as applicant is aware, he was the first to discover and point out the application of Hertz' analysis to the elevated conductor of a wireless telegraph system.

Applicant feels that this argument is sufficient comment upon the paragraph quoted at the beginning of this letter from the Office letter of May 13, 1902. Nevertheless, it is worth noting that he does not contend that either the vibrations in the elevated conductor, or the radiations emanating therefrom, are absolutely simple harmonic in character, such perfection of wave form being unattainable in any practical apparatus. Moreover, when a simple harmonic force is impressed upon a system having a natural rate of vibration of its own, there is always more or less of the natural vibration developed, and it is worth noting that in the important cases when the elevated conductor of a wireless telegraph system has a fundamental which is of the same frequency as the forced vibrations impressed upon it, the natural vibrations excited will not interfere with the wave form. Again if the elevated conductor be aperiodic, no natural vibrations will be set up in it when the forced vibrations are impressed, and the form of the forced vibrations will therefore not be disturbed. It is only in the case where the elevated conductor has a very pronounced selectivity of its own, that the impressing of forced vibrations upon it of a different frequency from its natural frequency will develop natural vibrations seriously interfering with the wave form of the vibrations developed in it.

It will also be noted that in the above [illegible], in passing from the consideration of the Hertz oscillator to [illegible] of

the vertical wire oscillator, the conducting sheet supposed to extend through the equatorial plane, was assumed to be infinitely conductive, and could not, therefore, represent with absolute accuracy the surface of the earth. In this connection it is to be noted that the potentials involved in wireless telegraphy are very large compared to those used in any of the other commercial applications of electricity, whereas the currents employed are in general relatively small compared to those which occur in some of the other applications of electricity, and furthermore, it must be remembered that in order to seriously disturb the potential of the earth at a given point, it is necessary to discharge into it an excessively large current as measured by these standards. It follows, therefore, that though the imperfect conductivity of the earth's surface may make it necessary to slightly modify the Hertz analysis, in order that it may strictly apply to the elevated conductor oscillator, yet such modification must result in an extremely minute correction, so long as the plane of the earth's surface is not seriously irregular in the immediate neighborhood of the elevated conductor.

Applicant sends herewith a sheet containing a lithographic fac simile of Fig. 12 of the drawings, from which it was requested in a further communication that a certain portion be erased. The erasure desired is represented upon the fac simile in red ink.

Respectfully,

Alex. P. Brown

Att'y for Applicant.

Serial No. 4505 Paper No. 13

Amendt E

Filed June 19 1902

IN THE UNITED STATES PATENT OFFICE.

--o--

Application of John Stone Stone,

Method of Selective Electric Signaling,

Filed Feb. 8, 1900, Ser. No. 4,505

--o--

Hon. Commissioner of Patents.

Sir:-

The various claims heretofore made in this case having been made at different times, and consequently being deemed lacking in harmony of nomenclature, it is considered desirable to cancel them and substitute others in their place, the latter differing only in phraseology. It has further been deemed desirable to add certain claims. Accordingly, applicant amends by canceling all the present claims and substituting the following:

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"1. The method of developing free or unguided simple harmonic electro-magnetic waves of a definite frequency, which consists in producing forced simple harmonic vibrations of the same frequency in an elevated conductor.

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The method of transmitting the energy of free simple harmonic electro-magnetic waves of [illegible] like waves [illegible] which consists in associating [illegible] the frequency of [illegible] as by the Abderhold.

The method of distributing the energy of free

or unguided electro-magnetic waves which consists in independently developing forced simple harmonic electric vibrations of different frequencies in an elevated conductor and receiving the several energies of the resulting electro-magnetic waves of different frequencies, each to the exclusion of the rest, in a separate electric translating device.

4. The method of distributing the energy of free or unguided electro-magnetic waves which consists in independently developing a number of forced simple harmonic electric vibrations of different frequencies in an elevated conductor and receiving the several energies of the resulting electro-magnetic waves, of different frequencies, each to the exclusion of the rest, in a separate circuit resonant to the same frequency as that of the waves, the energy of which is to be absorbed therein.

5. The method of distributing the energy of free or unguided electro-magnetic waves which consists in developing forced simple harmonic electric vibrations of different frequencies, each in a different elevated conductor, and receiving the several energies of the resulting electro-magnetic waves of different frequencies, each to the exclusion of the rest, in a separate electric translating device.

6. The method of distributing the energy of free or unguided electro-magnetic waves which consists in developing a number of forced simple harmonic electric vibrations of different frequencies, each in a different elevated conductor and receiving the several energies of the resulting electro-

magnetic waves of different frequencies, each to the exclusion of the rest, in a separate resonant circuit attuned to the same frequency as that of the waves, the energy of which is to be absorbed therein.

7. The method of rendering a circuit resonant to given high frequency, which consists in balancing the reactance of an air condenser by the reactance of a coil, the amplitude of whose potential energy is small compared to the amplitude of its kinetic energy when it is supporting a current of said given high frequency.

8. The method of constructing a coil to be used in a circuit to be made resonant to a given high frequency which consists in so proportioning the parts that the amplitude of its potential energy shall be small compared to the amplitude of its kinetic energy when supporting a current of given high frequency.

9. The method of developing free or unmodified simple harmonic electro-magnetic signal waves, which consists in passing from a condenser through a closed circuit having inductance adapted to produce under such conditions simple harmonic vibrations, and impressing the electro-magnetic waves so produced upon an open circuit or elevated conductor substantially as described.

10. The method of developing free or unmodified simple harmonic electro-magnetic signal waves which consists in discharging a condenser through a closed circuit having inductance adapted to produce under such conditions simple harmonic vibrations, impressing these waves upon

circuit or group thereof resonant to the frequency of these vibrations, and impressing the resulting electrical vibrations upon an open circuit or elevated conductor.

11. The method of selectively receiving the energy of free or unguided simple harmonic electro-magnetic signal waves of different frequencies, each to the exclusion of the rest which consists in receiving the same in an elevated conductor and translating or conveying the several energies of the resulting electrical oscillations, each to a separate circuit associated with said elevated conductor, and resonant to the frequency of the electro-magnetic waves, the energy of which it is to receive.

12. The method of selectively receiving the energy of simple harmonic electro-magnetic signal waves of different frequencies, each to the exclusion of the rest, which consists in receiving the same in an elevated conductor and translating or conveying the several energies of the resulting electrical oscillations, each to a separate group of resonant circuits associated with said elevated conductor and resonant to the [illegible] electro-magnetic waves the energy of which it is to receive.

[illegible] selectively receiving the energy [illegible] electro-magnetic signal [illegible] sion of the [illegible] in a plurality of [illegible] developing in such elevated conductor electrical oscillations corresponding in frequency to [illegible] waves [illegible] in translating

or conveying from each elevated conductor to an associated circuit the energy of the particular electrical oscillations to the frequency of which said associated circuit is made resonant.

11. The method of selectively receiving the energy of simple harmonic electro-magnetic signal waves of different frequencies, each to the exclusion of the rest, which consists in receiving the same in a plurality of elevated conductors, thereby developing in each elevated conductor electrical oscillations corresponding in frequency to the electro-magnetic [redacted] conveying from each elevated conductor to a group of resonant circuits associated therewith the energy of the particular electrical oscillations to the frequency of which said group of associated circuits is resonant.

12. The method of absorbing the energy of free or unguided simple harmonic electro-magnetic signal waves of one frequency to the exclusion of the energy of like waves of different [illegible] which consists in associating with an elevated conductor [illegible] resonant to the frequency of the wave [illegible] which is to be absorbed.

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13. The method of receiving the energy of simple harmonic electro-magnetic signal waves, which consists in receiving the same in an elevated conductor and [illegible] conveying the energy of the resulting electrical oscillations to an electrical translating device and [illegible] terminals of [illegible] associated therewith.

frequency of the electro-magnetic waves.

17. The method of distributing the energy of free or unguided electro-magnetic waves, which consists in independently developing a number of forced simple harmonic electric vibrations of different frequencies in an elevated conductor and receiving the several energies of the resulting electro-magnetic waves of different frequencies, each to the exclusion of the rest, in a group of circuits resonant to the same frequency as that of the waves the energy of which is to be absorbed therein.

18. The method of distributing the energy of free or unguided electro-magnetic waves, which consists in developing a number of forced simple harmonic electric vibrations of different frequencies each in a different elevated conductor, and receiving the several energies of the resulting electro-magnetic waves of different frequencies, each to the exclusion of the rest, in a separate group of circuits [illegible] frequency as that of the waves the energy [illegible] absorbed.

19. [illegible] of developing free or unguided simple harmonic electro-magnetic signal waves, which consists in disturbing the electrical equilibrium of a circuit containing a condenser, and a coil having inductance adapted [illegible] under such conditions simple harmonic vibrations. [illegible] the electrical vibrations so produced upon an [illegible] or elevated [illegible] described

[illegible]

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in disturbing the electrical equilibrium of a circuit comprising a condenser and a coil having inductance adapted to produce under such conditions simple harmonic vibrations, impressing these vibrations on a resonant circuit or , ing thereof attuned to the frequency of these vibrations, and impressing the resulting electrical vibrations upon [illegible] circuit or elevated conductor.

1. The method of receiving the energy of simple harmonic electro-magnetic signal waves, which consists in collecting the same in an elevated conductor and in translating the energy of the resulting electrical oscillations by an electrical translating device forming one of the elements of a resonant circuit associated with said elevated conductor and resonant to the frequency of the electro-magnetic waves.

2. The method of developing true or undamped simple harmonic electro-magnetic signal waves or radiations, which consists in disturbing the electrical equilibrium of a closed oscillating circuit containing a condenser and a coil having sufficient auxiliary inductance to produce under such conditions simple harmonic electrical oscillations, impressing such oscillations upon a resonant circuit associated with the elevated conductor.

3. The method of developing true or undamped simple harmonic electro-magnetic signal waves or radiations, which consists in disturbing the electrical equilibrium of a closed oscillating circuit containing a condenser and a coil having sufficient auxiliary inductance to produce under such conditions simple harmonic electrical oscillations, impressing such oscillations upon a resonant circuit associated with the elevated conductor, [illegible] of the [illegible]

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...effect of the mutual inductance between it and the ... circuits of the group and between it and the elevated conductor.

24. The method of developing free or unguided ... simple harmonic electro-magnetic signal waves or radiations, of different frequencies independently in a single elevated conductor, which consists in disturbing the electrical equilibrium of closed oscillating circuits associated with said elevated conductor, each being attuned to a different ... of the frequencies to be developed, and each of said oscillating circuits having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and the other oscillating circuits and the said elevated conductor.

25. The method of receiving the energy of simple harmonic electro-magnetic waves of a given frequency, to the exclusion of like waves of different frequencies, which consists in receiving the same in an elevated conductor and conducting the energy of the resulting electrical oscillations to a circuit associated with the elevated electrical conductor and made ... to the frequency of the electro-magnetic waves to be received, and which is to be received on a condenser ... auxiliary inductance coil whose inductance is sufficient to swamp the effect of the mutual inductance between the associated circuit and the elevated conductor.

26. The method of selectively receiving the energy of simple harmonic electro-magnetic signal waves of one frequency, to the exclusion of like waves of different frequencies, which consists in receiving the same in an elevated

conductor and translating or conveying the energies of the resulting electrical oscillations each to a separate circuit associated with said elevated conductor, each resonant to the frequency of the electro-magnetic waves, the energy of which is to be received, and each having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and the other associated circuits and between it and the elevated conductor.

27. The method of developing simple harmonic, electro-magnetic, signal waves or radiations of a given frequency, which consists in impressing upon a metallically continuous vertical oscillator forced simple harmonic electrical oscillations of the same frequency.

28. The method of simultaneously developing simple harmonic, electro-magnetic, signal waves or radiations of different frequencies, which consists in independently impressing upon a metallically continuous vertical oscillator forced, simple harmonic, electrical oscillations of the same frequencies.

29. The method of absorbing the energy of free or unguided, simple harmonic, electro-magnetic signal waves of one frequency, the exclusion of the energy of like waves of different frequency, which consists in associating with an elevated conductor a circuit resonant to the frequency of the waves the energy of which is to be absorbed, and having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and the elevated conductor.

30. The method of distributing the energy of free or unguided, electro-magnetic waves, which consists in independently developing a number of forced, simple harmonic electric vibrations of different frequencies in an elevated conductor, and receiving the several energies of the resulting electro-magnetic waves of different frequencies, each to the exclusion of the rest in a separate circuit resonant to the same frequency as that of the waves, the energy of which is to be absorbed, and having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and all of the circuits with which it is associated.

31. The method of distributing the energy of free or unguided, electro-magnetic waves, which consists in developing a number of forced, simple harmonic, electric vibrations of different frequencies, each in a different elevated conductor, and receiving the several energies of the resulting electro-magnetic waves of different frequencies, each to the exclusion of the rest, in a separate resonant circuit attuned to the same frequency as that of the waves, the energy of which is to be absorbed therein, and having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and all circuits with which it is associated.

32. The method of developing free or unguided, simple harmonic, electro-magnetic signal waves, which consists in discharging a condenser through a closed circuit having inductance adapted to produce under such conditions simple

harmonic vibrations and sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and an elevated conductor with which it is associated, and impressing the electrical vibrations so produced upon the said elevated conductor.

33. The method of developing free or unguided, simple harmonic, electro-magnetic, signal waves, which consists in discharging a condenser through a closed circuit having inductance adapted to produce under such conditions simple harmonic vibrations, impressing these vibrations on a resonant circuit or group thereof resonant to the frequency of these vibrations, each circuit having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and all circuits with which it is associated, and impressing the resulting electrical vibrations upon an open circuit or elevated conductor.

34. The method of selectively receiving the energy of free or unguided, simple harmonic, electro-magnetic, signal waves of different frequencies, each to the exclusion of the rest, which consists in receiving the same in an elevated conductor and translating or conveying the several energies of the resulting electrical oscillations, each to a separate circuit associated with said elevated conductor, and resonant to the frequency of the electro-magnetic waves, the energy of which it is to receive, each circuit having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and all circuits with which it is associated.

35. The method of selectively receiving the energy of simple harmonic, electro-magnetic, signal waves of different frequencies, each to the exclusion of the rest, which consists in receiving the same in an elevated conductor and translating or converting the several energies of the resulting electrical oscillations, each to a separate group of resonant circuits associated with said elevated conductor and resonant to the frequency of the electro-magnetic waves, the energy of which it is to receive, each circuit having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and all circuits with which it is associated.

36. The method of selectively receiving [redacted] of free or unguided, simple harmonic, electro-magnetic signal waves of different frequencies, each to the exclusion of the rest, which consists in receiving the same in a plurality of elevated conductors, thereby developing in each elevated conductor electrical oscillations corresponding in frequency to the electro-magnetic waves received by it and in translating or conveying from each elevated conductor to an associated circuit the energy of the particular electrical oscillations to the frequency of which said associated circuit is made resonant, each of said circuits having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and the elevated conductor and all circuits with which it is associated.

37. The method of selectively receiving the energy of simple harmonic, electro-magnetic, signal waves of differ-

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...ent frequencies, each to the exclusion of the rest, a set com-
...prising at least one and the same in a plurality of elevated con-
...ductors, thereby developing in each elevated conductor
electrical oscillations corresponding in frequency to the
electromagnetic waves received by it and in response to
conveying from each elevated conductor to a group of resonant
circuits associated therewith the energy of the particular
electrical oscillations to the frequency of which said group
of associated circuits is resonant, ... the
...ing sufficient auxiliary inductance to change the effect of the
mutual inductance between it and each of the other
all circuits with which it is associated.

38. ... the art of ... unguided, simple harmonic, electro-magnetic, signal waves of one frequency to the exclusion of the energy of like waves of different frequencies, which consists in receiving from ... elevated conductor a group of circuits, each resonant to the frequency of the wave ... and ... ted, each circuit having ... sufficient ... to change the effect of the mutual inductance between it and the other circuits with which it is associated.

39. ... the art of ... simple harmonic, electro-magnetic signal waves, ... consisting in receiving the same in an elevated conductor ... and ... in conveying the energy of the resulting electrical oscillations to an electrical translating device ... and the terminals of one of the elements of a resonant circuit associated with said elevated conductor and resonant to the

frequency of the electro-magnetic waves, each circuit having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and all circuits with which it is associated.

40. The method of distributing the energy of free or unguided electro-magnetic waves, which consists in independently developing a number of forced, simple harmonic, electric vibrations of different frequencies in an elevated conductor and receiving the several energies of the resulting electro-magnetic waves of different frequencies, each to the exclusion of the rest, in a group of circuits resonant to the same frequency as that of the waves, the energy of which is to be absorbed therein, each circuit having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and all circuits with which it is associated.

41. The method of distributing the energy of free or unguided electro-magnetic waves, which consists in developing a number of forced, simple harmonic, electric vibrations of different frequencies, each in a different elevated conductor, and receiving the several energies of the resulting electro-magnetic waves of different frequencies, each to the exclusion of the rest, in a separate group of circuits resonant to the same frequency as that of the waves the energy of which is to be absorbed, each of said circuits having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and the elevated conductor and all circuits with which it is associated.

42. The method of developing free or unguided,

simple harmonic, electro-magnetic signal waves, which consists in disturbing the electrical equilibrium of a circuit comprising a condenser, and a coil having inductance adapted to produce under such conditions simple harmonic vibrations, and impressing the electrical vibrations so produced upon an elevated conductor, each circuit having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and all circuits with which it is associated.

43. The method of developing free or unguided, simple harmonic, electro-magnetic signal waves, which consists in disturbing the electrical equilibrium of a circuit comprising a condenser and a coil having inductance adapted to produce under such conditions simple harmonic vibrations, impressing these vibrations on a resonant circuit or group thereof attuned to the frequency of these vibrations, and impressing the resulting electrical vibrations upon an elevated conductor each circuit having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and all circuits with which it is associated.

44. The method of receiving free or unguided, simple harmonic, electro-magnetic signal waves, which consists in receiving the same in an elevated conductor and translating or converting the energy of the resulting electrical oscillations to an electrical translating device forming one of the elements of a resonant circuit associated with said elevated conductor and resonant to the frequency of the electro-magnetic waves, each circuit having sufficient auxiliary inductance to swamp the effect of the mutual inductance between it and all circuits with which it is associated.

Respectfully submitted
Alex. C. Brown,
Atty for appellee

4000

Washington
June 15 1903

4505- Paper 14

Filed June 19 1902

IN THE UNITED STATES PATENT OFFICE.

Room No. 91. Serial No. 4505.

Application of John Stone Stone,

For Patent for Improvement in Method of Selective Electric Signaling.

Filed Feb. 8, 1900.

Hon. Commissioner of Patents,

Washington, D.C.

Sir:-

Applicant observes that in his amendment of May 28, 1902 he so amended his case as to make it read "It is to be here noted that the above described methods of simultaneously transmitting and receiving space telegraph messages by a common elevated conductor are not described as the preferred methods", etc.

As this passage is not in his judgment sufficiently explained in the text of his application, he amends by inserting after the word "methods", line 9, page 7, amendment of April 8, 1902, the following: "since the branch circuits V V, in Figs. 16 and 17 are not in themselves selective, and since the elevated conductors in Figs. 13 and 14 contain a number of induction coils in series, not essential to the operation of any one of the stations singly,"

Applicant amends by introducing after the paragraph to which the foregoing amendment applies, the following paragraph:

"The branch circuits V V, of Fig. 17 are not selective since they contain but one element of a tuned circuit, viz.,

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the inductance of M and M_1. Vibratory currents of whatever frequently they may be, communicated by the vertical wire to these circuits, will divide amongst them in simple inverse proportion to their electro-magnetic impedances and are not selective except for a slight reaction due to the associated circuits C' M' L' and C'_1 M_1 L'_1. These reactions, so far from tending to make the branches selective to the frequencies to which their associated circuits are intended to respond, will in fact, cause them to oppose more strongly currents of these frequencies than those to which the associated circuits are not attuned. Again it is obvious that the inductance of the coil M in Fig. 13 is merely an additional impedance in the elevated conductor, which, to say the least, cannot assist in the development of vibrations in the elevated conductor impressed by circuit C'_1 M'_1 L'_1 M_1. The same is obviously true of the coil M_1 in the elevated conductor with reference to the operation of the circuit C' M' L'. Now passing to the transmitting station shown at Fig. 16, it is obvious that the vibrations communicated by the circuit C' M' L' to the elevated conductor M are subject to a shunt due to the coil M_1 in the other branch of the elevated conductor, and conversely the vibrations developed in the elevated conductor by the associated circuit C'_1, M'_1, L'_1, are subject to a shunt due to the coil M in the other branch of the elevated conductor. Finally, the coil M in the elevated conductor in Fig. 14 can at best only present an impedance to the waves intended to be received by the circuit C', M', L', and conversely the coil M_1 in the elevated conductor can at best only present an impedance to the vibrations intended to be received by the circuit C' M' L'.

Amend the specification by inserting at the end thereof, and immediately before the claims, the following:

"In this specification I have described the development of free or unguided electro-magnetic signal waves of a given frequency, by employing in association with an elevated conductor, a circuit such as to produce therein forced simple harmonic electric vibrations of the frequency desired. I have also described a method of receiving or absorbing the energy of free or unguided simple harmonic electro-magnetic waves of one frequency to the exclusion of waves of a different frequency by associating with an elevated conductor a circuit made resonant to the frequency of the waves whose energy is to be absorbed. The circuit whereby forced simple harmonic electric vibrations are produced in the elevated conductor I have shown as a circuit containing a condenser and a self-induction coil so proportioned as to make the natural vibrations of a frequency which is the frequency of the vibrations to be forced or impressed in an elevated conductor. The circuit whereby the energy of the electro-magnetic waves of one frequency is absorbed to the exclusion of that of waves of other frequencies is in like manner a circuit containing a condenser and a self-induction coil so proportioned as to make the circuit resonant to a frequency which is the frequency of the waves, the energy of which is to be received. Both of the circuits I have spoken of are tuned circuits, and they may be conveniently distinguished with reference to their respective functions by denominating the circuit employed in the development of the vibrations as an oscillating or sonorous circuit, and by denominating the circuit employed in the reception or absorption of the vibrations as a resonant

circuit. I prefer to make this discrimination in nomenclature for the reason that while both the circuits are resonant circuits yet functionally only that one employed for receiving or absorbing is accurately so described.

Except for this distinction in function it is well to note that all oscillating or sonorous circuits are resonant circuits but only such resonant circuits as have their resistance less than the square foot of the ratio of four times their inductance by their capacity are oscillating or sonorous circuits.

Also throughout this specification I have described the electrical oscillations or vibrations and the free or unguided electro-magnetic waves or radiations as simple harmonic.

[redacted]

It is the object of my present invention to approach as nearly as possible to perfect simple harmonic wave, and such object is attained to within such a degree of precision as to preclude any interference with the operation of the system by any possible departure that may exist in the wave from the absolute simple harmonic form. My reason for confining the description of the electrical oscillations or vibrations and the electro-magnetic waves or vibrations to the simple harmonic type is that, in the operation of the system, only the simple harmonic components are effective in carrying out the object of the invention. Though it is impossible to prevent the presence of the minute overtones accompanying these simple harmonic waves, such overtones do not only do not contribute to the useful operation of the system, but may in fact operate as to such useful and complete operation, unless their amplitude be excessively small as is the case in the present invention.

It is for this reason that I have taken every precaution to approximate as closely as may be to the true or absolute simple harmonic wave-form, thereby reducing to a minimum the over tones which cause a departure from the true sine wave.

Specifically, though it may be possible to employ the purposes of multiple and selective wireless telegraphy W. T. electric vibrations and radiations departing considerably from the simple harmonic type by employing at the receiving end circuits selective to the fundamental of such vibrations and radiations, yet it will only be through the selective reception of that simple harmonic component of the vibrations or radiations which is their fundamental that the system will be operative. The other simple harmonic components of the vibrations or radiations add nothing to the operation of the system.

Moreover, if such over tones exist in the waves emenating from a transmitting station, their presence will preclude the possibility of placing receiving stations in the immediate neighborhood of such transmitting station for the reception of signal waves of frequencies corresponding to the frequencies of such over tones."

Amend the specification by inserting at line 15, page 15 thereof, the following:

The mathematical expression for the frequency to which a circuit is resonant when it is isolated from all other circuits i.e. has but a single degree of freedom is well known and may be stated as follows:-

$$n = \frac{1}{2\pi\sqrt{C_1 L_1}}$$ from which

$$L_1 = \frac{1}{C_1 p^2}.$$

where [illegible] is the frequency, C_1 is the capacity, L_1 is the inductance and p is the periodicity which equals $2\pi n$.

In the case of a circuit of two degrees of freedom, however, in order to make the comporant circuits each responsive to the same frequency as when isolated, in other words to overcome the modifying effect of the mutual inductance of each circuit upon the other, it necessary to consider, in the case of inductive relation, the expression:-

$$\frac{1}{C_1 p^2} = L_1 - \frac{M_{12}^2 p \left(L_2 p - \frac{1}{C_2 p}\right)}{R_2^2 + \left(L_2 p - \frac{1}{C_2 p}\right)^2},$$

where C_1 L_1 are the capacity and inductance of the first circuit C_2, L_2, R_2 are the capacity, inductance and resistance, respectively of the second circuit and M_{12} is the mutual inductance of the circuits.

From these expressions careful consideration will show that the effective inductance of the first circuit has been modified by its inductive relation with the second circuit and it is:-

$$L_1' = L_1 - \frac{M_{12}^2 p \left(L_2 p - \frac{1}{C_2 p}\right)}{R_2^2 + \left(L_2 p - \frac{1}{C_2 p}\right)^2}$$

Similarly we have to consider the expression:-

$$\frac{1}{C_2 p^2} = L_2 - \frac{M_{12}^2 p \left(L_1 p - \frac{1}{C_1 p}\right)}{R_1^2 + \left(L_1 p - \frac{1}{C_1 p}\right)^2},$$

from which it will be seen that the effective inductance of the second circuit has been modified by its inductive relation with the first circuit and is:

$$L'_1 = L_1 - \frac{M^2 p (L_2 p - \frac{1}{C_2 p})}{R_2^2 + (L_2 p - \frac{1}{C_2 p})^2}$$

These two inductances L'_1 and L'_2 are the apparent inductances which each of these circuits would have if acting as the primary to induce simple harmonic vibrations of frequency n in the other.

It is therefore necessary in order to overcome the modifying effect of the mutual inductance on either circuit to add to that circuit an auxiliary inductance coil of inductance large compared to the term of the form :-

$$\frac{M^2 p (L_2 p - \frac{1}{C_2 p})}{R_2^2 + (L_2 p - \frac{1}{C_2 p})^2}$$

, or at least as large [illegible] added to the natural inductance of the circuit, the sum of these inductances being very large compared to the said Term.

Respectfully,

Alex P. Brown,

atty for applt

Washington DC

June 18. 02

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Serial No. 4505— Paper No. 13—

Arnoldt &

Filed June 19 1902

IN THE UNITED STATES PATENT OFFICE.

Application of John Stone Stone

Ser. No. 4,505, filed Feb 8 1900

The Commissioner of Patents,

Sir—

A duly-entitled case is hereby entered as follows

[illegible] specification, and [illegible]

[illegible]

[illegible] specification I have used the term "actuating inductor" to designate the source of the [illegible] electro-magnetic field developed by [illegible] which [illegible] and the term "armature" to designate [illegible] which is [illegible] by the [illegible] specification relates, [illegible]

[illegible]

[illegible]

[

essential to the theory of the propagation of electrical and magnetic force, radiant light and radiant heat."

Respectfully submitted,

Alex P Browne
atty for applts

Washington, D. C.,

June 19, 1902.

350

Division. 2—181. Serial No. 4219

Letters should be addressed to "Commissioner of Patents, Washington, D. C."

DEPARTMENT OF THE INTERIOR.

U. S. Patent Office.

Washington, D. C., [illegible] 20, 1903.

SIR.—Your APPLICATION for a patent for an IMPROVEMENT IN [illegible]

Filed [illegible], has been examined and ALLOWED.

The final fee, Twenty Dollars, must be paid, and the Letters Patent bear date as of a day not later than SIX MONTHS from the time of the present notice of allowance.

If the final fee is not paid within that period the patent will be withheld, and your only relief will be by a renewal of the application, with additional fees, under the provisions of Sec. 4897, Revised Statutes. The Office aims to deliver patents upon the day of their date, and on which their term begins to run. But to do this properly applicants will be expected to pay their final fees at least TWENTY DAYS prior to the expiration of the six months allowed them by law. The printing, photolithographing, and engraving of the several patent parts, preliminary to final signing and sealing, will consume the intervening time, and such work will not be done until after payment of the necessary fees.

When you send the final fee you will also send, DISTINCTLY AND PLAINLY WRITTEN, the name of the INVENTOR and TITLE OF INVENTION AS ABOVE GIVEN, DATE OF ALLOWANCE (which is the date of this circular), DATE OF FILING, and, if assigned, the NAMES OF THE ASSIGNEES.

If you desire to have the patent issue to ASSIGNEES, an assignment containing a REQUEST to that effect, together with the FEE for recording the same, must be filed in this Office on or before the date of payment of final fee.

Additional copies of Specifications and Drawings will be charged for at the following rates: Single Copies, unmounted, 5 cents each. The money should accompany the order.

Very respectfully,

F. I. Allen.

Commissioner of Patents.

IN REMITTING THE FINAL FEE GIVE THE SERIAL NUMBER AT THE HEAD OF THIS NOTICE.

If payment is made by check or draft, the credit allowed is subject to the collection of the same.

After allowance, and prior to payment of the final fee, copies will be furnished carefully examining the description to see that their statements and language are correct. Any mistakes not occurred through the fault of the officers, and not affecting the merits of the case, will not be corrected after the delivery of the letters patent to the inventor or his agent.

2

Department of the Interior,

U. S. PATENT OFFICE.

Washington, D. C. Mch. 5 1867

PETITION

Petition of Edwin A. Allen

No. 61569

Method of Adjusting Electric Signaling

for recommendation

F. A. Allen

Commissioner of Patents

Serial No. 4506 Patented 16
Amendt H (Rule 78)
Filed Nov. 4 1902

IN THE UNITED STATES PATENT OFFICE.

Room #91, Serial No. 4506.

Application of John Stone Stone,

For Patent for Method of Selective Electric Signaling.

Filed February 8,1900. Allowed June 26,1902.

31 State Street,
Boston,Mass. Nov. 3,1902.

Hon, Commissioner of Patents,

Washington, D.C.

Sir:-

It is respectfully requested that the following claim be entered in the above entitled application under Rule 78, without withdrawing the case from issue.

45. The method of absorbing the energy of free or unguided simple harmonic electro-magnetic signal waves of one frequency, to the exclusion of the energy of like waves of different frequency, which consist in receiving the same in an elevated conductor and translating or conveying the resulting electric vibrations to a circuit associated with said elevated conductor, and resonant to the frequency of the waves, the energy of which is to be received.

It is believed that this claim is patentable, and that it may be allowed without further search on the part of the Office.

Respectfully,

John Stone Stone

Applicant.

The claim is patentable and it is recommended that the amendment be entered under Rule 78 without withdrawing the case from issue. The final fee has not been paid.

Nov 7 1902
F. I. Allen acty

Wm A Kinnan
Examiner, Division XVI.

Two papers 350
350

Address only as addressed to
The Commissioner of Patents,
Washington, D. C.

LETTER NO.

M. A. W.

DEPARTMENT OF THE INTERIOR.
UNITED STATES PATENT OFFICE.
WASHINGTON, D. C.

Serial No. 4505 Paper No. 17

Office of Examiner

Dated November 6th, 1902 1902

In the matter of the
Application of
John S. Stone,
Method of Selective Electric Signaling,
Filed February 8. 1900,
Ser. No. 4505.

Amendment.

Sir:

You are hereby informed that the recommendation of the Examiner, that the amendment be admitted under the provisions of Rule 78, has been approved by the Commissioner.

By direction of the Commissioner.

Very respectfully,

C. M. Drelan
Chief Clerk.

John S. Stone,
c/o Watson & Watson,
Washington, D. C.

100

2—327.

MEMORANDUM
OF
FEE PAID AT UNITED STATES PATENT OFFICE.

(Be careful to give correct Serial No.)

Serial No. 4505, 190

INVENTOR:
John Stone Stone

PATENT TO BE ISSUED TO
As for record

NAME OF INVENTION, AS ALLOWED
Method of & App's for Selective Electric Signaling

DATE OF PAYMENT:
Nov- 5-1902

FEE
$20

DATE OF FILING:
Feb- 5-1900

DATE OF CIRCULAR OF ALLOWANCE
June- 20-1902

The Commissioner of Patents will please apply the accompanying fee as indicated above.

Alex. P. Browne
Attorney.

SEND PATENT TO
Alex. P. Browne, Esq.
31 State St
Boston, Mass.

WATSON & WATSON
PATENT LAWYERS AND SOLICITORS,
WASHINGTON, D. C.
[illegible] F STREET

[illegible]

WASHINGTON D.C. [illegible], 1902.

[illegible] Commissioner of Patents,
[illegible]ington, D. C.

Sir:-

I [illegible] Watson & Watson for $10.
[illegible]
[illegible]
[illegible]

Serial No. 403, filed Feb. 8, 1902; [illegible]
" " 4,704 " Jan. 27, 1902 "
" " 105,710 " Oct. 7, 1901 "

[illegible],

Alfred Brown
Atty for Lee

1/6

STONE TELEGRAPH AND TELEPHONE CO.
OFFICE 31 STATE STREET
BOSTON MASS
LABORATORY 18 WESTERN AVENUE CAMBRIDGE
TELEPHONES 3394 MAIN BOSTON
AND 1018 CAMBRIDGE

JOHN STONE STONE

Nov. 19, 1903.

Hon. Commissioner of Patents,

Washington, D.C.

Sir:-

I herewith return Letters Patent No. 714,756, granted Dec.2, 1902, to Louis R.Whicher, Alex.P.Browne and Brainerd T.Judkins on the application of John Stone Stone and now owned by the Stone Telegraph and Telephone Company, and request that a certificate of correction be annexed thereto under the provisions of Rule 170, in order to correct the following errors incurred through the fault of the office in printing the specification, to wit:-

In line 83, page 1, change the semi-colon(;) to a period(.) and change "hut" to "But".

In line 91, page 1, change the period(.) to a comma(,) and change "It" to "it".

In line 109, page 5, change "$\frac{1}{C_1 p_2}$" to $\frac{1}{C_1 P^2}$

In line 124, page 5, change the first member of the equation from "$\frac{1}{C_1 P_2}$" to $\frac{1}{C_1 P^2}$

In line 91, page 10, change the dash(-) between the words "non-metallic" and "non-conducting" to a comma(,), cancel the dash (-) between the words "fact" and "dielectric"; and in line 92, page 10, insert a comma(,) between the words "dielectric" and "medium"; so that lines 91 and 92 will read, "non-metallic, non-conducting, in fact dielectric, medium" &c.

This certificate is requested so that the printed specification

Hon.Com.of Pats.....2.

will conform with the specification now on record in the archives of the Patent Office, and because, by reason of the changes in punctuation introduced by the printer, the meaning of certain parts of the specification has been completely changed.

Respectfully,

Alex P. Brown

Attorney for Stone,

Secty & Treas. Stone Tel. & Tel.Co.

Browne, Cl. 2 Q

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It is directed that a certificate of correction be endorsed upon Letters Patent No. 714,736, making the changes requested, with the exception that the period in line 91, page 1, should be changed to a semicolon and not to a comma, to conform to the record of the case.

E. B. Moore
Acting Commissioner.

November 25, 1903.

3362

Communications should be addressed to
The Commissioner of Patents,
Washington, D. C.

LETTER No.

DEPARTMENT OF THE INTERIOR.

UNITED STATES PATENT OFFICE,

WASHINGTON, D. C.

In the matter of
Letters Patent No.714,756,
Issued December 2,1902,
John Stone Stone,
Methods of Selective Signaling,
Mr.Alex P.Browne,attorney.

REPORT of the CHIEF of the ISSUE and GAZETTE DIVISION.

The patent is returned calling attention to four departures in the printed specification from the punctuation of the original manuscript,and two errors in the algebraic formulas.

In the matter of punctuation:---

1st In line 85,page 1,the semicolon after the word "systems" should be changed to a period,and the following word "but" should commence with a capital B,making a new sentence,to accord with the copy.

2nd In line 91,page 1,the period after the word "neighborhood" should be changed to a semicolon,(not to a comma as he requests) and the following word "It" should commence with a small i,to conform to the record.

3rd In line 91,page 10,a comma should be substituted for the dash after the word "non-metallic" and the dash after the word "fact" should be stricken out to conform to the copy.

4th In line 92,page 10,a comma should be inserted after the word "dielectric."

In the matter of changed formula:

1st In lines 105-110,page 5,and 2nd In lines 120-125, same page,in the first member of the formula the printer used the inferior "p" instead of the superior L^2,as was evidently intended by the writer of the specification.

straight wire attached freely to the terminal of the coil. These motions are, of course, due to the impact of the molecules, and the irregularity in the distribution of the potential, owing to the roughness and dissymmetry of the wire or filament. With a perfectly symmetrical and polished wire such motions would probably not occur. That the motion is not likely to be due to others causes is evident from the fact that it is not of a definite direction, and that in a very highly exhausted globe it ceases altogether. The possibility of bringing a body to unusual science in an exhausted globe, or even when not at all enclosed, would seem to afford a possible way of obtaining light effects, which, in perfecting methods of producing rapidly alternating potentials, might be rendered available for useful purposes.

In employing a commercial coil, the production of very powerful brush effects is attended with considerable difficulties, for

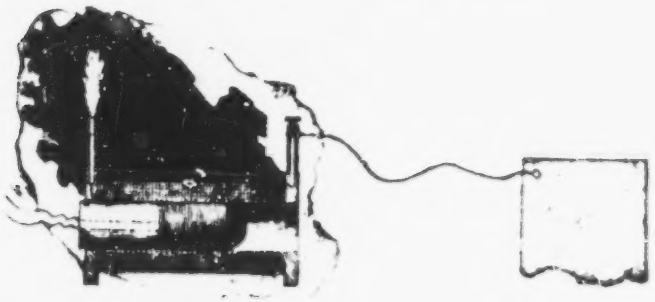
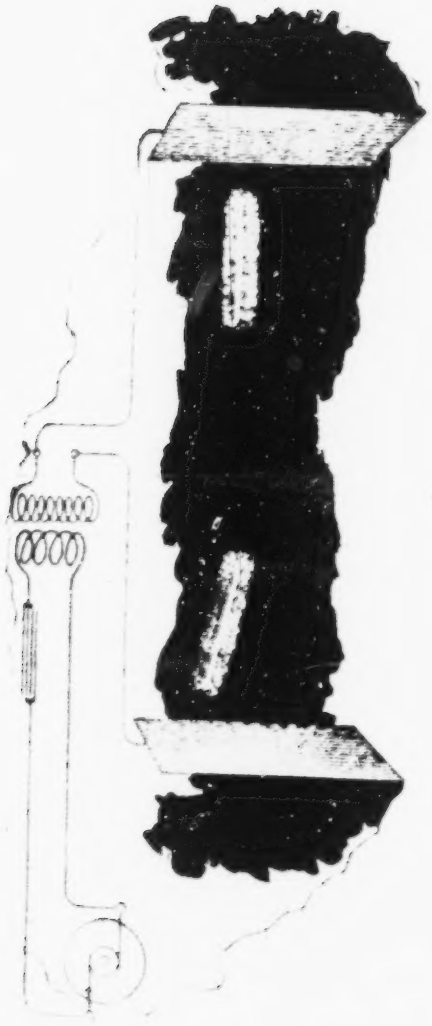


FIG. 1.

lovable pioneers. Many have been carried away by the enthusiasm and passion to discover, but in their zeal to reach results, some have been misled. Starting with the idea of producing electromagnetic waves, they turned their attention, perhaps, too much to the study of electromagnetic effects, and neglected the study of electrostatic phenomena. Naturally, nearly every investigator availed himself of an apparatus similar to that used in earlier experiments. But in those forms of apparatus, while the electromagnetic inductive effects are enormous, the electrostatic effects are excessively small.

In the Hertz experiments, for instance, a high tension induction coil is short circuited by an arc, the resistance of which is very small, the smaller, the more capacity is attached to the terminals; and the difference of potential at these is enormously diminished. On the other hand, when the discharge is not passing between the terminals, the static effects may be considerable, but only qualitatively so, not quantitatively, since their rise and fall is very sudden, and since their frequency is small. In neither case, therefore, are powerful electrostatic effects perceivable. Similar conditions exist when, as in some interesting experiments of Dr. Lodge, Leyden jars are discharged disruptively. It has been thought — and I believe asserted — that in such cases most of the energy is radiated into space. In the light of the experiments which I have described above, it will now not be thought so. I feel safe in asserting that in such cases most of the energy is partly taken up and converted into heat in the arc of the discharge and in the conducting and insulating material of the jar, some energy being, of course, given off by electrification of the air, but the amount of the directly radiated energy is very small.

When a high tension induction coil, operated by currents alternating only 20,000 times a second, has its terminals closed through even a very small jar, practically all the energy passes through the dielectric of the jar, which is heated, and the electrostatic effects manifest themselves outwardly only to a very weak degree. Now the external circuit of a Leyden jar, that is, the arc and the connections of the coatings, may be looked upon as a circuit containing alternating currents of excessively high frequency and fairly high potential, which are passed through the coatings and the dielectric between them, and there, for about the reasons that the external electrostatic effects cannot be very considerable,



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...generally speaking, of any considered apparatus, but low frequencies can be resorted to, recourse must, therefore, be had to some other means. The discharge of a condenser affords us a means of obtaining frequencies by far higher than are obtainable mechanically, and I have accordingly employed condensers in my experiments to the above end.

When the terminals of a high tension induction coil, Fig. 126, are connected to a Leyden jar, and the latter is discharging disruptively into a circuit, we may look upon the arc playing between the knobs as being a source of alternating, or generally speaking, undulating currents, and then we have to deal with the familiar system of a generator of such currents, a circuit connected to it, and a condenser bridging the circuit. The condenser in such case is a veritable transformer, and since the frequency is excessive, almost any ratio in the strength of the currents in both the branches may be obtained. In reality the analogy is not quite complete, for in the disruptive discharge we have most generally a fundamental instantaneous variation of comparatively low frequency, and a superimposed harmonic vibration, and the laws governing the flow of currents are not the same for both.

In converting in this manner, the ratio of conversion should not be too great, for the loss in the arc between the knobs increases with the square of the current, and if the jar be discharged through very thick and short conductors, with the view of obtaining a very rapid oscillation, a very considerable portion of the energy stored is lost. On the other hand, too small ratios are not practicable for many obvious reasons.

As the converted currents flow in a practically closed circuit, the electrostatic effects are necessarily small, and I therefore convert them into currents or effects of the required character. I have effected such conversions in several ways. The preferred plan of connections is illustrated in Fig. 127. The manner of operating renders it easy to obtain by means of a small and inexpensive apparatus enormous differences of potential which have been usually obtained by means of large and expensive coils. For this it is only necessary to take an ordinary small coil, adjust to it a condenser and discharging circuit, forming the primary of an auxiliary small coil, and convert upward. As the inductive effect of the primary currents is excessively great, the second coil need have comparatively but very few turns. By properly adjusting the elements, remarkable results may be secured.

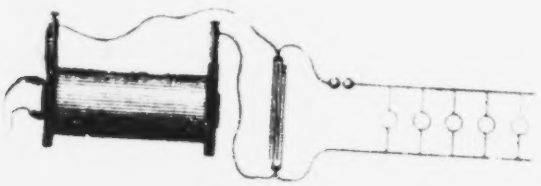

FIG 126

introduction on an industrial scale. Now that all modern research seems to point with certainty to the use of electricity of excessively high tension, the question must present itself to many whether it is not possible to obtain in a practicable manner this form of energy from heat. We have been used to look upon an electrostatic machine as a plaything, and somehow we couple with it the idea of the inefficient and impractical. But now we must think differently, for now we know that everywhere we have to deal with the same forces, and that it is a mere question of inventing proper methods or apparatus for rendering them available.

In the present systems of electrical distribution, the employment of the iron with its wonderful magnetic properties allows us to reduce considerably the size of the apparatus; but, in spite of this, it is still very cumbersome. The more we progress in the study of electric and magnetic phenomena, the more we be-

come convinced that the present methods will be short-lived. For the production of light, at least, such heavy machinery would seem to be unnecessary. The energy required is very small, and if light can be obtained as efficiently as, theoretically, it appears possible, the apparatus need have but a very small output. There being a strong probability that the illuminating methods of the future will involve the use of very high potentials, it seems very desirable to perfect a contrivance capable of converting the energy of heat into energy of the requisite form. Nothing to speak of has been done towards this end, for the thought that electricity of some 50,000 or 100,000 volts pressure or more, even if obtained, would be unavailable for practical purposes, has deterred inventors from working in this direction.

In Fig. 126 a plan of connections is shown for converting currents of high, into currents of low, tension by means of the disruptive discharge of a condenser. This plan has been used by

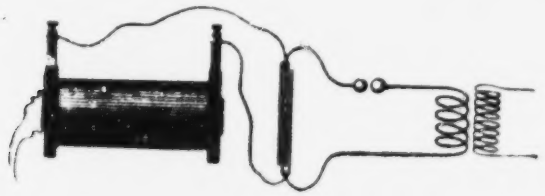

FIG. 127.

me frequently for operating a few incandescent lamps required in the laboratory. Some difficulties have been encountered in the arc of the discharge which I have been able to overcome to a great extent; besides this, and the adjustment necessary for the proper working, no other difficulties have been met with, and it was easy to operate ordinary lamps, and even motors, in this manner. The line being connected to the ground, all the wires could be handled with perfect impunity, no matter how high the potential at the terminals of the condenser. In these experiments a high tension induction coil, operated from a battery or from an alternate current machine, was employed to charge the condenser; but the induction coil might be replaced by an apparatus of a different kind, capable of giving electricity of such high tension. In this manner, direct or alternating currents may be converted, and in both cases the current-impulses may be of any desired frequency. When the currents charging the condenser are of the

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interrupter or break, or by the use of an alternator. Earlier English investigators to mention only Spottiswoode and J. E. H. Gordon, have used a rapid break in connection with the coil. Our knowledge and experience of to-day enables us to see clearly why these coils under the conditions of the test did not disclose any remarkable phenomena, and why able experimenters failed to perceive many of the curious effects which have since been observed.

In the experiments such as performed this evening, we operate the coil either from a specially constructed alternator capable of giving many thousands of reversals of current per second, or, by disruptively discharging a condenser through the primary, we set up a vibration in the secondary circuit of a frequency of many hundred thousand or millions per second, if we so desire; and in using either of these means we enter a field as yet unexplored.

It is impossible to pursue an investigation in any novel line without finally making some interesting observation or learning some useful fact. That this statement is applicable to the subject of this lecture the many curious and unexpected phenomena which we observe afford a convincing proof. By way of illustration, take for instance the most obvious phenomena, those of the discharge of the induction coil.

Here is a coil which is operated by currents vibrating with extreme rapidity, obtained by disruptively discharging a Leyden jar. It would not surprise a student were the lecturer to say that the secondary of this coil consists of a small length of comparatively stout wire; it would not surprise him were the lecturer to state that, in spite of this, the coil is capable of giving any potential which the best insulation of the turns is able to withstand; but although he may be prepared, and even be indifferent as to the anticipated result, yet the aspect of the discharge of the coil will surprise and interest him. Every one is familiar with the discharge of an ordinary coil; it need not be reproduced here. But, by way of contrast, here is a form of discharge of a coil, the primary current of which is vibrating several hundred thousand times per second. The discharge of an ordinary coil appears as a simple line or band of light. The discharge of this coil appears in the form of powerful brushes and luminous streams issuing from all points of the two straight wires attached to the terminals of the secondary. (Fig. 130.)

Now compare this phenomenon which you have just witnessed

with the discharge of a Holtz or Wimshurst machine—that other interesting appliance so dear to the experimenter. What a difference there is between these phenomena! And yet, had I made the necessary arrangements—which could have been made easily, were it not that they would interfere with other experiments—I could have produced with this coil sparks which, had I the coil

FIG. 130

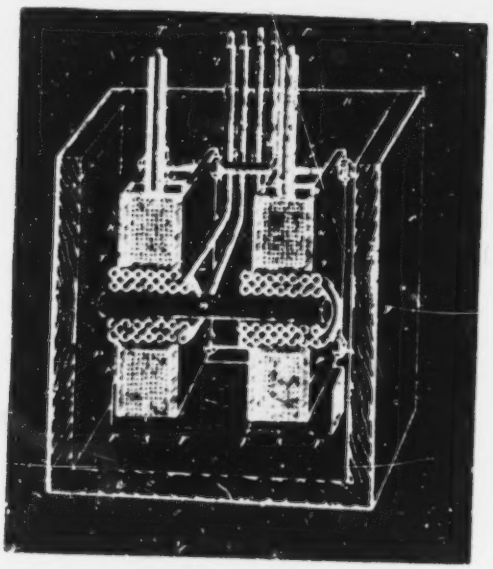
FIG. 131

hidden from your view and only two knobs exposed, even the keenest observer among you would find it difficult, if not impossible, to distinguish from those of an influence or friction machine. This may be done in many ways—for instance, by operating the induction coil which charges the condenser from an alternating-current machine of very low frequency, and preferably adjusting the discharge circuit so that there are no oscillations set up in it. We then obtain in the secondary circuit, if the knobs are of the required size and properly set, a more or less

as, to produce each phenomenon at its best, a very careful adjustment is required. But even if imperfectly produced, as they are likely to be this evening, they are sufficiently striking to interest an intelligent audience.

Before showing some of these curious effects I must, for the sake of completeness, give a short description of the coil and other apparatus used in the experiments with the disruptive discharge this evening.

It is contained in a box *a* (Fig. 132) of thick boards of hard



wood, covered on the outside with a sheet of copper carefully soldered all around. It might be advisable, in accurate investigation, where accuracy is of great importance, to dispense with the metal cover, as it might introduce disturbances, principally on account of its complex action upon the coil and the device of very small capacity and considerable self-induction magneto-circuit. When the conditions [illegible] are here considered, the employment of a copper cover offers some practical advantage, and there are certain [illegible] to be dealt upon.

The coil should be placed [illegible]

and the space between should, of course, not be too small, certainly not less than, say, five centimetres, but much more if possible; especially the two sides of the zinc box, which are at right angles to the axis of the coil, should be sufficiently remote from the latter, as otherwise they might impair its action and be a source of loss.

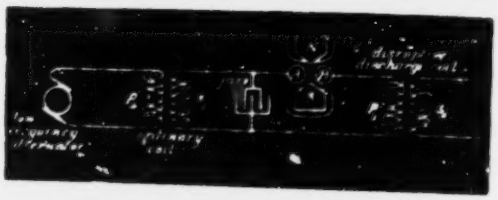
The coil consists of two spools of hard rubber *r, r*, held apart at a distance of 10 centimetres by bolts *c* and nuts *n*, likewise of hard rubber. Each spool comprises a tube *t* of approximately 8 centimetres inside diameter, and 3 millimetres thick, upon which are screwed two flanges *r, r*, 24 centimetres square, the space between the flanges being about 3 centimetres. The secondary, *s s*, of the best gutta percha-covered wire, has 26 layers, 10 turns in each, giving for each half a total of 260 turns. The two halves are wound oppositely and connected in series, the connection between both being made over the primary. This disposition, besides being convenient, has the advantage that when the coil is well balanced—that is, when both of its terminals *t, t*, are connected to bodies or devices of equal capacity—there is not much danger of breaking through to the primary, and the insulation between the primary and the secondary need not be thick. In using the coil it is advisable to attach to *both* terminals devices of nearly equal capacity, as, when the capacity of the terminals is not equal, sparks will be apt to pass to the primary. To avoid this, the middle point of the secondary may be connected to the primary, but this is not always practicable.

The primary *p p* is wound in two parts, and oppositely, upon a wooden spool *w*, and the four ends are led out of the oil through hard rubber tubes *l l*. The ends of the secondary *s, s*, are also led out of the oil through rubber tubes *l, l*, of great thickness. The primary and secondary layers are insulated by cotton cloth, the thickness of the insulation, of course, bearing some proportion to the difference of potential between the turns of the different layers. Each half of the primary has four layers, 24 turns in each, thus giving a total of 96 turns. When both the parts are connected in series, this gives a ratio of conversion of about 1 : 2·7, and with the primaries in multiple, 1 : 5·4; but in operating with very rapidly alternating currents this ratio does not convey even an approximate idea of the ratio of the E. M. F's. in the primary and secondary circuits. The coil is held in position in the oil on wooden supports, there being about 3 centimetres

In another arrangement with the magnet I take the discharge between the rounded pole pieces themselves, which in this case are insulated and preferably provided with polished brass caps.

The employment of an intense magnetic field is of advantage principally when the inductorium coil or transformer which charges the condenser is operated by currents of very low frequency. In such a case the number of the fundamental discharges between the knobs may be so small as to render the currents produced in the secondary unsuitable for many experiments. The intense magnetic field then serves to blow out the arc between the knobs as soon as it is formed, and the fundamental discharges occur in quicker succession.

Instead of the magnet, a draught or blast of air may be employed with some advantage. In this case the arc is preferably



established between the knobs a b, as in Fig. 1(a) of the knobs c d being generally joined, or entirely done away with, as in the disposition the arc is long and unsteady, and is easily affected by the draught.

When a magnet is employed to break the arc, it is better to choose the connections indicated diagrammatically in Fig. 1(b) as in this case the currents forming the arc are much more powerful, and the magnetic field exercises a greater influence. The use of the magnet permits, however, of the arc being replaced by a vacuum tube, but I have encountered great difficulties in working with an exhausted tube.

The other form of discharger used in these and similar experiments is indicated in Figs. 1(c) and 1(d). It consists of a number of brass pieces, as in Fig. 1(c), each of which comprises a spherical middle portion a with two extensions b c, which is merely used to fasten the piece in a lathe when polishing up the discharging

...and a column above, which consists of a knurled flange ... surmounted by a threaded stem *l* carrying a nut *n*, by means ... which a wire is fastened to the column. The flange *f* conveniently serves for holding the brass piece when fastening the

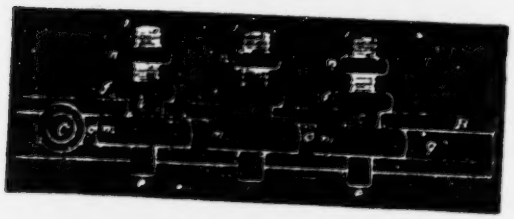


FIG. 135.

...and also for turning it in any position when it becomes ...essary to present a fresh discharging surface. Two stout ...ips of hard rubber *r r*, with planed grooves *q q* (Fig. 136) to fit ...e middle portion of the pieces *c c*, serve to clamp the latter ...nd hold them firmly in position by means of two bolts *c c* ...of which only one is shown) passing through the ends of the ...rips.

In the use of this kind of discharger I have found three principal advantages over the ordinary form. First, the dielectric ...trength of a given total width of air space is greater when a ...great many small air gaps are used instead of one, which permits

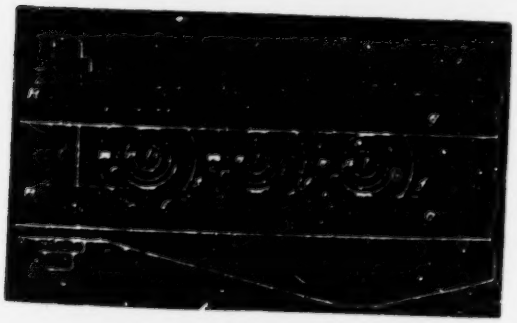


FIG. 136.

...working with a smaller length of air gap, and that means ...smaller loss and less deterioration of the metal; secondly, by ...means of splitting the arc up into smaller arcs, the polished ...faces are made to last much longer; and, thirdly, the appe...

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ratus affords some gauge to the experiments. I usually set the pieces by putting between them sheets of mica for the known certain very small distance which is known from the experiments of Sir William Thomson to require a certain electromotive force to be bridged by the spark.

It should, of course, be remembered that the sparking distance is much diminished as the frequency is increased. By taking any number of sparks the experimenter has a rough idea of the electromotive force, and he finds it easier to repeat an experiment, as he has not the trouble of setting the knobs again and again. With this kind of discharger I have been able to maintain an oscillating motion without any spark being visible with the naked eye between the knobs, and they would not show a very appreciable rise of temperature. This form of discharger also lends itself to many arrangements of condensers and circuits which are often very convenient and time saving. I have used it preferably in a disposition similar to that indicated in Fig. 131, when the currents forming the arc are small.

I may here mention that I have also used dischargers with single or multiple air gaps, in which the discharge surfaces were rotated with great speed. No particular advantage was, however, gained by this method, except in cases where the currents from the condenser were large and the keeping cool of the surfaces was necessary, and in cases when the discharge not being oscillating of itself, the arc as soon as established was broken by the movement, thus starting the vibrations at intervals in rapid succession. I have also used mechanical interrupters in many ways. To avoid the difficulties with frictional contacts the general plan adopted was to establish the arc and create through it at great speed a current pulse produced by many independent metal plates. It is understood, of course, that the employment of an engine's armature or other interrupter presents no effect worth noticing, unless the self-induction is small and resistance [illegible] that the [illegible] and speed such interrupters.

I will now refer to [illegible]

[illegible]

some experiments, and many times convenient for the purposes of adjustment, I cover the secondary with wax, and turn it off in a lathe to a diameter slightly smaller than the inside of the primary coil. The latter I provide with a handle reaching out of the oil, which serves to shift it in any position along the secondary.

I will now venture to make, in regard to the general manipulation of induction coils, a few observations bearing upon points which have not been fully appreciated in earlier experiments with such coils, and are even now often overlooked.

The secondary of the coil possesses usually such a high self-induction that the current through the wire is inappreciable, and may be so even when the terminals are joined by a conductor of small resistance. If capacity is added to the terminals, the self-induction is counteracted, and a stronger current is made to flow through the secondary, though its terminals are insulated from each other. To one entirely unacquainted with the properties of alternating currents nothing will look more puzzling. This feature was illustrated in the experiment performed at the beginning with the top plates of wire gauze attached to the terminals and the rubber plate. When the plates of wire gauze were close together, and a small arc passed between them, the arc *prevented* a strong current from passing through the secondary, because it did away with the capacity on the terminals; when the rubber plate was inserted between, the capacity of the condenser formed counteracted the self-induction of the secondary, a stronger current passed now, the coil performed more work, and the discharge was by far more powerful.

The first thing, then, in operating the induction coil is to combine capacity with the secondary to overcome the self-induction. If the frequencies and potentials are very high, gaseous matter should be carefully kept away from the charged surfaces. If Leyden jars are used, they should be immersed in oil, as otherwise considerable dissipation may occur if the jars are greatly strained. When high frequencies are used, it is of equal importance to combine a condenser with the primary. One may use a condenser connected to the ends of the primary or to the terminals of the alternator, but the latter is not to be recommended, as the machine might be injured. The best way is undoubtedly to use the condenser in series with the primary and with the alternator, and to adjust its capacity so as to annul the

self-induction of both the latter. The condenser should be adjustable by very small steps, and for a fine adjustment a small air condenser with movable plates may be used conveniently.

I think it best at this juncture to bring before you a phenomenon observed by me some time ago, which to the patient scientific investigator may perhaps appear more interesting than any of the results which I have the privilege to present to you this evening.

It may be quite properly ranked among the brush phenomena, in fact, it is a brush, formed at, or near, a single terminal of high potential.

In bulbs provided with a conducting terminal, though it be of

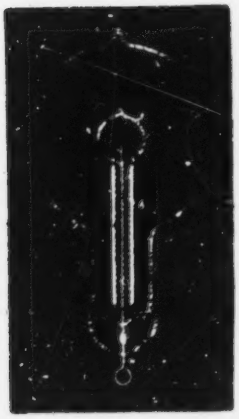

FIG. 141

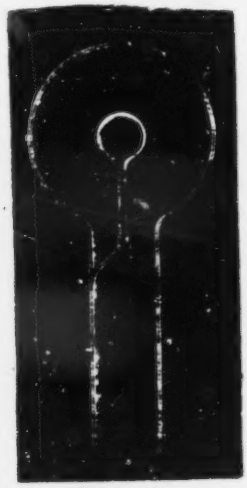

FIG. 142

aluminum, the brush has but an ephemeral existence, and cannot, unfortunately, be indefinitely preserved in its most sensitive state, even in a bulb devoid of any conducting electrode. In studying the phenomenon, by all means a bulb having a leading-in wire should be used. I have found it best to use bulbs constructed as indicated in Figs. 141 and 142.

In Fig. 141 the bulb comprises an incandescent lamp globe *f* in the neck of which is sealed a barometer tube *b*, the end of which is blown out to form a small sphere *s*. This sphere should be sealed as closely as possible in the centre of the large globe. Before sealing, a thin tube *t*, of aluminum sheet, may be slipped on the barometer tube, but it is not important to employ it.

I have been unable to produce the phenomenon with the disruptive discharge coil, although every other of these phenomena can be well produced by it—many, in fact, much better than with coils operated from an alternator.

It may be possible to produce the brush by impulses of one direction, or even by a steady potential, in which case it would be still more sensitive to magnetic influence.

In operating an induction coil with rapidly alternating currents, we realize with astonishment, for the first time, the great importance of the relation of capacity, self-induction and frequency as regards the general results. The effects of capacity are the most striking, for in these experiments, since the self-induction and frequency both are high, the critical capacity is very small, and need be but slightly varied to produce a very considerable change. The experimenter may bring his body in contact with the terminals of the secondary of the coil, or attach to one or both terminals insulated bodies of very small bulk, such as bulbs, and he may produce a considerable rise or fall of potential, and greatly affect the flow of the current through the primary. In the experiment before shown, in which a brush appears at a wire attached to one terminal, and the wire is vibrated when the experimenter brings his insulated body in contact with the other terminal of the coil, the sudden rise of potential was made evident.

I may show you the behavior of the coil in another manner which possesses a feature of some interest. I have here a little light fan of aluminum sheet, fastened to a needle and arranged to rotate freely in a metal piece screwed to one of the terminals of the coil. When the coil is set to work, the molecules of the air are rhythmically attracted and repelled. As the force with which they are repelled is greater than that with which they are attracted, it results that there is a repulsion exerted on the surfaces of the fan. If the fan were made simply of a metal sheet, the repulsion would be equal on the opposite sides, and would produce no effect. But if one of the opposing surfaces is screened, or if, generally speaking, the bombardment on this side is weakened in some way or other, there remains the repulsion exerted upon the other, and the fan is set in rotation. The screening is best effected by fastening upon one of the opposing sides of the fan insulated conducting coatings, or, if the fan is made in the shape of an ordinary propeller screw, by fastening on one

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show you is that this motor rotates with *one single* connection between it and the generator; that is to say, one terminal of the motor is connected to one terminal of the generator—in this case the secondary of a high-tension induction coil—the other terminals of motor and generator being insulated in space. To produce rotation it is generally (but not absolutely) necessary to connect the free end of the motor coil to an insulated body of some size. The experimenter's body is more than sufficient. If he touches the free terminal with an object held in the hand, a current passes through the coil and the copper disc is set in rotation. If an exhausted tube is put in series with the coil, the tube lights brilliantly, showing the passage of a strong current. In-

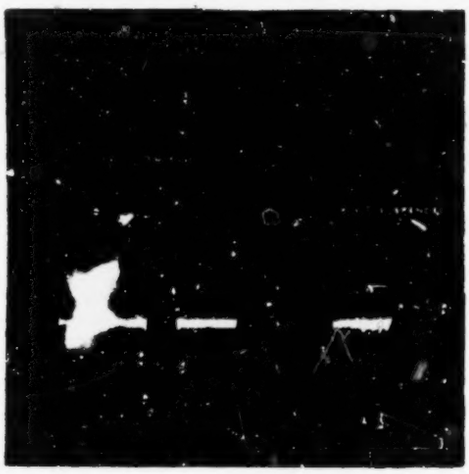

FIG. 146.

stead of the experimenter's body, a small metal sheet suspended on a cord may be used with the same result. In this case the plate acts as a condenser in series with the coil. It counteracts the self-induction of the latter and allows a strong current to pass. In such a combination, the greater the self-induction of the coil the smaller need be the plate, and this means that a lower frequency, or eventually a lower potential, is required to operate the motor. A single coil wound upon a core has a high self-induction; for this reason, principally, this type of motor was chosen to perform the experiment. Were a secondary closed coil wound upon the core, it would tend to diminish the self-

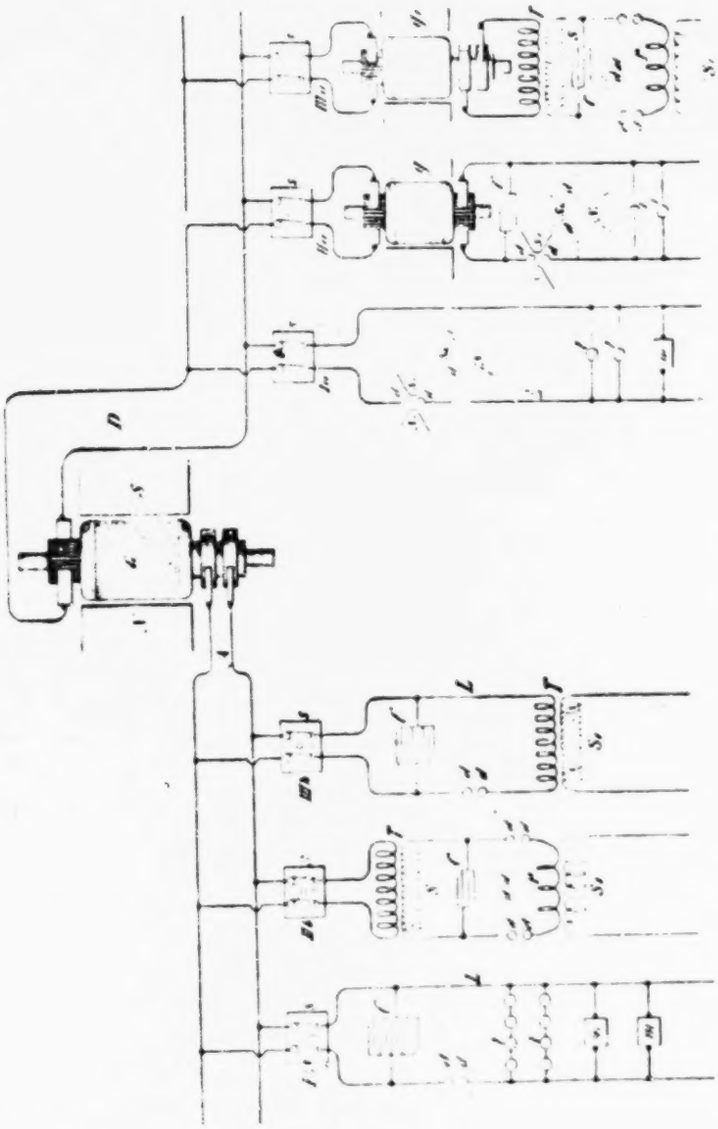

FIG. 165.

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plan is to charge condensers, from a direct or alternate current source, preferably of high tension, and to discharge them disruptively while observing well-known conditions necessary to maintain the oscillations of the current. In view of the general interest taken in high-frequency currents and effects producible by them, it seems to me advisable to dwell at some length upon this method of conversion. In order to give you a clear idea of the action, I will suppose that a continuous-current generator is employed, which is often very convenient. It is desirable that the generator should possess such high tension as to be able to break through a small air space. If this is not the case, then auxiliary means have to be resorted to, some of which will be indicated subsequently. When the condensers are charged to a certain potential, the air, or insulating space, gives way and a disruptive discharge occurs. There is then a sudden rush of current and generally a large portion of accumulated electrical energy spends itself. The condensers are thereupon quickly charged and the same process is repeated in more or less rapid succession. To produce such sudden rushes of current it is necessary to observe certain conditions. If the rate at which the condensers are discharged is the same as that at which they are charged, then, clearly, in the assumed case the condensers do not come into play. If the rate of discharge be smaller than the rate of charging, then, again, the condensers cannot play an important part. But if, on the contrary, the rate of discharging is greater than that of charging, then a succession of rushes of current is obtained. It is evident that, if the rate at which the energy is dissipated by the discharge is very much greater than the rate of supply to the condensers, the sudden rushes will be comparatively few, with long-time intervals between. This always occurs when a condenser of considerable capacity is charged by means of a comparatively small machine. If the rates of supply and dissipation are not widely different, then the rushes of current will be in quicker succession, and this the more, the more nearly equal both the rates are, until limitations incident to each case and depending upon a number of causes are reached. Thus we are able to obtain from a continuous-current generator as rapid a succession of discharges as we like. Of course, the higher the tension of the generator, the smaller need be the capacity of the condensers, and for this reason, principally, it is of advantage to employ a generator of very high tension. Besides, such a generator permits the attaining of greater rates of vibration.

The impulses of current may be of the same direction under the conditions before assumed, but most generally there is an oscillation superimposed upon the fundamental vibration of the current. When the conditions are so determined that there are no oscillations, the current impulses are unidirectional and thus a means is provided of transforming a continuous current of high tension, into a direct current of lower tension, which I think may find employment in the arts.

This method of conversion is exceedingly interesting and I was much impressed by its beauty when I first conceived it. It is ideal in certain respects. It involves the employment of no mechanical devices of any kind, and it allows of obtaining currents of any desired frequency from an ordinary circuit, direct or alternating. The frequency of the fundamental discharges depending on the relative rates of supply and dissipation can be readily varied within wide limits, by simple adjustments of these quantities, and the frequency of the superimposed vibration by the adjustment of the capacity, self-induction and resistance of the circuit. The potential of the currents, again, may be raised as high as any insulation is capable of withstanding safely by combining capacity and self induction or by induction in a secondary, which need have but comparatively few turns.

As the conditions are often such that the intermittence or oscillation does not readily establish itself, especially when a direct current source is employed, it is of advantage to associate an interrupter with the arc, as I have, some time ago, indicated the use of an air-blast or magnet, or other such device readily at hand. The magnet is employed with special advantage in the conversion of direct currents, as it is then very effective. If the primary source is an alternate current generator, it is desirable, as I have stated on another occasion, that the frequency should be low, and that the current forming the arc be large, in order to render the magnet more effective.

A form of such discharger with a magnet which has been found convenient, and adopted after some trials, in the conversion of direct currents particularly, is illustrated in Fig. 168. s s are the pole pieces of a very strong magnet which is excited by a coil c. The pole pieces are slotted for adjustment and can be fastened in any position by screws s_1 s_1. The discharge rods d d_1, thinned down on the ends in order to allow a closer approach of the magnetic pole pieces, pass through the columns of brass b b_1 and are fastened in position by screws s_2 s_2. Springs r r_1 and collars c c_1

are slipped on the rods, the latter serving to set the points of the rods at a certain suitable distance by means of screws s_1 s_2 and the former to draw the points apart. When it is desired to start the arc, one of the large rubber handles h h_1 is tapped quickly with the hand, whereby the points of the rods are brought in contact but are instantly separated by the springs r r_1. Such an arrangement has been found to be often necessary, namely in cases when the E. M. F. was not large enough to cause the discharge to break through the gap, and also when it was desirable to avoid short circuiting of the generator by the metallic contact of the rods. The rapidity of the interruptions of the current with a magnet depends on the intensity of the magnetic field and on the

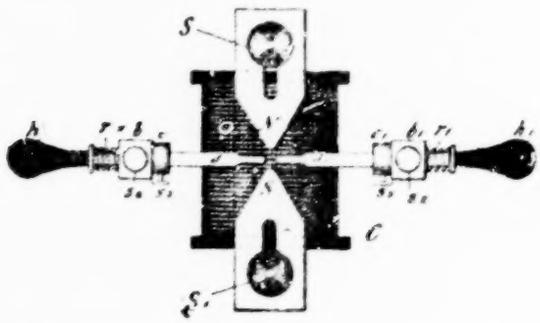
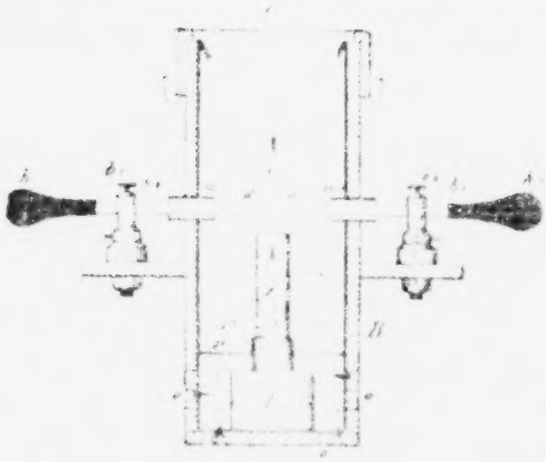


FIG. 166.

potential difference at the end of the arc. The interruptions are generally in such quick succession as to produce a musical sound. Years ago it was observed that when a powerful induction coil is discharged between the poles of a strong magnet, the discharge produces a loud noise not unlike a small pistol shot. It was vaguely stated that the spark was intensified by the presence of the magnetic field. It is now clear that the discharge current, flowing for some time, was interrupted a great number of times by the magnet, thus producing the sound. The phenomenon is especially marked when the field circuit of a large magnet or dynamo is broken in a powerful magnetic field.



It is desirable to exclude the light as perfectly as possible, as it interferes with some experiments. The form of discharger is simple and very effective when properly manipulated. The air being warmed to a certain temperature, has its insulating power impaired; it becomes dielectrically weak, as it were, and the consequence is that the arc can be established at much greater distance. The arc should, of course, be sufficiently insulating to allow the discharge to pass through the gap *downstream*. The arcs formed under such conditions, when long, may be made extremely sensitive, and the weak draught through the lamp chimney *c* is quite sufficient to produce rapid interruptions. The adjustment is made by regulating the temperature and velocity of the draught. Instead of using the lamp, it answers the purpose to provide for a draught of warm air in other way. A very simple way which has been practiced is to enclose the arc in a long vertical tube, with plates on the top and bottom for regulating the temperature and velocity of the air current. Some provision had to be made for deadening the sound.

The air may be rendered dielectrically weak also by convection. Dischargers of this kind have likewise been used by me in connection with a magnet. A large tube is for this purpose provided with heavy electrodes of carbon or metal, between which the discharge is made to pass, the tube being placed in a powerful magnetic field. The exhaustion of the tube is carried to a point at which the discharge breaks through easily, but the pressure should be more than 76 millimetres, at which the ordinary thread discharge occurs. In another form of discharger, combining the features before mentioned, the discharge was made to pass between two adjustable magnetic pole pieces, the space between them being kept at an elevated temperature.

It should be remarked here that when such, or interrupting devices of any kind, are used and the currents are passed through the primary of a disruptive discharge coil, it is not, as a rule, of advantage to produce a number of interruptions of the current per second greater than the natural frequency of vibration of the dynamo supplying the current, when such is used. It cannot be pointed out in full that while the devices mentioned in connection with the disruptive discharge are advantageous under certain conditions, they may be sometimes a source of trouble as they produce disturbances of other irregularities in the operation which it would be very desirable to overcome.

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There is, I regret to say, in this beautiful method of conversion a defect, which fortunately is not vital, and which I have been gradually overcoming. I will best call attention to this defect and indicate a fruitful line of work, by comparing the electrical process with its mechanical analogue. The process may be illustrated in this manner. Imagine a tank with a wide opening at the bottom, which is kept closed by spring pressure, but so that it snaps off *suddenly* when the liquid in the tank has reached a certain height. Let the fluid be supplied to the tank by means of a pipe feeding at a certain rate. When the critical height of the liquid is reached, the spring gives way and the bottom of the tank drops out. Instantly the liquid falls through the wide opening, and the spring, reasserting itself, closes the bottom again. The tank is now filled, and after a certain time interval the same process is repeated. It is clear, that if the pipe feeds the fluid quicker than the bottom outlet is capable of letting it pass through, the bottom will remain off and the tank will still overflow. If the rate of supply are exactly equal, then the bottom lid will remain partially open and no vibration of the same and of the liquid column will generally occur, though it might, if started by some means. But if the inlet pipe does not feed the fluid fast enough for the outlet, then there will be always vibration. Again, in such case, each time the bottom flaps up or down, the spring and the liquid column, if the pliability of the spring and the inertia of the moving parts are properly chosen, will perform [illegible] vibrations. In the analogue the fluid may be likened to electricity or electrical energy, the tank to the condenser, the spring to the dielectric, and the pipe to the conductor through which electricity is supplied to the condenser. To make this analogy quite complete it is necessary to make the assumption that the bottom, each time it gives way, is knocked or lightly struck by a hammer, to stop the impact involving some loss of energy, and that is, also, some dissipation of energy results due to frictional losses. In the passage through the liquid it is supposed to be under steady pressure. If the pressure of the liquid be assumed to vary rhythmically, [illegible] [illegible] [illegible]

As regards the latter, which in the electrical analogue corresponds to the losses due to the resistance of the circuits, it is impossible to obviate them entirely, but they can be reduced to a minimum by a proper selection of the dimensions of the circuits and by the employment of thin conductors in the form of strands. But the loss of energy caused by the first breaking through of the dielectric—which in the above example corresponds to the violent knock of the bottom against the inelastic stop—would be more important to overcome. At the moment of the breaking through the air space has a very high resistance, which is probably reduced to a very small value when the current has reached some strength, and the space is brought to a high temperature. It would materially diminish the loss of energy if the space were always kept at an extremely high temperature, but then there would be no disruptive break. By warming the space moderately by means of a lamp or otherwise, the economy as far as the arc is concerned is sensibly increased. But the magnet or other interrupting device does not diminish the loss in the arc. Likewise, a jet of air only facilitates the carrying off of the energy. Air, or a gas in general, behaves curiously in this respect. When two bodies charged to a very high potential discharge disruptively through an air space, any amount of energy may be carried off by the air. This energy is evidently dissipated by bodily carriers, in impact and collisional losses of the molecules. The exchange of the molecules in the space occurs with inconceivable rapidity. A powerful discharge taking place between two electrodes, they may remain entirely cool, and yet the loss in the air may represent any amount of energy. It is perfectly practicable, with very great potential differences in the gap, to dissipate several horse power in the arc of the discharge without even noticing a small increase in the temperature of the electrodes. All the frictional losses occur then practically in the air. If the exchange of the air molecules is prevented, as by enclosing the gap hermetically, the gas inside of the vessel is brought quickly to a high temperature, even with a very small discharge. It is difficult to estimate how much of the energy is lost in sound waves, audible or not, in a powerful discharge. When the currents through the gap are large, the electrodes may become rapidly heated, but this is not a reliable measure of the energy wasted in the arc, as the loss through the gas itself may be comparatively small. The air or a gas in general is, at ordinary pressure at least

clearly not the best medium through which a disruptive discharge should occur. Air or other gas under great pressure is of course a much more suitable medium for the discharge gap. I have carried on long-continued experiments in this direction, unfortunately less practicable on account of the difficulties and expense in getting air under great pressure. But even if the medium in the discharge space is solid or liquid, still the same losses take place, though they are generally smaller, for just as soon as the arc is established, the solid or liquid is volatilized. Indeed, there is no body known which would not be disintegrated by the arc, and it is an open question among scientific men, whether an arc discharge could occur at all in the air itself without the particles of the electrodes being torn off. When the current through the gap is very small and the arc very long, I believe that a relatively considerable amount of heat is taken up in the disintegration of the electrodes, which partially on this account may remain quite cold.

The ideal medium for a discharge gap should only *crack*, and the ideal electrode should be of some material which cannot be disintegrated. With small currents through the gap it is best to employ aluminum, but not when the currents are large. The disruptive break in the air, or more or less in any ordinary medium, is not of the nature of a crack, but it is rather comparable to the piercing of innumerable bullets through a mass offering great frictional resistances to the motion of the bullets, this involving considerable loss of energy. A medium which would merely crack when strained electrostatically—and this possibly might be the case with a perfect vacuum, that is, pure ether—would involve a very small loss in the gap, so small as to be entirely negligible, at least theoretically, because a crack may be produced by an infinitely small displacement. In exhausting an oblong bulb provided with two aluminum terminals, with the greatest care, I have succeeded in producing such a vacuum that the secondary discharge of a disruptive discharge coil would break disruptively through the bulb in the form of fine spark streams. The curious point was that the discharge would completely ignore the terminals and start far behind the two aluminum plates which served as electrodes. This extraordinary high vacuum could only be maintained for a very short while. To return to the ideal medium, think, for the sake of illustration, of a piece of glass or similar body clamped in a vice, and the latter tightened more and

more. At a certain point a minute increase of the pressure will cause the glass to crack. The loss of energy involved in splitting the glass may be practically nothing, for though the force is great, the displacement need be but extremely small. Now imagine that the glass would possess the property of closing again perfectly the crack upon a minute diminution of the pressure. This is the way the dielectric in the discharge space should behave. But inasmuch as there would be always some loss in the gap, the medium, which should be continuous, should exchange through the gap at a rapid rate. In the preceding example, the glass being perfectly closed, it would mean that the dielectric in the discharge space possesses a great insulating power; the glass being cracked, it would signify that the medium in the space is a good conductor. The dielectric should vary enormously in resistance by minute variations of the E. M. F. across the discharge space. This condition is attained, but in an extremely imperfect manner, by warming the air space to a certain critical temperature, dependent on the E. M. F. across the gap, or by otherwise impairing the insulating power of the air. But as a matter of fact the air does never break down *disruptively*, if this term be rigorously interpreted, for before the sudden rush of the current occurs, there is always a weak current preceding it, which rises first gradually and then with comparative suddenness. That is the reason why the rate of change is very much greater when glass, for instance, is broken through, than when the break takes place through an air space of equivalent dielectric strength. As a medium for the discharge space, a solid, or even a liquid, would be preferable therefor. It is somewhat difficult to conceive of a solid body which would possess the property of closing instantly after it has been cracked. But a liquid, especially under great pressure, behaves practically like a solid, while it possesses the property of closing the crack. Hence it was thought that a liquid insulator might be more suitable as a dielectric than air. Following out this idea, a number of different forms of dischargers in which a variety of such insulators, sometimes under great pressure, were employed, have been experimented upon. It is thought sufficient to dwell in a few words upon one of the forms experimented upon. One of these dischargers is illustrated in Figs. 168*a* and 168*b*.

A hollow metal pulley P (Fig. 168*a*), was fastened upon an arbor *a*, which by suitable means was rotated at a considerable

speed. On the inside of the pulley, but disconnected from the same, was supported a thin disc *h* (which is shown thick for the sake of clearness), of hard rubber in which there were embedded two metal segments *s s* with metallic extensions *e e* into which were screwed conducting terminals *t t* covered with thick tubes of hard rubber *t t*. The rubber disc *h* with its metallic segments *s s*, was finished in a lathe, and its entire surface highly polished so as to offer the smallest possible frictional resistance to the motion through a fluid. In the hollow of the pulley an insulating liquid such as a thin oil was poured so as to reach very nearly to the opening left in the flange *f*, which was screwed tightly on the front side of the pulley. The terminals *t t*, were connected to the opposite coatings of a battery of condensers so that the discharge occurred through the liquid. When the pulley was rotated, the liquid was forced against the rim of the pulley and considerable fluid pressure resulted. In this simple way the discharge gap

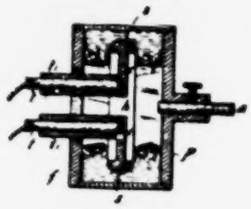

FIG. 168a.

FIG. 168b

was filled with a medium which behaved practically like a solid, which possessed the quality of closing instantly upon the occurrence of the break, and which moreover was circulating through the gap at a rapid rate. Very powerful effects were produced by discharges of this kind with liquid interrupters, of which a number of different forms were made. It was found that, as expected, a longer spark for a given length of wire was obtainable in this way than by using air as an interrupting device. Generally the speed, and therefore also the fluid pressure, was limited by reason of the fluid friction, in the form of discharger described, but the practically obtainable speed was more than sufficient to produce a number of breaks suitable for the circuits ordinarily used. In such instances the metal pulley *p* was provided with a few projections inwardly, and a definite number of breaks was then produced which could be computed from the speed of

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duced without the discharge gap, and there might even not be any quenched superimposed vibration; yet the differences of potential at the various points of the circuit, the impedance and other phenomena, dependent upon the rate of change, will bear no similarity in the two cases. Thus, when working with currents discharging disruptively, the element chiefly to be considered is not the frequency, as a student might be apt to believe, but the rate of change per unit of time. With low frequencies in a certain measure the same effects may be obtained as with high frequencies, provided the rate of change is sufficiently great. So if a low frequency current is raised to a potential of, say, 75,000 volts, and the high tension current passed through a series of high resistance lamp filaments, the importance of the rarefied gas surrounding the filament is clearly noted, as will be seen later; or, if a low frequency current of several thousand amperes is passed through a metal bar, striking phenomena of impedance are observed, just as with currents of high frequencies. But it is, of course, evident that with low frequency currents it is impossible to obtain such rates of change per unit of time as with high frequencies, hence the effects produced by the latter are much more prominent. It is deemed advisable to make the preceding remarks, inasmuch as many more recently described effects have been unwittingly identified with high frequencies. Frequency alone in reality does not mean anything, except when an undisturbed harmonic oscillation is considered.

In the branch *a* a similar disposition to that in *b* is illustrated, with the difference that the currents discharging through the gap *d d* are used to induce currents in the secondary *s* of a transformer T. In such case the secondary should be provided with an adjustable condenser for the purpose of tuning it to the primary.

a b illustrates a plan of alternate current high frequency conversion which is most frequently used and which is found to be most convenient. This plan has been dwelt upon in detail on previous occasions and need not be described here.

Some of these results were obtained by the use of a high frequency alternator. A description of such machines will be found in my original paper before the American Institute of Electrical Engineers, and in periodicals of that period, notably in THE ELECTRICAL ENGINEER of March 18, 1891.

I will now proceed with the experiments.

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coils, also by varying the frequency and potential of the currents. But it is perhaps of greater interest to note, that the lamp increases in brightness when the plate is disconnected (Fig. 179a). In this case all the energy the primary receives is now sunk into it, like the charge of a battery in an ocean cable, but most of that energy is recovered through the secondary and used to light the lamp. The current traversing the primary is strongest at the end *b* which is connected to the terminal t_1 of the induction coil, and

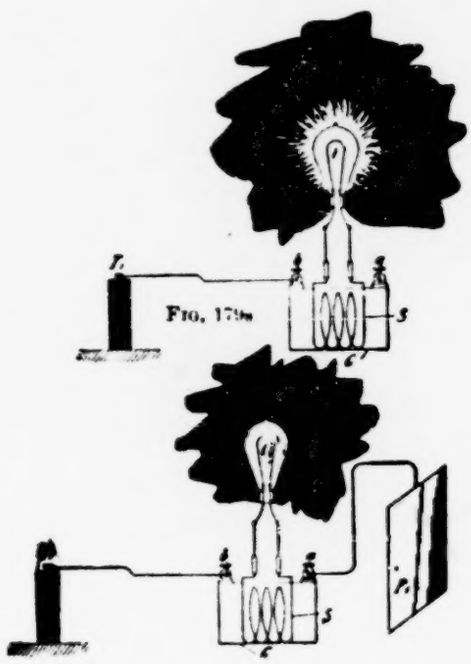

FIG. 179b.

diminishes in strength towards the remote end *a*. But the dynamic inductive effect exerted upon the secondary s is now greater than before, when the suspended plate was connected to the primary. These results might have been produced by a number of causes. For instance, the plate t_1 being connected, the reaction from the coil c may be such as to diminish the potential at the terminal t_1 of the induction coil, and therefore weaken the current through the primary of the coil c. Or the disconnecting

of the plate may diminish the capacity effect with relation to the primary of the latter coil to such an extent that the current through it is diminished, though the potential at the terminal T_1 of the induction coil may be the same or even higher. Or the result might have been produced by the change of phase of the primary and secondary currents and consequent reaction. But the chief determining factor is the relation of the self-induction and capacity of coil c and plate P_1 and the frequency of the currents. The greater brightness of the filament in Fig. 179*a*, is, however, in part due to the heating of the rarefied gas in the lamp by electrostatic induction, which, as before remarked, is greater when the suspended plate is disconnected.

Still another feature of some interest I may here bring to your attention. When the insulated plate is disconnected and the secondary of the coil opened, by approaching a small object to the secondary, but very small sparks can be drawn from it, showing that the electrostatic induction is small in this case. But upon the secondary being closed upon itself or through the lamp, the filament glowing brightly, strong sparks are obtained from the secondary. The electrostatic induction is now much greater, because the closed secondary determines a greater flow of current through the primary and principally through that half of it which is connected to the induction coil. If now the bulb be grasped with the hand, the capacity of the secondary with reference to the primary is augmented by the experimenter's body and the luminosity of the filament is increased, the incandescence now being due partly to the flow of current through the filament and partly to the molecular bombardment of the rarefied gas in the bulb.

The preceding experiments will have prepared one for the next following results of interest, obtained in the course of these investigations. Since I can pass a current through an insulated wire merely by connecting one of its ends to the source of electrical energy, since I can induce by it another current, magnetize an iron core, and, in short, perform all operations as though a return circuit were used, clearly I can also drive a motor by the aid of only one wire. On a former occasion I have described a simple form of motor comprising a single exciting coil, an iron core and disc. Fig. 180 illustrates a modified way of operating such an alternate current motor by currents induced in a transformer connected to one lead, and several other arrangements of circuits

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plate P_3. On the primaries are wound secondaries s and s_1, of coarse wire, connected to the devices *d* and *l* respectively. By varying the distances of the condenser plates c and c_1, and c and c_1 the currents through the secondaries s and s_1 are varied in intensity. The curious feature is the great sensitiveness, the slightest change in the distance of the plates producing considerable variations in the intensity or strength of the currents. The sensitiveness may be rendered extreme by making the frequency such, that the primary itself, without any plate attached to its free end, satisfies, in conjunction with the closed secondary, the condition of resonance. In such condition an extremely small change in the capacity of the free terminal produces great variations. For instance, I have been able to adjust the conditions so that the mere approach of a person to the coil produces a considerable change in the brightness of the lamps attached to the secondary. Such observations and experiments possess, of course, at present, chiefly scientific interest, but they may soon become of practical importance.

Very high frequencies are of course not practicable with motors on account of the necessity of employing iron cores. But one may use sudden discharges of low frequency and thus obtain certain advantages of high-frequency currents without rendering the iron core entirely incapable of following the changes and without entailing a very great expenditure of energy in the core. I have found it quite practicable to operate with such low frequency disruptive discharges of condensers, alternating-current motors. A certain class of such motors which I advanced a few years ago, which contain closed secondary circuits, will rotate quite vigorously when the discharges are directed through the exciting coils. One reason that such a motor operates so well with these discharges is that the difference of phase between the primary and secondary currents is 90 degrees, which is generally not the case with harmonically rising and falling currents of low frequency. It might not be without interest to show an experiment with a simple motor of this kind, inasmuch as it is commonly thought that disruptive discharges are unsuitable for such purposes. The motor is illustrated in Fig. 182. It comprises a rather large iron core *i* with slots on the top into which are embedded thick copper washers *c c*. In proximity to the core is a freely-movable metal disc D. The core is provided with a primary exciting coil c_1 the ends *a* and *b* of which are connected to

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100-volt and the latter a 50-volt are placed in certain positions as indicated, the 100-volt lamp being below the 50-volt lamp. When the arc is playing at *d d* and the sudden discharges are passed through the bars B B_1, the 50-volt lamp will, as a rule, burn brightly, or at least this result is easily secured, while the 100-volt lamp will burn very low or remain quite dark, Fig. 183*b*. Now the bars B B_1 may be joined at the top by a thick cross bar B_2 and it is quite easy to maintain the 100-volt lamp at full candle-power while the 50-volt lamp remains dark, Fig. 183*c*. These results, as I have pointed out previously, should not be considered to be due exactly to frequency but rather to the time rate of change which may be great, even with low frequencies. A great many other results of the same kind, equally interesting, especially to those who are only used to manipulate steady currents, may be obtained and they afford precious clues in investigating the nature of electric currents.

In the preceding experiments I have already had occasion to show some light phenomena and it would now be proper to study these in particular; but to make this investigation more complete I think it necessary to make first a few remarks on the subject of electrical resonance which has to be always observed in carrying out these experiments.

ON ELECTRICAL RESONANCE.

The effects of resonance are being more and more noted by engineers and are becoming of great importance in the practical operation of apparatus of all kinds with alternating currents. A few general remarks may therefore be made concerning these effects. It is clear, that if we succeed in employing the effects of resonance practically in the operation of electric devices the return wire will, as a matter of course, become unnecessary, for the electric vibration may be conveyed with one wire just as well as, and sometimes even better than, with two. The question first to answer is, then, whether pure resonance effects are producible. Theory and experiment both show that such is impossible in Nature, for as the oscillation becomes more and more vigorous, the losses in the vibrating bodies and environing media rapidly increase and necessarily check the vibration which otherwise would go on increasing forever. It is a fortunate circumstance that pure resonance is not producible, for if it were there is no telling what dangers might not lie in wait for the innocent experimenter. But to a

...degree resonance is producible, the magnitude of the ... being limited by the imperfect conductivity and imperfect elasticity of the media or, generally stated, by frictional losses. The smaller these losses, the more striking are the effects. The same is the case in mechanical vibration. A stout steel bar may be set in vibration by drops of water falling upon it at proper intervals; but with glass, which is more perfectly elastic, the resonance effect is still more remarkable, for a goblet may be burst by singing into it a note of the proper pitch. The electrical resonance is the more perfectly attained, the smaller the resistance or the impedance of the conducting path and the more perfect the dielectric. In a Leyden jar discharging through a short stranded cable of fine wires these requirements are probably best fulfilled, and the resonance effects are therefore very prominent. Such is not the case with dynamo machines, transformers and their circuits, with commercial apparatus in general in which the presence of iron cores complicates the action or renders it impossible. As regard to Leyden jars with which resonance effects are frequently demonstrated, I would say that the effects observed are often *attributed* but are seldom *due* to true resonance, for the error is quite easily made in this respect. This may be undoubtedly demonstrated by the following experiment. Take, for instance, two large insulated metallic plates or spheres which I shall designate a and b; place them at a certain small distance apart and charge them from a frictional or influence machine to a potential so high that just a slight increase of the difference of potential between them will cause the small air or insulating space to break down. This is easily reached by making preliminary trials. If now another plate—fastened on an insulating handle and connected by a wire to one of the terminals of a high tension secondary of an induction coil, which is set in action by an alternator (preferably high frequency)—is approached to one of the charged bodies a or b, so as to approach further one of them, the discharge will invariably pass between them; at least it will, if the potential of the coil and with the plate is sufficiently high. But the explanation will soon be found in the fact that the approached plate acts inductively upon the bodies a and b and causes a spark to pass between them. When this spark occurs, the charges which the bodies had received from the influence machine are partly neutralized, since the bodies are brought in electri-

cal connection through the arc formed. Now this arc is formed whether there be resonance or not. But even if the spark would not be produced, still there is an alternating E. M. F. set up between the bodies when the plate is brought near one of them; the reason the approach of the plate, if it *does* not always actually, will, at any rate, *tend* to break down the air space by inductive action. Instead of the spheres or plates A and B we may take the coatings of a Leyden jar with the same result, and in place of the machine,—which is a high frequency alternator preferably, because it is more suitable for the experiment and also for the argument,—we may take another Leyden jar or battery of jars. When such jars are discharging through a circuit of low resistance the same is traversed by currents of very high frequency. The plate may now be connected to one of the coatings of the second jar, and when it is brought near to the first jar just previously charged to a high potential from an influence machine, the result is the same as before, and the first jar will discharge through a small air space upon the second being caused to discharge. But both jars and their circuits need not be tuned any closer than a basso profundo is to the note produced by a mosquito, as small sparks will be produced through the air space, or at least the latter will be considerably more strained owing to the setting up of an alternating E. M. F. by induction, which takes place when one of the jars begins to discharge. Again another set of a similar nature is quite easily made. If the circuits of the two jars are, say, parallel and close together, and the experiment has been performed of discharging one by the other, and now a coil of wire be added to one of the circuits whereupon the experiment does not succeed, the conclusion that this is due to the fact that the circuits are [illegible] not tuned, would be far from being safe. For the two circuits act as condenser coatings and the addition of the coil across them is equivalent to bridging them, at the point where the coil is placed, by a small condenser, and the effect of the latter might be to prevent the spark from passing through the discharger by diminishing the alternating E. M. F. acting across the [illegible]. All these remarks, and many more which might be added, I refrain [illegible] of wandering too far from the [illegible] permissible idea of confining the [illegible] might gain an entirely [illegible] ing every experiment [illegible] the experimenter as [illegible]

In order to make reliable observations of electric resonance effects it is very desirable, if not necessary, to employ an alternator giving currents which rise and fall harmonically, as in working with make and break currents the observations are not always trustworthy, since many phenomena, which depend on the rate of change, may be produced with widely different frequencies. Even when making such observations with an alternator one is apt to be mistaken. When a circuit is connected to an alternator there are an indefinite number of values for capacity and self-induction which, in conjunction, will satisfy the condition of resonance. So there are in mechanics an infinite number of tuning forks which will respond to a note of a certain pitch, or loaded strings which have a definite period of vibration. But the resonance will be most perfectly attained in that case in which the motion is effected with the greatest freedom. Now in mechanics, considering the vibration in the common medium—that is, air—it is of comparatively little importance whether one tuning fork be somewhat larger than another, because the losses in the air are always considerable. One may, of course, enclose a tuning fork in a chamber exhausted by this reducing the air resistance to a minimum obtain better resonant action. Still the difference would not be very great. But it would make a great difference if the tuning fork were immersed in mercury. In the electrical resonator it is of enormous importance to arrange the conditions so that the vibration is effected with the greatest freedom. The strength of the resonance effect depends, under otherwise equal conditions, on the quantity of electricity set in motion or on the strength of the current driven through the circuit. But the circuit opposes the passage of the currents by reason of its impedancy and this has, to secure the best action it is necessary to reduce the impedance to a minimum. It is impossible to overcome resistance, but nothing in part, for the ohmic resistance cannot be reduced. But when the frequency of the impulses is very great, the flow of the current is practically determined by self induction. This self-induction can be overcome by combining it with capac-

[illegible] that is the frequency [illegible] have such values as to [illegible] the greatest quantity of [illegible] current, that is [illegible] It is clear that in such

combinations there will be, for a given frequency, and consider only the fundamental vibration, values which will give the best result, with the condenser in shunt to the self-induction coil, of course more such values than with the condenser in series. But practical conditions determine the selection. In the latter case in performing the experiments one may take a small self-induction and a large capacity or a small capacity and a large self-induction, but the latter is preferable, because it is inconvenient to adjust a large capacity by small steps. By taking a coil with a very large self-induction the critical capacity is reduced to a very small value, and the capacity of the coil itself may be sufficient. It is easy, especially by observing certain artifices, to wind a coil through which the impedance will be reduced to the value of the ohmic resistance only; and for any coil there is, of course, a frequency at which the maximum current will be made to pass through the coil. The observation of the relation between self-

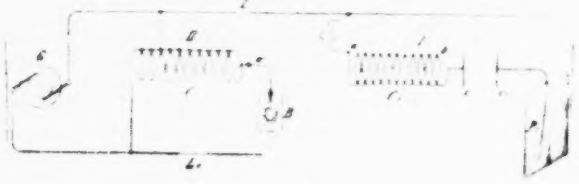

FIG. 184

induction, capacity and frequency is becoming important in the operation of alternate current apparatus, such as transformers or motors, because by a judicious determination of the elements the employment of an expensive condenser becomes unnecessary. Thus it is possible to pass through the coils of an alternating current motor under the normal working conditions the required current with a low e.m.f. and do away entirely with the false current, and the larger the motor, the easier such a plan becomes practicable; but it is necessary for this to employ currents of very high potential or high frequency.

In Fig. 184 L is shown a plan which has been followed in the study of the resonance effects by means of a high frequency alternator. C is a coil of many turns, which is divided into small separate sections for the purpose of adjustment. The final adjustment was made sometimes with a few thin iron wires (though this is not always advisable) or with a closed secondary. The coil

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c_1 is connected with one of its ends to the line L from the alternator G and with the other end to one of the plates c of a condenser $c\,c_1$, the plate (c_1) of the latter being connected to a much larger plate P_1. In this manner both capacity and self-induction were adjusted to suit the dynamo frequency.

As regards the rise of potential through resonant action, of course, theoretically, it may amount to anything since it depends on self-induction and resistance and since these may have any value. But in practice one is limited in the selection of these values and besides these, there are other limiting causes. One may start with, say, 1,000 volts and raise the E. M. F. to 50 times that value, but one cannot start with 100,000 and raise it to ten times that value because of the losses in the media which are great, especially if the frequency is high. It should be possible to start with, for instance, two volts from a high or low frequency circuit of a dynamo and raise the E. M. F. to many hundred times that value. Thus coils of the proper dimensions might be connected each with only one of its ends to the mains from a machine of low E. M. F., and though the circuit of the machine would not be closed in the ordinary acceptance of the term, yet the machine might be burned out if a proper resonance effect would be obtained. I have not been able to produce, nor have I observed with currents from a dynamo machine, such great rises of potential. It is possible, if not probable, that with currents obtained from apparatus containing iron the disturbing influence of the latter is the cause that these theoretical possibilities cannot be realized. But if such is the case I attribute it solely to the hysteresis and Foucault current losses in the core. Generally it was necessary to transform upward, when the E. M. F. was very low, and usually an ordinary form of induction coil was employed, but sometimes the arrangement illustrated in Fig. 184 II., has been found to be convenient. In this case a coil C is made in a great many sections, a few of these being used as a primary. In this manner both primary and secondary are adjustable. One end of the coil is connected to the line L_1 from the alternator, and the other line L is connected to the intermediate point of the coil. Such a coil with adjustable primary and secondary will be found also convenient in experiments with the disruptive discharge. When true resonance is obtained the top of the wave must of course be on the free end of the coil as, for instance, at the terminal of the phosphorescence bulb B. This is

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easily recognized by observing the potential of a point on the wire or near to the coil.

In connection with resonance effects and the problem of transmission of energy over a single conductor which was previously considered, I would say a few words on a subject which constantly fills my thoughts and which concerns the welfare of all. I mean the transmission of intelligible signals or perhaps even power to any distance without the use of wires. I am becoming daily more convinced of the practicability of the scheme; and though I know full well that the great majority of scientific men will not believe that such results can be practically and immediately realized, yet I think that all consider the developments in recent years by a number of workers to have been such as to encourage thought and experiment in this direction. My conviction has grown so strong, that I no longer look upon this plan of energy or intelligence transmission as a mere theoretical possibility, but as a serious problem in electrical engineering, which must be carried out some day. The idea of transmitting intelligence without wires is the natural outcome of the most recent results of electrical investigations. Some enthusiasts have expressed their belief that telephony to any distance by induction through the earth is possible. I cannot stretch my imagination so far, but I do firmly believe that it is practicable to disturb by means of powerful machines the electrostatic condition of the earth and thus transmit intelligible signals and perhaps power. In fact, what is there against the carrying out of such a scheme? We now know that electric vibrations may be transmitted through a single conductor. Why should we not try to avail ourselves of the earth for this purpose? We must not be frightened by the idea of distance. In the cosmic conflicts counting the mile posts the earth may appear as a large body to that happiest of all men, the mathematician who gauges all by the heavens and by their standard judges the magnitude of this globe, it appears very small. And so I think it must seem to the electrician, for when he considers the speed with which electrical impulses are propagated through the earth all the points of distance must completely vanish.

A piece of good apparatus would be first to know what is the capacity of the earth and what charge it can hold. Though we have no positive evidence of a charged body existing in space without matter, physically theoretical bodies may be found of such character that the earth would be [illegible]

by whatever process it was separated from other bodies—and this is the accepted view of its origin—it must have retained a charge, as occurs in all processes of mechanical separation. If it be a charged body insulated in space its capacity should be extremely small, less than one-thousandth of a farad. But the upper strata of the air are conducting, and so, perhaps, is the medium in free space beyond the atmosphere, and these may contain an opposite charge. Then the capacity might be incomparably greater. In any case it is of the greatest importance to get an idea of what quantity of electricity the earth contains. It is difficult to say whether we shall ever acquire this necessary knowledge, but there is hope that we may, and that is, by means of electrical resonance. If ever we can ascertain at what period the earth's charge, when disturbed, oscillates with respect to an oppositely electrified system or known circuit, we shall know a fact possibly of the greatest importance to the welfare of the human race. I propose to seek for the period by means of an electrical oscillator, or a source of alternating electric currents. One of the terminals of the source would be connected to earth as, for instance, to the city water mains, the other to an insulated body of large surface. It is possible that the outer conducting air strata, or free space, contain an opposite charge and that, together with the earth, they form a condenser of very large capacity. In such case the period of vibration may be very low and an alternating dynamo machine might serve for the purpose of the experiment. I would then transform the current to a potential as high as it would be found possible and connect the ends of the high tension secondary to the ground and to the insulated body. By varying the frequency of the currents and carefully observing the potential of the insulated body at a watching for the disturbance at various neighboring points of the earth's surface resonance might be detected. Should, as the majority of scientific men in all probability believe, the period be extremely small, then a dynamo machine would not do and a proper electrical oscillator would have to be produced and perhaps it might not be possible to obtain such rapid vibrations. But whether this be possible or not, and whether the earth contains a charge or not, and whatever may be its period of vibration, it certainly is possible—for of this we have daily evidence—to produce some electrical disturbance sufficiently powerful to be perceptible by suitable instruments at any point of the earth's surface.

Assume that a source of alternating currents be connected, as in Fig. 185, with one of its terminals to earth (conveniently to the water mains) and with the other to a body of large surface P. When the electric oscillation is set up there will be a movement of electricity in and out of P, and alternating currents will pass through the earth, converging to, or diverging from, the point C where the ground connection is made. In this manner neighboring points on the earth's surface within a certain radius will be disturbed. But the disturbance will diminish with the distance, and the distance at which the effect will still be perceptible will depend on the quantity of electricity set in motion. Since the body P is insulated, in order to displace a considerable quantity, the potential of the source must be excessive, since there would be limitations as to the surface of P. The conditions might be adjusted so that the generator or source S will set up the same electrical movement as though its circuit were closed. Thus it is certainly practicable to impress an electric vibration of at least of a certain low period upon the earth by means of proper machinery. At what distance such a vibration might be made perceptible can only be conjectured. I have on another occasion considered the question how the earth might behave to electric disturbances. There is no doubt that, since in such an experiment the electrical density at the surface could be but extremely small considering the size of the earth, the air would not act as a very disturbing factor, and there would be not much energy lost through the action of the air, which would be the case if the density were great. Theoretically, then, it could not require a great amount of energy to produce a disturbance perceptible at great distance, or even all over the surface of the globe. Now, it is quite certain that at any point within a certain radius of the source S a properly adjusted self-induction and capacity device can be set in action by resonance. But not only can this be done, but another source S1, Fig. 185, similar to S, or any number of such sources, can be set

Fig. 185.

rod is in synchronism with the latter, and the vibration thus intensified and spread over a large area, or a flow of electricity produced to or from the source s. If the same be of opposite phase to the source s. I think that beyond doubt it is possible to operate electrical devices in a city through the ground or pipe system by resonance from an electrical oscillator located at a central point. But the practical solution of this problem would be of incomparably smaller benefit to man than the realization of the scheme of transmitting intelligence, or perhaps power, to any distance through the earth or environing medium. If this is at all possible, distance does not mean anything. Proper apparatus must first be produced by means of which the problem can be attacked and I have devoted much thought to this subject. I am firmly convinced that it can be done and hope that we shall live to see it done.

ON THE LIGHT PHENOMENA PRODUCED BY HIGH-FREQUENCY CURRENTS OF HIGH POTENTIAL AND GENERAL REMARKS RELATING TO THE SUBJECT.

Returning now to the light effects which it has been the chief object to investigate, it is thought proper to divide these effects into four classes: 1. Incandescence of a solid. 2. Phosphorescence. 3. Incandescence or phosphorescence of a rarefied gas; and 4. Luminosity produced in a gas at ordinary pressure. The first question is: How are these luminous effects produced? In order to answer this question as satisfactorily as I am able to do in the light of accepted views and with the experience acquired, and to add some interest to this demonstration, I shall dwell here upon a feature which I consider of great importance, inasmuch as it promises, besides, to throw a better light upon the nature of most of the phenomena produced by high-frequency electric currents. I have on other occasions pointed out the great importance of the presence of the rarefied gas, or atomic medium in general, around the conductor through which alternate currents of high frequency are passed, as regards the heating of the conductor by the currents. My experiments, described some time ago, have shown that, the higher the frequency and potential difference of the currents, the more important becomes the rarefied gas in which the conductor is immersed, as a factor of the heating. The potential difference, however, is, as I then pointed out, a more im-

may remain lighted if the plate be interposed, or may even increase in luminosity. The effect depends on the position of the plate and tube relatively to the coil, and may be always easily foretold by *assuming* that conduction takes place from one terminal of the coil to the other. According to the position of the plate, it may either divert from or direct the current to the tube.

In another line of work the writer has in frequent experiments maintained incandescent lamps of 50 or 100 volts burning at any desired candle power with both the terminals of each lamp connected to a stout copper wire of no more than a few feet in length. These experiments seem interesting enough, but they are not more so than the quiet experiment of Faraday, which has been revived and made much of by recent investigators, and in which a discharge is made to jump between two points of a bent copper wire. An experiment may be cited here which may seem equally interesting. If a Geissler tube, the terminals of which are joined by a copper wire, be approached to the coil, certainly no one would be prepared to see the tube light up. Curiously enough, it does light up, and, what is more, the wire does not seem to make much difference. Now one is apt to think in the first moment that the impedance of the wire might have something to do with the phenomenon. But this is of course immediately rejected, as for this an enormous frequency would be required. This result, however, seems puzzling only at first; for upon reflection it is quite clear that the wire can make but little difference. It may be explained in more than one way, but it agrees perhaps best with observation to assume that conduction takes place from the terminals of the coil through the space. On this assumption, if the tube with the wire be held in any position, the wire can divert little more than the current which passes through the space occupied by the wire and the metallic terminals of the tube; through the adjacent space the current passes practically undisturbed. For this reason, if the tube be held in any position at right angles to the line joining the binding posts of the coil, the wire makes hardly any difference, but in a position more or less parallel with that line it impairs to a certain extent the brilliancy of the tube and its facility to light up. Numerous other phenomena may be explained on the same assumption. For instance, if the ends of the tube be provided with washers of sufficient size and held in the line joining the terminals of the coil, it will not light up, and then nearly the whole of the current, which would otherwise

practice by combining an electric generator with his oscillator. He pointed out what conditions must be observed in order that the period of vibration of the electrical system might not disturb the mechanical oscillation in such a way as to alter the periodicity, but merely to shorten the stroke. He combines a condenser with a self induction, and gives to the electrical system the same period as that at which the machine itself oscillates, so that both together then fall in step and electrical and mechanical resonance is obtained, and maintained absolutely unvaried.

Next he showed a model of a motor with delicate wheelwork, which was driven by these currents at a constant speed, no matter what the air pressure applied was, so that this motor could be employed as a clock. He also showed a clock so constructed that it could be attached to one of the oscillators, and would keep absolutely correct time. Another curious and interesting feature which Mr. Tesla pointed out was that, instead of controlling the motion of the reciprocating piston by means of a spring, so as to obtain isochronous vibration, he was actually able to control the mechanical motion by the natural vibration of the electro-magnetic system, and he said that the case was a very simple one, and was quite analogous to that of a pendulum. Thus, supposing we had a pendulum of great weight, preferably, which would be maintained in vibration by force, periodically applied; now that force, no matter how it might vary, although it would oscillate the pendulum, would have no control over its period.

Mr. Tesla also described a very interesting phenomenon which he illustrated by an experiment. By means of this new apparatus, he is able to produce an alternating current in which the E. M. F. of the impulses in one direction preponderates over that of those in the other, so that there is produced the effect of a direct current. In fact he expressed the hope that these currents would be capable of application in many instances, serving as direct currents. The principle involved in this preponderating E. M. F. he explains in this way: Suppose a conductor is moved into the magnetic field and then suddenly withdrawn. If the current is not retarded, then the work performed will be a mere fractional one; but if the current is retarded, then the magnetic field acts as a spring. Imagine that the motion of the conductor is arrested by the current generated, and that at the instant when it stops to move into the field, there is still the

maximum current flowing in the conductor; then this current will, according to Lenz's law, drive the conductor out of the field again, and if the conductor has no resistance, then it would leave the field with the velocity it entered it. Now it is clear that if, instead of simply depending on the current to drive the conductor out of the field, the mechanically applied force is so timed that it helps the conductor to get out of the field, then it might leave the field with higher velocity than it entered it, and thus one impulse is made to preponderate in e. m. f. over the other.

With a current of this nature, Mr. Tesla energized magnets strongly, and performed many interesting experiments bearing out the fact that one of the current impulses preponderates. Among them was one in which he attached to his oscillator a ring magnet with a small air gap between the poles. This magnet was oscillated up and down 80 times a second. A copper disc, when inserted within the air gap of the ring magnet, was brought into rapid rotation. Mr. Tesla remarked that this experiment also seemed to demonstrate that the lines of flow of current through a metallic mass are disturbed by the presence of a magnet in a manner quite independently of the so-called Hall effect. He showed also a very interesting method of making a connection with the oscillating magnet. This was accomplished by attaching to the magnet small insulated steel rods, and connecting to these rods the ends of the energizing coil. As the magnet was vibrated, stationary nodes were produced in the steel rods, and at these points the terminals of a direct current source were attached. Mr. Tesla also pointed out that one of the uses of currents, such as those produced in his apparatus, would be to select any given one of a number of devices connected to the same circuit by picking out the vibration by resonance. There is indeed little doubt that with Mr. Tesla's devices, harmonic and synchronous telegraphy will receive a fresh impetus, and vast possibilities are again opened up.

Mr. Tesla was very much elated over his latest achievements, and said that he hoped that in the hands of practical, as well as scientific men, the devices described by him would yield important results. He laid special stress on the facility now afforded for investigating the effect of mechanical vibration in all directions, and also showed that he had observed a number of facts in connection with iron cores.

3436-3437

THE WORK OF HERTZ

...the Physical Society of London saw their way to translate and publish a collection of, at any rate, some of these Papers.*

Portrait Study.

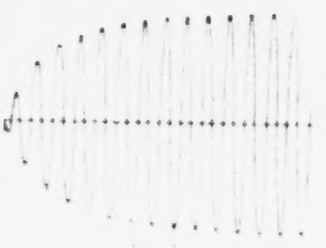
The portrait (Fig. 1) which I show is not a specially pleasing one. It is from a photograph taken by Mr. Yule, one of the band of foreign students who flocked to Hertz's laboratory at Bonn. It is excellent as a photograph, though it fails to represent Hertz at his best, perhaps because it was not taken till after the phrasing of trouble had set in, which ultimately carried him off.

In closing these introductory and personal remarks, I should like to say that the enthusiastic admiration for Hertz's spirit and character, felt and expressed by students and writers who came into contact with him, is not easily to be exaggerated. Never was a man more faithfully attended or watched during the possibilities of illness; and he was accustomed to deprecate the prominence given to him by speakers and writers in this country, lest it might seem to exhalt him unduly above Helmholtz and other workers among his own sensitive countrymen.

Fig. 1.

Speaking of the other great workers in physics in Germany, not out of place to record the sorrow with which we have learnt the recent death of Dr. August Kundt, Professor in the University of Berlin, successor of von Helmholtz in that capacity.

When I consented to discourse on the work of Hertz my intention was to repeat some of his actual experiments and endeavour to demonstrate his less known discoveries and observations. But the frustration exerted upon me by electric oscillations experiments when I, too, was independently working at them in the spring of 1888,† resumed its hold, and my lecture will accordingly be a mere experimental demonstration of the outcome of Hertz's work rather than any precise repetition and performance of his results.



If the loss per swing [illegible] very small [illegible] gradually damped, so that when left to itself it [illegible] to respond [illegible] to [illegible] of about any [illegible] This is the case with [illegible] and the tones of my voice. [illegible] must be extremely slight, for [illegible] they cease to excite the ear.

If, on the other hand, the receiving body has a persistence of vibration [illegible] tumbling after it is left to itself, like an ill-hung [illegible] bell, for instance, then [illegible] facility of response [illegible] great accuracy of tuning [illegible] it is to be fully called [illegible] that the [illegible] is not [illegible] rately synchronised with [illegible] it fails to [illegible] it [illegible] to resound.

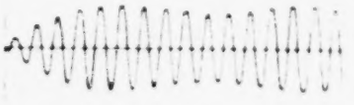


Fig. 2.

Conversely, if the [illegible] a persistent vibration [illegible] essential [illegible] it will destroy it when [illegible] it [illegible] regulated the previous [illegible] Whereas if [illegible] strongly damped [illegible] whatever will respond [illegible] equally ill to it.

What I have said [illegible] sounding bodies [illegible] media competent to transmit waves. Now a sensitive [illegible] a microphone, which speaks to [illegible] waves into [illegible] the radiant energy is likewise able to set up [illegible] tentacles. But we have no delicate means [illegible] these electrical or ethereal waves, and if they are to produce perceptible effect at a distance, they must be [illegible] spreading tube, prevented from spreading, and concentrated on [illegible] distant receiver.

* [illegible] Vol. XXXI. pp. 286, 287. Also [illegible]

† [illegible] Vol. [illegible] p. 27.

This is the function of the telegraph wire; it is to the ether what a speaking tube is to air. A metal wire in air (*in function*, nearly rigid but slightly elastic walls.

Sphere Charge from Electrophorous.

Furthermore, any conductor electrically charged or discharged with sufficient suddenness must emit electrical waves into the ether, because the charge given to it will not settle down instantly, but will surge to and fro several times first, and these surgings or electric oscillations must, according to Maxwell, start waves in the ether, because at the end of each half swing they cause electrostatic, and at the middle of each half swing they cause electromagnetic effects, and the rapid alternation from one of these modes of energy to the other constitutes etherial waves.* If a wire is handy they will run along it, and may be felt a long way off. If no wire exists they will spread out like sound from a bell, or light from a spark, and their intensity will decrease according to the inverse square of the distance.

Maxwell and his followers well know that there would be such waves; they knew the rate at which they would go, they knew that they would go slower in glass and water than in air, they knew that they would curl round sharp edges, that they would be partly absorbed but mainly reflected by conductors, that if turned back upon themselves they would produce the phenomena of stationary waves, or interference, or nodes and loops; it was known how to calculate the length of such waves, and even how to produce them of any required or predetermined wave-length from 1,000 miles to a foot. Other things were known about them which would take too long to enumerate: any homogeneous insulator would transmit them, would refract or concentrate them if it were of suitable shape, would reflect none of a particular mode of vibration at a certain angle, and so on, and so on.

All this was known, I say, known with varying degrees of confidence, but by some known with as great confidence as, perhaps even more confidence than, is legitimate before the actuality of experimental verification.

Hertz supplied the verification. He inserted suitable conductors in the path of such waves, conductors adapted for the occurrence in them of induced electric oscillations, and to the surprise of everyone, himself doubtless included, he found that the secondary electric surgings thus excited were strong enough to display themselves by minute electric sparks.

Syntonic Leyden Jars.

I shall show this in a form which requires great precision of tuning or syntony, both emitter and receiver being persistently vibrating things giving some 30 or 40 swings before damping has a serious effect. I take two Leyden jars with circuits about a yard in diameter, and situated about two yards apart (Fig. 5). I charge and discharge one jar, and observe that the surgings set up in the other can cause it to overflow if it is syntonised with the first.†

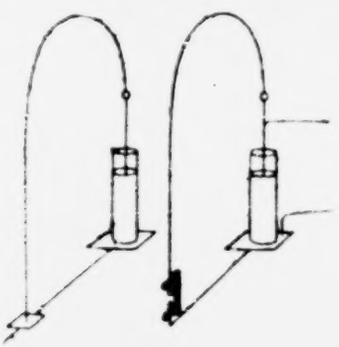


FIG. 5.

A closed circuit such as this is a feeble radiator and a feeble absorber, so it is not adapted for action at a distance. In fact, I doubt whether it will visibly act at a range beyond the $\frac{1}{4}\lambda$ at which true radiation of broken off energy occurs. If the coatings of the jar are separated to a greater distance, so that the dielectric is more exposed, it radiates better; because in true radiation the electrostatic and the magnetic energies are equal, whereas in a ring circuit the magnetic energy greatly predominates. By separating the coats of the jar as far as possible we get a typical Hertz oscil-

FIG. 6.

lator (Fig. 6), whose dielectric extends out into the room, and this radiates very powerfully.

Ordinary Size Hertz Vibrator.

In consequence of its radiation of energy, its vibrations are rapidly damped, and it only gives some three or four good strong swings. Hence it follows that it has a wide range of excitation, i.e., it can excite sparks in conductors barely at all in tune with it.

The two conditions, conspicuous energy of radiation and persistent vibration electrically produced, are at present incompatible. Whenever these two conditions coexist, considerable power or activity will, of course, be necessary in the source of energy. At present they only coexist in the sun and other stars in the electric arc and in furnaces.

Two Circular Vibrators sparking in sympathy.

The receiver Hertz used was chiefly a circular resonator, not a good absorber but a persistent vibrator, well adapted for picking up disturbances of precise and measurable wave-length. I find that the circular resonators can act as senders too; here is one exciting quite long sparks in a second one.

Electric Syntony.—That was his discovery, but he did not stop there. He at once proceeded to apply his discovery to the verification of what had already been predicted about the waves, and by laborious and difficult interference experiments he ascertained that the previously calculated length of the waves was thoroughly borne out by fact. These interference experiments in free space are his greatest achievement.

He worked out every detail of the theory splendidly, separately analysing the electric and the magnetic oscillation, using language not always such as we should use now, but himself growing in theoretic insight through the medium of what would have been to most physicists a confusing maze of troublesome facts, and disentangling all their main relations most harmoniously.

Holtz Machine, A and B Sparks; Glass and Quartz Plates on Screen.

While Hertz was observing sparks such as these, the primary or exciting spark and the secondary or excited one, he observed as a bye issue that the secondary spark occurred more easily if the light from the primary fell upon its knobs. He examined this new influence of light in many ways, and showed that although spark light and electric brush light were peculiarly effective any source of light that gave very ultra violet rays produced the same result.†

Wiedemann and Ebert, and a number of experimenters, have repeated and extended this discovery, proving that it is the cathode knob on which illumination takes effect; and Hallwachs made the important observation, which Righi, Stoletow, Branly, and others have extended, that a freshly polished zinc or other oxidisable surface, if charged negatively, is gradually discharged by ultra violet light.

It is easy to fail in reproducing this experimental result if the right conditions are not satisfied, but if they are, it is absurdly easy, and the thing might have been observed nearly a century ago.

(To be continued.)

MEETINGS OF SCIENTIFIC SOCIETIES, &c.

TO-DAY (FRIDAY), June 8th.

PHYSICAL SOCIETY.

5 p.m. (1) Discussion of the Paper by W. Baly and Prof. Ramsay "On the Relations of Pressure, Volume, and Temperature of Rarefied Gases." (2) An Exhibition of Photographs of Flames by Capt. Abney.

ROYAL INSTITUTION.

9 p.m. Friday Evening Discourse: "The Newtonian Constant of Gravitation," by C. Vernon Boys, F.R.S.

WEDNESDAY, June 13th.

ROYAL SOCIETY.

Ladies' Conversazione.

*** Particulars of meetings to be held or Papers to be read before Scientific Societies during the ensuing week should reach us not later than Thursday, 9 a.m.

* Strictly speaking, in the waves themselves there is no lag or difference of phase between the electric and the magnetic vibrations; the difference exists in emitter or absorber, or both, the transmitting medium. True radiation of energy does not begin till about a quarter wave-length from the source, and within that distance the initial quarter period differs of phase a obliterated.

† See *Nature*, Vol. XLI, p. 368; or *J. J. Thomson. Recent Researches*," p. 396.

‡ The experiments there in the lecture was on the lines of those [illegible] pp. 314 and 340, the con[illegible] described in "*Proc. Roy. Soc.*

absolute values for u and for $-u$, which are equal. It is equal to zero for $u=0$, increases with the increase of u, and for $u=\pm\infty$ tends asymptotically towards the value $\frac{1}{2\pi\overline{L}}$ as its limit. If, then (Fig. 16), we take as abscissæ the values of u, and as ordinates the absolute values of y, and if we take as origin the point O, and as the positive direction of the axis of u the line O X', we find the line F O F_2 which has for asymptote the straight line, L L, parallel to the axis of the abscissæ. In order to find $y_1 - y_2$ we take O $O_1 = n$ and $O_1 p_1 = O_1 p_2 = u$; there results O $p_1 = n - m$, O $p_2 = n + m$, whence the ordinates p_1 P_1 and p_2 P_2 represent y_1 and y_2, and we have at once $y_1 - y_2 = p_1 P_1 - p_2 P_2 = -(p_2 P_2 - p_1 P_1)$.

The mode of variation of this difference appears clear if we draw p_1 P_1 M the line symmetric with respect to O_1 Y_1 to Q P_2 F_2. Now we have $y_1 - y_2 = -P_1 P_2$. We can, if we wish, take this length as ordinate, and thus find, that taking as origin the point O_1 as axis of the ordinates the line O_1 Y_1 and as the positive direction of the axis of abscissæ O_1 X, $y_1 - y_2$ is represented as a function of m by the curve O_1 P M N.

The sign (−) of the value derived from the condition $p_2 P_2 > p_1 P_1$ tells that the flux under consideration rotates towards the left, or in the direction opposed to the movement of the armature. Now this flux, which turns towards the left, produces in the metal of the fixed part of the machine, induced currents on which it then exercises forces tending to draw it from its proper rotation, towards the left. Thence, *vice versâ*, the induced currents in the fixed part of the machine solicit the armature to turn towards the right, in the direction in which it already moves. Whence results that the rotating flux due to the currents in the armature provokes induced currents, which help the rotation, and give place to a couple, which joins to the principal couple of which we spoke in the preceding article. The value of the couple due to the induced currents varies with the variation of m, and increases with the increase of the ordinate p_1 P of the line O_1 M N. It is *zero* for $m=0$ and greatest for $m=n$. Owing to it, the total couple acting on the armature instead of being reduced to zero for $m=O_1$ A (Fig. 15), is not reduced to zero for any value a little larger, a little nearer to n.

Alternating Flux.—The alternating vector resulting from the composition of two vectors rotating in opposite senses, has an amplitude equal to double the smallest of the two component vectors (Art. 4). However, the alternating flux is proportional to

$$\frac{n-m}{\sqrt{r^2+4\pi^2 L^2 (n-m)^2}}$$

It can be zero only for $m=n$.

THE WORK OF HERTZ.*

(*Continued from page 158.*)

Zinc Discharging Negative.—Electricity in Light; Gold Leaf Electroscope; Glass and Quartz Tubes; Quartz Prism.

Take a piece of zinc, clean it with emery paper, connect it to a gold leaf electroscope and expose it to an arc lamp. If charged positively nothing appears to happen, the action is very slow; but a negative charge leaks away in a few seconds if the light is bright. Any source of light rich in ultra violet rays will do; the light from a spark is perhaps most powerful of all. A pane of glass cuts off all the action, so does atmospheric air in sufficient thickness (at any rate town air); hence sunlight is not powerful. A pane of quartz transmits the action almost undiminished, but fluor-spar may be more transparent still. Condensing the arc rays with a quartz lens and analysing them with a quartz prism or reflection grating, we find that the most effective part of the light is high up in the ultra violet, surprisingly far beyond the limits of the visible spectrum. (Figs. 7 and 8).

This is rather a digression, but I have taken some pains to show it properly because of the interest betrayed by Lord Kelvin on this matter, and the caution which he felt about accepting the results of the Continental experimenters too hastily.

It is probably a chemical phenomenon, and I am disposed to express it as a modification of the volta contact effect* with illumination.

Return now to the Hertz vibrator, or Leyden jar with its coatings well separated, so that we can get into its electric as well as its

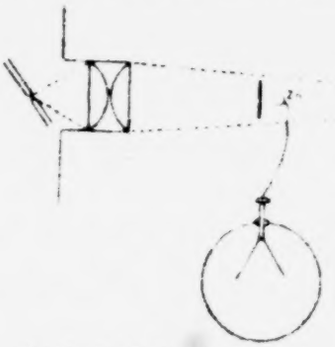


FIG. 7.—Zinc Rod with Glass Screen.

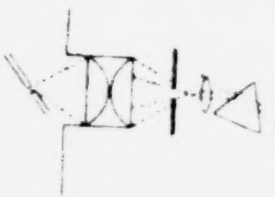


FIG. 8.—Zinc Rod with Ultra violet Light.

magnetic field. Here is a great one giving waves 30 metres long, radiating while it lasts with an activity of 100 *h.p.*, and making ten million complete electric vibrations per second.

Large Hertz Vibrator in action; Abel's Fuse; Vacuum Tubes; Strike no Arc.

Its great radiating power damps it down very rapidly, so that it does not make above two or three swings; but nevertheless, each time it is excited, sparks can be drawn from most of the reasonably elongated conductors in this theatre.

A suitably situated gas leak can be ignited by these induced sparks. An Abel's fuse connecting the water pipes with the gas pipes will blow off; vacuum tubes connected to nothing will glow (this fact has

* A lecture delivered at the Royal Institution on Friday, June 1st, by Prof. Oliver Lodge, F.R.S., ably assisted during both preparation and performance by W. Edward E. Robinson.

* While preparing for the lecture it occurred to me to try if possible, during the course of some new experiments on the effect of light on electricity, the action of rock and ore, because if the effect is not limited to metals it is important in connection with atmospheric electricity. I found that a large mass of iron pyrites in contact with a moist zinc plate was able to work in and out of the varnish during illumination. (*Comptes Rendus*, Vol. CX., p. 808, 1890). Now, the mountain rock of Cornwall, charged with charged earth are exposed to very ultra violet rays at the surface, in which quiet up carrying and sudden downpour of electricity would go on in a manner not very unlike the well known behaviour of water spouts; and this perhaps may be the reason, or one of the reasons why it is not unusual to experience a thunderstorm after a day like this. I have now tried these experiments on such geological specimens as were ready, and find that many of them discharge negative electricity under the action of a naked arc, especially from the side of the specimens which was somewhat dusty, but that when wet they discharge much less rapidly, and when positively charged hardly at all. Iron and garnet and discharge negative electrification, too, under ultra violet illumination, but not so quickly as limestone, much whiter, ferruginous clay, and some other specimens. Granite rarely acts, it seems to be too well. The ice and soil were tried on their usual moist condition, but when thoroughly dry soil discharges quite rapidly. A zinc rod tested was found to discharge as quickly as does a surface of perfectly bright metal, such as iron, but many discharged much more quickly than ordinary dull iron and rather more quickly than when the bright zinc surface is thinly oiled or wetted with water. To-day (June 5) I find that the rock of the geranium discharge positive electrification five times as quickly as negative, under the action of an arc light, and that glass cuts the effect while quartz transmits it.

* See Brit. Assoc. Report 1884, pp. 502-519, or *Phil. Mag.* (August), pp. 267-282.

was familiar to all who have worked with Hertz waves since 1889): electric leads, if anywhere near each other, as they are in some incandescent lamp-holders, may spark across to each other, thus making an arc and blowing their fuses.

The blowing of fuses by electric radiation frequently happened at Liverpool till the suspensions of the theatre lamps were altered.

The striking of an arc by the little reverberating sparks between platinum points connected with the 100 volt mains I incidentally saw at Karlsruhe.

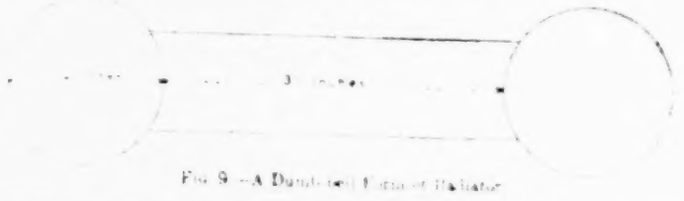


Fig. 9.—A Dumb-bell Form of Radiator.

Fig. 11.

There are some who think that lightning flashes can do none of these things. They are mistaken.

Various specimens of various emitters and receivers have been used by different people (see Table). The radiator of dumb bell type (Fig. 9), the orthodox (Fig. 10), a circular ring (Fig. 11) for interference when it is but little damped, and a straight wire resonator, because it is a much better absorber, by Bjerknes, Voller, Barton, and others, is well known and kept from space dissipation by guiding wires.

Mr Boys has experimented on the mechanical force exerted by electrical surgings, and Hertz also made observations on this kind.

Going back to older methods of detecting electrical radiation we have, most important of all, a discovery made long before it existed, by a creature that developed a sensitive cavity on its [illegible]

Detectors of Radiation.

Chemical	Thermal	Electrical	Mechanical	Visual
Photographic Plate	Thermopile	Spark (Hertz)	Electrometer (Lodge and Rutherford)	Luminous Gas (Hertz)
Explosive Gases	Radiometer (Crookes and Ritter)	Telephone—Air gap and Arc (Dolbear)	Sensitive Wires (Hughes)	Lamp (Lodge)
Dilute Electric Cell	Expanding Wire (Boys)	Vacuum Tube (Crookes)		
	Thermal Junction (Klemencic)	Galvanometer (Fitzgerald)		
		Air gap and Electroscope (Righi and Lodge)		
		Trigger Tube (Watson and Schuster)		

* The cross against the frog's leg indicates that it does not appear really to respond to radiation unless [illegible] The name against the other thumps are unimportant, but suggest the persons who applied the detector to electric radiation. The [illegible] name against the telephone indicates that its position in the microphonic column may be doubtful.

Basic forms are the spheres and ellipsoids (or elliptical plates), which I have mainly used, because they are powerful radiators and absorbers and because their theory has been worked out by Prof. Lamb and J. J. Thomson. Also dumb bells without air gap, and many other shapes, the most recent of mine being the case of a hollow cylinder with sparks at ends of a diameter [illegible] Fig. 12, being a feeble radiator, but a very persistent vibrator,* and, therefore, well adapted for interference and diffraction experiments. But, indeed, spheres can be made to vibrate longer than one by putting them into copper hats or enclosures, in which an aperture of varying size can be made to let the waves out.

Many of these senders will do for receivers too, giving off sparks to other insulated bodies or to earth; but, besides the Hertz type

Fig. 10.—Standard Hertz radiator.

receiver, many other detectors of radiation have been employed. Vacuum tubes can be used, either directly or on the trigger principle as by Zehnder (Fig. 13),† the resonator spark precipitating a discharge from some auxiliary battery or source of energy, and so rendering a feeble disturbance very visible. Explosives may be used for the same purpose, either in the form of mixed water gases or in the form of an Abel's fuse. Fitzgerald found that a tremendously

* Thomson, "Recent Researches," 344. † Wied. Ann. XLVII. 47; 77.

a creature which never so much as had a name to be remembered by (though, perhaps, we may call it Adinidan). Here, in recent times, we recall the photographic plate and the thermopile with its modification, the radiomicrometer [illegible] and the thermopile with its modification, the radiomicrometer [illegible] or otherwise known Siemens pyrometer applied to astronomy by Langley, applied to the detection of electric waves in wires by

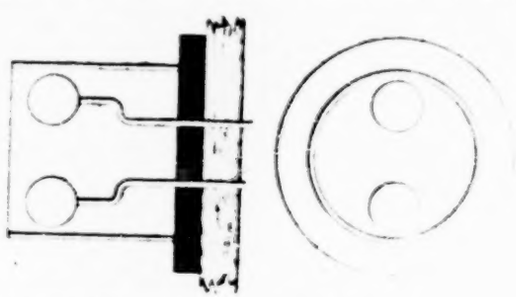


Fig. 12.—Dr. Lodge's Hollow Cylindrical Resonator [illegible] against the Incandescent Lamp Holder Fuse. [illegible]

Rubens and Ritter and Paalzow and Arons [illegible] was applied to the same purpose by Bjerknes, Dr. Barton, and others.

And, before all these, the late Mr Gregory, [illegible] made his singularly sensitive experiments, whereby waves in free space could be detected by the [illegible] and temperature they

* Fitzgerald, Nature, Vol. XLV. [illegible] and Vol. XLVII. p. 172.
† Wied. Ann. XLVII. 77 [illegible]

caused in a platinum wire, a kind of early and sensitive form of Harlew voltmeter.

Going back to the physiological method of detecting surgings, Hertz tried the frog's-leg nerve and muscle preparation, which to the steadier types of electrical stimulus is so surprisingly sensitive, and to which we owe the discovery of current electricity. But he failed to get any result. Ritter has succeeded; but, in my experience, failing in the normal and proper result. Working with my colleague Prof. Gotch, at Liverpool, I too have tried the nerve and muscle preparation of the frog (Fig. 15), and we find that an extremely violent stimulus of a rapidly alternating character, if pure and unaccompanied by secondary actions, produces no effect—no stimulating effect, that is, even though the voltage is so high that sparks are ready to jump between the needles in direct contact with the nerve.

All that such oscillations do, if continued, is to produce a temporary paralysis or fatigue of the nerve, so that it is unable to transmit the nerve impulses evoked by other stimuli, from which paralysis it recovers readily enough in course of time.

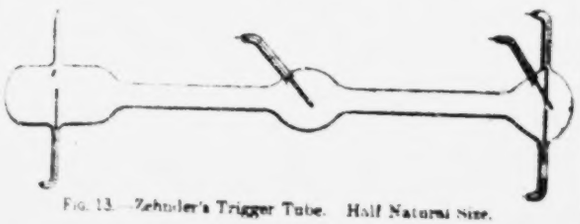


Fig. 13.—Zehnder's Trigger Tube. Half Natural Size.

This has been expected from experiments on human beings, such experiments as Tesla's and those of d'Arsonval. But an entire animal is not at all a satisfactory instrument wherewith to attack the question: its nerves are so embedded in conducting tissues that it may easily be doubted whether the alternating type of stimulus ever reaches them at all. By dissecting out a nerve and muscle from a deceased frog after the historic manner of physiologists, and applying the stimulus direct to the nerve, at the same time as some other well known $\frac{1}{100}$th of a volt stimulus is applied to another part of the same nerve further from the muscle, it can be shown that rapid electric alternations, if entirely unaccompanied by static charge or by resultant algebraic electric transmission, evoke no excitatory response until they are so violent as to give rise to secondary effects such as heat or mechanical shock. Yet, notwithstanding this inaction, they gradually and slowly exert a paralysing or obstructive action on the portion of the nerve to which they are applied, so that the nerve impulse excited by the feeble just perceptible $\frac{1}{100}$th-volt stimulus above is gradually throttled as its way down to the muscle, and remains so throttled for a time varying from a few minutes to an hour after the cessation of the violence.

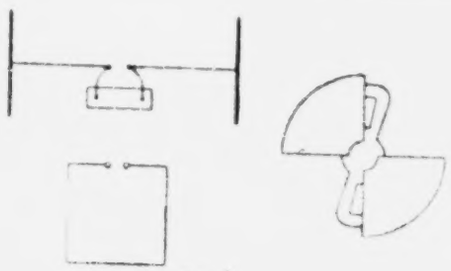


Fig. 14.

I had intended to exhibit this effect, which is very marked and definite, but it is impossible to show everything in the time at my disposal.

Air Gap and Electroscope charged by Blast Rod and discharged by moderately distant Sphere excited by Coil.

Among trigger methods of detecting electric radiation, I have spoken of the Zehnder vacuum tubes; another method is one used by Boltzmann.* A pile of several hundred volts is on the verge of charging an electroscope through an air gap just too wide to break down. Very slight electric surgings precipitate the discharge across the gap, and the leaves diverge. I show this in a modified and simple form. On the cap of an electroscope is placed a highly polished knob or rounded end connected to the sole, and just not touching the cap (Fig. 16). Such an electroscope overflows suddenly and completely with any gentle rise of potential. Bring excited glass near it, the leaves diverge gradually and then suddenly collapse, because the air space maps; remove the glass, and they redivverge with negative electricity; the knob above the cap being then charged positively, and to the verge of sparking. In this condition any electrical waves, collected if weak by a foot or so of wire projecting from the cap, will discharge the electroscope by exciting surgings in the wire, and so breaking down the air gap. The chief interest about this experiment seems to me the extremely definite dielectric strength of so infinitesimal an air space. Moreover, it is a detector for Hertz waves that might have been used last century; it might have been used by Benjamin Franklin.

For to excite them no coil or anything complicated is necessary; it is sufficient to flick a metal sphere or cylinder with a silk handkerchief and then discharge it with a well-polished knob. If it is not well polished the discharge is comparatively gradual, and the vibrations are weak; the more polished are the sides of an air gap the more sudden is the collapse and the more vigorous the consequent radiation, especially the radiation of high frequency, the higher harmonics of the disturbance.

For delicate experiments it is sometimes well to repolish the knobs every hour or so. For metrical experiments it is often

Fig. 15.—Experiment of Gotch and Lodge on the physiological effect of rapid pure electric alternations. Nerve and muscle preparation, with fine needles or size non polarisable electrodes applied to the nerve. C and D are the terminals of a rapidly alternating electric current from a conductor at zero potential, while A and B are the terminals of an ordinary very weak galvanic or induction coil stimulus only just sufficient to make the muscle twitch.

better to let the knobs get into a less efficient but more permanent state. This is true of all senders or radiators. For the generation of the, so to speak, "infra red" Hertz waves any knobs will do, but to generate the "ultra violet" high polish is essential.

Microphonic Detectors.

Receivers or detectors, which for the present I temporarily call microphonic, are liable to respond best to the more rapid vibrations. Their sensitiveness is to me surprising, though of course it does not approach the sensitiveness of the eye, at the same time, I am by no means sure that the eye differs from them in kind. It is these detectors that I wish specially to bring to your notice.

Prof. Minchin, whose long and patient work in connection with photo-electricity is now becoming known, and who has devised an instrument more sensitive to radiation than even Boys radiomicrometer, in that it responds to the radiation of a star while the radiomicrometer does not, found some years ago that some of his slight excitable cells lost their sensitiveness capriciously on tapping, and later he found that they frequently regained it again while Mr. Gregory's Hertz-wave experiments were going on in the same room.

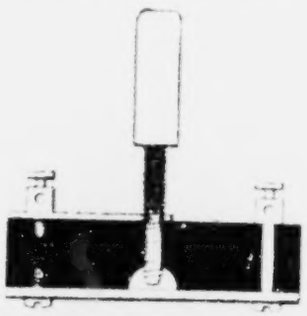


Fig. 16.—Air gap for Electroscope. Natural Size.

These "impulsion cells," as he terms them, are troublesome things for ordinary persons to make and work with, at least I have never presumed to try—but in Mr. Minchin's hands they are surprisingly sensitive to electric waves.*

The sensitiveness of selenium to light is known to everyone, and Mr. Shelford Bidwell has made experiments on the variations of conductivity exhibited by a mixture of sulphur and carbon.

Nearly four years ago M. Edouard Branly found that a burnished coat of porphyrised copper spread on glass diminished its resistance enormously, from some millions to some hundreds of ohms when it was exposed to the neighbourhood, even the distant neighbourhood, of Leyden jars or coil sparks. He likewise found that a tube of metallic filings behaved similarly, but that this recovered its original resistance on shaking. Mr. Croft exhibited this fact

* Phil. Mag., Vol. XXXI., p. 225.

* Phil. Trans., XL., p. 369.

...at the Physical Society. Brandy also makes pastes and ... things in Canada balsam and in sulphur and found ... coherers sensitive.

... the matter arose somewhat differently, as an outcome ... gap detector employed with an electroscope by Boltzmann ... had observed in 1887 that two knobs sufficiently close together, ... close to stand any voltage such as an electroscope can show, ... when a spark passed between them, actually cohere; com... an ordinary bell ringing current if a single voltaic cell was ... circuit, and if there were no such cell, exhibiting an electro... force of their own sufficient to disturb a low resistance gal... meter vigorously, and sometimes requiring a faintly perceptible ... of force to detach them. The experiment was described to ... Institution of Electrical Engineers,* and Prof. Hughes said he ... observed the same thing.

Action of Sparks, respecting to Feeble Stimuli; Small Sphere Coherer; Distant Sphere Electrophorus.

... the arrangement, which I call a coherer, is the most asto... sensitive detector of Hertz waves. It differs from the ... gap in that the insulating film is not really insulating, the

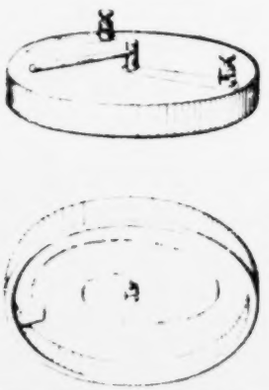


Fig. 17. Wood's coherer, consisting of a pair of thin steel wire in micro... ...ed with graphite and on aluminium plate. When the cohe... ...ed as shown in the illustration the tips ... ...ch other, rests lightly against the aluminium plate.

... broken down not only much more easily, but also in a less dis... and more permanent manner than an air gap. A tube ... ...ing a series of bad contacts, clearly works on the same ... though a tube of filings is by no means so sensitive yet ... many respects easier to work with, and, except for very ... stimuli, is more metrical. If the filings used are coarse, say ... ...ter borings, the tube approximates to a single coherer; if ... fine it has a larger range of sensibility. In every case ... these receivers feel are sudden jerks of current; smooth

Fig. 18. Iron Borings Coherer, one third natural size.

... vibrations are ineffective. They seem to me to respond best ... ...s a few inches long, but doubtless that is determined chiefly ... the dimensions of some conductor with which they happen to be ... (Fig. 19, described in connection therewith).

Experiments on Sparks, by Electrophorus, by Sparks ... Electrical Machine.

... I prefer to explain the action as follows. Suppose two fairly ... ...ces of metal in light contact, say two pieces of iron, con... ...ected in a single voltaic cell; a film of what may be called oxide ... ...ust between the surfaces, so that only an insignificant cur... is allowed to pass, because a volt or two is insufficient to ... through the insulating film except perhaps at one or two atoms ... the film is not permitted to conduct at all, it is not very sensi... The most sensitive condition is attained when an infinitesimal ... passes, strong enough just to show on a moderate gal... meter.

... not the slightest surging occur, say by reason of a sphere ... charged and discharged at a distance of forty yards, the film

... Engineer, London, Vol. LXXI, p. 735, and Vol. LXXII, p. ... ...ournal of Electrical Engineers, 1890, Vol. XIX, pp. 352-4. ... Lightning Conductors and Lightning Guards." Whittaker, pp. 332-3.

... at once breaks down perhaps not completely, but to a great extent of intensity, but just enough. As I have said, some molecular... within each other's range, incipient cohering occurs, and the momentary electric current acts as it were as a flux. I have a regular variety of electric welding. A stronger stimulus enables more molecules to hold on, the process is surprisingly metrical, and so far as I roughly know at present, the change of resistance is pro... portional to the energy of the electric radiation from a source of given frequency.

It is to be specially noted that the battery current is not needed to effect the cohesion, only to demonstrate it. The battery can be applied after the spark has occurred, and the resistance will be found changed as much as if the battery had been on all the time.

The incipient cohesion electrically caused can be mechanically destroyed. Sound vibrations, or any other feeble mechanical disturbances, such as scratches or taps, are well adapted to restore contact to its original high-resistance sensitive condition. The more feeble the electrical disturbance the slighter is the corresponding mechanical stimulus needed for restoration. When working with a radiating sphere (Fig. 19) at a distance of forty yards or a few, I could not, for this reason, shout to my assistant, to cause him to press the key of the coil and make a spark, but I showed him a duster instead, this being a silent signal which had no disturbing effect on the coherer or tube of filings. I mention 40 yards because that was one of the first outdoor experiments, but I should think that something more like half an mile was nearer the limit of sensitiveness. However, this is a rash statement not at present verified. At 40 yards the exciting spark could be distinctly heard, and it was interesting to watch the spot of light begin its long excursion and actually travel a distance of 2in. or 3in. before the sound arrived

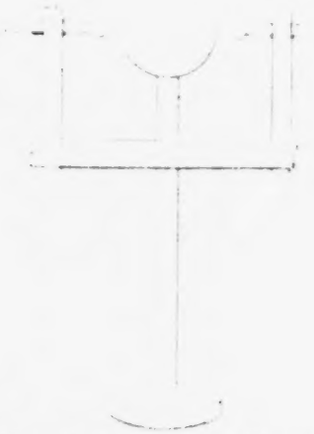


Fig. 19. Electrical signalling in the theatre of the Royal Institution during the Coherer Lecture. The sphere is on the lecture table in the theatre.

This experiment proved definitely enough that the effect was travelled quicker than sound, and disposed completely of all sceptical doubts as to the sound waves being, perhaps, the real cause of the phenomenon.

Invariably, when the receiver is in good condition, sound or other mechanical disturbance acts one way, viz., in the direction of increasing resistance, while electrical radiation invariably acts the other way, decreasing it. While getting the receiver into condition, or when it is getting out of order, vibration and sometimes electric discharges act irregularly, and an occasional good shaking clears the filings good. I have taken rough measurements of the resistance by the simple process of restoring the original galvanometer deflection by adding or removing resistance coils. A light coil of fine iron, of selected iron turnings, had a resistance of 2 ohms, but in the sensitive state. A feeble stimulus, caused by a distant electrical phoros spark, brought it down 400 ohms. A further stimulus reduced it by 200 and 100, while a trace of spark given to a part of the circuit itself, ran it down 1,000 ohms.

This is only to give an idea of the quantities. I have not yet done any seriously metrical experiments.

From the wall diagram which summarises the various devices and which were prepared a month or so ago, I see I have omitted selenium, a substance which in certain states is well known to behave to visible light as these other manipulators behave to Hertz waves.

And I want to suggest that there possibly the sensitiveness of the eye is of the same kind. As I am not a physiologist I cannot be seriously blamed for making wild and hazardous speculations in that region. I therefore wish to express that some part of the retina is an electrical organ, say like that of some fishes, maintaining an electromotive force which is prevented from stimulating the nerves

solely by an intervening layer of badly conducting material, or of conducting material with gaps in it; but that when light falls upon the retina these gaps become more or less conducting, and the nerves are stimulated.

I do not feel clear which part is taken by the rods and cones, and which part by the pigment cells; I must not try to make the hypothesis too definite at present.

If I had to make a demonstration model of the eye on these lines, I should arrange a little battery to excite a frog's nerve and muscle preparation through a circuit completed all except a layer of filings or a single bad contact. Such an arrangement would respond to Hertz waves. Or, if I wanted actual light to act instead of grosser waves, I would use a layer of selenium.

But the bad contact and the Hertz waves are the most instructive, because we do not at present really know what the selenium is doing, any more than what the retina is doing.

And observe that (to my surprise, I confess) the rough outline of a theory of vision thus suggested is in accordance with some of the principal views of the physiologist Hering. The sensation of light is due to the electrical stimulus; the sensation of black is due to the mechanical or tapping back stimulus. Darkness is physiologically not the mere cessation of light. Both are positive sensations, and both stimuli are necessary, for until the filings are tapped back vision is persistent. In the eye model, the period of mechanical tremor should be, say, $\frac{1}{10}$th second, so as to give the right amount of persistence of impression.

No doubt in the eye the tapping back is done automatically by the tissues, so that it is always ready for a new impression, until fatigued. And by mounting an electric bell or other vibrator on the same board as a tube of filings, it is possible to arrange so that a feeble electric stimulus shall produce a feeble steady effect, a stronger stimulus a stronger effect, and so on, the tremor asserting its predominance, and bringing the spot back whenever the electric stimulus ceases.

An electric bell thus close to the tube is, perhaps, not the best vibrator: clockwork might do better, because the bell contains in itself a jerky current, which produces one effect, and a mechanical vibration, which produces an opposite effect; hence the spot of light can hardly keep still. By lessening the vibration—say, by detaching the bell from actual contact with the board, the electric jerks of the intermittent current drive the spot violently up the scale: mechanical tremor brings it down again.

You observe that the eye on this hypothesis is, in electrometer language, heterostatic. The energy of vision is supplied by the organism; the light only pulls a trigger. Whereas the organ of hearing is idiostatic. I might draw further analogies, about the effect of blows or disorder causing irregular conduction and stimulation of the galvanometer in the one instrument, of the brain cells in the other.

A handy portable exciter of electric waves is one of the ordinary hand electric gas lighters, containing a small revolving doubler—an inductive or replenishing machine. A coherer can feel a gas lighter across a lecture theatre. Minchin often used them for stimulating his impulsion cells. I find that when held near they act a little before the spark occurs, plainly because of the little incipient sparks at the brushes or tinfoil contacts made. A Voss machine acts similarly, giving a small deflection while working up before it sparks. And notice here that our model eye has a well-defined range of vision. It cannot see waves too long for it.

(To be concluded.)

ELECTRICAL TRADES SECTION.

The members of the Electrical Trade Section of the London Chamber of Commerce met in the afternoon of Thursday, June 7th, at the offices, Rudolph House, Eastcheap, under the presidency of Major Flood Page.

After the usual preliminaries were disposed of, the CHAIRMAN said that the members would remember that when they did him the honour of appointing him to the chair he accepted the office on condition that the appointment should be for only two years. The subject was discussed pretty freely at the time, and the conclusion that it would be far better that they should have a change of Chairman every two years. For that period he had presided over the Section, and he now took the opportunity of thanking them for the kindness and forbearance with which they had treated him during the time he had held that honourable position. He had been, more or less, in bad health the whole time, and had not been as active, perhaps, as he might otherwise have been. He proposed that it now became his privilege to nominate his successor, and he had great pleasure in proposing that Mr. Emile Garcke should be elected to the office.

Mr. SELLON seconded the motion, which was agreed to unanimously.

Mr. GARCKE, having taken the chair, said that while thanking them for the confidence which they reposed in him by placing him in that responsible position, he felt that he occupied it under the great disadvantage of its having been filled first by Mr. Crompton and then by Major Flood Page. He could but say that he would do his best to perform his duties to the satisfaction of the members. He would like to refer to the very valuable services rendered to the Section by Major Flood Page during his period of office, and to propose a vote of thanks to him for his services. Although that gentleman had not enjoyed the best of health, they must all recognise that he had devoted a great deal of time to the interests of the Section with the result that they had been enabled to carry out some very important business matters in which they were all interested, such as the subject of overhead wires and various other questions which had to go before the Board of Trade, in connection with which Major Flood Page had rendered very valuable service.

A MEMBER briefly seconded the motion, which was cordially passed.

Major FLOYD PAGE, in expressing his acknowledgment, said that he would be still able to be of some little use to the Section, because the Council had done him the honour of electing him to be a permanent member of that body, and therefore, in addition to the fact that Mr. Garcke, as Chairman of the Section, would be entitled to attend the meetings of the Council, he (Major Flood Page) would always be there to act upon any suggestion which Mr. Garcke might recommend.

On the motion of the CHAIRMAN, seconded by Mr. SYDNEY MORSE, Mr. Siemens was elected Deputy-Chairman.

After a short discussion, a committee was formed to watch the interests of the Section in connection with the rating of electric works, and a letter was read on the subject of the Locomotive Act from the Board of Trade, intimating that the representations of the Section on the question of their amendment had been brought to the notice of the Home Office.

The consideration of the provisions of the Electric Lighting Act with regard to alleged nuisances was left in the hands of the same committee.

On the suggestion of the CHAIRMAN, seconded by Mr. MORSE and supported by Mr. SELLON, it was decided to circularise the various departments of the electrical industry, urging upon them the desirability of supporting the Section in promoting the interests appertaining to each.

The proceedings then ended.

AMERICAN NOTES.

(FROM OUR OWN CORRESPONDENT.)

NEW YORK, *June 2, 1894.*

New Telephone Rates. The local New York City Telephone Company on June 1st introduced a new system of charges for telephone service, based upon the number of messages sent by a subscriber. All lines will be metallic circuits, and the subscriber sending messages of not less than 1,000, nor over 2,000 annually, may elect if he will have a line for his sole use or share one with another subscriber. The lowest annual rate, $100, is for "two party" lines only and 700 messages, the charge for additional messages being $15 per 100. The highest rate for a "direct" line is $150 per annum, 1,000 messages being the limit, the charge for those in excess of that number being $12 per 100. A "two party" line for this service costs $ less per annum. For 2,000 messages per annum the charge for a "direct" line is $220, and for a "two party" line, excess messages being $8 per 100. For [illegible] messages "direct" lines only can be used, and the rate will be $5 per 100, with $7 per 100 for excess messages.

Central Stations in Massachusetts. [illegible] Board of the Gas and Electric Light Commissioners of Commonwealth of Massachusetts for [illegible] the last year out of [illegible] central electric light stations in State 28 paid dividends, 20 paid [illegible] earn expenses. Of the $ [illegible] stations paid $ [illegible], and the [illegible] the greater part of the remainder [illegible] those of Boston, paid 7 per cent. [illegible] per cent. and two 5 per cent. The [illegible] companies were returned at $ [illegible] surplus of $ [illegible].

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...course, if an alternating current supply is available, and a suitable voltmeter, the method may be modified by putting the voltmeter in place of the galvanometer and using alternating current in the primary P. The voltmeter would have to be of high resistance, or an electrostatic one.

Without a galvanometer at all, a very rough test may be made by simply placing a compass needle at the centre of the coil, and observing its deflections when one pole of a battery (with high resistance in circuit) is connected to the bobbin, whilst the other pole is touched successively to the two free ends of the coil.

THE WORK OF HERTZ *

(Concluded from page 196.)

Sparks not to Long Tube except by help of a polished knob.

The powerful disturbance caused by the violent flashes of a Wimshurst or Voss machine it is blind to. If the knobs of the machine are well polished it will respond to some high harmonics, due to the vibrations in the terminal rods, and these are the vibrations to which it responds when excited by a coil. The coil should have knobs instead of points. Sparks from points or dirty knobs hardly excite the coherer at all. But hold a well polished sphere or third knob between even the dirty knobs of a Voss machine, and the coherer responds at once to the surgings got up in it.

Feeble short sparks again are often more powerful exciters than are strong long ones. I suppose because they are more sudden.

This is instructively shown with an electrophorus lid. Spark it to a knuckle, and it does very little. Spark it to a knob and it works well. But now spark it to an insulated sphere, there is some effect. Discharge the sphere, and take a second spark, without recharging the lid. Do this several times, and at last, when the spark is inaudible, invisible, and otherwise imperceptible, the coherer some yards away responds more violently than ever, and the spot of light rushes from the scale.

If a coherer be attached by a side wire to the gas pipes, and an electrophorus spark be given to either the gas pipes or the water pipes or even to the hot water system in another room of the building, the coherer responds.

In fact, when thus connected to gas ... one day when I tried it, the spot of light could hardly keep five seconds still. Whether there was a distant thunderstorm, or whether it was only picking up telegraphic jerks, I do not know. The jerk of turning on or off an extra Swan lamp can affect it when sensitive. I hope to try for long wave radiation from the sun, filtering out the only very well known waves by a thick board or other sufficiently opaque substance.

We can easily see the difference in regard to a distant source of radiation now, viz., to have the coherer placed in the library between two knobs.

Also I exhibit a small complete detector made by my assistant, Mr. Davies, which is quite portable and easily set up. The essentials are all in a copper cylinder three inches by two. A bit of wire about two inches long, pegged into it, helps it to collect waves. It is just conceivable that at some distant date, say by dint of inserting gold wires or powder in the rotus, we may be enabled to see waves which at present we are blind to.

Observe how simple the production and detection of Hertz waves are now. An electrophorus or a frictional machine serves to excite them, a voltaic cell, a rough galvanometer, and a bad contact serves to detect them. Indeed, they might have been observed at the beginning of the century, before galvanometers were known. A frog's leg or an iodide of starch paper would do almost as well.

A bad contact was at one time regarded as a simple nuisance because of the singularly uncertain and capricious character of the current transmitted by it. Hughes observed its sensitiveness to sound waves, and it became the microphone. Now it turns out to be sensitive to electric waves if it be made of any oxidisable metal (not of carbon), and we have an instrument which might be called a micro something, but which, as it appears to act by cohesion, I call at present a coherer. Perhaps some of the capriciousness of an anathematised bad contact was sometimes due to the fact that it was responding to stray electric radiation.

The breaking down of cohesion by mechanical tremour is an ancient process, observed on a large scale by engineers in rails, axles and girders. Indeed, the cutting of small girders by persistent blows of hammer and chisel reminded me the other day of the tapping back of our cohering surfaces after they have been exposed to the welding effect of the electric jerk.

* A lecture delivered at the Royal Institution on Friday June 1st, by Prof. Oliver Lodge, F.R.S., ably assisted during both preparation and performance by Mr. Edward E. Robinson.

If a coherer is shut up in a complete metal enclosure ... cannot get at it, but if wires are led from it to an outside ... galvanometer, it remains nearly as sensitive as it was before (not quite), for the circuit picks up the waves and they run ... the insulated wires into the closed box. To screen it effectively, it is necessary to enclose battery and galvanometer and every bit of wire connection; the only thing that may be left outside is the needle of the galvanometer. Accordingly, here we have a complete arrangement of battery and coil and coherer, all shut up in a copper box. The coil is fixed against the side of the box at such height that it can act conveniently on an outside suspended compass needle. The slow action of the coil has no difficulty in getting through copper, as everyone knows; only a perfect conductor could screen off that, but the Hertz waves are effectively kept out by sheet copper.

It must be said, however, that the box must be exceedingly well closed for the screening to be perfect. The very narrowest chink permits their entrance, and at one time I thought I should have to solder a lid on before they could be kept entirely out. Clamping the copper lid on to a flange in six places was not enough. But by the use of pads of tinfoil, chinks can be avoided, and the inside of the box becomes then electrically dark.

If even an inch of the circuit protrudes, it at once becomes slightly sensitive again; and if a single branch wire protrudes through the box, provided it is insulated where it passes through, the waves will utilise it as a speaking tube, and run blithely in. And this whether the wire be connected to anything inside or not, though it acts more strongly when connected.

If wires are to be taken out of the box to a coherer in some other enclosure, they must be enclosed in a metal tube, and this tube must be well connected with the metal of both enclosures, if nothing is to get in but what is wanted.

Similarly, when definite radiation is desired, it is well to put the radiator in a copper hat, open in only one direction. And in order to guard against reflected and collateral surgings running along the wires which pass outside to the coil and battery, as they are liable to do, I am accustomed to put all these things in a packing case lined with tinfoil, to the outside of which the sending hat is fixed, and to pull the key of the primary exciting circuit by a string from outside.

With reference to the reflecting power of different substances it may be interesting to give the following numbers, showing the motion of the spot of light when 8in. waves were reflected into the copper box, the angle of incidence being about 45deg., by the following mirrors:—

Sheet of window glass	0 or at most 1 division.
Human body	7 divisions.
Drawing board	12
Towel soaked with tap water	12
Tea paper (lead)	40
Dutch metal paper	70
Tinfoil	80
Sheet copper	100 and up to one scale.

Even then, with the lid of the hat well clamped on, something gets out, but it is not enough to cause serious disturbance of qualitative results. The sender must evidently be thought of as emitting a momentary blaze of light which escapes through every chink or, indeed, since the waves are some inches long, the difficulty of keeping them out of an enclosure may be likened to the difficulty of excluding sound, though the difficulty is not quite so great as that, since a reasonable thickness of metal is really opaque. I fancied once or twice I detected a trace of transparency in such metal sheets as ordinary tinplate, but unnoticed chinks elsewhere may have deceived me. It is a thing easy to make sure of as soon as I have more time.

One thing in this connection is noticeable, and that is how little radiation gets either in or out of a small round hole. A narrow long chink in the receiver box lets in a lot; a round hole the size of a shilling lets in hardly any, unless, indeed, a bit of insulated wire protrudes through it like a collecting ear trumpet.

It may be asked how the waves get out of the metal tube of an electric gas lighter. But they do not; they get out through the handle, which being of ebonite is transparent. Wrap up the handle tightly in tinfoil, and a gas lighter is powerless.

Optical Experiments.

And now in conclusion I will show some of the ordinary optical experiments with Hertz waves, using as source either one of two devices; either a 5in. sphere with sparks to ends of a diameter (Fig. 20), an arrangement which emits 9in. waves, but of so dead beat a character that it is wise to enclose it in a copper hat to prolong them, and send them out in the desired direction; or else a 2in. hollow cylinder with spark knobs at ends of an internal diameter. This last emits 3in. waves of a very fairly persistent character, but with nothing like the intensity of one of the outside radiators.

As receiver there is no need to use anything sensitive, so I employ a glass tube full of coarse iron filings, put at the back of a copper hat with its mouth turned well askew to the source.

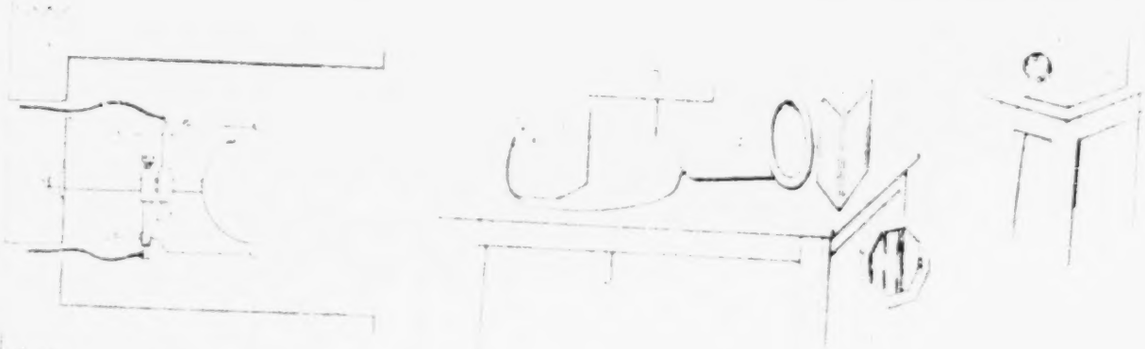
which is put outside the door at a distance of some yards, so that only a little direct radiation can reach the tube. Sometimes the tube is put lengthways in the hat instead of crossways, which makes it less sensitive, and has also the advantage of doing away with the polarising or rather analysing power of a crossway tube.

The radiation from the sphere is still too strong, but it can be stopped down by a diaphragm plate with holes in it of varying size clamped on the sending hat.

Having thus reduced the excursion of the spot of light to a foot or so, a metal plate is held as reflector, and at once the spot travels a couple of yards. A wet cloth reflects something, but a thin glass plate, if dry, reflects next to nothing, being, as is well known, too thin to give anything but "the black spot." I have fancied that it reflects something of the 3in. waves.

Refracting Prism and Lens.

A block of paraffin about a cubic foot in volume is cast into the shape of a prism with angles 75deg., 60deg., and 45deg. Using the large angle, the rays are refracted into the receiving hat (Fig. 2), and produce an effect much larger than when the prism is removed.



Ordinary flint glass lens is next placed near the source, and by means of the light-spot it is focussed between source and receiver. The lens is seen to increase the effect.

Using Glass Cylinders as Lenses.

The lens helps us to set correctly an 18in. circular copper disc position for showing the bright diffraction spot. Removing the lens the effect is much the same as when it was present. Add the lens and the effect is greater. With a diffraction grating of copper strips 2in. broad and 2in. apart, I have not yet succeeded in getting good results. It is difficult to get sharp nodes and interference bands with these sensitive detectors in a room. I expect to do better when I can try out of doors away from so many reflecting surfaces. Indoors it is like trying delicate optical experiments in a small whitewashed chamber well supplied with looking glasses. Nor have I ever succeeded in getting clear concentration with this zone plate having Newton rings based to it in tinfoil. But really there is nothing of much interest now in diffraction effects except the demonstration of the waves and the measure of their length. There was immense interest in Hertz's time, because then the wave character of the radiation had to be proved, but every possible kind of wave must give interference and diffraction effects, and their theory is, so to say, worked out. More interest attaches to polarisation, double refraction, and dispersion experiments.

Polarising and Analysing Grid.

Polarisation experiments are easy enough. Radiation from a sphere is already strongly polarised, and the tube acts as a partial analyser, responding much more vigorously when its length is parallel to the line of sparks than when they are crossed; but a convenient extra polariser is a grid of wires something like what was used by Hertz only on a much smaller scale, say an 18in. octagonal frame of copper strip with a harp of parallel copper wires (see Fig. 2). The spark line of the radiator being set at 45deg., a vertical grid placed over receiver reduces the deflection to about one-half, and a crossed grid over the source reduces it to nearly nothing. Rotating either grid a little rapidly increases the effect, which becomes a maximum when they are parallel. The interposition of a third grid, with its wires at 45deg. between those of the two, restores some of the obliterated effect.

Radiation reflected from a grid is strongly polarised, the normal, of course, to that of the radiation which excites it. They are thus analogous in their effect to Nicol's prisms of plates.

The electric vibrations which get through the grid are at right angles to the wires. Vibrations parallel to the wires are reflected or absorbed.

Reflecting Paraffin Prism.

To demonstrate that the so-called plane of polarisation of radiation transmitted by a grid is at right angles to the plane of vibration,* i.e., that when light is reflected from the boundary of a transparent substance at the polarising angle the electric vibrations of the reflected beam are perpendicular to the plane of incidence, I use the same paraffin prism as before; but this time I employ the largest face as a reflector, and set it at something near the polarising angle. When the line of wires is parallel to the plane of incidence, plenty of radiation is reflected by the paraffin face. Turning the grid so that the electric vibrations are parallel to the plane of incidence, we find that the paraffin [illegible] angle is able to reflect hardly anything. [illegible] the effects investigated by Fresnel and the [illegible] dealt with by M. Cailletet are the necessary [illegible] Time does not allow of the introduction [illegible] to the wayfaring man.

A NEW PHENOMENON OBSERVED IN THE PASSAGE OF ELECTRICITY THROUGH BADLY CONDUCTING LIQUIDS.†

BY G. TRAUBE.

During the electrolysis of good liquid conductors the [illegible] known to be confined to the proximity of the electrodes. [illegible] as I know, no chemists have hitherto been observed in the case of badly conducting liquids of weak dissociation, such as water and electric currents on the other hand. I have observed [illegible] of electricity through certain badly conducting liquids, such as [illegible] of aniline dyes, to be attended by changes proceeding [illegible] continuously from the electrodes to the centre, usually by the formation of a precipitate in the middle of the liquid [illegible] between the electrodes. The phenomena are most easily [illegible] by means of a microscope and an arrangement [illegible] scribed.

If, for instance, a current of about 20 volts pressure [illegible] through an aqueous solution of Congo red, a crystalline [illegible] halo is formed round both electrodes of a somewhat [illegible] the anode and somewhat paler than the rest. The [illegible] cathode, but divided off from it by a darker boundary [illegible]

* J. C. Traube, *Ber. d. Deutsch. Chem. Ges.*, 1883, p. 1935, and many experiments by Mr. Traube. Vol. XV., p. 2433.
† *Berichte der Deutschen Chemischen Gesellschaft*, Vol. XXVII., No. 2, 1894.

The Art of Soldering. By William [illegible] Municipal Technical [illegible] Birmingham.

It is impossible to discuss the whole art of soldering in a little pamphlet of 32 pages, but the author has put together some very useful notes on the chemistry of fluxes, the composition of hard and soft solders, and gives a few practical hints about their use. The bridges peculiar to electrical work are not mentioned; but even those electricians and there are many who can handle a bit or blowpipe in a way that satisfies an old navy tinsmith, and can achieve results of soldering which a new recruit would have believed impossible, may find something worth knowing in Mr. [illegible]'s little book.

THE WORK OF HERTZ.

CORRECTIONS AND EXPLANATIONS BY THE LECTURER.

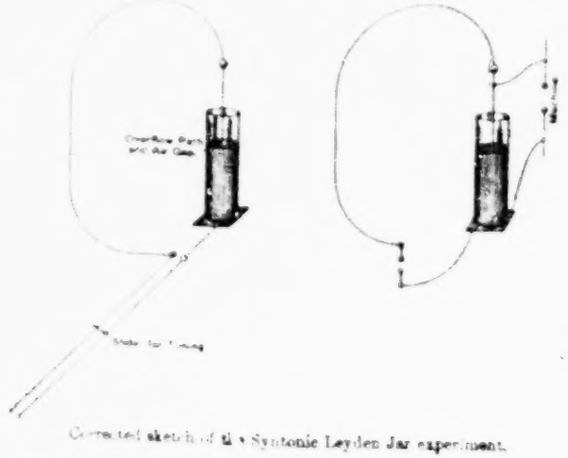
In connection with the illustrations to a lecture of mine at the Royal Institution, recently reported in *The Electrician* for 9th, 16th, 23rd, there are some misapprehensions which may be well to set right for the benefit of students and others who may wish to repeat some of the experiments. Many of the experiments lend themselves to easy repetition, since they involve nothing novel in the way of apparatus except what is quite easily constructed; many of them can be performed with the ordinary stock apparatus of an amateur's laboratory.

Figs. 2, 3, and 4 (page 154) are curves obtained by Hjerkness with the apparatus depicted in Fig. 14, which is intended to show

1. A Hertz vibrator connected to an induction coil.
2. A closed-circuit receiver properly tuned with the vibrator, and
3. A suitable electrometer for inserting in the arrangement.

The receiver is not provided with knobs, as depicted in Fig. 14, but its open circuit is terminated by the quadrants of the electrometer, which is shown on an enlarged scale alongside. The needle is at zero potential and is attracted by both quadrants. By calculation from the indications of this electrometer Hjerkness plotted the curves Figs. 2, 3, and 4. Fig. 2 represents the oscillations of the primary vibrator, rapidly stopped by radiation of energy. Fig. 3 represents the wave-train thereby set up in the resonating circuit when the two are accurately in tune, and which persist for many swings. Fig. 4 shows the oscillations excited in the same circuit when slightly out of tune with the exciter. A receiver of this kind makes many swings before it is seriously damped.

In Fig. 3 the emitting circuit is properly shown, but the receiving circuit is not shown properly. The following sketch is correct.



Corrected sketch of the Syntonic Leyden Jar experiment.

Fig. 6, if its plates and rods are magnified enormously without magnifying the knobs, may serve to represent the gigantic vibrator mentioned on pages 186 and 187: whereas the ordinary 5 m. Hertz vibrator is shown in Fig. 10, on a scale about an inch to a foot.

A new figure, Fig. 7, may be added instead of the last [illegible] note on page 186, to illustrate the arrangement by which I showed the effect on one spark of the light from another. It will be observed that with this arrangement the B knobs are at the same potential up to the instant of the flash, and in that case the ultra-violet portion of the light of the A spark causes the occurrence of the B spark. But it is interesting to note, what Elster and Geitel have found, that if the B knobs were subjected to steady strain instead of impulsive strain, i.e. if they were connected to the [illegible] instead of the outer coatings, then the effect of the ultra-violet light on either spark gap would be to [illegible] the [illegible] diminish, so that the spark would [illegible] extinguished, as it were. With [illegible] it would not be possible to illuminate the sparks by the light of the other, the sparks are then alternative not successive.

The work of Elster and Geitel [illegible] mentioned in the penultimate paragraph of [illegible] reviewed in a separate article which is shortly to appear in *The Electrician*.

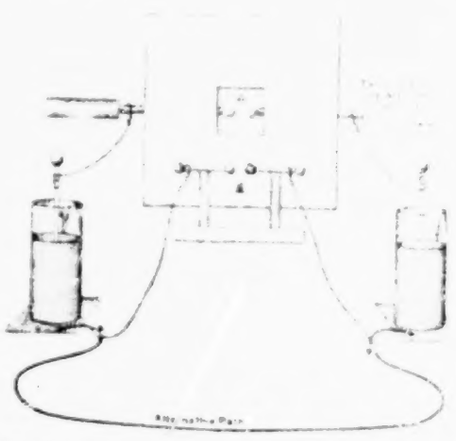


Fig. 22.—Layout arranged to show effect of one spark of light on another. The B sparks were made easier by light cast on the A sparks through the end window in the middle, with a lens. A quartz lens transmits the effect.

With reference to the silent discharging power of light for negative electricity from clean metallic surfaces, Fig. 8 is drawn much as the experiment was shown, it being understood that the lenses are of quartz, not glass. But there is no need to condense the beam at all in this experiment, the naked arc acts powerfully on clean zinc or aluminium, or, indeed, on most metals. But if there be a few minutes' delay after sandpapering the surfaces the effect is very noticeably diminished. In Fig. 8 all the optical parts are of quartz, and the position of the zinc sphere indicates its position in the most effective region of ultra violet light.

A few lines below Fig. 9 the references in the text have got mixed: the reference to Fig. 9 should be to Fig. 10, and the reference to Fig. 10 should be deleted. The knobs of Fig. 11 should be nearly in contact. Fig. 12 is not a resonator or receiver, but an emitter; it emits a long series of 3m. waves at each spark, and it was arranged against the outside of a tinfoil lined box containing battery and induction coil for exciting it. Alongside of it and outside the same box was arranged the larger radiator, Fig. 20, the wires from which pass into the box through glass tubes, and are there connected with the terminals of the secondary coil. The object of this metal lined box or packing-case is to keep in all the stray waves, which else are liable to start from any part of the circuit, &c., to insure that the ostensible source shall likewise be the real one. The sending arrangement shown in Fig. 21 would do very well, but the box should be of metal. The wires of the receiving circuit are screened from direct radiation by being inclosed in a compo pipe.

Fig. 18 does not represent what I have called a coherer, but a simple tube of iron borings or filings, as used by me following M. Branly. Fig. 17 is the coherer, though the spiral should be longer to give elasticity enough, and no "stop" is desirable as the pressure has to be regulated by trial. The contact best adapted for sensitiveness is one with quite appreciable pressure. Some practice is needed to work with these things.

The spherical radiator shown in Fig. 19, which was at pleasure either two inches or five inches in diameter, though it could excite the filings tube Fig. 18 when 60 yards away in the open air, yet could not excite it perceptibly when screened off by so many walls and metal surfaces as exist between the Library and Theatre of the Royal Institution. It could, however, still easily excite the coherer, which is immensely more sensitive, and also more troublesome and occasionally capricious than is a tube of iron filings.

In Fig. 16 the handle should be shown of ebonite too, to permit a delicate adjustment without discharge. The instrument is intended to be placed on, or otherwise connected with, the cap of an electroscope, while the left hand terminal is connected to its sole or outer case. Any electrification then given to the right hand screw soon causes overflow at the excessively minute spark-gap inside. The leaves only diverge a little way and then suddenly collapse.

FIG. 23.—Zonoplate of Tinfoil on Glass.

A zone plate or series of rings of equal area, made of tinfoil pasted upon glass with alternate spaces bare, is shown in Fig. 23 herewith, and is intended to act as a diffraction lens, concentrating to a focus the 3in. waves from the radiator Fig. 12.

Lastly, a table of numbers interpolated in the second column of page 204, beginning "with reference to the reflecting power . . . ." and ending "up against stops," is seriously out of its places, since it interrupts the sense of another paragraph. It belongs properly just above the first italic heading on page 205.

The account of the "optical experiments" given towards the end of the lecture is very compressed. It may be well to give a few additional remarks on this subject in another article.

ARC LIGHTING AT HASTINGS.

On Saturday last the occasion of the first lighting up by arc lamps of the entire length of the Hastings and St. Leonards sea front and promenade, extending from the extreme easterly point, known as the Fish Market, to the west end of the Marina, was appropriately celebrated. After a banquet, given by the Hastings and St. Leonards Electric Light Company, at which the Mayors of Hastings and Winchester and a number of other gentlemen were entertained, the invited company proceeded to the end of Hastings Pier, where the Mayor of Hastings formally switched on this long line of arc lights. The company then made a closer investigation of the lighting by driving along the sea-front.

For many years a certain amount of arc lighting has been done at Hastings by Brush continuous-current lamps, supplied in series from Brush dynamos, and the ordinary house lighting has been worked on the alternating-current transformer system. This practice entailed the use of two distinct sets of plant at the generating station, and rendered it impossible to combine the two loads, at least as far as the engines and dynamos were concerned. Upon the extension of the public lighting from the original 15 lamps, occupying little more than half a mile of sea front, to the present 52 lamps, extending some two and a half miles, it was very wisely determined to so arrange matters that the steady arc light load might be put on the same generators as would be used for the house supply, thereby materially improving the load factor and economy of the station. The work of carrying out these alterations and extensions was undertaken by the Brush Electrical Engineering Company, who have succeeded in turning out the work in an effective and thoroughly satisfactory manner. Contrary to the teachings of those who maintain that the continuous current arc invariably gives the best results in street lighting, the conditions on the sea front seem to be such as are favoured by the use of the alternate current arc. The light, which is thrown upwards, strikes pleasantly against the upper portions of the houses which skirt the sea front, and in this way an effect more generally resembling the even distribution of day light is produced.

Each lamp is fed from a separate transformer, this latter taking the primary power at 2,000 volts and transforming it down to 50 volts. A small choking coil placed in the lamp circuit serves to regulate the voltage on the arc. The transformers of the 52 lamps are grouped in parallel on two pairs of mains, the connections being so made that the failure of either main will extinguish only alternate lamps. These two mains are switched on to the station bus bars, being fed at 2,000 volts from the Mordey-Victoria alternators, which also supply the house mains. The alternators are rope-driven by Raworth steam engines. The contracting company have been ably assisted in carrying out this work by Mr M. G. Ross, the engineer and manager to the local company, and by Mr. E. Geipel, the resident outside engineer, and all parties connected with the enterprise are to be congratulated on this successful piece of work.

HEINRICH HERTZ.*

The first day of this year took away from us a fellow worker whose loss affects us most deeply. If, after a long career of discovery and a life rich in achievements, one of the old masters of science passes to his rest, we lament his death but we bow to the inexorable laws of nature. In Heinrich Hertz a discoverer of the first rank has been torn away from us in the middle of his work, and almost at the commencement of the prime of life. The sad news has spread far and wide, and so it is very fitting that we also should pay a tribute to his memory. Let us first glance over the development of the external events of his life during the short space of time allotted to it.†

Heinrich Rudolf Hertz was born at Hamburg on February 22, 1857, and was the eldest son of the then attorney (and later Senator) Hertz. His mother was a native of Frankfort-on-Main. After having attended a city school until his confirmation, he studied privately at home during the years 1873-4, and at Easter, 1874, he entered the highest class of the upper school of the Johanneum in his native town. At Easter, 1875, he left school, in his eighteenth year, with a certificate of fitness for the University.

Even as a boy he displayed great talent, but more especially a strong liking for, and an uncommonly great interest in, the exact sciences. As a scholar of twelve years of age he attended Sunday classes in geometrical drawing held at the Technical School. In addition to his scholastic studies he industriously practised the use of tools, and he went through that course of practical training in carpentry and lathe work which is of so great importance to the physicist; his skill enabled him to construct quite serviceable instruments from the simplest materials, and, among other things, he once made for himself a spectroscope.

* Memorial Address by Prof. Hermann Ebert, delivered at the meeting of the Physical Society of Erlangen, March 7, 1894. Translated by James L. Howard.

†For the following biographical notice the author acknowledges his deep indebtedness to Frau Prof. Hertz.

When he left the Gymnasium it became necessary for him to choose a profession. His desire to construct something useful and permanent and his innate modest temperament, which at that time caused him to doubt greatly his ability to accomplish anything satisfactory in pure science, as well as his newly awakened joy at the prospect of making a practical trial of his powers, all these led him to choose the profession of an engineer, and, indeed, that of a civil engineer. As a preparation for this calling he served during the year 1875-6 as an apprentice in the city engineer's office at Frankfort on Main, such preparation being at that time a necessary preliminary before entering the profession. After this he went during the Summer Semester of 1876 to the Technical High School at Dresden. During the twelve months subsequent to October 1876, his studies were interrupted by his year of military service, which he passed at Berlin in the Railway Regiment. In the autumn of 1877 he went to Munich. This was the most remarkable turning point in Hertz's career, which converted him from a man of practice to one of learning. Here he recognised that his nature could only find full satisfaction in dealing with science, and he applied himself in Munich specially to mathematics and physics.

After only a year, in the autumn of 1878, he removed to the University of Berlin, where he entered the laboratory of Von Helmholtz. His progress was unusually rapid. In 1879 he gained a prize offered by the Philosophical Faculty for a research on extra currents induced in coils and wires, a work which presented difficulties both of theory and experiment. In 1880 he graduated as doctor, and in the same year Von Helmholtz chose him as assistant in the Physical Institute, only three years after he had first devoted himself to the study of physics.

At Easter, 1883, when in his twenty sixth year, he became Privat Docent at Kiel, acting on the advice of Von Helmholtz and he immediately obtained a commission to teach theoretical physics from the Prussian Minister of Instruction. At Easter, 1885, when twenty eight years of age, he received a call as ordinary Professor of Physics at the Technical High School at Karlsruhe. From this place originated his epoch making experimental researches. In 1886 he married Elizabeth Doll, daughter of the Professor of Geodesy at the same High School.

When in the year 1887 death took away from Bonn Olausius, the founder of the mechanical theory of heat, there was no hesitation in conferring upon Hertz, although only thirty two years of age, the honour of succeeding a Clausius, and at Easter, 1889 he was called to Bonn.

Having thus succeeded to a secure and honourable position, respected and admired both in Germany and abroad, at an age when the powers of research usually first begins to make itself manifest, he was soon visited by the insidious enemy which was destined to bring so brilliant a career to such a tragic close. In the middle of the year 1892 a chronic blood poisoning, originating, probably, from a gathering in the jaw cavity, had already begun to undermine his hitherto excellent health. The crisis, which occurred in November, 1892, was passed by a successful operation, and he was able to continue his lectures throughout the Summer Semester of 1893, and (although with great efforts) until December 7th of the same year, only a short time before his decease. His malady then returned, and in a few weeks proved fatal; he died on New Year's Day in the 37th year of his age. According to the testimony of those who were near him and particularly of his wife, who nursed him faithfully to the last, his sufferings were indescribable. In him there passed away not only a man of great learning, but also a noble man, who had the singular good fortune to find many admirers, but none to hate or envy him; those who come into personal contact with him were struck by his modesty and charmed by his amiability. He was a true friend to his friends, a respected teacher to his students, who had begun to gather round him in numerous large numbers, some of them coming from great distances, and to his family he was a loving husband and father.

The course of events in the external life of Heinrich Hertz was simple and plain. But what a world is opened before us when we consider his scientific life, which was bound up within such narrow limits of time! To give a condensed sketch of its development is the object of the present address.

We generally speak only of his later epoch making researches as they alone have become known far and wide. But it is very instructive to glance once more over the earlier researches from the higher standpoint reached by the later ones. Further, we perceive how the later discoveries which have transformed the whole subject, were originated and developed from the former, these being in a certain restricted sense stepping stones to the latter series of experiments, for Hertz was not led by mere accident to his investigations on the propagation of electric waves; it was a comprehensive and well arranged process of argument which was crowned by these researches, even if a happy chance often furnished him with the means of more quickly reaching the goal. I shall confine myself to the electrical researches and therefore merely mention Hertz's work on the evaporation of liquids and in particular of mercury in vacuo, on the pressure of saturated mercury vapour, his meteorological investigations, his researches connected with [illegible] the theory of solids; these all show the [illegible] work.

His scientific activity began as we have already seen, with the solution of a prize problem. The research proposed by the Faculty of the University of Friedrich Wilhelm at Berlin for the year 1879 was the experimental investigation of the induced electric currents. The problem, the solution of which was intended to be advanced by this research, was [illegible] the other theories of electric phenomena [illegible]. These theories were based on the assumption that [illegible] fluid which moved through the conductor [illegible] thing of the nature of matter was as concerned in electric [illegible] this hypothetical something must possess [illegible] small degree. If it had mass it must possess inertia [illegible] jected to "electromotive forces," and [illegible] set in motion, contain a certain amount of kinetic energy [illegible] of its mass and velocity. This kinetic energy would manifest [illegible] if the current in a coil were alternately suddenly made and interrupted, because "extra currents" are then set up in the [illegible] consequence of the mutual inductive action of the separate parts on each other, and the energy of these extra currents would be present that of the moving electrical masses. An exact [illegible] estimate of this energy, and hence of the quantity of electricity, say, in a cubic millimetre of a wire traversed by a current, was hardly to be expected because of the difficulty attending the measurements; one had to be content with seeking an upper limit for the quantity of energy and thus furnishing an answer to the question how great can this quantity of energy possibly be?

The first considerable experimental investigation of Hertz was devoted to this problem. It appeared with the title "Experiments to determine an Upper Limit for the Kinetic Energy of an Electric Current." The result of the experiments was negative, since the upper limit became smaller and smaller the more exactly the experiments were performed. It was necessary to conclude that the quantity looked for would eventually become zero if all errors of experiment could be successfully eliminated. But it was certainly a matter of great importance for Hertz that in his first research the domain of electricity he already convinced himself that assumptions as to the material nature of electricity were untenable, and that the postulated fluid vanished just as he sought to [illegible] with more accurate means of observation.

In this first work, published when he was only twenty six years of age, great experimental skill was displayed. We find him working with long stretched wires and large wire rectangles which he stretches in the cellar of the laboratory, pieces of apparatus which he was destined to use later in such a masterly fashion as he [illegible]. One particularly clever device was the arrangement of a [illegible] tator by the simple rotation of which a complicated system of conductors could be automatically and quickly inserted in the [illegible] cut out or reversed, in regular order. That Hertz was a master of the mathematical theory, the most important [illegible] his work, is shown by the calculation of the [illegible] turns and layers in such a way that [illegible] the self induction of [illegible].

Hertz returned [illegible] Upper Limit [illegible] when he employed a [illegible] more sensitive, but [illegible] very thin silver tube [illegible] a strong current in the [illegible] ing to the older theory, the [illegible] cubic millimetre of silver, was in this case as great as possible. In this moving electricity was only subject to the electromotive force of the voltaic cell [illegible], the plate was traversed [illegible] symmetrically from anode to cathode, and [illegible] a sensitive galvanometer [illegible] perpendicular [illegible] between these wires. The plate was now [illegible] and rapidly rotated about an axis through its centre perpendicular to its plane. If moving electricity possessed any property [illegible] alogous to inertia the current would be deflected by this rotation out of its original path, just as [illegible] surface of the earth from the east to the [illegible] its rotation from their south to north direction and strike the [illegible] at an angle. In this case a component of the current would flow between the two transverse electrodes, and this would be [illegible] by the galvanometer, even though only small [illegible]. Numerous sources of error, thermal currents caused by unequal heating of the electrodes by the air currents, alterations in the rotating plate due to centrifugal force, &c., all these were encountered and to some extent masked the effect looked for. But Hertz knew how to reduce these sources of error to a minimum by a judicious combination of separate experiments under varying conditions. In spite of this, 2500 separate observations failed to give any positive result. The upper limit so determined is that the kinetic energy of an electric current whose density [illegible] electromagnetically [illegible]

unity is, per cubic millimetre of a silver film, not so great as that of $\frac{1}{10000}$th of a milligram moving at the rate of a millimetre per second. At the end of this Paper he points to the possibility of obtaining positive results in the case of electrolytes, in which the motion of the electricity is bound up with that of the material ions. This conjecture of Hertz has been confirmed by later researches of Colley and Pescoudres. Here, however, it is not the inertia of electricity itself, but that of the bodies carrying it, by which the phenomena are brought about.

His thesis for the degree of Doctor in 1880 treats of induction in rotating spherical conductors or hollow spheres between magnets according to the theory of Neumann.

(To be continued.)

DIRECT-READING APPARATUS FOR THE DETERMINATION OF THE MAGNETIC QUALITIES OF IRON.*

BY DR. A. KOEPSEL.

The author, who is the designer of the apparatus described, having set out with the idea that for a direct reading instrument an incomplete magnetic circuit must necessarily be employed, began by the investigation of two points: first, whether results could be obtained with an incomplete magnetic circuit which could

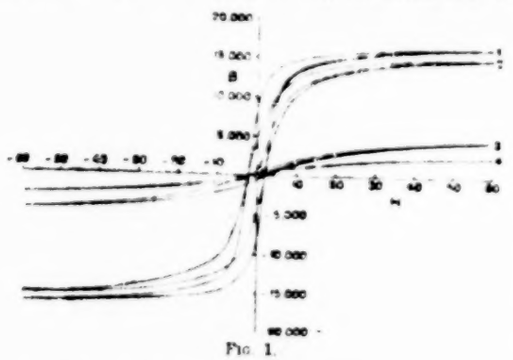


FIG. 1.

be definitely referred to those obtainable with a closed circuit, so that the latter could be easily deduced from the former; and, secondly, whereabouts in an incomplete circuit is the best position for the division, with the object in view of getting the magnetisation curves as correctly as possible. A division in the sample itself was found to be out of the question, as even when the pieces were pressed tightly together a considerable alteration of the curve of magnetisation was observed. Fig. 1 shows in curves 1-4 the

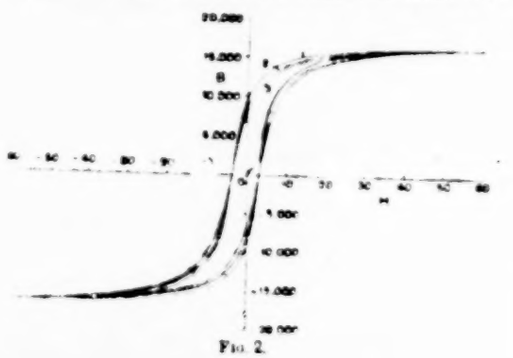


FIG. 2.

curves of magnetisation obtained by the ballistic method from a bar of soft iron 6mm. in diameter, the return being by a large yoke, the curves referring to the following cases:—(1) The bar whole and undivided; (2) The bar cut in two, and the surfaces pressed tightly together; (3) The surfaces 1·3mm. apart; (4) The surfaces 2·8mm. apart.

On the other hand, a division in the yoke itself had comparatively little effect, as shown in Fig. 2, curves 1-3, which represent the curves of magnetisation of a similar bar under the following conditions. (1) With an undivided yoke. (2) Yoke divided, the surfaces pressed tightly together. (3) The surfaces 1mm. apart. As the yoke had 100 times the surface of the sample, the magnetic resistance of the division was 100 times as small as in the former case. It is then of great importance to get the yoke as large as possible, which was done in the author's case by making the yoke a surface of rotation, which one can imagine formed by rotating the yoke

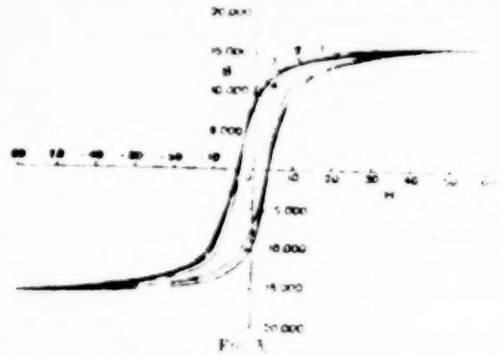


FIG. 3.

about the test bar as an axis, the bar and the magnetising coil being thus completely enclosed. It was then found that, although the curve obtained by pressing the half cylinders together (No. 2, Fig. 3) was not the same as that obtained with an undivided yoke (No. 1), yet the latter could be obtained from the former by the shearing process; and, further, the experiments showed that a gap of 1·8mm. between the cylinders did not very much alter the form and position of the curves (Nos. 3 and 4).

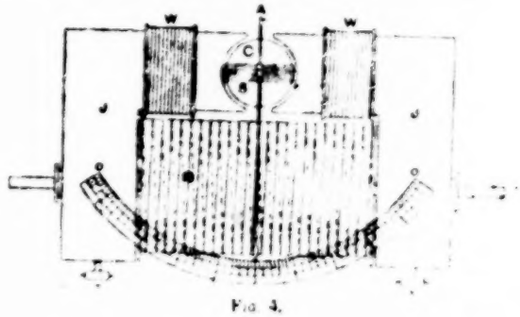


FIG. 4.

A gap of 5mm., however, was enough to afford room for a flat wound coil carrying a current and controlled by a torsion head, the amount of whose rotation to bring the coil to zero is a measure of the field. This coil, however, had to be made very small, and had, consequently, a very small torque; and therefore a design had to be evolved which, while not increasing the air space, should allow of a larger area of coil. This object was attained by return

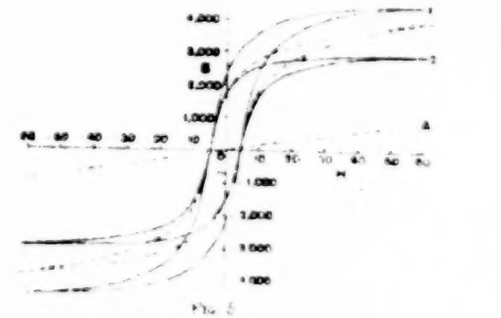


FIG. 5.

ing to the simple form of yoke shown in Fig. 4. The yoke J is bored out at A like the pole pieces of a dynamo, and the piece bored out is replaced by a soft iron cylinder, C, having a diameter 2mm. less, and in the cylindrical air space so made a coil is placed, working on pivots, and capable of rotation, and which is traversed by a current of about 0·01 ampere led in by palladium springs. The openings oo of the yoke serve for the introduction of the

The explanation of the results obtained appears to be that when the cables are charged with positive electricity the polarisation produced is sufficient during the time of one alternation to considerably increase the resistance of the slight leakage to earth by the formation, probably, of a film of oxides; this obstruction is cleared off by the succeeding wave of negative charge, which, as is well understood, opens the leak. The time of an alternation is however, quite insufficient to produce any such effect on the water pipe earth, and, in consequence, the net result is a passage of negative electricity to earth through the cables, and of the corresponding positive quantity to earth by the water-pipes.

The maximum effect that has been observed so far amounts to an apparent E.M.F. slightly exceeding 10 volts, with the eleven circuits connected to one machine; but it appears that a greater effect would be produced by still further increasing the length of mains in connection.

HEINRICH HERTZ.*

(*Continued from page 274.*)

In 1881 we already find him investigating electrical equations which do not belong to the older theories. An interesting Paper written at this time is "On the Distribution of Electricity on the Surface of Bodies in Motion." The theory of action at a distance shows that in every electrically-charged body at rest the charge resides wholly on the surface, so that the interior of a hollow sphere is quite free from any trace of the hypothetical fluid, and throughout the whole conductor the electric potential has everywhere the same value, even in the interior of the mass of the conductor. Hertz asks himself, "What happens if bodies so charged are moved towards each other?" The distribution of electricity on the surface must at any instant be quite different from that on the surface of bodies at rest, even if these could be brought to exactly the same position in space as the moving conductor momentarily occupies; further, the potential is now no longer constant, either on the surface or in the interior of the body, and whereas a hollow metallic conductor at rest completely screens its interior from external electrical forces, this is no longer the case when the conductor is in motion. Currents are set up in its interior, and along with them heat is developed, resulting in an apparent loss of energy. Continuous motion of charged bodies can therefore only be kept up by supplying external work.

Hertz developed very skilfully the formulæ for these cases, and the general formulæ of electrostatics are greatly extended by them. He applied the general solutions to the specially important cases of a solid of revolution rotating in an electric field with constant velocity about an axis, and particularly considered solid and hollow spheres and cylinders. In the latter, even in a uniform field, electric currents are set up which are deflected in a singular fashion by the rotatory motion; inductive effects act through the metallic body upon its interior, so that it no longer behaves as a perfect screen, and so on. In connection with this Hertz arranged an experiment. Over a horizontal and only moderately good-conducting glass plate a needle, provided at its ends with horizontal metallic plates, is suspended by a metal wire. As soon as these plates are charged so that they become electric poles their oscillations becomes greatly damped. The phenomenon is analogous to the damping of a swinging magnetic needle which excites opposing induction currrents in a copper conductor surrounding it. In this work we find the following significant passage:—"If an electric pole be moved at a constant distance above a flat plate the electrification, when once excited, follows it, and the simplest and, indeed, the usual explanation is that the electricity, supposed material, is the thing which moves, but we reject this hypothesis." We here see Hertz already freeing himself from the "usual explanations."

In the year 1883 he devoted his attention to a group of phenomena which always interested him, namely, electrical discharges in gases. In his first work on this subject, "On a Phenomenon accompanying Electric Discharge," he describes some singular luminous rays and cloud-like or arborescent appearances observed when the electrical discharge from an induction coil is allowed to pass out of a tube into a mass of gas which is not too highly rarefied; the positive electrode was inside the tube and the negative one near its mouth. The experiments were greatly varied, and the description of them, although only eight pages long, is full of detail.

To the same year belong the "Researches on the Glow-Discharge," which were carried out in Berlin, although the Paper is dated from Kiel. At that time there existed but three methods for the production and study of the phenomena of electric discharges as they occur in rarefied gases; namely, the influence machine, the induction coil and large voltaic cells of high electromotive force. Of these Hertz chose the third, and constructed a secondary battery with 1,000 pairs of lead plates, enabling him to obtain an electromotive force equal to that of 1,500 Daniell cells in series. The current yielded by it was led by wires into discharge vessels of various shapes. Hertz observed more especially the luminous appearances near the cathode with high vacua.

Here it is the rays of the glow discharge and the cathode rays, which are certainly related to them, concerning which Hertz's work discloses many important facts, although he was not able to entirely lift the veil from them. Apparently this was not possible except from his higher point of view attained through the later researches, namely, that of the doctrine of electric oscillations and waves. Even here we find occasional mention of electrical waves and of electrical movements which are propagated through a medium like waves; but the ideas are not yet so clear as they came to be eventually by reason of the later striking experiments.

The first part of the Paper is devoted to an old and much debated question, "Are the discharges through a rarefied gas continuous or discontinuous? Are they still discontinuous in the particular case considered here, when we apply to the gas an apparently continuous battery current?"

Hertz endeavours by ingenious arrangements to prove that his discharges are continuous. On looking over the lines of the argument, however, it is seen that they are only able to establish a lower limit to the number of separate discharges in a second. Whether discontinuities of very high frequency occur or not cannot be definitely decided by the method used, a fact of which Hertz himself was quite aware. If we consider the phenomena after assuming the existence of oscillations, evidence for which is furnished by the striation of the luminous column, thus rendering it analogous to the interference phenomena of a periodically varying source, a distance of 1·6cm. between the striæ, which is easily obtained, would correspond to a wave length of 3 cm. From Hertz's later investigations we know that this represents an electric disturbance, with a frequency of 10,000 million per second. Fluctuations with such high frequencies were no longer observable by the method used, since they do not obey the ordinary laws of electric currents, as was shown by Hertz's later work. I cannot here enter into details concerning the experiments. It would appear that his proof had not satisfied him on this point, for at the end of the Paper referred to he suggests the intermediate assumption, according to which the flow of electricity through a gas is, on the whole, continuous, but that in the tube itself electrical motions of an oscillatory character may be superposed on the constant current, a view which is rendered even more tenable by more recent investigation.

He likewise considered the very important question of the course of the stream lines in a gas traversed by electric discharges. A necessary introduction to this was the proof that cathode rays do not deflect a magnet, although they are deflected by it. It appeared, further, that the cathode rays do not indicate the path of the discharge, but are set up in the course of the discharge, and then obey definite laws of propagation. Experiments upon the absorption of cathode rays were indicated, which have since led to a series of beautiful experiments by Philipp Lenard.

In the last part of this Paper he shows, among other things, that the cathode rays do not exert any electrostatic action, and that they certainly cannot be regarded as electrified particles shot out from the cathode, although many physicists often adhere to and express this view.

I should like to refer to the experiments here described concerning the peculiar property of cathode rays, that of bringing about the equalisation of electric potential in a direction transverse to them, and so promoting "transverse discharges," experiments which have been extended by other observers. This behaviour of cathode rays reminds us of a quite analogous property of light waves, discovered by Hertz; namely, that the ultra-violet waves possess the same equalising power in a high degree.

The general results of the work can be better understood when it is stated that they support a view expressed in similar form by other observers, for example, E. Wiedemann and Goldstein, namely, that the cathode rays consist of a certain form of ether-motion more nearly allied to light than to any other natural agent, and that they are set up by electrical actions, but afterwards constitute an independent phenomenon, just like the light sent out from an electric lamp.

(*To be continued.*)

* Memorial Address by Prof. Hermann Ebert, delivered at the meeting of the Physical Society of Erlangen, March 7, 1894. Translated by James L. Howard.

Transmission of Pictures by Electric Current.—M. Bertillon, the inventor of the anthropometrical system of identification adopted by the Paris police, is endeavouring to revive the use of the picture telegraph, as he thinks that it would be of the greatest service in rapidly transmitting and disseminating the portraits of suspected Anarchists and other criminals.

fully into the question, and arrives at the conclusion that the image measured in this way is 1¼ times the true diameter of the pupil, and thus shows that it is necessary to multiply the measurement actually obtained by ⅘ in order to get the true result. When this correction is made these pupillometers give a perfectly accurate result. They are simple in construction and rapid in action. The errors arising from parallax and from confusing the border of the iris with the pupil, which are so serious in most pupillometers, are entirely overcome in this.

The simplest form employed in the author's experiments was one due to Robert-Houdin, and is illustrated in Fig 2. It consists of a shallow copper cylinder 12 millimetres deep, the front being provided with an opening and a small hole, *b*. A screen pierced with a small hole, *a*, and provided with an index, *c*, slides over this opening by turning about an axis, *d*, in the circumference of the circle. The distance between the two holes *a* and *b* can be read off on the scale by the index *c*. All lateral light can be shut off by the use of a dark cloth. Other instruments have been devised on the same principle. One due to Gorham consists of a metal tube closed at one end with the exception of a radial opening. A metal disc pierced with holes arranged radially in pairs at various distances apart is attached at the closed end of the tube in such a manner that it can be turned so as to present different sectors to the radial opening at the end of the tube. In this manner, by looking along the tube and turning the disc, two bright spots of light are seen, and the distance apart of the spots seen can be regulated by simply turning the disc. When two of the holes are such that the circles of diffusion touch each other, it is known that the distance

Fig. 2.

apart of these holes is equal to the diameter of the pupil. M Gorham proposed to use this instrument as a photometer by measuring the size of the pupil when the tube is turned towards different lights. The distances of the lights were adjusted till the diameter of the pupil was the same whichever light was looked at, and it was assumed that under these circumstances the square of the ratio of the distances was equal to the relative candle-power of the lights. This assumption is, however, doubtful, as the contraction of the pupil does not depend merely on the intensity of the illumination. Before concluding the account of the various pupillometers yet devised the method of photographic records used in 1887 by Beliarminoff must not be forgotten. This scientist used a chronophotographic apparatus, by means of which the diameter of the pupil could be ascertained at any instant during the course of the tests. This method undoubtedly is the most accurate, but it is too complicated and costly for use.

As regards the direct action of light upon the iris, some experiments made by Brown Sequard in 1847 appear to prove that only the luminous rays have any effect, heat rays and chemical rays being inactive. The eyes experimented upon were those of fish and batracians. They were extracted from the orbits immediately after death, and the pupils were found to contract on the approach of a candle, and to expand again in the dark, the effects being reproducible some times as frequently as 100 times in an hour. The interposition of a plate of alum did not alter these effects, showing they were not the result of heat rays. The persistence of the pupil movements, long after the nerves had lost all sensitiveness to irritation, seemed to prove that the action was muscular and not nervous. Moreover, utilising the fact discovered by Brücke that the cornea and crystalline of the ox and the rabbit absorb the violet and ultra-violet rays, light was allowed to fall on the eyes of frogs after having been previously filtered by passing through the eye of a rabbit. The pupillary contraction was found to take place just as before. All the evidence is thus in favour of the view that only the luminous rays are capable of producing the movements of the iris. Experiments of a like nature on human eyes are however, still wanting, and it is to be hoped that some will before long be made.

Actual measurements of the diameter of the pupil of the eye have been very rarely made. Lambert, in his book on photometry published during the last century, gives a few measurements and conclusions founded on them. The principal of these conclusions is that if the eye be exposed to different degrees of illumination, the area of the pupil exposed does not vary inversely as the illumination, but in such a manner that the product of the illumination and the area exposed becomes less and less the feebler the illumination. M. Charles Henry is trying to reproduce these experimental results of Lambert with better and more reliable apparatus.

HEINRICH HERTZ.*

(*Continued from page 299.*)

The last research carried out in Berlin is entitled "On the Behaviour of Benzine as an Insulator and Absorber." All insulating materials exhibit in a greater or less degree the often very troublesome property of absorbing and retaining a portion of the electric potential acting upon them. In the older theories this process of "absorption" is represented by assuming that the electricity partially wanders from the charged condenser plates into the insulating material between them, and is there retained. But it was soon observed that the property of absorption is essentially connected with want of homogeneity of material, so that homogeneous crystals, for example, exhibit the phenomenon only in a small degree. In order to obtain more definite results Hertz undertook experiments with liquids which can easily be rendered perfectly homogeneous, and he found in commercial benzine a medium which insulated sufficiently well for his purpose. It then appeared that the dielectric power of benzine increased under the continued action of electric forces. The cause of this was traced to the increase in the amount of suspended or dissolved impurities which were set free; under the influence of electric charges, therefore, the liquid is "electrically cleaned." It was evident, also, that the power of absorption decreased after this prolonged cleaning, so that this property must really be attributed to want of homogeneity. No migration of free electricity takes place, but the electric stress takes hold of the separate foreign particles embedded in the medium, and arranges them in a sort of strained or polarised condition. Hertz showed that this was the case by suddenly letting the liquid flow out of the trough which he had used as a condenser in these experiments, or by lowering into it two metallic plates connected with an electrometer, which clearly indicated the presence of this polarised state in the medium.

Although somewhat anticipating its chronological order I will here mention a short communication "On the Dimensions of a Magnetic Pole in Different Systems of Units," in which Hertz shows, although quite objectively, in the then burning question of the dimensions which should be chosen for electric units. He shows that the so-called "electro-magnetic system" is not more justifiable than the "electrostatic system," simply because it does not lead to want of agreement between the theories of Maxwell and Clausius; he then points out the cause of this want of agreement, and shows that the ratio of units in the two theories is exactly inverted if the magnetic measure of the current is taken as a starting point instead of the electric one.

We come now to the unique and splendid theoretical investigation of the year 1884, which is certainly the most important one in connection with the further development of Hertz's ideas, namely "On the Relations between Maxwell's Fundamental Equations of Electrodynamics and those of Opposed Theories." We may characterise this as Hertz's greatest contribution to theoretical physics.

As the title itself indicates Hertz now declares himself definitely opposed to the orthodox theories of electric phenomena which at that time were put forward in Germany, and he passes over to the camp of Maxwell's followers. But why does he take this step? He

* Memorial Address by Prof. Hermann Ebert, delivered at the meeting of the Physical Society of Erlangen, March 7, 1894. Translated by James L. Howard.

was not attracted by the fact that in Maxwell's theory at that time the part which explained light as an electro-magnetic phenomenon was still shrouded with a certain degree of mystery. He was not allured by the wide perspective and the multitude of new problems towards the solution of which a researching mind would be attracted; no, it was after a prolonged struggle with his inward conviction that he freed himself from the old ideas which had become fast rooted even in him. He proved, firstly, that the systems of equations of the older theories are incomplete, that from their certain members are missing, the absence of which leaves a supporter of the theory at disadvantage would concede to be a defect. But if these terms are added the formulæ begin to be unwieldy and awkward, in place of finite expressions we have infinite series which certainly converge towards a finite limit, but which appear so opposed to nature that the dissatisfaction on arriving at such formulæ is not compensated by the fact that we at last possess the complete expressions for the observed phenomena. Hertz then deduces from the unwieldy formulæ a system of equations of great symmetry and simplicity, a system in which is immediately detected as a known one in Maxwell's theory. The necessary improvement in the older theories leads, therefore, to that of Maxwell, and this must be chosen as the starting point in all further progress. But even Maxwell's formulæ are here expressed in a new form, and this is an important advance in the theory. Maxwell, free as he was, could not completely emancipate himself from the older views, and his formulæ possess a slight awkwardness and want of simplicity, traceable to the fact that the fundamental ideas of his theory is not yet logically and clearly expressed by them; they still retain traces of conceptions belonging to the older systems and ordinary conceptions, as Hertz occasionally and significantly calls them. Hertz has definitely removed these ordinary notions, thus clearly exhibiting the kernel of Maxwell's theory. Already in this Paper of 1884 we meet with that system of six partial differential equations which served afterwards as Hertz's guide along the tedious and devious path of his experimental researches.

Hertz had thus acquired new views from his theoretical considerations, and with this discovery in theory his life work was indicated for him. He must now strive to prove experimentally the superiority of Maxwell's theory and to trace all the immediate consequences of it. That the task of finding out the best method was no easy one even for a Hertz we may infer from the fact that he was occupied during three years merely in preparing the necessary apparatus.

One of the most important consequences of Maxwell's theory was that disturbances of electrical equilibrium produced at any place must be propagated as waves through space with definite velocity, and, with the velocity of light. This was plainly a fact to work upon. If this propagation was to be traced through, the successive elaboration by the disturbances must be rapid, and if a definite effect was to be observed they must also follow each other at regular intervals; that is, periodically varying electrical conditions, or electric oscillations must be set up, the period of which would have to be very small so that the corresponding wave length, taking into account the extraordinarily high velocity of propagation, should be only a few decimetres.

The method of exciting electrical oscillations was indeed known, and that of producing rapid electric disturbances had already been investigated in Helmholtz's laboratory. As far back as 1870 Von Bezold had actually measured the length of electric waves and observed their interference in wires, and yet some links in the chain were wanting. One, or rather two, further conditions were necessary. We are fortunate in possessing Hertz's own account of the original his epoch-making work. In the introductory notice to his collected Papers on electric waves* he gives a classically beautiful picture of the gradual advance of a genius in research, in which his modesty compels him to omit much that we ourselves must fill in, namely, the importance of his earlier work.

He tells us that his interest in electrical oscillations was originally awakened by the Berlin prize of 1879, which was to be awarded for an experimental proof of a relation between electrodynamic forces and dielectric polarisation in insulators. Prof. von Helmholtz advised young Hertz to dedicate himself to this research. Hertz answered, however, that the then known oscillations were too slow to ensure success, and he therefore gave up the research, but from that time he was on the look out for everything connected with electrical oscillations. Consequently he immediately recognised the importance for his purpose of an observation which in itself appeared very trivial. One of those accidents occurred which often point the inquiring observer to the right path and lead to important consequences. Hertz tells the story himself very neatly. In the collection of physical apparatus at Karlsruhe he found an old pair of so-called Riess's or Knochenhauer's spirals, short, flat coils of insulated wire, with the turns all in the same plane. Hertz showed them in lecture and performed experiments with them. He there

* "Electric Waves," by H. Hertz, translated by D. E. Jones. Page 1. Macmillan.

upon noticed that the [illegible] small induction coil, [illegible] inside [illegible] inserted in the circuit of the [illegible] covery of the "electric spark gap" [illegible] ntative measurements possible. [illegible] previously been somewhat [illegible] above all that a very [illegible] experiments in which sparks played [illegible] upon as "impure" and [illegible] distance of time, provided only the discharges for example, must [illegible] small capacity, the paths of the discharge were of simple form and consisting of [illegible] short wire, or the [illegible] distance were fulfilled, in general, [illegible] electrical [illegible] We have here the real kernel of Hertz's work, and [illegible] sum up the experimental evidence of all [illegible] following sentences:

1. If we allow small condensers with small [illegible] through short and simply constituted circuit [illegible] long spark gap, we obtain a sharply defined discharge of very [illegible] duration, which is the long sought for [illegible] trical equilibrium. This was a discovery which [illegible] by no theory a nearly [illegible] which, however, all the later work depends. [illegible] further that at the same time success was [illegible] point, since at most of the reported [illegible] that Hertz had a [illegible] of the [illegible]

2. Such [illegible] circuit of [illegible] even when the two circuits are separated from each other [illegible] distances. Hertz had therefore [illegible] which he could detect the waves produced by the exciter [illegible] pagated to any distance.

In the work which now appeared, "On very Rapid Electric [illegible] latter, we find him occupied with these [illegible] studying his apparatus, and gradually [illegible] [illegible] As an exciter of oscillations he uses [illegible] metal rods, to the ends of which metal [illegible] connected. The exciter is backed in the middle by a [illegible] with small spherical knobs between which [illegible] exciter is charged by an induction coil [illegible] whose discharge only plays a secondary [illegible] intermediation. The resonators [illegible] are, likewise provided with [illegible] that they show the most distinct resonance [illegible] they are "electrically tuned." When a resonator [illegible] up in them, sparks pass across the gap, and the greatest [illegible] the spark measures the intensity of the effect.

Such is the principle of the new and simple means which [illegible] has introduced into the physical laboratory, and which [illegible] physicists are at present working in various directions, [illegible] endeavouring to penetrate into the unknown. It was [illegible] strange accidental circumstance that the discovering [illegible] later work of Hertz met with immediate recognition rather [illegible] to their intrinsic value. How often the greatest discoveries [illegible] long unheeded. Hertz found in his earlier experiments [illegible] resonance phenomenon which attracted his [illegible] ness and singularity and characteristic [illegible] to splendid character. [illegible] of the resonator sparks were [illegible] the primary circuit. If the latter [illegible] spark gap they appeared small and hardly [illegible] came considerably larger and [illegible] between the two spark gaps. [illegible] Later [illegible] light on this [illegible] drama crash on [illegible] year [illegible] came to the conclusion that this singular [illegible] is traceable only to ultra-violet [illegible] M[illegible] termed these researches and discoveries [illegible] experimental physics that [illegible] these experiments did not [illegible] closer relation between [illegible] Hertz popular, so that everything [illegible] read.

For people, however, the [illegible] though only subsidiary, [illegible] we were on the track of [illegible] electric oscillations. We [illegible] Hertz [illegible] ratus. In the following [illegible] linear Electric Oscillations [illegible] most difficult and the most important of [illegible] searches; it is often [illegible] it forms a necessary step to the following [illegible] become familiar with the phenomenon [illegible]

to deal with the propagation of oscillations through space. The apparatus was already furnished; as exciter he made use of a straight metal rod with a spark-gap in the middle and a spherical conductor at each end to give it capacity. When sparks pass rapid electrical surgings occur; we have a rectilinear oscillation whose effect is radiated out into surrounding space. As receivers he used tuned circles of wire, likewise provided with very small spark-gaps whose length could be measured with a micrometer. These were brought into all kinds of positions with respect to the exciter, and Hertz studied and measured the effects. These effects were very different at different points in the neighbourhood and in the various positions of the receiver, but a law was soon found to apply to them. "The discovery and disentanglement of these extremely regular phenomena gave me peculiar pleasure," says Hertz. By an argument which was ingenious, though simple in its results and indisputably clear throughout, he established in each case how the electrical radiation must act at the different points in the neighbourhood of the oscillation, in order to produce the observed effect on the receiver, and he finally succeeded in giving a clear and intelligible account of the propagation of the radiation through space. Many remarkable phenomena then presented themselves, of which the older theories could offer no explanation. In the same year, 1888, he showed in his Paper on "The Forces of Electric Oscillations, treated according to Maxwell's Theory," that this theory gives exactly the same distribution of forces as his experiments had yielded, with all their peculiarities and apparent anomalies. Hertz set out in this Paper from the simplified form of Maxwell's theory which he had established in 1884.

Great discoveries now followed one after another, each representing a new triumph of Maxwell's theory, and, above all, of the newer views. The papers which were presented to the Berlin Academy between November 10, 1887, and December 13, 1888, mark a new era.

The Berlin prize problem now received a definite solution in the research "On Induction Phenomena produced by Electric Disturbances in Insulators." It was shown that "alternating conditions of electric stress or dielectric polarisation" produce electro-dynamic action and inductive effects, analogous to those set up in a conductor by a rising or decaying voltaic current. The older theories had for the most part disregarded the intervening medium, according to them the effect travelled directly across it, whereas Maxwell's theory had these electro-dynamic actions as one of its most important consequences. At the same time the old controversy concerning the action of "unclosed circuits" was set at rest.

Three months later appeared the Paper "On the Velocity of Propagation of Electro-dynamic Actions." In this research an experimental proof was given of the fact that electro-dynamic actions are propagated through space with finite velocity. For the velocity of electric waves in air a quantity of the same order as the velocity of light was obtained. For the velocity of propagation along stretched wires he found a value different from that in air; theory required them to be the same. In consequence of an error in calculation the velocity of waves in wires was found smaller than the velocity of light. But he here showed himself an unbiassed lover of truth. Although convinced of the truth of the theory he submitted his actual results, and confessed that he had here met with an unavoidable difficulty. Let us quote his own words on the subject, written four years later in the introduction to his book after he had explained the discrepancy:—"I have described these results in great detail because I wished to convince the reader that I was not merely endeavouring in this research to support a preconceived opinion by the most convenient and suitable interpretation of experiment. On the other hand, I have carried out the experiments, which in themselves were not easy, with the greatest possible care in the face of a preconceived opinion. And yet, with all my good fortune, I have had decided misfortune just in this experiment. For, instead of reaching the true result with small trouble, which a properly arranged plan would probably have enabled me to do, I have apparently taken great pains, and fallen into error."

It was not discovered until later that the deviations from the theory were caused simply by the walls of the room, which reflected the electric waves impinging on them. Edouard Sarasin and De la Rive have finely shown that the velocity of propagation in wires has the same value as in air, each being that of light, by repeating Hertz's experiments on a large scale, and with every precaution, in the large machine shop of the Geneva Waterworks. The result is therefore quite decided for us now; but the disturbances which crept into Hertz's own experiments have given us a proof of his extraordinary acuteness.

The account of the research "On Electro-dynamic Waves and their Reflection" was published in the same year. Although Hertz had hitherto only succeeded in working with waves propagated along wires, he now demonstrated the existence of similar waves in free space. Opposite the radiator a large screen of zinc plate, with a plate suspended on the wall, the electric waves emitted from the radiator were reflected from this plate and in front of the direct waves interference phenomena were produced, consisting of stationary waves with nodes and loops. When, therefore, Hertz moved the circle of wire which served as a receiver to and fro between the screen and the radiator the sparks in the receiver circuit disappeared at certain points, reappeared at other points, disappeared again, and so on. Thus there was found a periodically alternating effect corresponding to nodes and loops of electric radiation, showing clearly that in this case also the radiation was of an undulatory character, and the velocity of its propagation finite.

In the Paper "On the Propagation of Electric Waves along Wires" he shows that alternating electrical movements with frequencies as great as those under consideration (about a hundred million per second) are confined to the surface of the conductor along which they are propagated, and do not penetrate into its interior. This is a very important experimental confirmation of a theory of Poynting, founded upon the ideas of Faraday and Maxwell, concerning electric currents. According to this theory an electric current is a phenomenon which has its seat in the region outside the wire conveying it rather than in the interior of the wire. The magnetic effect of a current shews us that something goes on in this outside space which is very closely connected with the passage of the current. We are not to look for something flowing along the wire, but must rather consider that the energy enters the wire from without, and is thereupon converted into the special form of heat. It is thus not the copper core of a cable which conveys the energy from the sending to the receiving station, but the insulating layers surrounding the core; the terms "conductor" and "non-conductor" exactly change places. It is certainly true, as Hertz very pointedly remarks, that this apparent paradox only arises because we neglect to state what we mean by the term *conduction*. In reality the electric fluid of the older theories is abolished, in its stead have been introduced electric and magnetic forces existing independently in space, and advancing through it, carrying their energy with them, and for these the circumstances of conductivity are exactly the inverse of those for the hypothetical electric fluids.

In the course of his experiments Hertz had learned the method of producing, and working with, very short electric waves of 26cm. length. The oscillations corresponding to them could be collected by a concave cylindrical mirror and concentrated into a single beam of electric radiation. According to Maxwell's electro magnetic theory of the phenomena of light such a beam must behave like a beam of light. That this is the case was shown by Hertz in his Paper "On Electric Radiation," the communication which has become the most popular one, and has created the greatest astonishment far and wide. The modest man says, in the introduction to his collected Papers, "These experiments succeeded each other quickly, and without any difficulty. The experiments with the cylindrical mirrors soon attracted notice, and they have been often repeated and verified. They have met with an approval quite beyond my expectation."

He showed how such electric radiation was propagated in straight lines like light, that it could not pass through metals, but was reflected by them; that, on the other hand, it was able to penetrate through wooden doors and stone walls; he also proved, by setting up metallic screens, that a space existed behind them in which no electric action could be detected, producing in this way electric shadows; and, by passing the rays through a wire grating, he succeeded in polarising them, just as light is polarised by passage through a Nicol prism. But the most striking experiment was that in which he directed the electric ray on a large pitch prism, weighing about 12cwt., the ray was deviated, being refracted like a ray of light in a glass prism. Thus he gave to the whole its finishing touch, and the edifice was now completed.

In the communication which appeared three years later and this was dated from Bonn, "On the Mechanical Effects of Electric Waves in Wires," he demonstrated that not only does a wave of changes of electric state travel from the radiator through space with the velocity of light, but that along with it and inseparable from it there exists a magnetic wave, as theory requires.

In his last experimental work he finally returns to the phenomena of discharge in gases and shows also at the same time, as Wiedemann and Ebert, that cathode rays do pass through thin films of metal, but are stopped by a dielectric film, no matter how thin it may be.

And now inexorable death sets a limit to the further progress of the clever experimenter. We are indebted to him for many other Papers of a theoretical character, as on the fundamental equations of Electro-dynamics in Bodies at Rest and on Maxwell's theory, a great advance in the mathematical theory of electric and magnetic phenomena.

On his finished but unpublished work, on the Principles of Mechanics, to the early appearance of which the scientific world looks forward with intense interest,

Let us cite once more in proof of [illegible]

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at a distance, and concerning electrical and magnetic effects he has shown that they are propagated from particle to particle through space with finite velocity. This is a result of great and general, one might almost say philosophical significance. The mysterious darkness which surrounded those secret distance actions of former times has been cleared away; the dogma, honoured by science until now although unwillingly tolerated by reason, that something can act where it is not, has lost its application to the case of electric and magnetic actions. Further, the identity of the form of energy in the case of two powerful agents in nature has been conclusively established; light and electrical radiation are essentially the same, different manifestations of the same processes. The old elastic solid theory of optics is thus resolved into an electromagnetic theory. The velocity of propagation of light is the same as that of electro-magnetic waves, and therefore by the laws of optics the scope of optics is enormously widened; to the ultra violet, visible and infra red rays with their wave lengths which can be reckoned only in thousandths of a millimetre, are to be added waves many metres in length; the spectrum is infinitely extended, even if the rods and cones of our eyes do not respond to the new vibrations.

But in another direction we owe much to Hertz's investigations; we are, it appears to me, brought much nearer by them to a solution of the burning question, "What is electricity?" Hertz shows that there is no real electricity which can be regarded as a fluid as in the older theories; what we wished to explain by assuming it are conditions or states of a medium which, although hypothetical, manifests itself by its effects, "the ether, which permeates all matter." Lead to this hypothesis, the phenomena of magnetism, electricity, and light apparently tend at last a single explanation in the vibrations of the ether. Whenever such an edifice is completed, it shall be considerably nearer the possibility of finding a single explanation for the whole of nature. These are the results of the most recent discoveries, in which Hertz has played a most conspicuous part.

A glance over the list of his contributions to science, we ask in astonishment, "Is it possible that one man in the space of thirteen years could furnish such a wealth of new avenues of research?" In the intense suffering of Hertz and his premature decease awakes our deepest sorrow, at the thought of what this mind might have explained makes us rail against the latter fate that took from us; we may still say his was a short but happy and richly rewarded life. The fame of our Hertz is secure and will shine out during centuries of increasing intellectual development, whatever great deeds they may hide in their bosom; the influence of his discoveries will make itself felt as long as electro-magnetic waves continue to heat and illumine the earth.

AMERICAN NOTES.

[FROM OUR OWN CORRESPONDENT.]

NEW YORK, *July 7, 1894.*

Long Distance Electric Roads.—Every now and then we hear of a new scheme for a long distance electric railway, the latest project being for one between Washington and New York, whose promoters have applied for incorporation. None of these ambitious schemes have thus far gone beyond the promotion stage, unless we except the feeble attempts made by the Chicago, St. Louis line, whose prospectus dwelt in such glowing terms on the profits to be derived from transporting World's Fair visitors. In some cases the scheme for a long distance line conceals another purpose, the real object being to secure franchises on better terms for short lines which are represented as sections of a trunk line which is never built.

Purifying Water and Deodorizing Garbage.—Some of the members of the Tammany City Government seem to be greatly interested in a process for purifying the municipal water supply and deodorizing city garbage by electrical means. In the latter case sea water through which an electric current has been passed is mixed with the regular water supply in homeopathic doses. We cannot learn how the process is to be applied to deodorize a garbage island that has become a pestilent nuisance, but this use has been proposed. As residents in the vicinity have applied for an injunction against further dumping there, though in the face of the promise of wonders when the electrical apparatus gets started, we fear that this latest political contribution to electrical science may not have an opportunity to demonstrate its merits in this respect.

Electro Medical Science.—An employé of the Edison lamp works of Harrison, N.J., a few days ago was rendered unconscious by a shock from an electric current, in which state he remained for several days, notwithstanding the efforts of his physician. Finally, becoming convinced that the patient did not recover on account of being "full of electricity," the doctor, applying his electrical knowledge, connected one end of an insulated wire to a water pipe and the other end to a damp sponge, which was rubbed over the body of the injured man. After the first application an improvement was noticed, we learn, and in a short time the patient recovered consciousness and is now convalescent. All of which is hailed by the newspapers as a new curative principle for the treatment of electric shocks.

CORRESPONDENCE.

ENGINE REPAIRS.

TO THE EDITOR OF THE ELECTRICIAN.

SIR,—I am glad to find from Mr. A. Lazenby's letter that the difficulties with closed type engines referred to by me in "Electric Motive Power" are now lessened in the improved types of the Willans engine, and I note that in condensing engines the temperature of the lubricant in the crank chamber does not often exceed 150° F.—Yours, &c.,

Suffolk House, Cannon street, E.C., July 16, 1894. ARTHUR T. SNELL.

LIGHTNING AND WOOD CASING.

TO THE EDITOR OF THE ELECTRICIAN.

SIR,—With reference to your remarks on page 157 regarding the phenomenon of sparking resulting from Hertzian waves impinging upon separated mains leads terminating in two flexible conductors, I should like to point out that danger is also incurred where insulated conductors of opposite poles are placed in contact with each other at the points of crossing in wood casing. In some wiring I have inspected, the first fuse protecting these points was either the main, or was of such large diameter as to render it doubtful if it would act at the comparatively small current that would result from an arc so formed. If the fuse did not blow, and the arc was maintained, the wood casing in the immediate neighbourhood of the latter would probably become ignited.

If this occurred during the night, or at any time with no one at hand to switch off, or if no main switch were provided, it might be difficult to extinguish the fire or limit the damage.

As far as my experience goes, this faulty method of wiring appears to be on the increase, and it would be a desirable for the offices to insist on the separation of conductors until protected by a small fuse.—Yours, &c., CHAS. A. HAWKINS.

July 6, 1894.

LARNE.

TO THE EDITOR OF THE ELECTRICIAN.

SIR,—Your "Note" with reference to Larne in *The Electrician* of the 13th inst. is inaccurate, as there has been no new penalty clause added to our agreement. At the meeting you refer to, the engrossed copy of the agreement was before the Board for signature, but a Commissioner objected to its being completed on the ground that the penalty clause of the draft copy had been omitted in the fair copy, and it was then decided to consult the Board's solicitor, by whom the agreement had been prepared. The solicitor attended a special meeting on the 7th inst., and was able to show the doubting Commissioner that his suspicions were groundless, and that there was no necessity to make any alterations or additions to the agreement. It was then signed by the Chairman and the Commissioners. The discussion over this lighting agreement has been vigorously carried on since last October, and, apparently, there are some members of the Board who do not think the matter has received adequate attention even now. The arc lights referred to are of 1,200 c.p. each, and not of 1,700 c.p. as printed.—Yours, &c., ARCHER TURNER,

Electric Light Station, Larne. Manager and Engineer.

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DEFENDANT'S EXHIBIT J-4

adapted to remove any doubt as to the identity of light, radiant heat, and electromagnetic wave-motion. I believe that from now on we shall have greater confidence in making use of the advantages which this identity enables us to derive both in the study of optics and of electricity.

Explanation of the Figures.—In order to facilitate the repetition and extension of these experiments, I append in the accompanying Figs. 35, 36_a, and 36_b, illustrations of the apparatus which I used, although these were constructed simply for the purpose of experimenting at the time and without any regard to durability. Fig. 35 shows in plan and elevation (section) the producing mirror. It will be seen that the framework of it consists of two horizontal frames (*a*, *a*) of parabolic form, and four vertical supports (*b*, *b*) which are screwed to each of the frames so as to support and connect them. The sheet metal reflector is clamped between the frames and the supports, and fastened to both by numerous screws. The supports project above and below beyond the sheet metal so that they can be used as handles in handling the mirror.

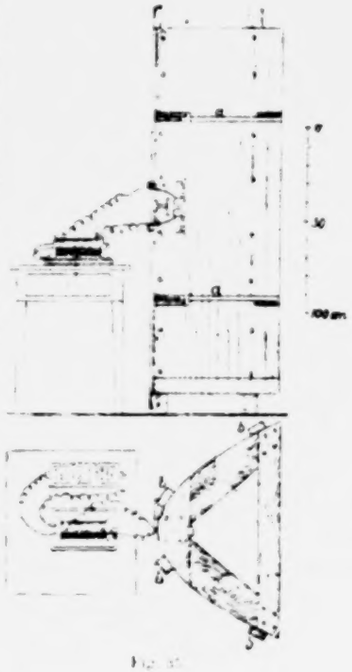

Fig. 35.

Fig. 36_a represents the primary conductor on a somewhat larger scale. The two metal parts slide with friction in two sleeves of strong paper which are held together by indiarubber bands. The sleeves themselves are fastened by four rods of sealing-wax to a board which again is tied by indiarubber bands to a strip of wood forming part of the frame which can be seen in Fig. 35. The two leading

wires covered with gutta-percha terminate in two poles [illegible] in the knobs of the primary conductor. This arrangement allows of all necessary motion and adjustment of the various parts of the conductor. It can be taken to pieces and put together again in a few minutes, and this is essential in order that the knobs may be frequently repolished. Just at the points where the leading wires pass through the mirror they

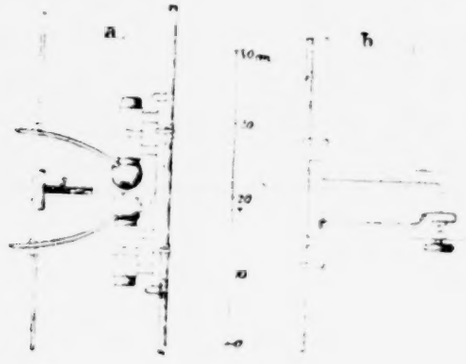

Fig. 36.

are surrounded during the discharge by a bluish light. The smooth wooden screen s is introduced for the purpose of shielding the spark-gap from this light, which otherwise would interfere seriously with the production of the oscillations. Lastly, Fig. 36_b represents the secondary spark-gap. Both parts of the secondary conductor are again attached by sealing-wax rods and indiarubber bands to a slip forming part of the wooden framework. From the inner ends of these parts the leading wires, surrounded by glass tubes, can be seen proceeding through the mirror and bending towards one another. The upper wire carries at its pole a small brass knob. To the lower wire is soldered a piece of watch-spring which carries the second pole, consisting of a fine copper point. The point is intentionally chosen of softer metal than the knob; unless this precaution is taken the point easily penetrates into the knob, and the minute sparks disappear from sight in the small hole thus produced. The figure shows how the point is adjusted by a screw which presses against the spring that is insulated from it by a glass plate. The spring is bent in a particular way in order to secure

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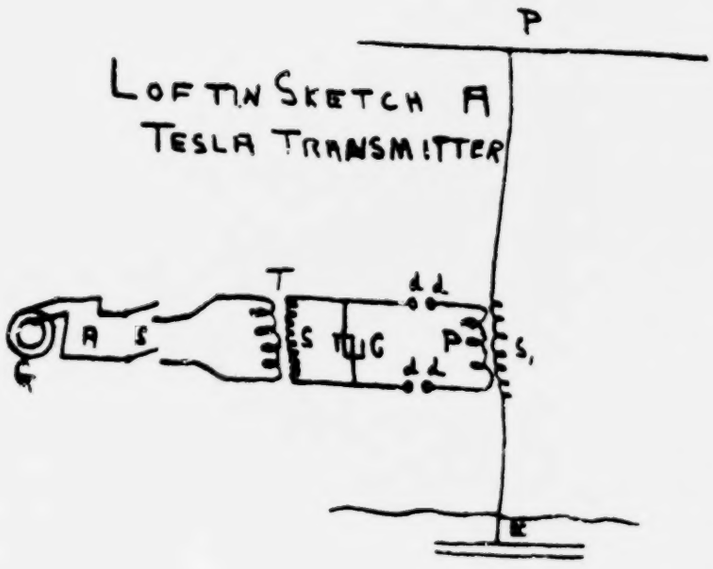
DEFENDANT'S EXHIBIT R-4



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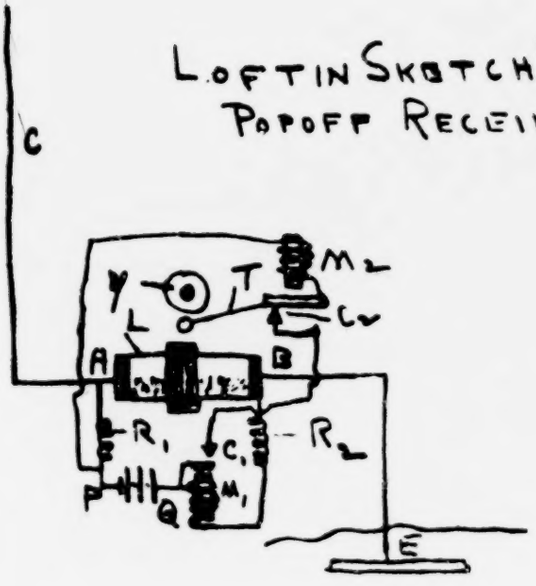
DEFENDANT'S EXHIBIT S-4

LOFTIN SKETCH B
POPOFF RECEIVER



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Navy Manual, by Robison, 1915

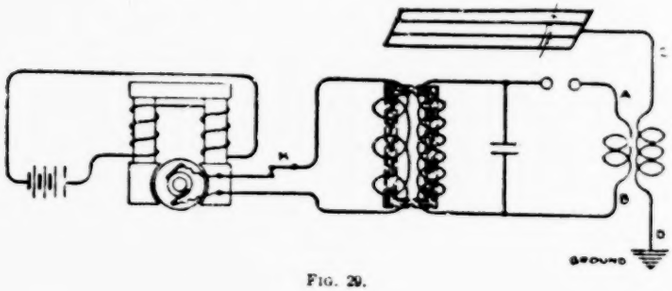


FIG. 29.

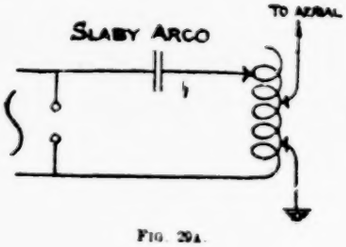


FIG. 29A.

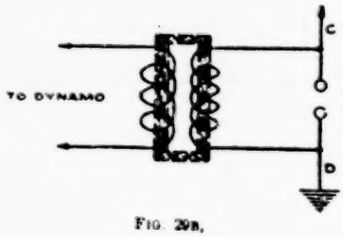


FIG. 29B.

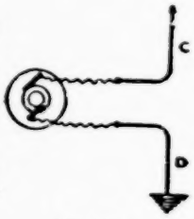


FIG. 29C.

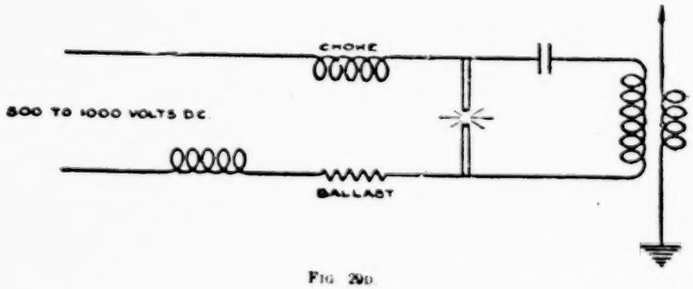


FIG. 29D

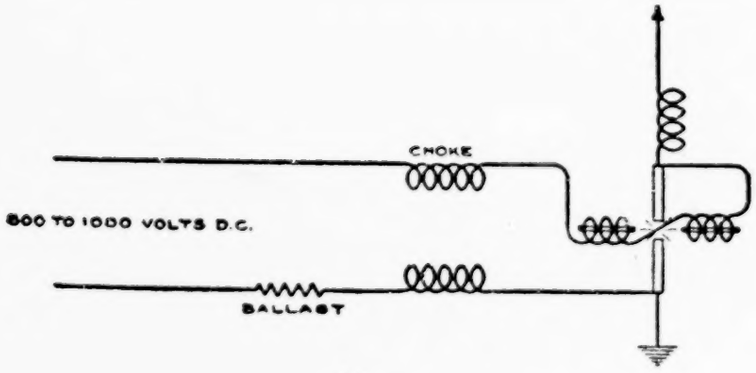
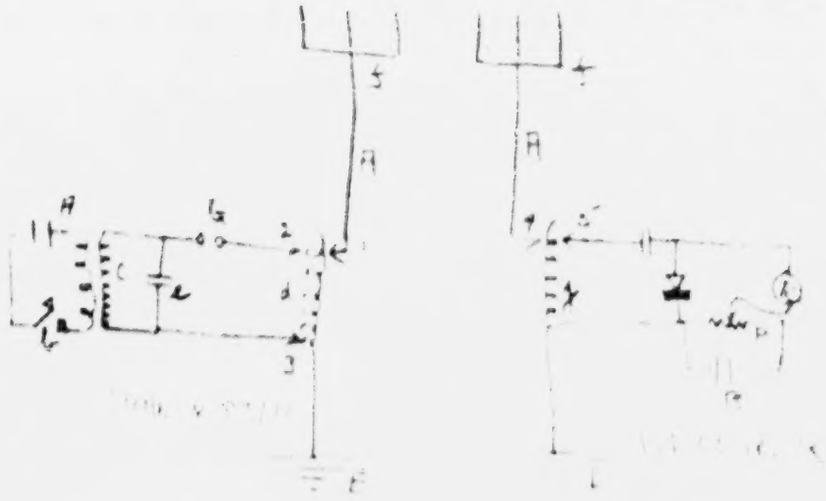


FIG. 29E.

LOFTIN SKETCH P

[fol. 3466] DEFENDANT'S EXHIBIT B-5

The Electrician, London, June 11, 1909

The Telefunken or Quenched Spark Discharger. By J. A. Fleming, F.R.S.

In my lecture last Friday evening at the Royal Institution time did not permit me to do more than give a brief description and show one experiment with the multiple small-gap flat plate discharger which has been devised by the experts of the Gesellschaft für Drahtlose Telegraphie for giving practical effect to Prof. M. Wien's method of excitation by shock in spark telegraphy. The methods now in use by that company were being described by Count Arco in a lecture at Cologne at the same hour as my lecture in London, under the title "Das Neue Telefunken System." Although Count Arco had kindly forwarded to me an advance copy of his lecture, I refrained at his request from more than a general statement of the nature of the discharger pending the publication of his lecture in the "Elektrotechnische Zeitschrift."

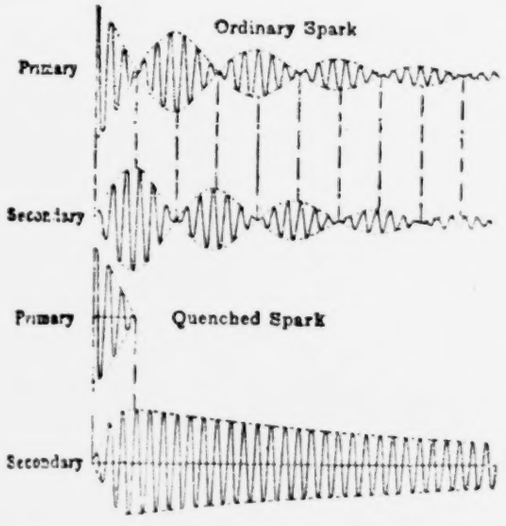


FIG. 1.—Oscillations in inductively-coupled circuits.

As there seems to be an impression that the Telefunken discharger and that of von Lepel are identical, it may be well if I describe here, briefly, experiments which I had not time to shown on Friday evening, and which seem to me to prove that the operative principles involved in the two appliances are different. I explained in the lecture that when isochronous primary and secondary oscillation circuits are connected inductively or directly, as long as the spark endures in the primary circuit so long will those reactions take place which result in the production of a complex oscillation in both circuits resolvable into oscillations of two frequencies. I illustrated this by an experiment with two

equal pendulums hung side by side on a loose string, and showed by means of my cymometer that in the similar electrical case of two equal coupled circuits oscillations of two frequencies were present. If time had permitted, it could have been also shown by the cymometer that these two oscillations were present in the primary as well as in the secondary oscillation circuit when using the ordinary spark-gap in the primary. The Telefunken discharger is based [fol. 3467] on the known fact that the damping of very short sparks is extremely large, and that if we can "quench" or stop the primary oscillations after one or two swings the secondary circuit then continues to oscillate freely with a single period, as shown in Fig. 1.

The discharger I used consisted of 12 round flanged plates of copper, 5 in. in diameter, the surfaces being turned true and having a groove in them (see Fig. 2). A mica ring is interposed between each pair of copper plates of such size that the mica half covers each groove. This groove is important, for without it the discharge spark tends to take place always at the edge of the mica. The mica is of such thickness as to make an air space of not greater than 0.01 in. between the flat copper surfaces. In this discharger we have then, say, 11 air gaps, each about 0.01 in. wide and of circular section. When this discharger replaces the ordinary spark-gap in the primary circuit it damps out instantly the primary spark, and hence excites the free oscillations in the secondary circuit by shock. If, then, we place the cymometer alongside of the secondary circuit we find in it oscillations of only one frequency and not two. Also, if we place it alongside the primary circuit, we cannot detect in that circuit any oscillations, because they are so rapidly damped out that they have too small a mean-square value to affect the cymometer or cause the Neon tube to glow perceptibly.

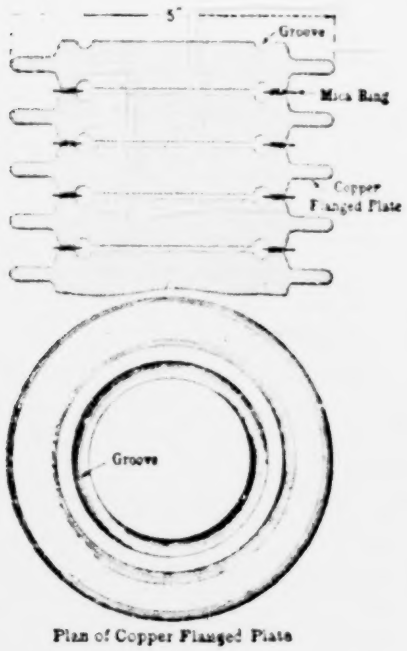


FIG. 2. Plan and section showing portion of disc cover.

In consequence of this rapid damping it is possible to employ an alternator having a frequency of 1,000 to 2,000 to create a corresponding number of primary discharge sparks per second, without producing any true arc discharge. The rapid cooling of the discharge surfaces entirely prevents it.

The discs for this purpose are made of copper or silvered copper plates, and in the case of large discharges the discs are made hollow and water-cooled.

The rapid succession of highly-damped primary sparks creates then an equally rapid succession of very feebly damped trains of oscillations in the secondary circuit having a very large mean-square value, and therefore possessing many of the properties of undamped oscillations generated without any true-arc effect. The operation of this discharger seems to me therefore essentially different from one in which an oscillatory arc is created between metal [fol. 3468] surfaces by the employment of a continuous or direct current, neither is its operation dependent on the presence of an atmosphere of hydro-carbon vapour. On the contrary, it may be described as having most perfect arc-quenching properties possible.

The Telefunken discharger could not, therefore, be placed in the circuit of the antenna as is the generator shown in the diagram of circuits in the article describing the von Lepel system in THE ELECTRICIAN of May 14th, whereas that later mode of connection is quite consistent with a performance of a discharger which is essentially an arc method and not a spark method.

Three other properties of the Telefunken discharger deserve notice. It is almost noiseless, and, being entirely enclosed, could be used in an inflamable atmosphere. It seems, therefore, likely to be of use in balloons or airships where an open or naked spark could not be employed. Finally, as the whole of the energy transferred to the secondary circuit expends itself in the production of radiation of one single wave-length it must be more economical than methods which generate waves of two wave-lengths, but capture at the receiver radiation conveyed by only one of these wave-lengths.

DEFENDANT'S EXHIBIT C-5

The Electrician, London, November 10, 1911

The Telefunken System of Wireless Telegraphy

Commercial wireless telegraphy in Germany owed its early progress to two groups of workers—namely, Prof. Braun, of Strassburg, on the one hand, whose wireless telegraph company became amalgamated with Messrs. Siemens & Halske, and, on the other hand, Prof. Slaby and Count von Arco, who were associated with the Allgemeine Elektricitäts-Gesellschaft (more generally known by the abbreviation "A.E.G."). Both these companies carried on a business in wireless telegraphy, but in 1903 the advantages of consolidation became evident, and the two companies combined to form the Gesellschaft für drahtlose Telegraphie m.b.H., Berlin. Thenceforth this Company supplied stations based on the combination of the Braun-Siemens and Slaby-Arco systems, and the resulting system became familiar under the shorter name "Telefunken." As was only to be expected, this amalgamation of interests produced a rapid development.

In what follows we are able, through the courtesy of the Telefunken Company (to use an abbreviated title) to give a complete account of the "singing spark" system and the apparatus with which the Telefunken stations are equipped.

Up to the year 1907 the slow spark was used by the Company (that is, about 20 sparks per second), but in that year the spark frequency was raised, with the result that the range of existing stations became approximately doubled. Since that time, however, a further great change has been introduced by using "singing quenched sparks."

It is well known that when two oscillating circuits are coupled together, the energy sways backwards and for[fol. 3469]wards from one to the other, and that each circuit emits waves of two frequencies; and this leads to serious inefficiency in practice with the usual spark, because only one of the two frequencies can be utilised. In 1906 Prof. Max Wien contributed an important article to the "Physikalische Zeitschrift," in which he showed that if the oscillations in the primary circuit were stopped as soon as the secondary circuit was oscillating, the latter would continue to oscillate at its natural period, and would therefore emit waves of only one frequency. A much higher efficiency

is, therefore, to be expected with the "quenched spark" than with the ordinary spark.

What takes place is shown graphically in Fig. 1. The two top curves show a train of oscillations in the primary and secondary circuits in the case of the ordinary spark, and it is seen that a maximum amplitude in one corresponds with a minimum amplitude in the other. Instead of the secondary giving a regular train of oscillations with decreasing amplitude it oscillates with "beats," in the same way as beats are heard when two notes of nearly similar pitch are sounded together. In the case of such coupled circuits, by means of a wave meter the two waves can be detected easily; and as a tuned station can only respond to the frequency to which it is turned, only one of these waves can be used, and thus half the energy is wasted. It is true that a single wave is obtained in the two extreme cases of very tight and very loose coupling, but neither of these afford a practical solution.

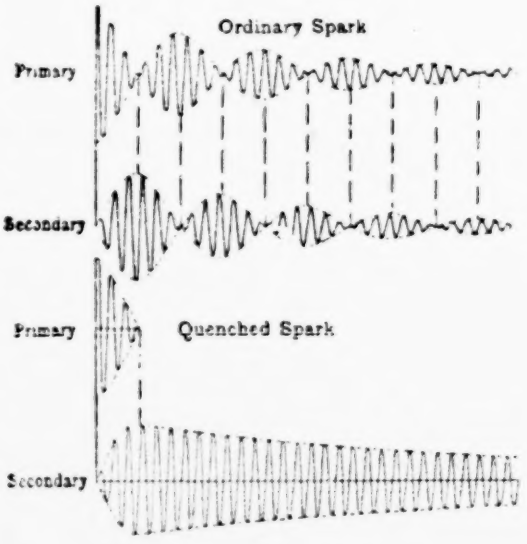


Fig. 1.—Diagram of oscillations in coupled circuits. (a) Ordinary spark, (b) quenched spark.

In the quenched spark system, on the other hand, the spark is quenched as soon as the energy in the primary circuit is a minimum and that in the secondary a maximum. Thus, after quenching, the primary no longer oscillates, and the secondary oscillates with its natural period; so that, under suitable conditions, a feebly damped train is obtained, as indicated in the lower part of Fig. 1.

In all probability many people worked unwittingly with the quenched spark before the appearance of Prof. Wien's Paper, for the conditions for quenching are easily obtained. With ordinary circular electrodes placed close together, or even with quite thin plates placed edge to edge so as to

form a small gap, quenched sparks are obtained and will continue so long as the heat is conveyed away rapidly [fol. 3470] enough. As soon, however, as the electrodes become hot the spark becomes an arc (that is, the metal is volatilised and takes part in the conduction) and quenching no longer occurs. Also a single wave is not obtained unless the spark gap is quite small, as is shown by the curves in Fig. 2 (due to Prof. Wien). If the gap is not very small two waves are obtained, both differing from that of resonance as already mentioned.

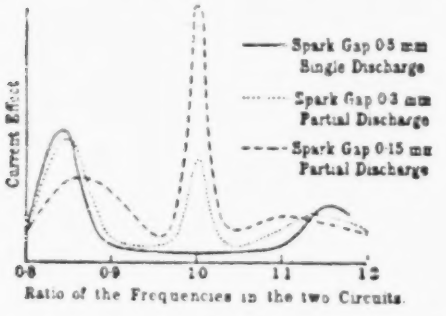


Fig. 2.—Curves showing the importance of small gaps in producing a single wave by quenched spark.

In the Telefunken system the exciting circuit containing the quenched spark gaps is coupled either directly or inductively to the syntonised antenna system. The coupling is made sufficiently close that the transfer of energy from the exciting circuit to the antenna takes place quickly, but, on the other hand, the coupling is so loose that quenching begins after the first "beat" oscillation. It is found that the most suitable degree of coupling is 20 per cent., whence it follows that the number of half waves in the primary before quenching occurs (being 1/λ) is five. To give the best result it is necessary that the reaction of the secondary circuit should assist the quench-

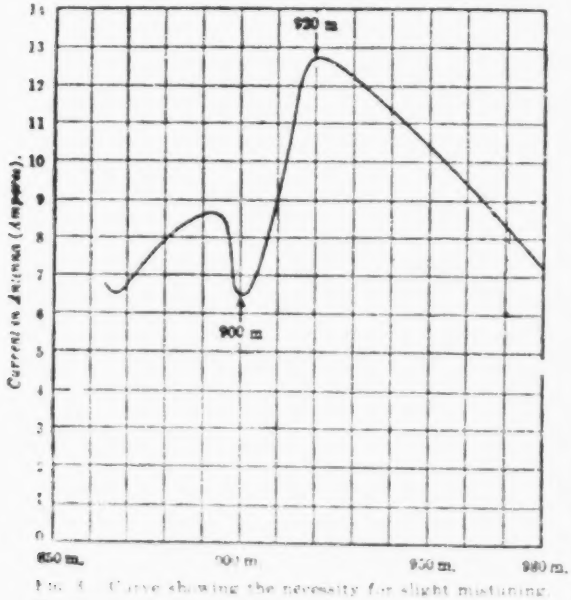


Fig. 3.—Curve showing the necessity for slight mistuning. Primary wave maintained constant at 900 metres. Secondary wave varied.

ing in the primary, and for that reason the two circuits are slightly mistuned—namely, to the extent of about 2 per cent. The closer the coupling the greater must be the mistuning. In practice the coupling is varied until an ammeter in the antenna shows a maximum, and in this way two or three maxima can be found, but the best result is obtained with about 20 per cent coupling.

Fig. 3 is an illustration of the effect of tuning. Here the primary wave was kept constant, and it is seen that the maximum in the antenna was not obtained when the circuits [fol. 3471] were in tune; one occurs on each side of the position of syntony, but the best condition appears in this case when the secondary wave length is 920 metres as compared with 900 for the primary.

In Fig. 4 are given resonance curves of the primary, when the secondary wave length is kept constant, for different couplings and primary wave lengths. It will be noticed that the primary wave is of practically the same length as

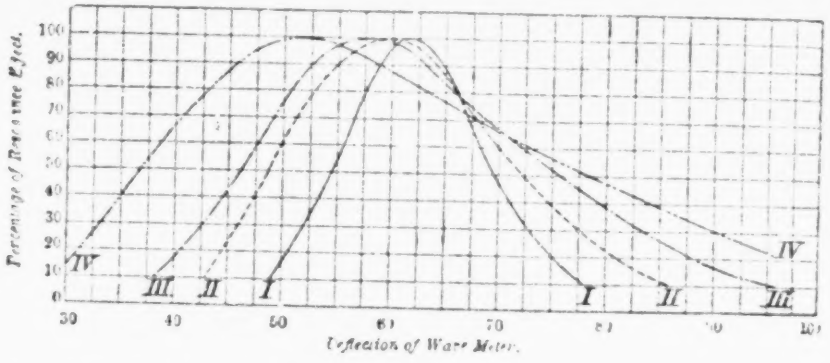


Fig. 4.—Resonance curves with quenched spark for various couplings and secondary wave constant.

	Coupling	Primary Wave Length	Secondary Wave Length		Coupling	Primary Wave Length	Secondary Wave Length
I	0·05%	1340	1340	III	9%	1294	1340
II	7%	1312	1340	IV	18·2%	1230	1340

the secondary wave for a very loose coupling, but there is an increasing difference as the coupling is made closer. The curves in this figure are not symmetrical because the wave meter readings were merely deflections, not wave lengths.

Since each spark gives rise to a definite series of oscillations if the quenching is precise, it follows that this system permits the use of a very regular series of sparks. By using

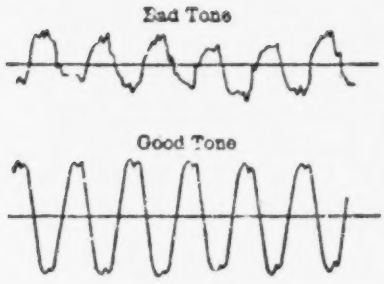


FIG. 5.—Oscillograph records of good and bad tones.

a rapid series a musical note is obtained in the telephone corresponding to the frequency of the oscillation groups or sparks, and this note is very easy to hear. Consequently the quenched spark system has three main advantages:

1. The transmitting apparatus and antennæ are small.

1. The transmitting apparatus and antennæ are small.

2. Large ranges.

3. High speed.

For producing the discharge continuous current might be used, but this has the disadvantage that it tends to give arcs, and high tensions are not produced easily. Further, continuous current would lead to complications in the receiver, and for this reason alternating currents of com- [fol. 3472] mercial frequencies were also discarded. Recourse was, therefore, had to an alternator giving a frequency of 500 (*i.e.*, 1,000 sparks per second). If there is merely one spark per half period a very good tone is obtained. This point is illustrated by the oscillograph records in Fig. 5. In the upper curve three partial sparks take place per half period and the tone is bad, whereas in the lower curve only one discharge per half period takes place. It is necessary to have the alternator circuit nearly resonant. It is not made quite resonant because the spark resistance introduces a variation. Thus the circuit is tuned for, say, 1,300 revs. per min., but the alternator is run at 1,500 revs. per min.

The speed of the alternators that are used can be varied about 50 per cent., and a pure tone can be obtained for each speed. Thus the tone can be varied continuously through half an octave; in addition, there are regulating devices combined with the machine or transformer, by which the

tone can be adjusted to the lower fifths and to the two lower octaves. These last-mentioned variations, in the case of small stations up to 2 kw., can be effected by depressing keys.

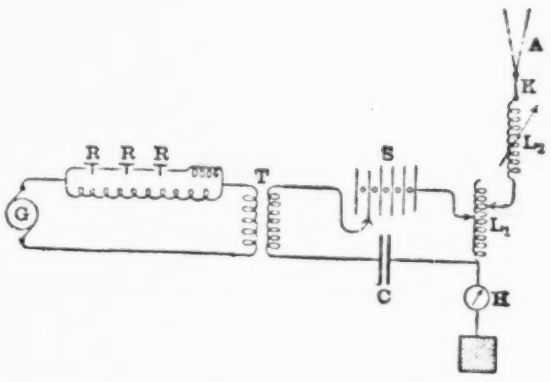


Fig. 6. Diagram of transmitting system.

Before describing the component parts of the Telefunken system it may be convenient to refer to Figs. 6 and 7, which show the connections for transmitting and receiving respectively. The alternating current is brought to a transformer, where it is raised to an appropriate pressure (4,000 to 70,000 volts, depending on the size of the station), the secondary being connected with the spark discharger on the one hand and to a capacity on the other. This circuit is coupled either directly or inductively to the antenna. The capacity is not variable in small stations, but may be half cut out in large stations if desired. The antenna contains a variable inductance, and is earthed through an ammeter.

The damping of the waves radiated is about 0.08 to 0.1 with slowly radiating umbrella and *T* antennæ, if the latter are working with their natural wave length, and only 0.05 to 0.03 if the wave length is increased to three or four times the natural length. The period of the high-frequency circuit is absolutely constant, so that, in contradistinction to arc lamp excitation, the resonance can be completely utilised. Owing to the very slight damping of the antenna, intermediate circuits between the exciter and the antenna have not been introduced. The damping of such a circuit [fol. 3473] would have to be one-tenth that of the antenna to work satisfactorily; that is, not more than 0.01 to 0.005. This is difficult to achieve, and would lead to rather com-

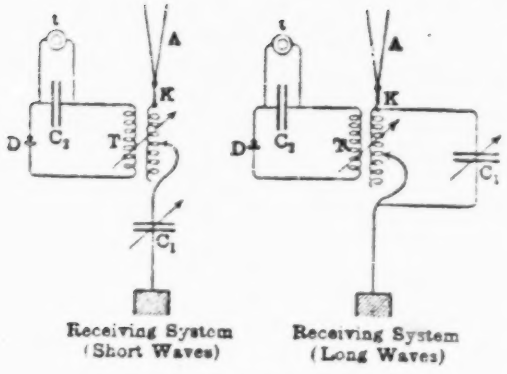


FIG. 7.—Systems Used for Receiving.

plicated arrangements. The only cases in which an intermediate circuit may be necessary are when it is impossible to use a standard form of antenna.

For receiving, the antenna is switched over to a transformer, which couples it inductively with a closed receiving circuit. For short waves the primary of this transformer is in series, with a variable capacity and thence to earth. For long wave lengths, on the other hand, the inductance and capacity are in parallel. The secondary of the transformer is taken to the detector and a small fixed capacity in series. Across the poles of this capacity is the telephone.

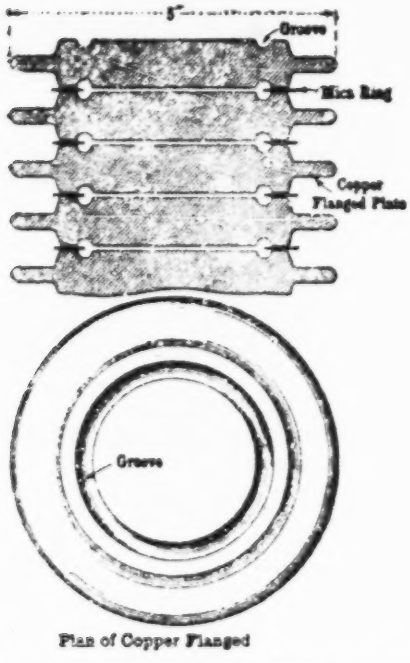


FIG. 8.—Section and Plan of Spark Discharger.

Owing to the oscillations in the primary sending circuit persisting for only a short proportion of the whole time, the primary losses are not so important as usual, and therefore paper condensers are often used instead of Leyden jars, a number being connected in series. Further, brush discharges from the edges of the condensers do not occur nearly so much as in the case of slowly quenched circuits, doubtless because local ionisation is reduced.

Inductances for the smaller stations are made of finely-stranded wire, but for the larger stations copper strip is used in the form of flat spirals. In the case of wound inductances very fine specially enameled copper wire is used to keep down the eddy

(Here follows 1 photolithograph, side to fol. 3474.)

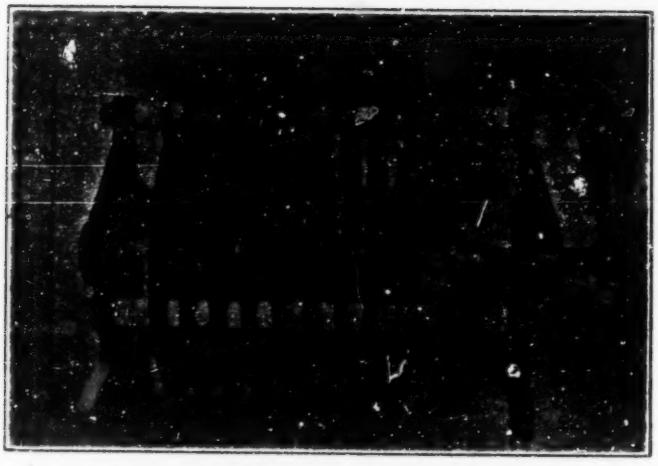


FIGURE 9 —VIEW OF SPARK DISCHARGER.

FIGURE 11 — ARRANGEMENT FOR TESTING DETECTORS

current loss to a minimum, and as the resistance must be very low to correspond with the antenna, and since large currents are used, as many as 10,000 to 20,000 separate insulated wires are sometimes run in parallel. Since all such wires should carry the same current, special windings are employed by which each wire has the same resistance and inductance.

[fol. 3475] *The Spark Discharger.*—A section of the spark discharger as now used by the Telefunken Company is shown in Fig. 8. It consists of circular plates of copper, each faced with a plate of silver, which is ground dead true except that it is slightly recessed at the centre. There is a groove some distance from the centre and the metal plates are separated by mica rings to a distance of 0.2 mm. The spark forms at any point of the flat surface; it is then forced towards the periphery in a radial direction by the electromagnetic field, and is eventually extinguished on its path. A number of these spark-gaps are held in series, as shown in Fig. 9. It will be noticed that between each pair of these discs is a larger disc of thin copper, which is effective in radiating the heat generated by the spark. These radiating discs are carried by three porcelain tubes, and these tubes are so placed that the inner discs can rest upon the two lower tubes. Thus it is a very easy matter to take a disc out or to replace it. The spark gaps are pressed together in the frame by means of a screw, and the insulation provided at each end consists of short glass cylinders. The whole arrangement, as is shown by the illustration, is very compact and serviceable. Short-circuiting plugs, which are simply "U"-shaped pieces of metal, are provided, in order to short-circuit as many gaps as may not be required. Two of these are seen in position in the illustration. By connecting a suitable number of gaps in series it is possible to keep the energy per gap from exceeding a certain value, and thus to prevent overloading. Since the energy transmitted varies as the square of the number of spark gaps the regulation by short-circuiting covers a wide range. Thus if there are 10 gaps and 9 are cut out, the maximum energy is reduced to 1 per cent. In the case of small dischargers

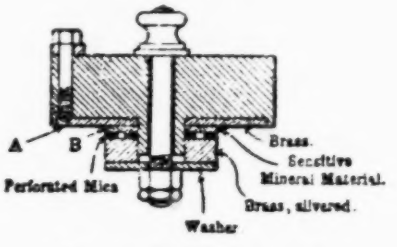


FIG. 10.—Section of detector.

point of connection of the circuit to the discharger is made variable and short-circuiting clips are not used. The pressure per gap is 1,200 volts.

Water cooling is not adopted, but dischargers are sometimes used with air ducts, and the radiating discs are also varied in size according to requirements.

The Detector.—Since the waves to be received are intermittent but rapid, so called integrating or contact detectors are chiefly employed for receiving, the contact being between a mineral and graphite or a metal. A high-frequency safety device is employed to protect the detector in case of sudden overloads.

The construction adopted will be understood by reference to Fig. 10, which, however, is not to scale, though roughly full size. From this it will be seen that the essential parts are a washer of brass, A, as one terminal, against which is pressed a sensitive mineral washer. The desired pressure is obtained by screwing down a second brass washer B (which may be regarded as the other terminal), through [fol. 3476] a mica washer which is perforated with a number of holes. The surface of B next the mica is corrugated and silvered, and it will be realised that the pressure necessary to secure contact between B and the mineral must be considerable. In fact, to anyone having the idea that the detector is a delicate piece of apparatus, the rapidity and ease with which these detectors are assembled and adjusted in the laboratories of the Telefunken Co. comes as a surprise.

The detectors are adjusted by mounting them inverted in a block, as seen in Fig. 11, and adjusting the nut until comparison with a standard detector is satisfactory. A complete detector is seen to the left of this illustration. In the laboratory, detectors are not only adjusted for sensitiveness, but are also adjusted to an internal resistance best suited to the coupling conditions of the receiver; further, they are tested for about 100 times the working intensity and are submitted to a vibration test.

The detector is used without an auxiliary battery and rectifies the alternating impulses into a pulsating continuous current. With a telephone as a receiver there is a distinct advantage in having these impulses of a regular frequency, because the diaphragm will then respond most readily and give a musical note, whereas irregular disturbances, even of considerably greater energy, will produce no appreciable

effect. In fact the higher the tone the more sensitive the telephone, and the less trouble is there from atmospheric disturbances. A galvanometer, on the other hand, would give the mean detector current, and its deflection would increase with the energy irrespective of the regularity of the impulses. The musical tone is very easily distinguished, and if pure it can be heard quite clearly even when very weak. A range of tones of about 200 to 2,000 vibrations per second is obtainable, and various tuned transmitters can be easily distinguished from each other. The musical tone is thus important, the more so in that it is not readily confused with atmospherics.

Receiving set.—The receiving set is very compact, and is shown well in Fig. 12. At the back is seen the antenna switch, and when this is thrown over for receiving, the antenna is connected to the primary coil of the coupling transformer. On the other hand, when this switch is open for sending, the circuit is automatically broken on each side of the detector and also the telephone circuit. One of these primary coils is shown in position, and two more are seen along side the apparatus. The inductance in the antenna can be varied in three steps for each coil by means of a plug which can be inserted into any one of the three holes on the face of the coil. Since two or more coils are provided, and these can be easily interchanged, a large range of inductance is available. The primary is connected in series or in parallel with the capacity and thence to earth. The capacity is of the usual air type with semicircular plates and is continuously variable by turning the knob seen in the illustration.

(Here follows photolithograph, side folio 3477)

FIGURE 12 RECEIVING SET

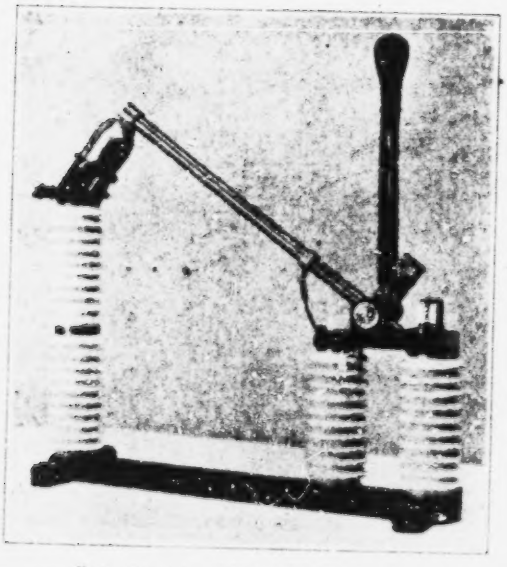


FIGURE 13 ANTENNA SWITCH

The secondary of the transformer can be moved outwards, as it is hinged, and when it is moved outwards to the horizontal position it can also be turned round upon a [fol. 3478] horizontal axis. Consequently, the coupling can be varied between extreme limits. The inductance in the secondary can also be varied in six steps by changing the position of the plug, which is seen at the end of a flexible connection. A small switch will be noticed below the coupling transformer. The object of this is to connect the inductance and capacity in series for receiving short waves and in parallel for receiving long waves. The detector is seen below the switch, and terminals are provided for connecting up the telephone or call apparatus as desired. A continuous wave range of 250 to 2,500 metres is covered by turning the condenser and by a single interchange of coupling coils.

Since the energy from the antenna is transferred from the coupling coil of the antenna to an aperiodic circuit containing the detector, the receiving antenna alone requires syntonising, and this is effected simply by turning the condenser. Owing to the smallness of the damping of the quenched spark waves, very exact tuning is obtainable.

When stations have highly damped antennæ of large capacity, this simple arrangement cannot be adopted because the enormous atmospheric disturbances met with in the case of large antenna are carried with almost their full force to the detector, causing serious reduction in its sensitiveness and often damaging it. This difficulty is obviated by the use of a very weakly damped intermediate circuit, which is coupled very loosely with the antenna, and not too closely with the detector circuit.

For stations above a certain size a separate antenna switch is used, as shown in Fig. 13. With the switch down, as seen in this illustration, the antenna is connected for receiving, and when it is pulled over to the right, connection is made for transmitting.

(To be continued.)

DEFENDANT'S EXHIBIT D-5

Wireless Telegraphy, by Zenneck, 1915

• • • • • • •

Whenever the coupling is fairly close, K' is considerably greater than $\left(\frac{d_1-d_2}{2\pi}\right)^2$, so that the quantity K' is not much different from the coupling coefficient K. (See note 4, p. 87.)

Under these conditions there are in general[57] two distinct oscillations the so-called "coupling oscillations" (coupling waves") produced *in both the primary and the secondary circuit*, having *two distinct frequencies*, N' and N'', *and two distinct decrements*, d' and d''.

If, as heretofore, we use I_1 and V_1 to indicate current and voltage in the primary circuit, I_2 and V_2 the same in the secondary then I_1 (and V_1) as well as I_2 (and V_2) are the results of two oscillations. Hence we may write:

$$\begin{aligned} I_1 &= I_1' + I_1'' \\ V_1 &= V_1' + V_1'' \end{aligned} \quad \text{for the primary circuit.}$$

$$\begin{aligned} I_2 &= I_2' + I_2'' \\ V_2 &= V_2' + V_2'' \end{aligned} \quad \text{for the secondary circuit.}$$

[fol. 3479] The various oscillations have the following frequencies, wave lengths and decrements.

$$\left.\begin{matrix} I_1' \text{ (and } V_1' \text{)} \\ I_2' \text{ (and } V_2' \text{)} \end{matrix}\right\} N', \lambda' \text{ and } \delta'$$

$$\left.\begin{matrix} I_1'' \text{ (and } V_1'' \text{)} \\ I_2'' \text{ (and } V_2'' \text{)} \end{matrix}\right\} N'', \lambda'' \text{ and } \delta''$$

59. *The Frequency of Coupling Waves.* — *a. Primary Circuit without Spark Gap.* — Let the index I refer to the oscillation having the higher frequency and shorter wave length. Then we have[57]:

. . . . . .

Hence, the greater K', *i.e., the closer the coupling, the more will the frequencies (wave-lengths) of the coupling waves differ from each other and from the original common frequency (wave-length).*

b. Primary Circuit with Spark Gap. — In this case also the relations between the frequencies before and after coupling are of the *form* of equations (1). It is not definitely known, however, though this is of no practical importance, whether the factor K' has the relation to the coefficient of coupling, K, and the decrements given by equation (1) of Art. 58. The quantity which actually determines the extent of the coupling and which may be directly measured by test [Art. 87] is the factor K' for circuits with spark gap also.

K' is called the "degree of coupling." Its value is frequently expressed in percentage, thus: "3 per cent. coupling" means $K'=0.03$. The relation between N^I, N^{II} and N, as well as z^I, z^{II} and z is given in Table X for different values of K'.

c. The *resultant oscillation* produced from the two coupling oscillations of different frequency is of the form shown diagrammatically in Fig. 130, and shown in Fig. 124 as obtained with an oscillograph (H. Diesselhorst [88]) and in Fig. 125 as photographed from the spark discharges (H. Rau [89]). The resultant oscillation may be conceived as having the frequency N and an amplitude which periodically increases and decreases, similarly to the *beats* or *pulsations* of a tone which are observed in acoustics.

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FIGURE 124

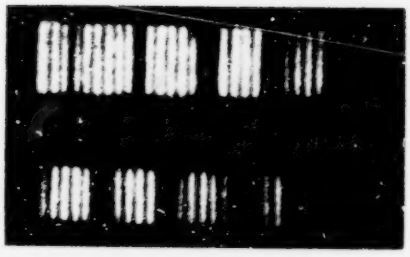

FIGURE 125

The greater the difference between the frequencies of the two oscillations, *i.e.*, the closer the coupling, the greater is the number of pulsations obtained per second. This number, S, which is the number of times per second that the amplitude passes through zero, is given by

$$S = N^I - N^{II} = \text{approx. } NK'$$

Hence the duration of one beat or pulsation is approximately $= \frac{1}{NK'}$ seconds $= \frac{1}{K'}$ periods.

d. The *energy relations*, as is evident from Fig. 130, are as follows: Originally the entire energy resides in the pri- [fol. 3481] mary circuit. After half of one pulsation the amplitude of the oscillation in the primary circuit is zero, while that in the secondary is a maximum and the entire energy has been transferred to the secondary circuit. After another half pulsation all the energy is again back in the primary and the secondary is at zero, etc., etc. In short, the energy continues to swing back and forth between the primary and secondary circuits.

60. *The Decrements of the Coupling Waves.—a. Primary Circuits without Spark Gap* (P. Drude[89]).—The relations of the decrements before and after coupling are expressed by:

$$\left.\begin{aligned} d^I &= \frac{d_1+d_2}{2}\frac{N^I}{N} = \frac{d_1+d_2}{2}\frac{\lambda}{\lambda^I} \\ d^{II} &= \frac{d_1+d_2}{2}\frac{N^{II}}{N} = \frac{d_1+d_2}{2}\frac{\lambda}{\lambda^{II}} \end{aligned}\right\} \quad \frac{d^I}{d^{II}} = \frac{N^I}{N^{II}} = \frac{\lambda^{II}}{\lambda^I}$$

So that while for low degrees of coupling the decrements of the two oscillations are approximately equal to the average value of the decrement before coupling, *as the coupling becomes closer, the decrement of the oscillation having the shorter wave-length increases and that of the oscillation having the longer wave becomes less than the average value mentioned above.*

Theoretically the closest possible coupling exists when $K'=1$; in practice about the highest value obtainable is approximately $K'=0.6$. For this latter value, we have:

$$\begin{aligned} N^I &= 1.6\,N & d^I &= 0.8\,(d_1+d_2) \\ N^{II} &= 0.8\,N & d^{II} &= 0.4\,(d_1+d_2) \end{aligned}$$

Hence in practice the frequency and decrement of the oscillation of shorter wave-length will at most be twice what they are for that of the longer wave.

b. Primary Circuit with Spark Gap. (C. Fischer[30]). —In this case the relations of *a* do not hold.

1. The decrements of both oscillations, particularly if the coupling is loose, are greater than would follow from *a*.

2. It is by no means always the oscillation of shorter wave-length which is the most highly damped. *On the contrary, this usually is more slightly damped than the oscillation of greater wave-length.*

The conditions obtained by coupling a condenser circuit containing a spark gap with another having no gap, were observed by C. Fischer, whose results are shown in Figs. 126 and 127. Fig. 126 refers to the case of primary and secondary capacities being practically equal[1] while in Fig. 127[2] the capacity in the primary circuit is much greater than that in the secondary.

61. *Amplitude and Phase of the Oscillations*[31].—*a. Amplitude.* The current amplitudes of the individual oscillations have the same relation, approximately, as their frequencies, *i. e.*,

$$J^{(1)}_1 : J^{(2)}_2 = N^1 : N^{11}$$
$$J^{(2)}_1 : J^{(1)}_2 = N^{11} : N^1$$

[tol. 3482] *The current amplitude of the oscillation having the shorter wave-length is therefore greater than that of the longer wave oscillation.*

Assume a given known value for the initial potential V_{10} of the primary circuit, then we have the following expres-

[1] $C_1 : C_2 = 0.85 : 1.0$ MF. $L_1 : L_2 =$ approx. 22,000 C. G. S. Length of gap .36 mm.

[2] $C_1 : C_2 = 0.29 : 1.0$ MF. $L_2 = 6230$ C.G.S. Gap 6.8 mm. approx. $C_1 : C_2 = 0.45 : 1.0$ MF. $L_2 = 73{,}000$ C.G.S.

[3] If the current in one of the circuits is not quasi-stationary, the current amplitude is to be understood as the value at the current anti-node.

sions for the current and voltage amplitudes in a secondary circuit having quasi-stationary current:[4]

. . . . . .

b. Phase. If we consider as positive the direction of the oscillating current I (one) in both circuits, the vector dia-

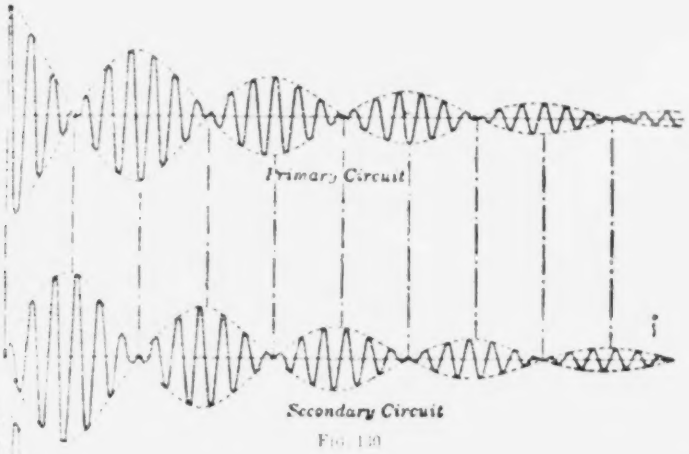

Fig. 130

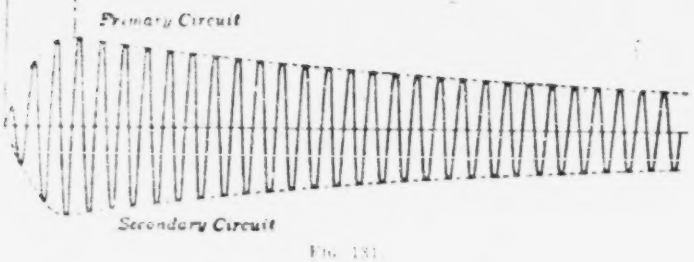

Fig. 131

gram will have the form of Fig. 128. The angles of phase displacement φ' and φ'' are given approximately by

. . . . . .

[4] If neither primary nor secondary circuit has quasi-stationary current, these relations, to the extent of their involving the voltage, hold only approximately; those independent of V_{∞} are correct if the value of the current anti node is taken as the current amplitude.

In all practical cases, as long as the coupling is fairly close[1] these angles are very small. We may therefore state roughly: *of the oscillations in the primary and secondary circuits having the same frequency,*

. . . . . .

the one pair (I_1', and I_2') are almost in phase, while the other pair (I_1'', and I_2''[2]) are approximately 180° *apart.*

c. The maximum amplitude of the resultant oscillation in the secondary circuit depends not only upon the amplitude of the two component oscillations, but also upon their phase and damping.

4. Quenching Action in Coupled Circuits (M. Wien[92])

62. *Form of the Oscillations.*—In Art. 59 it was stated that under the conditions therein specified the oscillations in the primary and secondary circuits would be of the nature illustrated in Fig. 130.[3] In the primary circuit, after lapse of half a pulsation, the amplitude of the oscillation is zero or nearly zero. It then increases again, this being due to the fact that the secondary, whose amplitude is at its maximum at that moment, induces an EMF in the primary, producing a difference of potential between the electrodes of the spark gap.

The conditions may be such, however, that the spark gap, during the time in which the amplitude in the primary circuit is very small, becomes so deionized, that the EMF induced by the secondary is no longer sufficient to start or "ignite" a spark discharge across the gap. As a result the spark gap remains quenched—whence the terms "quenching action" or "quenched gap." The oscillations in the primary then discontinue entirely and the secondary circuit continues to oscillate with its natural damping and at its graph Fig. 132 [H. Rau[93]].)

[1] Assume $d_1 = 0.08$ and $d_2 = 0.2$; then K' need only be large as compared to 0.02. If the secondary circuit is less damped the conditions become still more favorable.

[2] i is used in Fig. 128 instead of the capital I.

[3] Assumption: $d' = d'' = 0.08$; $K' = 0.16$.

natural frequency just as if the primary circuit did not exist. Compare the diagrammatic Fig. 131 and the spark photo-

[4] Assumption: $d_1 = 0.03$; otherwise just as for Fig. 130.

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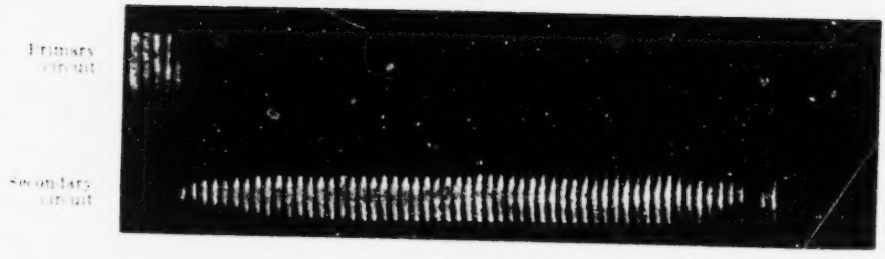


FIGURE 132.

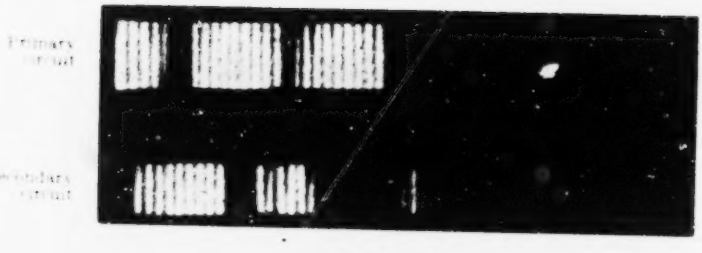


FIGURE 133.

[fol. 3484] 63. *Various Types of Quenched Gaps.* — *a. Very short metallic spark gaps* (M. Wien) are of special importance in practice.

Not only the *material* of which the electrodes are made but also the *gas* in the gap between them is of importance. Particularly good quenching action is obtained with silver and copper, aluminium is less satisfactory and zinc, tin and magnesium do not give good quenching (M. Wien[95]); platinum-iridium alloy is also quite effective with short gap lengths (H. Boas[93]). The quenching action is increased if the sparks are passed through *hydrogen* instead of air (J. *Espinosa de los Monteros*[94]).[9]

b. For laboratory purposes the so-called *mercury-arc lamp*, i.e., an exhausted glass tube with mercury electrodes (R. Rendahl[95]) is very well adapted. Apparently the only essential element in the form of this lamp is the provision of a sufficiently large space over the electrodes for cooling and condensing the mercury vapor. Moreover the tube must have a high vacuum and pure mercury must be used.

c. With primary circuits having long gaps, which in themselves would have no quenching action, it is possible to [fol. 3485] secure quenching by greatly increasing the damping of the primary circuit through an inserted resistance, or better still, by inserting a glass tube filled with gas at very low pressure (*e.g.*, 3 mm. mercury) and having metallic electrodes — a so-called "quenching tube" (M. Wien[95]).

64. *Requirements for Good Quenching.* — *a. Time-lapse of One Pulsation.* In view of the fact that the primary circuit consumes less energy the sooner the oscillations in it are quenched,[10] *i.e.*, for the sake of efficiency, it is desirable to make the coupling as close as possible. The closer the coupling, the shorter will be the time-lapse or duration of one pulsation, which is the time during which the primary circuit remains active [59c].

On the other hand, however, the time during which the amplitude in the primary remains very small and, hence, the time during which the spark gap is subjected to deioniza-

[9] In regard to hydrogen quenched spark gaps [see Art. 109c].

[10] For the same decrement; this also affects the efficiency [*b*].

tion becomes shorter as the coupling is made closer. If this time is made too short, "pure" quenching is no longer obtained, *i.e.*, the primary oscillation is not suppressed after one-half a pulsation. Either coupling oscillations result or intermediate conditions between distinct coupling oscillations and pure quenching are obtained; thus the primary oscillations disappear only after one and one half or two and one half pulsations (Fig. 133, H. Rau").

Hence close coupling is desirable for efficiency, while loose[28] coupling is needed for pure quenching. It follows that for every spark gap there must exist a "critical degree of coupling," at which pure quenching is still just obtainable. This is of course always used in order to secure as high efficiency as possible. The higher the critical percentage of coupling, the better will be the quenching action of the given spark gap.

b. Pureness of the Pulsations. It is most favorable for the quenching action if the amplitude of the resultant oscillation in the primary circuit really becomes *zero* after the first half pulsation, that is, if the pulsations are *pure*. The essential condition for this, however, is that both oscillations, after half a pulsation, have the same amplitude but are opposite in phase.

Whether this condition obtains depends upon the accuracy of the tuning between the primary and secondary circuits; the more exact the tuning, the purer will be the pulsations, other things being equal. Moreover, even with perfect tuning, it is evident that the pureness of the pulsations depends upon the initial amplitude of the two oscillations and their *decrements*. In this connection, therefore, the decrement of the primary and secondary circuits becomes of importance. As the decrements of the coupling oscillations also depend on the degree of coupling, the latter affects the quenching action in this way also.

Apparently this effect of the degree of coupling plays a part in connection with the following phenomenon (H. Rieg[29]). If the degree of coupling is gradually increased a *first* critical coupling is reached, beyond which pure quenching is no longer attainable. If, however, we proceed to make [fol. 3486] the coupling much closer, a degree of coupling is reached at which pure quenching is again obtained (*second* critical percentage of coupling). In fact, under certain conditions, a *third* critical coupling may occur. The critical de-

gree of coupling of a quenched gap is therefore by no means always a single definite quantity.

The pureness of the pulsations probably also plays a part in the explanation of the fact that by bringing the primary and secondary circuits slightly out of resonance, a pure quenching can be obtained, after the quenching had been spoiled with primary and secondary entirely in tune (H. Riegger [7]).

c. The magnitude of the EMF induced in the primary by the secondary circuit is also affected by the degree of coupling; in fact, is proportional to the coefficient of coupling, other things being equal. Hence the greater the coefficient, so much greater is the danger that a discharge will pass across the spark gap after half a pulsation.

d. Lastly, the *temperature of the electrodes*, that is, not the average temperature, but the maximum at any point (*local heating*) affects the quenching, as when the temperature becomes very high the gas is highly ionized, thereby greatly reducing the quenching action as well as the discharge voltage. This makes it easier for another spark to jump across the gap after the first half pulsation. Hence, care must be taken that the temperature does not rise too high at any part of the gap electrodes.[96]

65. *Concerning the Nature of the Quenching Action.*—*a.* The general requirement for the best quenching action is identical with the requirement for the quickest possible deionization of the spark gap. The deionization may have several causes, viz.:

1. The *recombining* of the positive and negative ions; when two ions of opposite charge collide, this may result in a neutralization of their charges.

2. *Diffusion* of the ions from the gap space between the electrodes into space without; just as a gas (*e. g.*, illuminating gas), pouring out from some opening will spread out in all directions (diffuse) in the surrounding medium (*e. g.*, air), so the ions diffuse from the space in which they were formed into the surrounding gas.

3. *Absorption* of the ions at the gap electrodes. If an ion comes close to a piece of metal, the latter will have the same

effect upon it as any uncharged conductor has on a charged body, viz., an attractive force. Consequently the ion comes into contact with the metal and gives its charge up to it.

This last kind of deionization is also influenced by the diffusion of the ions. The faster new ions are diffused from the outer space to the surface of the gap electrodes, the quicker will deionization take place, corresponding to a greater coefficient of diffusion.[11]

4. *Deionization by the Electric Field between the Gap Electrodes.*—If an electric field exists between the gap elec- [fol. 3487] trodes, the positive ions are attracted to the negative electrode, the negative ions to the positive electrode, where they give up their charge. In the case in point a field

. . . . . .

[11] The coefficient of diffusion D is defined as follows: If c' is the concentration factor (=change in the number of ions present in 1 cc., along a length of 1 cm.), then the number of ions diffused through a section 1 cm. sq. per sec. is Dc'.

Table IV. (Continued)

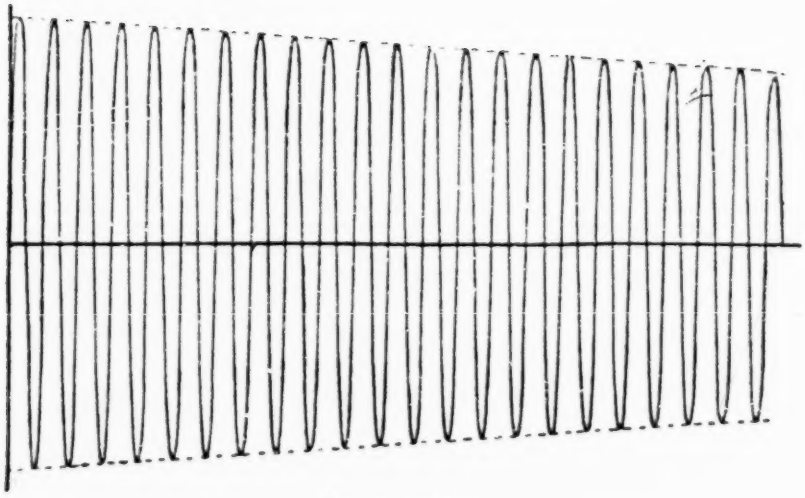


FIG. 464.—$d = 0.01$

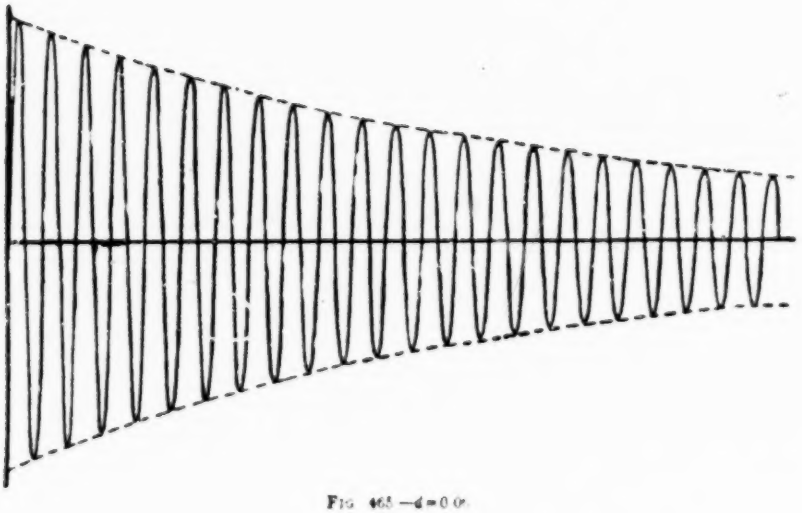


FIG. 465.—$d = 0.0$

[fol. 3488]

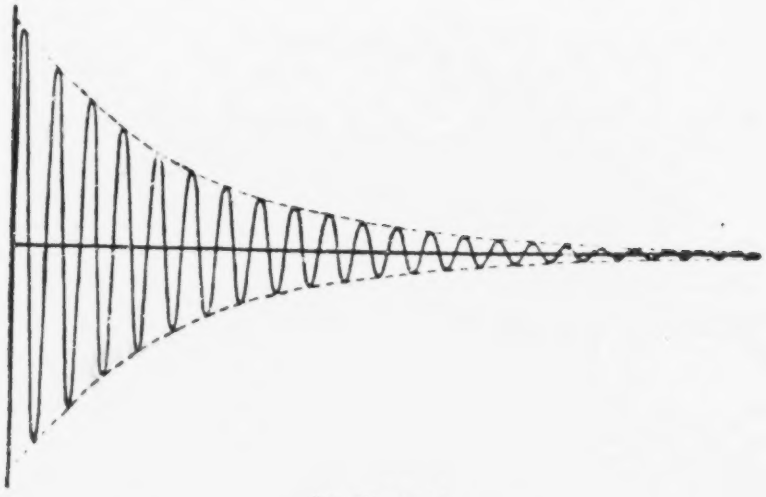


Fig. 466.—d=0.2

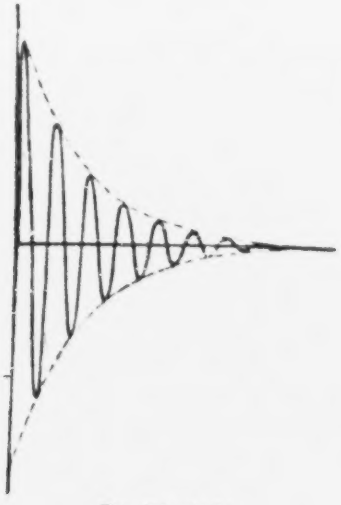


Fig. 467.—d=0.5

DEFENDANT'S EXHIBIT E 5

Wireless Telegraphy and Telephony, by Eccles, 1918

Quenched Spark Methods—General Account of the Phenomena. Probably all short spark dischargers set their circuits into oscillation by what is variously called "impact" or "shock" excitation; and the terms "short spark" and "quenched spark" are often taken to be synonymous. Max Wien published in 1906 the first full account and explanation of the phenomenon. His explanation is expressed

diagrammatically in Fig. 110. The two curves (*a*) show the beating oscillations (on a time base) produced in a tuned pair of coupled circuits by a persistent spark in the pri- [fol. 3489] mary; the curves (*b*) show how the quenching of the spark at an early stage leaves the secondary circuit in possession of all the energy and free to vibrate with its natural frequency. The damping of the primary should be at least ten times that of the secondary. Thus quenching ensures singleness of frequency. Quenched sparks are

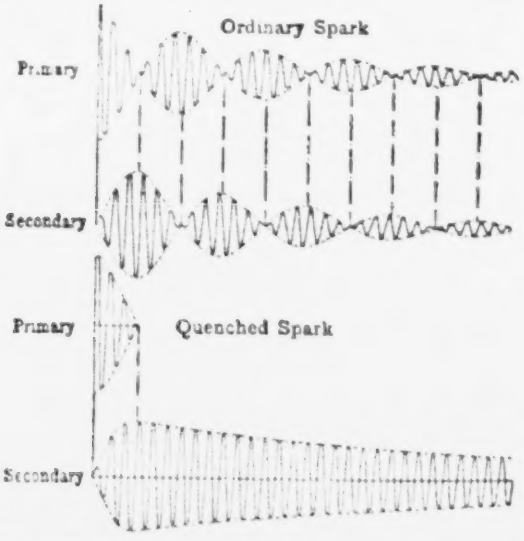


FIG. 110. Diagram of oscillations in coupled circuits. (*a*) Ordinary spark. (*b*) Quenched spark.

easily obtained by putting two electrodes close together and providing for the rapid removal of heat from the region of the spark. If the metal is allowed to get hot some volatilisation takes place and an arc is established. The importance of size of gap is shown by the resonance curves of

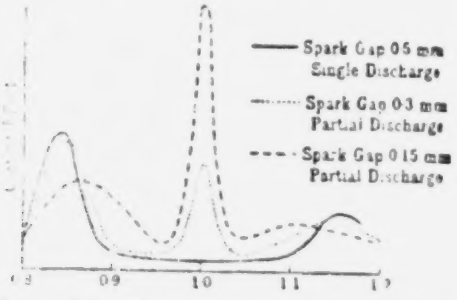


FIG. 111. Curves showing the importance of small gaps in producing a single wave by quenched sparks.

Fig. 111, which were obtained by Wien using a pair of flat parallel circular brass plates.

The condenser used in shunt to short sparks is usually large. It should be so large that its discharge current across the gap is sufficient to annul the supply current and relight the spark in the opposite

[fol. 34901]

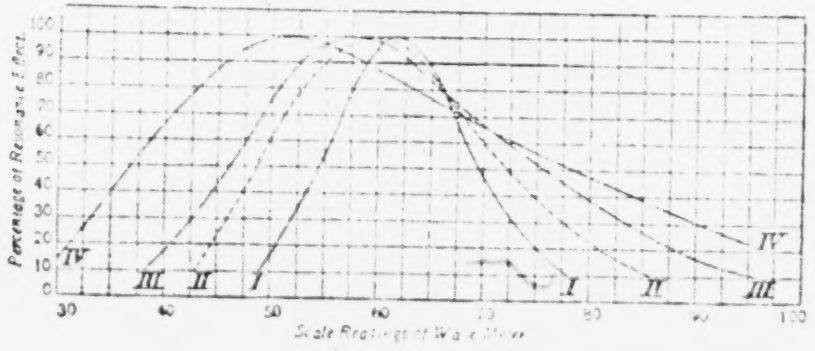


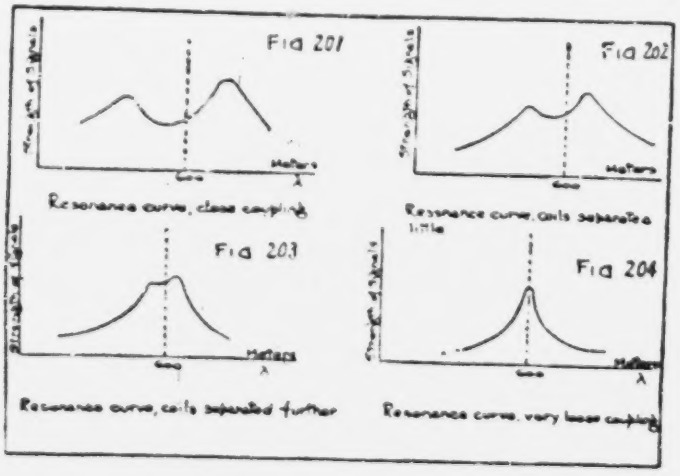
Fig. 112 — Resonance curves with quenched spark for various couplings, secondary wave constant

	Couple	Primary Wave Length	Secondary Wave Length		Couple	Primary Wave Length	Secondary Wave Length
I	0.95%	1330	1340	III	9%	1294	1340
II	7%	1312	1340	IV	18.2%	1230	1340

Defendant's Exhibit F-5

Principles Underlying Radio Communication, 1922

In Fig. 204 the signals are strong at or near only one wave length, and diminish rapidly if any of the apparatus adjustments are changed. This is said to be a "pure"



wave.[1] It is desirable to have as sharp a resonance curve as possible, and hence loose coupling is the rule when a plain gap is used. The advantage is that all the power sent out is concentrated into a narrow range of wave lengths, and that receiving stations can tune to the one wave length emitted [fol. 3491] by the transmitting station which they desire to receive and exclude all other wave lengths from other transmitting stations.

Action of the Quenched Gap; Relation to Coupling.—Refer again to the inductively coupled apparatus of Fig. 195 and to the waves of Fig. 154 in Chapter 3. Also refer to the description of the quenched gap in Section 156. The action of the quenched gap is to open the primary circuit, by suppression of the spark at the end of its first train of waves (point *D* in Fig. 154). This prevents the secondary from inducing oscillations in the primary again; that is, from giving energy back to the primary. The secondary or antenna oscillations are not thereafter interfered with by the primary and the antenna goes on oscillating until the energy is all dissipated as waves or heat (see Fig. 155). The length of the train will depend only upon the decrement of the antenna circuit. By reducing the resistance, the dielectric losses, the brush discharges and leakage, the antenna current may be made to oscillate for a comparatively long time, at the frequency for which the set was adjusted. This quenching of the primary avoids the double waves of Figs. 201, 202, and 203, even with close coupling. In fact, the coupling should be close for good operation with the quenched gap. Some care has to be taken in the adjustment of the coupling, but when adjusted properly this gap gives a high pitched, clear note. The wavemeter will readily show when a single sharp wave is obtained (see Section 168), and the sound in the telephone receiver will indicate the proper adjustment for good tone. The quenched gap

[1] The United States radio law requires that if a transmitting station emits more than one wave length, the energy in no one of the lesser waves shall exceed one-tenth of the energy in the principal wave. See the pamphlet, "Radio Communication Laws of the United States," issued by the Bureau of Navigation, Department of Commerce. Copies may be secured from the Superintendent of Documents, Government Printing Office, Washington, for 15 cents each.

is very efficient because the close coupling produces a large current in the antenna.

It is well to note that the principles of operation of the quenched gap and plain gap are exactly opposite. The former aims to stop the primary oscillations quickly, after the secondary has been brought to full activity. The latter aims to keep the primary oscillations going as long as possible, all the time giving energy to the secondary as it is radiated away; the coupling is loose and the primary decrement is kept low. The rapid decrease of the oscillations in a quenched gap circuit is assisted by having a large ratio of capacity to inductance. This has the incidental advantage that the voltages across the condenser and coil are thus kept low.

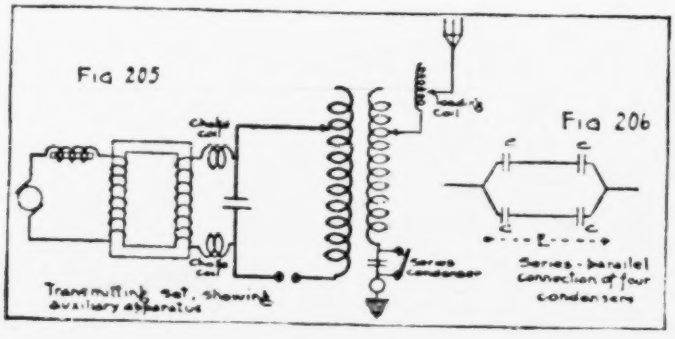
166. *Damping and Decrement.*—If the energy in the antenna circuit is dissipated at too rapid a rate, owing either to radiated waves or heat losses, the oscillations die out rapidly and not enough waves exist in a received train to set up oscillations of a well-defined period in a receiving antenna. Such waves are strongly damped and have a large decrement. They produce received currents of about the same value for a considerable range of wave lengths. Thus selective tuning is not possible.[2] To increase the number of waves sent out in each wave train from the open circuit (that is, to make the oscillations last longer) the resistance of the circuits must be kept low. When using a plain spark gap the coupling between closed and antenna circuits must be small enough not to take energy too fast from the closed [fol. 3492] oscillating circuits. At each condenser discharge the primary has a train of oscillations which at best die out long before another train starts (see Fig. 192); these oscillations are stopped more quickly, however, if the energy is drawn rapidly out of the circuit by the antenna. Close coupling is permissible only when a quenched gap is used (see remarks at the end of the preceding section). With any other kind of gap the secondary is kept oscillating by energy continually received from the primary.

A great many factors contribute to the resistance of the antenna circuit, and this must be kept as low as possible.

[2] See also section 116. The United States radio laws require that no station shall transmit a wave having a decrement exceeding 0.2.

The antenna must have a good low-resistance ground, must use wires of fairly low resistance, and must not be directly over trees or other poor dielectrics. The resistance of the closed circuit particularly must be very low. Heavier currents flow here than in the antenna wires. For this reason the closed circuit wires should be short and of large surface, preferably stranded wires or copper tubing. The condenser should be a good one, free from power loss.

167. *Additional Appliances.*—A number of additional appliances are necessary or desirable for the operation of a



damped wave generating set. The operation is improved by having a variable reactance (iron core inductor) in series with the alternator, to tune the alternator circuit to the alternator frequency. See Bureau of Standards Circular 74, p. 230.

Changes of Wave Length.—In many sets of apparatus it is customary to have connections arranged by means of which different chosen wave lengths, say 300 or 600 meters, can be transmitted without the necessity of a readjustment of the apparatus after each change. An antenna alone without any inductance coil has a natural wave length of its own, dependent upon its inductance and capacity. See Sections 116 and 145. The antenna is usually so designed that its natural wave length is shorter than the wave length to be used, and the wave length is brought up by adding inductance in series or merely by the added inductance of the secondary of the oscillation transformer. In the case of a small antenna, such as that on a small ship, it is necessary to use a large inductance. Since it is desirable to have the coupling loose, a part of the secondary inductance can be in a separate coil called the antenna "loading coil." This loading

[fol. 3493] coil is not coupled to the primary. Fig. 205 shows this arrangement. For a quick change of wave length a single switch is often provided, which, by a mechanism of levers, changes simultaneously the adjustments on all three coils. From these coils are taken out taps over which three switch blades pass, adjusting all the inductances to approximately the values needed for the particular wave length desired, keeping the circuits in resonance and at the proper coupling. For fine adjustments an additional variable inductor may be provided in the primary and in the secondary.

Fig. 205 also shows an arrangement whereby the operator can obtain wave lengths *shorter* than the natural wave length of the antenna by inserting a condenser in series (see Sec. 35) in the antenna circuit. In this case the loading coil will be set at zero turns to diminish the wave length. The condenser inserted must be capable of withstanding high voltages similar to those in the main transmitting condenser. By using a small capacity the wave length can be reduced to approach one-half of the natural wave length. It should not be reduced that much, however, for the radiation is inefficient if the condenser is too small. A zero capacity (an open circuit cutting off the antenna entirely from the ground) would be necessary to produce half-wave length exactly.

Choke coils. Fig. 205 shows also choke coils to prevent the high frequency condenser discharge from getting into the transformer and puncturing the insulation. The coils choke down the radio frequency current but do not obstruct the low frequency charging current from the transformer. They must be specially designed so that they do not have capacity enough to allow the radio-frequency current to pass. They can often be dispensed with. See also Appendix 9, page 578.

168. *Adjustment of a Typical Set for Sharp Wave and Radiation.*—The set is assumed to be an inductively coupled set, arranged as in Fig. 205. The first step in adjusting it to work properly is to tune the closed circuit to the wave length which is to be used. This is usually done by varying the primary inductance, which includes the primary of the oscillation transformer. The primary capacity is usually fixed in value and not readily changed. Manufacturers usually mark on the primary variable inductance

the wave lengths corresponding to various settings. If this has not been done, it will be necessary to determine the wave length by the aid of a wavemeter having in its circuit a sensitive hot-wire ammeter. The wavemeter is placed at a distance of one or more meters from the coil of the closed circuit, and with the set in operation but the antenna circuit opened, the wavemeter coil is so turned that a small current is observed in the wavemeter ammeter. With the wavemeter set at the chosen wave length the closed circuit inductance is varied until resonance is obtained. If no resonance point is found, it is probable that the closed circuit inductance or capacity is either too large or too small. This inductance should be varied and a resonance point will be located after a few trials. It may also be necessary to increase or decrease the number of condensers used.

[fol. 3494] The next process is to adjust the secondary inductance and the coupling to obtain a pure sharp wave; that is, to get as much as possible of the power into the wave length that is to be used. Both primary and secondary circuits are closed and coupled together, using at first a fairly loose coupling unless the spark gap is a quenched gap. The secondary of the oscillation transformer or the antenna loading coil is varied until resonance is obtained, as shown by a maximum reading of the hot-wire ammeter in series with the antenna. This adjustment may be checked with a wavemeter. The wave length at which maximum current is obtained should be the same as the wave length for which the primary was adjasted. The wave meter should not be coupled to the secondary of the oscillation transformer, but to a loading coil or other coil at a distance, or to the ground connection. The coupling is then made closer until two points of resonance appear. It is desirable to have a pure wave; that is, have only one resonance point. Therefore the coupling is loosened until it is certain that there is just one sharp point of resonance. If the set has a quenched gap, the coupling is kept close, and varied only enough to insure a single, sharp, wave. The radiation or maximum current at the desired wave length will not occur when the coupling is tightest, nor will it necessarily occur when the reading of the *an*tenna ammeter is greatest. The condition for efficient transmission is that maximum energy radiation should be secured at the wave length to which the set is adjusted.

It is next necessary to adjust the generator voltage and the length of the spark gap to get maximum current in the antenna at the desired wave length, and a good clear spark tone. The field current of the alternator and the length of the spark gap are adjusted until maximum current and best tone are obtained, the wave length and coupling adjustments being kept fixed. It is often desirable to vary the coupling a little and then repeat this adjustment, since in some cases a small increase of coupling may make it possible to obtain increased antenna current without seriously affecting the sharpness of the radiated wave. For a quenched gap, the coupling adjustment need for maximum antenna current and best tone is very critical.

The first two adjustments mentioned are made for the purpose of obtaining in the circuits resonance to the radio frequency which it is desired to radiate. It is, however, also important to obtain proper tuning with respect to the low audio frequency (perhaps 60 to 1,000 cycles) generated by the alternator. The audio frequency to which the circuit should be tuned to get the best *best* tone and most satisfactory operation is not the frequency supplied by the alternator, but is some 10 per cent to 20 per cent lower than the alternator frequency. The reactances of the transformer and of the rotor of the alternator are very important in determining the audio-frequency tuning characteristics, and for a given transmitting set the transformer and alternator are usually so designed that their reactances will be of the proper magnitudes at the operating fre- [Vol. 3495] quency. If the transformer and alternator do not have the proper reactance, it may be necessary to supply an inductance in series with the alternator field. If such a series inductance is used, its setting to a proper value constitutes a fourth adjustment of a spark set. For a further discussion of tuning to the audio frequency, see Bureau of Standards Circular 74, p. 230, and H. E. Hallborg, Proceedings Institute Radio Engineers, vol. 3, p. 107, June, 1915.

DEFENDANT'S EXHIBIT G-5

Wireless Telegraphy, by Leggett, 1921

Author's Preface

It is a matter for comment that whilst numerous works have been published, and others are still being produced, dealing with the highly important science of Wireless Telegraphy, yet none of these give more than a mere outline of the Quenched-Spark System, a system which has been employed in almost every country throughout the world. In view of its extensive adoption in such countries as the United States of America, Australia, Japan, China, and Germany, and considering that it can for land stations claim to rank with the Marconi System in importance, this lack of literature in England is difficult to understand. It is, however, probably the result of national prejudice, since the system had its origin in Germany, where it was experimented with and established by the Telefunken Co. The history and development are given in detail in the Introductory Chapter, and the efficiency of the Quenched-Spark Gap is so undoubted that its scientific merits cannot be ignored or dismissed by appeals to false patriotism. The original Telefunken System has been developed to such a large extent in other countries, including England, that the Quenched-Spark System, which is its outcome, can now be viewed as an International System.

The Author hopes and believes that the present book fills a distinct gap in wireless literature, as there is no volume at present in English which deals in detail with the Quenched-Spark System, either as manufactured in this or in other countries, or of the original Telefunken System. Much of the apparatus has never previously been illustrated and described in the English language, and much, including very many illustrations, has never yet been published in any country. The Author is indebted to Messrs. Siemens Bros. & Co., Ltd., of Woolwich, for the majority of the photographs from which blocks have been made.

In the matter of block reproduction, at present a very expensive process, the Author wishes to give acknowledgment to the publishers, who have agreed with the writer that in technical descriptions a block is often of far more use than many pages of descriptive matter, and have, in

consequence, spared no expense in the preparation of illustrations.

The Author has had considerable experience of actual manufacture, installation and operation of nearly all the [fol. 3496] apparatus described, and he hopes, therefore; that serious technical errors will not be found in the present volume. In this endeavor to avoid errors the Author has been fortunate in obtaining the assistance of several experts in the reading of the proofs. He wishes to render thanks to Mr. H. Machen, A.M.I.E.E., Chief of the Wireless Department, Messrs. Siemens Bros. & Co., Ltd., Woolwich, for his careful revision of proofs and for many suggestions of improvement, and also for much valuable assistance during his career.

The Author would particularly pay acknowledgment to Mr. J. L. Bale, of Messrs. Chapman & Hall, who has throughout given much assistance to the Author in rendering into book form what was previously a set of technical notes taken over a period of several years.

For further general proof reading, and particularly for suggestions and information regarding aeronautical wireless, the Author wishes to express his sincere thanks to Mr. S. T. G. Andrews, B.Sc. (Engineering). His gratitude is also due to Dr. L. Isserlis, B.A., Mathematical Tripos, and Mr. S. G. Starling, B.Sc., A.R.C.S., Examiner in Physics, London University, who have been kind enough to read the proofs of Chapter II, and offer suggestions.

The chapter on wireless propagation embodies an analogy which the Author has himself found very useful in interpreting wireless phenomena. Whilst not offered as an actual explanation, possibly open to criticism, it should not detract from the more practical portions of the book.

The chapter upon maintenance has been included in order to render the book of greater use to operators of the Quenched Spark System, who are rapidly increasing in number now that a number of well-known shipping lines are fitting many of their new vessels with this system.

Acknowledgment is also due to the "English Mechanic" for permission to reproduce much of the matter of the earlier chapters, which the Author originally wrote for this Journal.

In conclusion, the Author would state that whilst in agreement with the spirit of the extract from the "Elec-

trician" (given on p. vi), he does not himself believe the actual position to be as bad as this extract would imply, but the apparent general backwardness in English wireless may be partly attributed to the mistaken policy of Government Departments in withholding much scientific information obtained during the late War at great expense to the country. A particular example is afforded by the Signals Experimental Establishment Pamphlets which are available to those able to use the Library of the Institution of Electrical Engineers, and doubtless to many commercial firms having foreign connections, but which cannot be purchased by the general public who have borne the expense of their production. In this connection the Author believes Prof. Townsend of Oxford undertook for the military authorities extensive scientific researches showing comparisons between Open-, Quenched-, and Rotary-Spark Gaps. No details of these tests of efficiency, which would un- [fol. 3497] doubtedly be of great assistance to shipowners and others requiring to install new wireless apparatus, have yet been published.

Bernard Leggett.

London, November, 1920.

In Fleming's treatise the achievements of Mr. Marconi and the apparatus of the Marconi Company are dealt with at great length, but it is a matter for comment that the apparatus of this company's greatest competitor, namely, the Telefunken and Quenched-Spark system, receives very scanty notice, and indeed its name does not appear in the index to his book.

Eccles' book is far more general in nature, but as the book is much more restricted in size, his matter on the Telefunken and Quenched-Spark systems is necessarily small.

The sources of information regarding the original Telefunken system are very restricted, especially to those unable to read German. Such restriction of information is purely insular. The average English reader is practically unaware of the existence of any important commercial system of wireless telegraphy other than that of the Marconi Company, and is quite astounded when told of the existence of another system which, outside England and a few of its Colonies, is perhaps for land stations the most extensively adopted by other countries.

Since the original home of the Quenched-Spark system is Germany, national prejudice has, until recently, prevented the full recognition of this important system of wireless telegraphy, in spite of its great scientific merits.

There is, however, only one test of any scientific apparatus, namely, its efficiency. Since the Quenched-Spark Gap has at least twice the efficiency of any other form of spark gap, it is far from patriotic to neglect the possibilities of this system. On the contrary, it is a truer form of patriotism to examine, impartially and scientifically, the merits and demerits of foreign scientific work, German or otherwise, and then to utilise the results of such examination to the furtherance of British science and technology.

. . . . . .

As evidence that the only true test of any scientific apparatus depends upon actual results, the author might mention the following incident described by an English paper, "The China Coast Shipping Gazette," as long ago as 3rd November, 1911.

The English steamer "Brodmore" was in Hankow harbour in distress with a perishable cargo of meat. The skipper, owing to destruction of the land lines by insurgents, was unable to wire to Shanghai for a relief ship to salve his cargo. He approached the British Consul, with a request that a British warship in harbour should be utilised to send a wireless message to Shanghai and was informed that the wireless range of this warship was insufficient for it to do so. Lying in the harbour was the German warship "Leipsig" fitted with Telefunken apparatus. As it was in permanent communication with the German warship "Nurnberg" in Shanghai, the captain of the "Leipsig" [fol. 3498] offered to assist the "Brodmore" skipper by sending his message, the cargo so being eventually salved.

The above mentioned paper noted upon the incident to the following effect: "The system upon which the English Navy depends shows itself in a very bad light, and the English ships are unable to bridge large distances, while the German warships fitted with the Telefunken system are in easy permanent direct communication between Hankow and Shanghai. The German warship 'Leipsig' in Hankow, is, we hear, in permanent communication with the 'Nurnberg' in this harbour, and exchanges regular

. . . . . .

This shows us that, with coupled circuits, which of necessity to avoid radiation of energy upon many wavelengths, we are compelled to adopt, *we obtain in the aerial two oscillations of very different wavelengths having maxima* λ_1 *and* λ_2.

Since, at any instant, a receiving station can only be tuned to one wavelength (the largest λ_2), *the energy of the other*

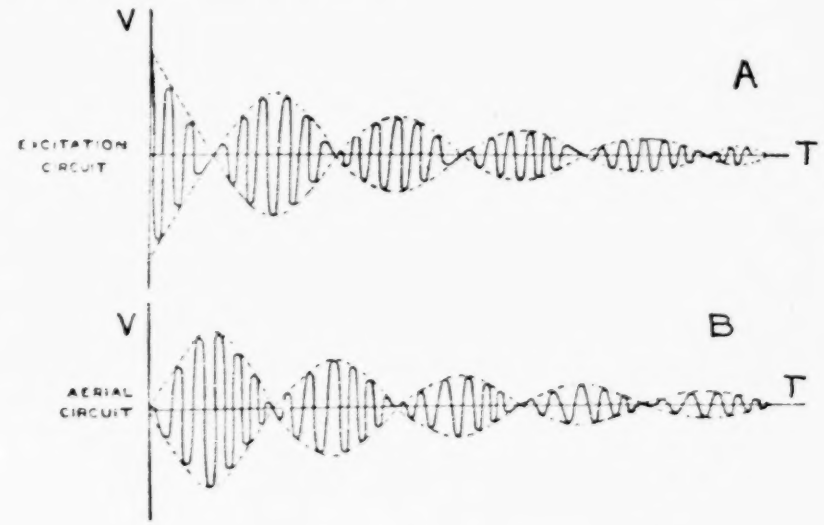


FIG. 13.—Oscillations in open-spark transmitter (Wien).

maximum wavelength λ_1 represented by the shaded area (since energy is proportional to the square of the current) and which is large in proportion to the energy of λ_2, *is totally wasted* and only gives rise to "jamming," or interference, at other neighbouring receiving stations.

The Necessity of Quenching

On pages 46 and 47 we showed by mathematical analysis the existence of two oscillations in a secondary or aerial circuit, since we obtained two different periods of oscillation.

From consideration of resonance, on page 53, we obtained a value for the secondary voltage, which was seen to have two components, each of which represented a distinct oscillation. We also found that the total current in the aerial [fol. 3499] had two components, which explained the double peak of the resonance curve, obtained in practice for coupled circuits.

The actual presence of this dual oscillation can be actually shown by use of the Braun cathode tube.

If this is done we obtain curves for the variation of voltage in the two circuits as follows:

Those familiar with the theory of sound will at once recognize that the aerial and excitation circuits both oscillate with "beats". There are, in each circuit, two oscillations of different periods and damping, which as they agree or differ in phase give rise to electrical "beats" similar to beats obtained with mechanical systems vibrating to produce sound.

Since the energies of the oscillations in each circuit sometimes assist and sometimes oppose each other, we must always have a loss of energy in the latter case.

The forced oscillation in the aerial is produced by the further transfer of energy from the excitation circuit, and, as the latter is an alternating source of current, for short periods we will have the forcing voltage equal zero.

This will allow energy to surge back from the aerial circuit, since the voltage of the latter, owing to the free oscillation, is not zero, and the spark gap will be bridged, so causing a great loss of energy owing to its high resistance, which dissipates the electrical energy as heat and light energy.

Further advance of time permits the oscillations produced in the excitation circuit to again excite the aerial, this cycle continuing until all the energy is dissipated either by radiation from the aerial or by resistance losses at the spark gap.

If we can now discover some means whereby immediately the excitation circuit has first imparted its energy to the aerial circuit, the resistance of the spark gap of the former circuit is made so great that energy surging back into it is unable to bridge the spark gap, all the energy connected magnetically and statically with the two circuits will (neglecting the very small resistance of the aerial circuit) only have one means of dissipation, namely, by useful radiation from the aerial circuit. Since the forced oscillation of the excitation circuit ceases to exist, *all the energy will be radiated on one wavelength, namely, the natural wavelength of the aerial circuit.*

The act of stopping the flow of energy in the excitation circuit is known as "quenching," since it is brought about by preventing or quenching the return spark. Also since all the energy is transferred from the excitation to the

aerial circuit after the passage of a single spark, the aerial circuit is said to be "impact" of "shock excited".

Quenching is best brought about by use of a special form of spark gap described in detail in the next section.

The effects of quenching are very noticeable in practice. [fol. 3500] Considering first the variations of voltage in the two circuits, these are shown as follows:

It will be noticed the oscillations of the excitation circuit are practically non-existent, and that the train of oscillations of the aerial has a very low logarithmic decrement, and therefore a long persistence. Beats do not occur, and there is therefore no waste of energy in beat production.

The aerial oscillations tend therefore to continuous oscillations and the area of the curve they produce, being proportional to voltage (or current), determines the energy. The great increase in aerial energy will be at once recognised, when compared to the oscillation of the aerial when the return sparking is not quenched and beats occur.

Consider now the effect of quenching on the resonance curve.

Curves for oscillations produced by open and Quenched-Spark gaps are given on pp. 334 and 335 of Fleming's "Principles of Electric Wave Telegraphy" from actual experiments by Fleming and Dyke.

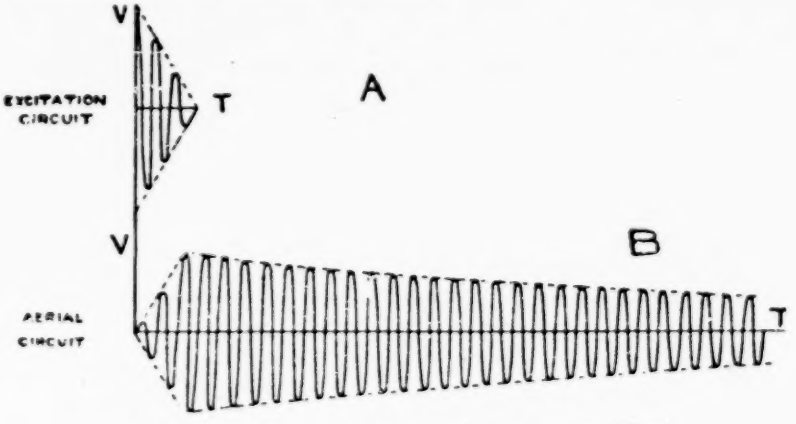


FIG. 14.—Oscillations in quench-spark transmitter. (Wien.)

As, however, unless one recognises the differences in coupling in the original curves, the whole difference between open and quenched gaps is apt to be overlooked, the author has taken the liberty of redrawing them in a series of curves

(Fig. 15), each of which show the open and quenched-gap curves for the same particular degrees of coupling.

In the case of the open-gap curves when quenching does not occur, the curve will be found to have two distinct peaks of very different wavelength and low current value, which is proportional to the energy radiated.

For a coupling of 26 per cent., with the quenched gap there is only one sharply defined peak (the other having

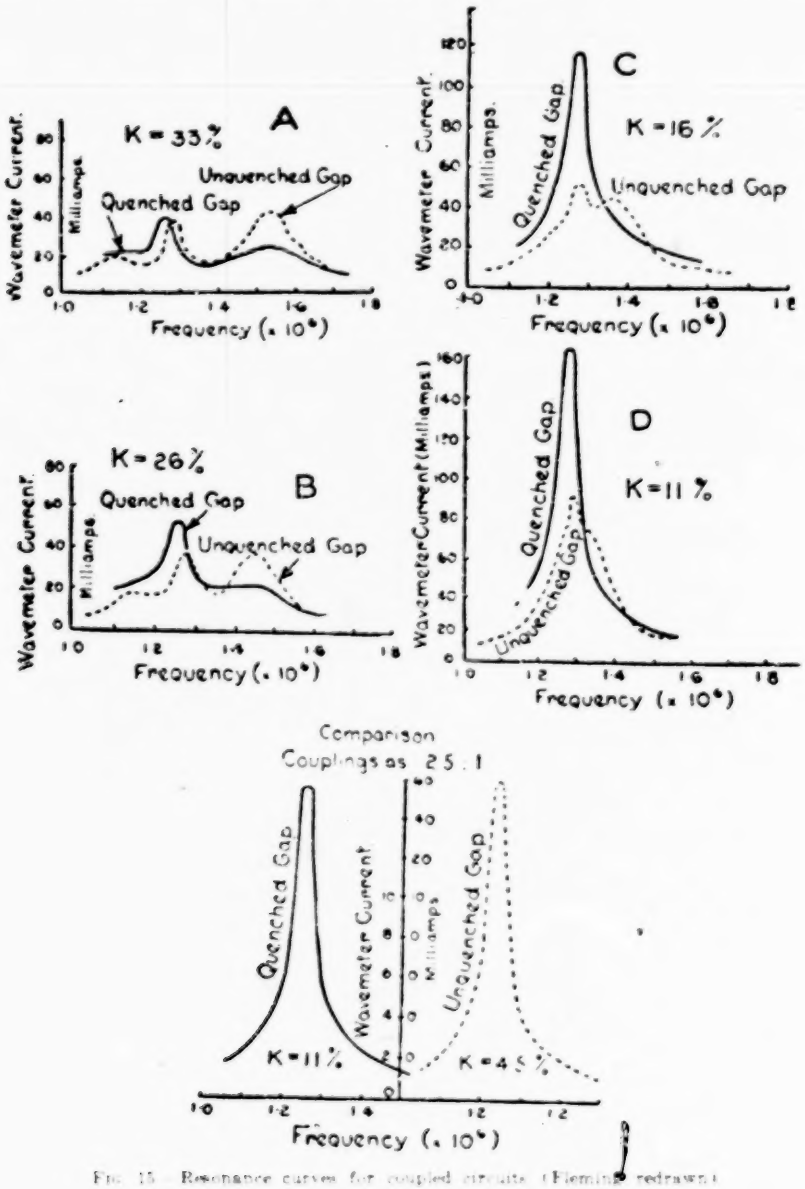


FIG. 15.—Resonance curves for coupled circuits. (Fleming, redrawn.)

nearly disappeared at a coupling of 26 per cent.). Compared with the open-spark curve of similar coupling, its current value is much greater, and therefore more energy is radiated upon a sharply defined wavelength.

In the case of the double peaked open-gap curves, a receiving station can only resonate to one wave length, and [fol. 3501] therefore the energy of the other is totally wasted and only serves to cause interference to other stations.

The last curves of this series show the difference of coupling necessary to obtain the same current effect with open and quenched gaps. These couplings are, according to Fleming, 11 per cent. for the quenched gap as opposed to a much weaker coupling of 4.5 per cent. for the open gap. This means that the coupling must be weakened and therefore a less transference of energy from excitation and aerial circuit takes place, and to render the aerial currents equal [fols. 3502-3505] much greater energy in the prime circuit must be present. According to Fleming's figures it would be presumably necessary to use $\frac{11}{4.5} = 2.5$ times the prime energy to obtain the same aerial energy, i. e., with the quenched gap the efficiency is about 75 per cent. if we take the usual value of 25 per cent. for the open gap, a figure for the quenched gap which *which* has been quenched by its opponents.

DEFENDANT'S EXHIBIT N-5

MAUBORGNE's Sketches-

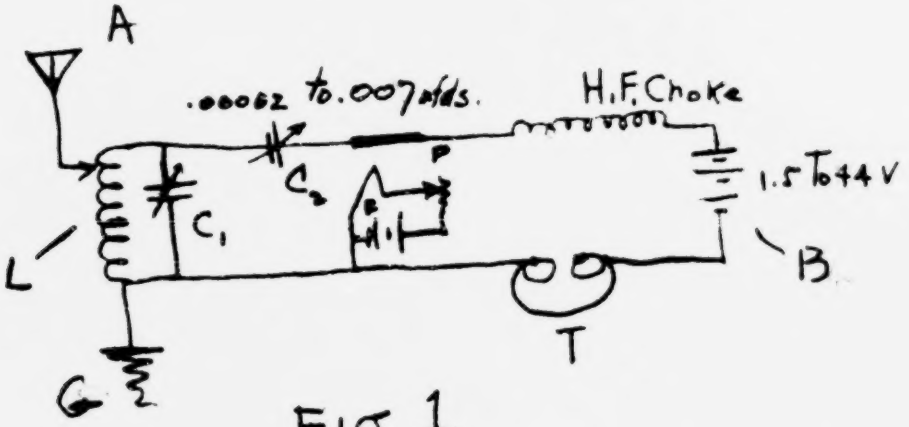


Fig. 1

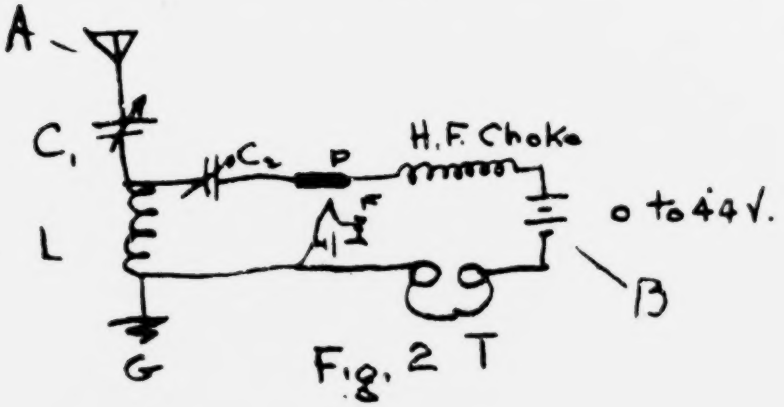


Fig. 2

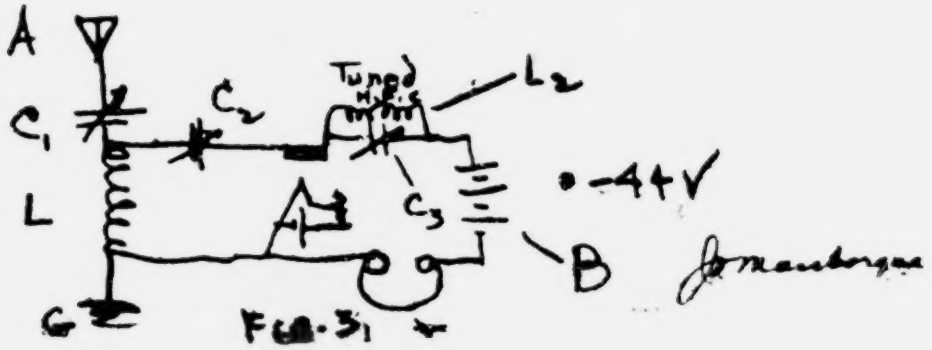


Fig. 3 J. Mauborgne

MALBORGNE's Sketches

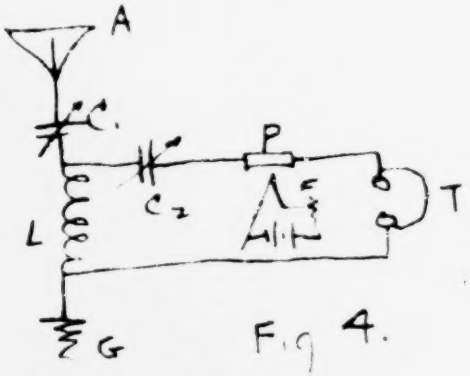


Fig 4.

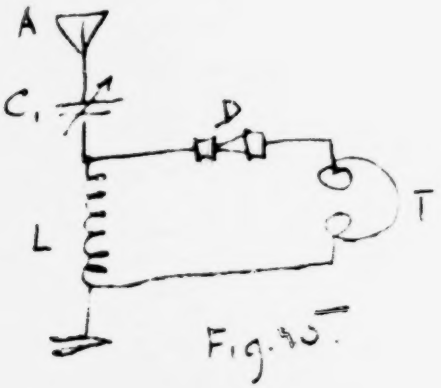


Fig. 5.

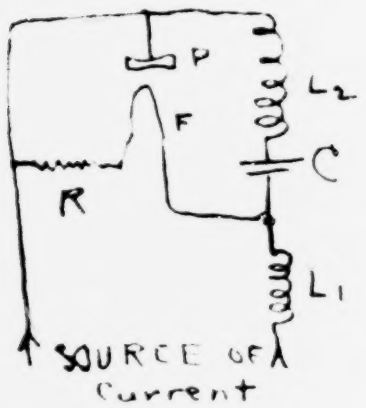


Fig. 6.

J. Marconi

MAUBORGNE's Sketches

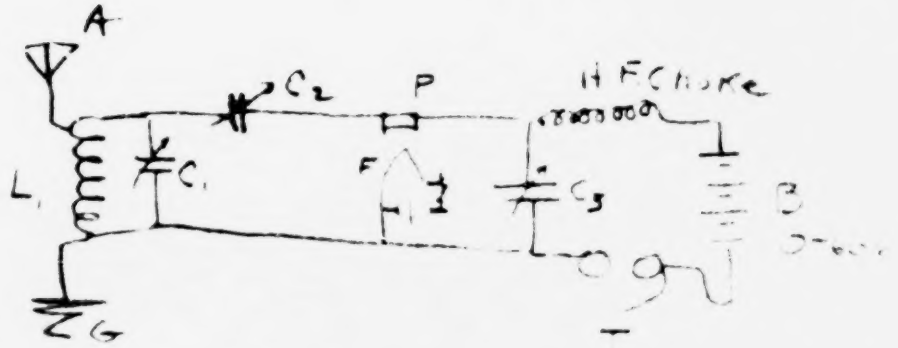


Fig 7

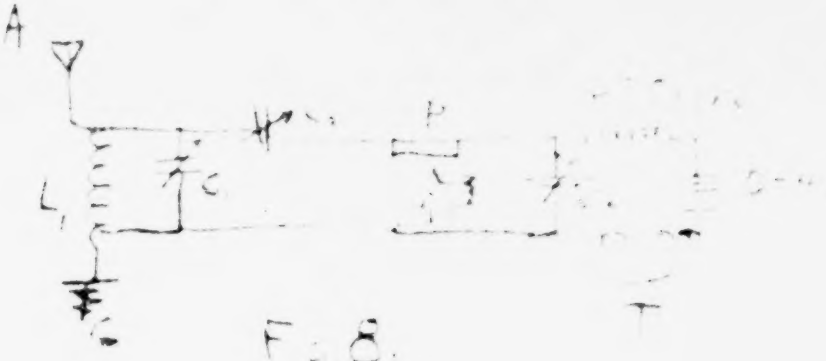


Fig 8.

344

GVVPIOA

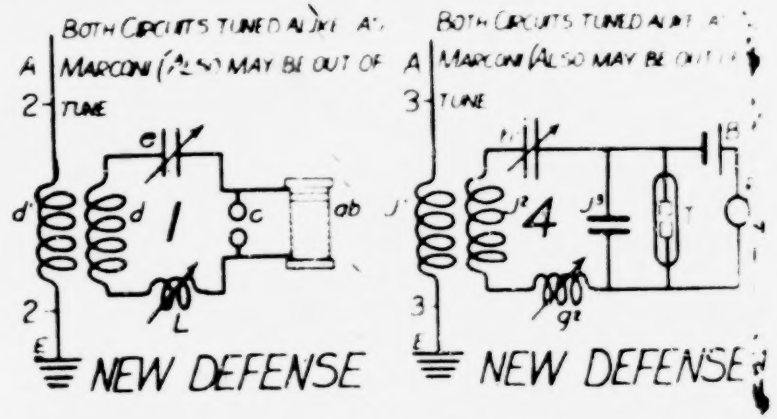
PICKARD CHART

STONE 4-CIRCUIT TUNING PATENT

714,756 FILED PRIOR TO MARCONI'S FILING AND GRANTED PRIOR TO MARCONI'S

~~NEW DEFENSE TO~~ VALIDITY & NON-INFRINGEMENT

~~IN PENDING BROOKLYN TRIAL AGAINST ATLANTIC, &c.~~



TRANSMITTER FIG 5 RECEIVER FIG 6

ALMOST IDENTICAL WITH FIG'S 1 & 2 OF MARCONI PAT IN SUIT

~~NEVER BEFORE USED IN TRIAL AGAINST MARCONI PAT~~

~~SAVE IN INCOMPLETED TRIAL IN ATLANTIC COMMUNICATION CO~~

U. S. COURT OF CLAIMS
MARCONI WIRELESS TELEGRAPH CO. OF AMERICA, Plaintiff.
v.
THE UNITED STATES, Defendant.

No. 33,642.

DEFENDANT'S EXHIBIT G-5

Pickard Chart - Stone 4-circuit tuning patent.

Notary Public.

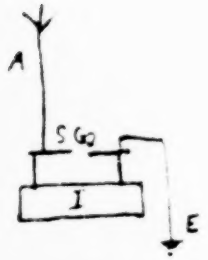


Fig 1

Plain Antenna Transmitter
A = Antenna
SG = Spark Gap
E = Earth
I = Induction Coil

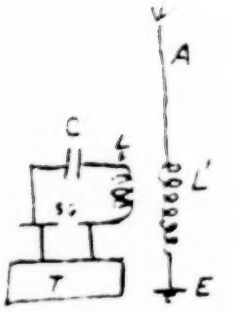


Fig 2

Tuned Oscillatory Circuit Transmitter
A = Antenna
L = " Coupling and tuning coil
E = Earth
C = Condenser
L = Primary oscillation
SG = Spark Gap
T = Transformer and secondary oscillation circuit

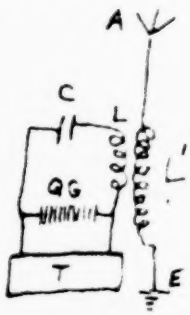


Fig 3

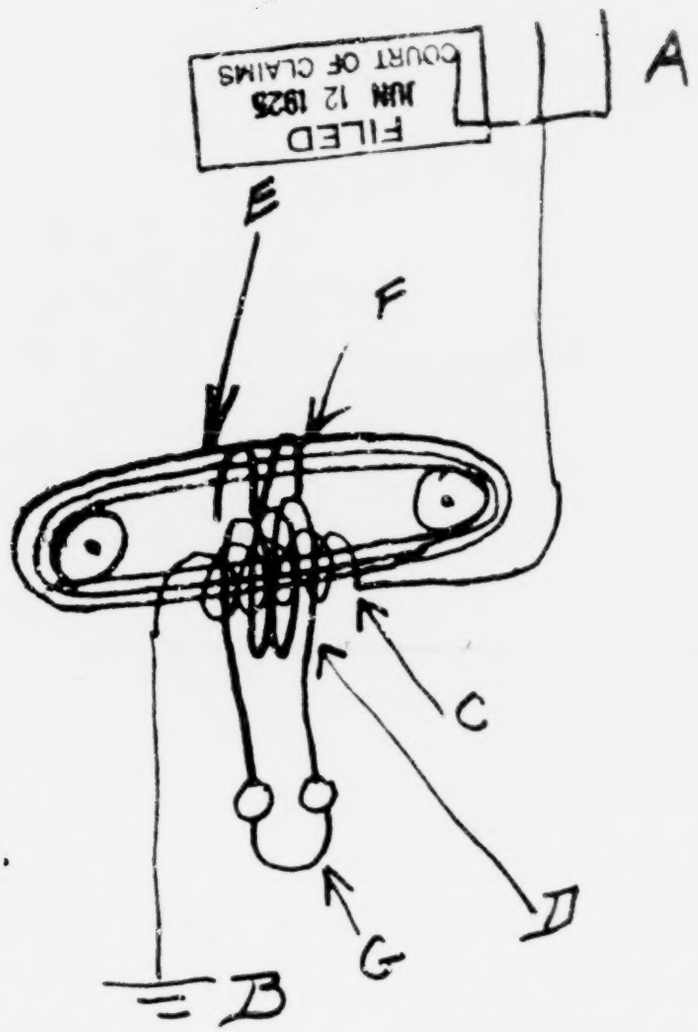
IN THE MATTER OF CLAIMS OF THE UNITED STATES.
vs. THE POSTAL TELEGRAPH COMPANY OF AMERICA.
vs.
THE UNITED STATES.
No. 33,642.

DEFENDANT'S EXHIBIT C-5.
Marriott Sketch.

Notary Public

Impulse Excitation Transmitter

A = Antenna
L' = " Coupling and tuning inductance
E = Earth
C = Condenser
L = Primary inductance
QG = Quenched Gap
T = Transformer and oscillation coil



FILED
JUN 12 1925
COURT OF CLAIMS

In the United States Court of Claims

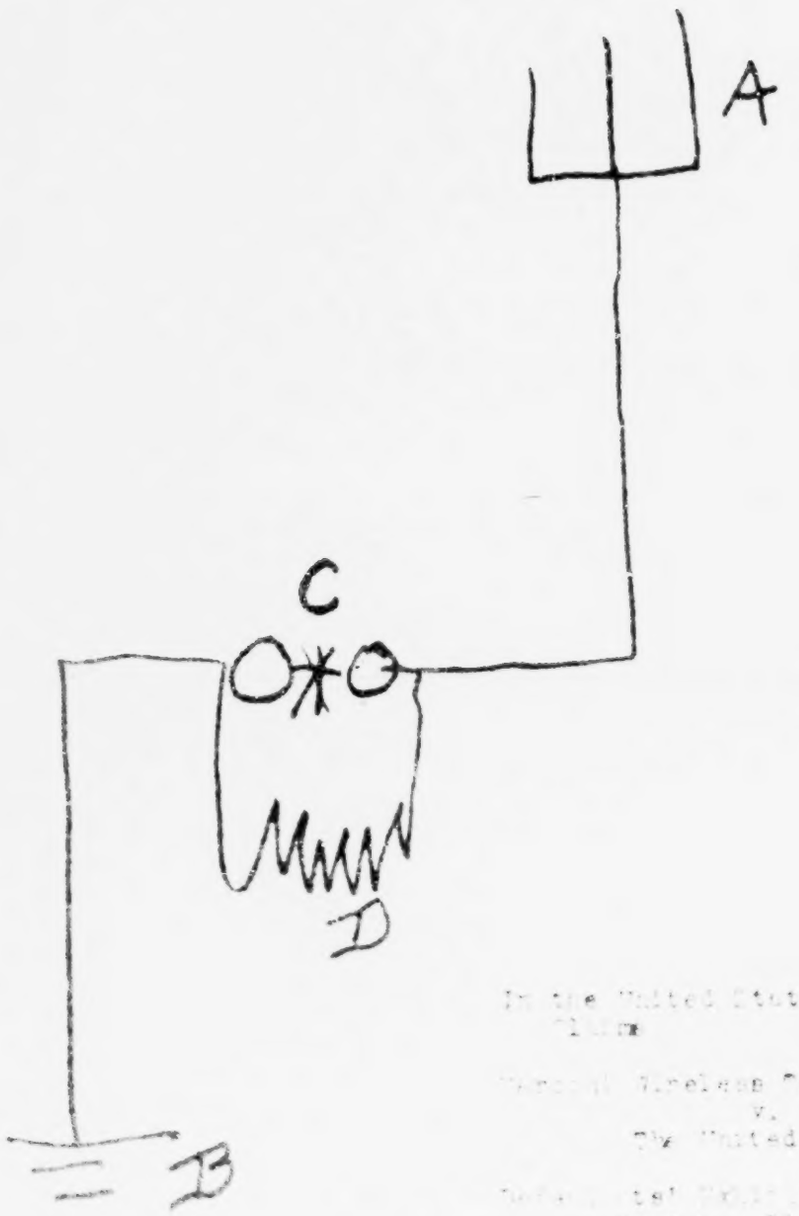
Marconi Wireless Telegraph Company

v.

The United States

Defendants' Exhibit S-5
Sayvis Sketch

Clarence A. Dietz



In the United States Court of
Claims

[illegible] Wireless Telegraph Company
v.
The United States

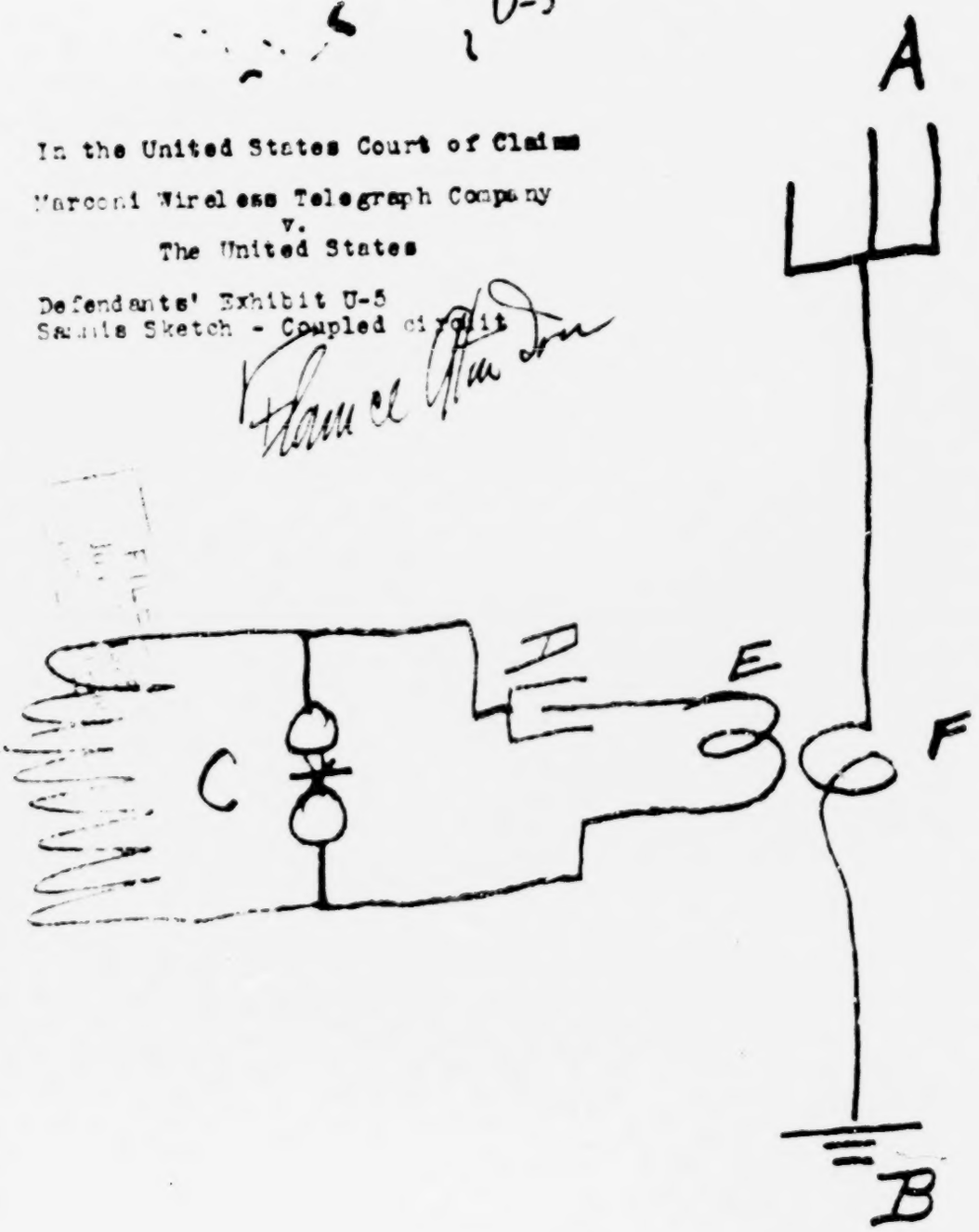
[illegible]

U-5

In the United States Court of Claims

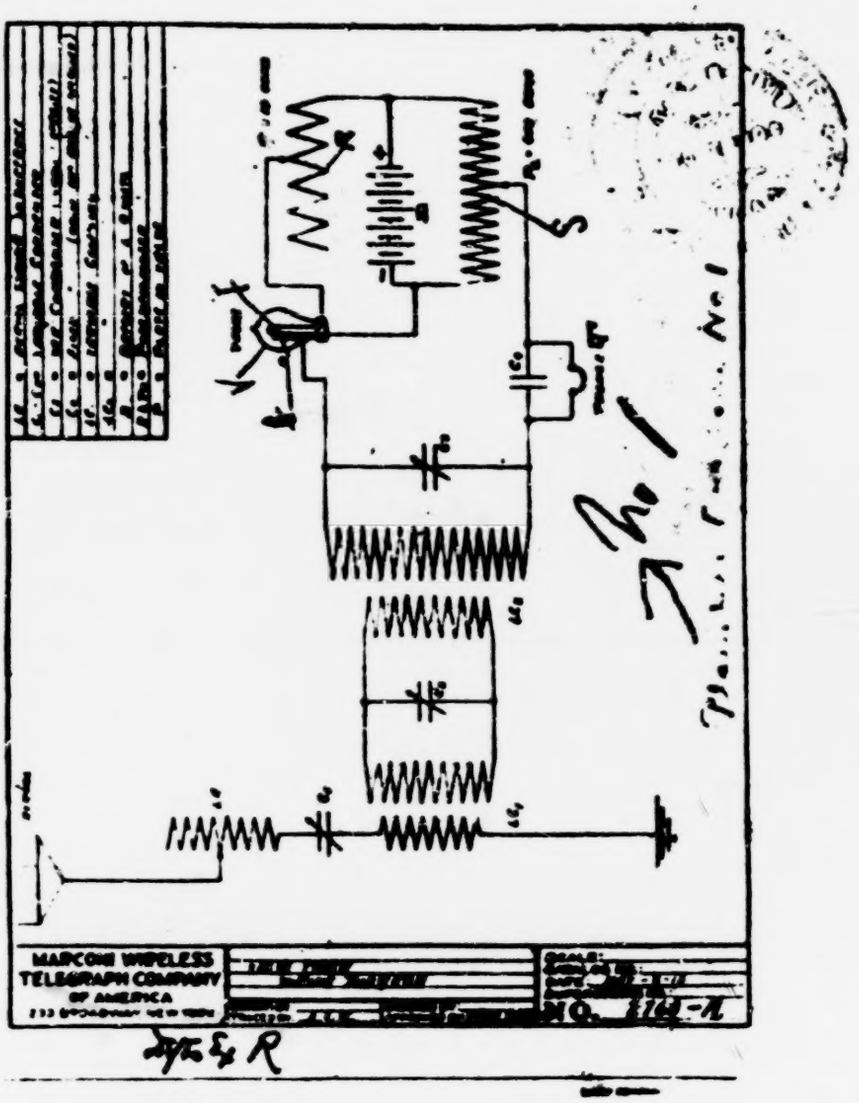
Marconi Wireless Telegraph Company
v.
The United States

Defendants' Exhibit U-5
Sample Sketch - Coupled circuit

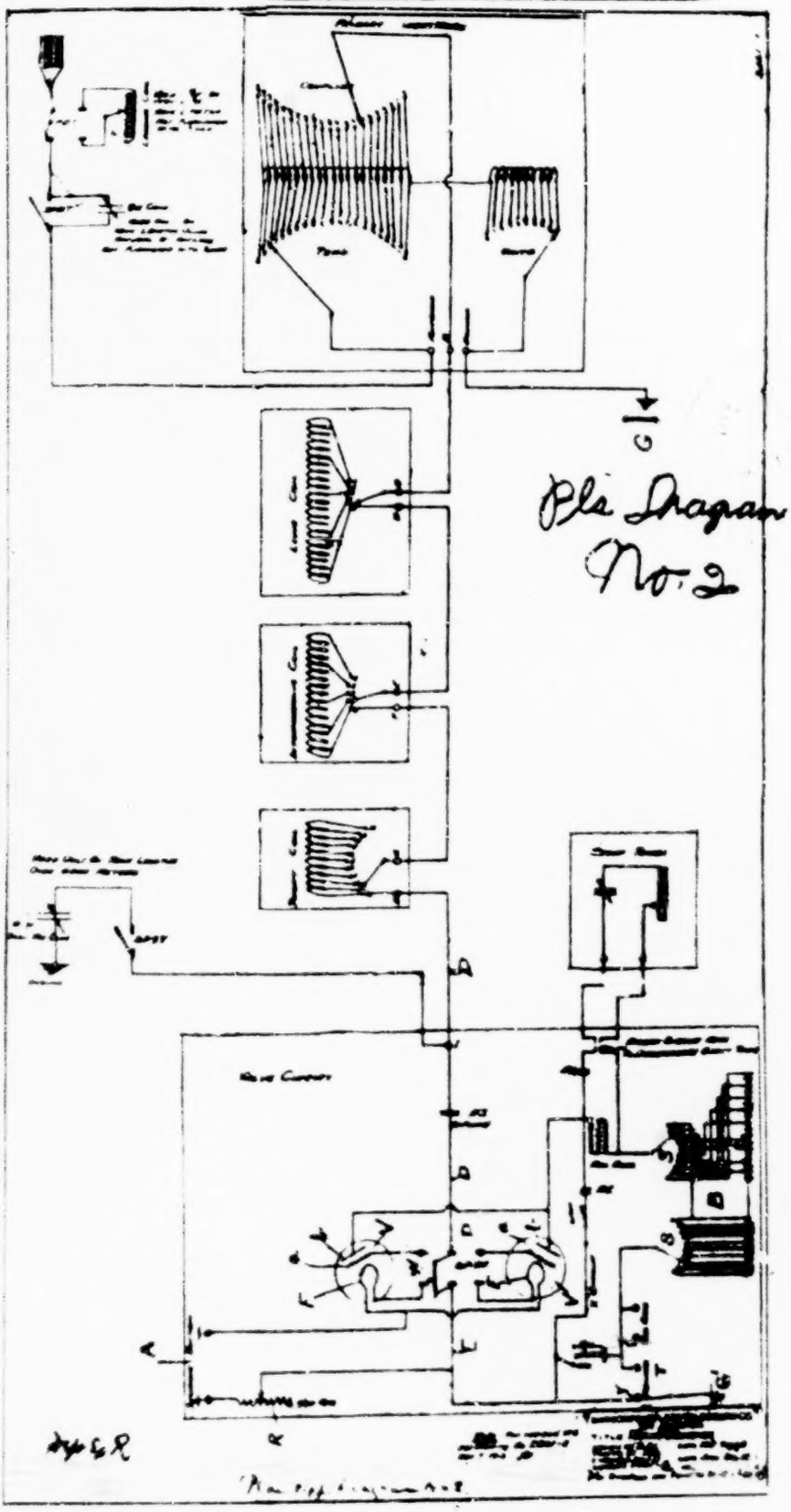


V-5

Defendant's Exhibit V-5



DEFENDANT'S EXHIBIT W-5



Ble Diagram No. 2

[fol. 3516] 2—390

DEFENDANT'S EXHIBIT X-5

United States of America, Department of the Interior,
United States Patent Office.

To all to whom these presents shall come, Greeting:

This Is To Certify that the annexed is a true copy from the Records of this Office of the File Wrapper, Contents and Drawing in the matter of the Letters Patent of Guglielmo Marconi, Assignor to Marconi's Wireless Telegraph Company, Limited, Number 763,772, Granted June 28, 1904, for Improvement in Apparatus for Wireless Telegraphy.

In Testimony Whereof I have hereunto set my hand and caused the seal of the Patent Office to be affixed at the City of Washington, this 14th day of May, in the year of our Lord one thousand nine hundred and fourteen and of the Independence of the United States of America the one hundred and thirty-eighth.

[Seal Patent Office, United States of America.]

J. T. NEWTON,
Acting Commissioner of Patents.

(Here follows 1 photolithograph, side folio 3517)

2-437

39541A

ABANDONED Renewed Feb. 29, 1904
NUMBER (SERIES OF 1900). 36,010

1900
~~ABANDONED~~
DIV. 16
PATENT No. 763,772

DIV. 16
(EX'R'S BOOK). 82-5

Name Guglielmo Marconi

Assor to Marconi's Wireless Telegraph Company, Limited, of same place.
(their)

of London

County of

~~State~~ of England

Invention

Apparatus for Wireless Telegraphy

, 190 , filed

Division of App. No. PARTS OF APPLICATION FILED.

	ORIGINAL.	RENEWED.
Petition	Nov 10 , 1900	, 190
Affidavit	" " , 1900	, 190
Specification	" " , 1900	, 190
Drawing	" " , 1900	, 190
Model or Specimen	none , 190	, 190
First Fee Cash $15	Nov 10 , 190	, 190
" " Cert.	, 190	, 190
Appl. filed complete	NOV 10 , 1900	, 190
Examined L. R. Campbell	June 1 , 1904	, 190
Countersigned J. R. Batson		, 190
	For Commissioner.	For Commissioner.
Notice of Allowance	June 1 19 04	, 190
Final Fee Cash $25	June 9 , 19 04	, 190
" " Cert.	, 19 0	, 190
Patented	June 28	, 19 4

Associate Attorney Wm. C. Patterson
6-5-04
Washington
D. C.

Attorney Betts, Batts, Sheffield & Betts
165 Broadway
N. Y.

Name
Patent No.

Serial Number
Date of Patent

[fol. 3518] Amount Received $15. Chief Clerk, CK.

To the Commissioner of Patents:

Your Petitioner, Guglielmo Marconi, a Subject of the King of Italy, residing at 18 Finch Lane, Threadneedle Street, in the City of London, England, Electrician, which is his postal address, prays that Letters Patent may be granted to him for the "Improvements in apparatus for "wireless telegraphy," set forth in the annexed specification: and he hereby appoints Frederic H. Betts, Samuel R. Betts, James R. Sheffield *and* Louis F. H. Betts, constituting The Firm of Betts, Betts, Sheffield & Betts, of 120 Broadway, in The City, County and State of New York, United States of America, his attorneys, with full power of substitution and revocation, to prosecute this application, to make alterations and amendments therein, to receive the Patent and to transact all business in the Patent Office connected therewith.

GUGLIELMO MARCONI.

U. S. Revenue Stamp, 25 Cents. W. H. B. Nov. 9, 1900.

[fol. 3519] Cancelled per Sub Spec.

To all whom it may concern:

Be it known that I, Guglielmo Marconi, a Subject of the King of Italy, residing at 18 Finch Lane, Threadneedle Street, in the City of London, England, Electrician, have invented certain new and useful "Improvements in apparatus for wireless telegraphy," of which the following is a Specification:—

The object of this invention is not only to increase the efficiency of the apparatus hitherto employed, but also to so control the action as to cause intelligible communications to be established with one or more stations only out of a group of several receiving stations.

[fol. 3520] In the specification of a former patent No. 586193 a transmitter is described which consists of an induction coil, one terminal of the secondary

circuit being connected to a metal sphere connected to earth and the other to a similar sphere connected to an insulated conductor which generally takes the form of a more or less vertical wire which may or may not terminate or have attached to it a metal body of extended surface, giving it increased electrical capacity.

According to the present invention the vertical wire is connected to earth through the secondary winding of a transformer of a kind suitable for the transformation of very rapidly alternating electric currents and the primary of this transformer is connected to the spheres or terminals of the sparking appliance.

A condenser of suitable capacity is introduced in series with the primary or each end of the primary may be connected to one of the plates of two condensers of suitable capacity, the other plates of which are connected to the sparking appliance.

This device enables much more energy to be imparted to the radiator than heretofore the approximately closed circuit of the primary being a good conserver and the open circuit of the secondary a good radiator of wave energy.

The arrangement works as follows:—

On pressing the key and actuating the induction coil (in order to produce a signal) the condenser in circuit with the transformer is charged and subsequently discharges through the spark gap. If the capacity, the inductance, and the resistance of [fol. 3521] the circuit are of suitable values, the discharge

is oscillatory, with the result that alternating currents of high frequency pass through the primary of the transformer, and induce similar oscillations in its secondary these oscillations being communicated to the elevated conductor.

The circuit of the elevated conductor should be suitably attuned for this purpose.

The effect of these oscillations in the elevated conductor is to inductively affect similar distant conductors if the self induction

and capacity of the said conductors is of a suitable value or values.

At the receiving end a receiver is employed capable of being actuated by electrical oscillations of high frequency such as are described in the specifications Nos. 627,650; 647,007; 647,008; 647009 and 586,193.

The four circuits namely those including the primary and the secondary of the transformer in the transmitter and the primary and the secondary of the transformer in the receiver should be so adjusted as to make the product of the self induction multiplied by the capacity the same in each case that is to say their electrical time period should be the same but they may also be octaves of each other.

In employing this invention to localise the transmission of intelligence to one out of several receiving stations the time period of the circuits at each of these stations is so arranged as to be different from those of the other stations. If the time period of the circuits of the [fol. 3522] transmitting station are varied until they are in resonance with those of one of the receiving stations that one alone out of all the number of receiving stations will respond, provided that the distance between the transmitter and receiver is not too small.

The adjustment of the self induction and capacity of the circuits can be made in any convenient manner those which are preferred being set out in the following description.

Figures 1 and 2 are diagrams of the transmitter and of the receiver respectively, whilst Figure 3 shows a side view and Figure 4 an edge view of a transformer used at the transmitting station and Figures 5 to 8 show various induction coils used at the receiving station.

a is a battery, b a Morse key, c a Ruhmkorff coil the primary of which is in circuit with the battery whilst the terminals of the secondary are connected to the primary d of a transformer one of the connections being through a condenser e, or there may be a condenser in both of the connections. The secondary d' of the transformer is connected to an aerial conductor A which may have at its top a metallic cylinder f and to earth or a capacity E. Between the secondary and the aerial conductor or it might be between the secondary and earth is sometimes inserted an inductance coil g having numerous coils and the connection is such that a greater or less number of [fol. 3523] turns of the coil can be put in circuit, the proper number to use being ascertained by experiment.

The receiver (Figure 2) consists of an aerial conductor A which may have a cylinder f' at its top connected through an inductance coil g' similar to g and through the primary f' of an induction coil to earth or a capacity E: a small condenser h may be inserted in parallel with the primary f'.

Cancelled Per Sub Spec.

The secondary f^2 of the induction coil is divided in the middle and has its inner ends connected to the plates of a condenser f^3 while its outer ends are connected it may be through inductance coils g^2 similar to g to a detector or coherer T: a condenser h' may be inserted in parallel with the detector. The local circuit containing a battery ceil B and relay or telegraph instrument R is connected through choking coils c' c^2 to the plates f^3 of the condenser.

The condensers h h' are preferably in the form of two metallic tubes separated by a dielectric and sliding telescopically on

each other as in this way their capacity can readily be varied with accuracy to tune the circuits.

The following are details of arrangements which have been found to work well.

The cable used for the aerial conductor at either station and for the transformer $d\ d'$ at the transmitting station is in all the examples given composed of seven strands [fol. 3524] of copper wire .889 mm. in diameter. The aerial conductor at the receiving station is in each instance exactly similar to that at the transmitting station for the corresponding tune.

The details of the transformers $d\ d'$ are as follows:

Transformer No. 1. The total length of the primary d is .946 metres and it is bent round a square d^2 of insulating material of which the side is .3048 metres long while the secondary d' consists of two turns or squares one lying on each side of the primary (see Figures 3 and 4). The insulation of both primary and secondary consists of 1.25 mm. of rubber and 1 mm. of jute making a total thickness of 2.25 mm.

Transformer No. 2 is exactly similar to No. 1 except that the total length of the primary d is 1.93 metres.

Transformer No. 3. The primary consists of ten turns of cable wound on a cylindrical core 10.16 cm. in diameter; over this but separated from it by 2 mm. of paper or other insulating material is wound the secondary also of ten turns.

The inductance coils $g\ g'$ are of copper wire 6.25 mm. in diameter wound on a cylinder 10.64 cm. in diameter an interval of 2.28 mm. being left between adjacent turns while the inductance coils g^2 inserted in series with the secondary f^2 of the induction coil at the receiving station are

of copperwire, silk covered, of .19 mm. [fol. 3525] diameter wound on cylinders 3.7 cm. in diameter.

Figures 5 to 8 show details of the induction coils j' j^2.

These diagrams are greatly enlarged half longitudinal sections, but are not strictly to scale. In place also of showing the section of each coil or layer of wire as a longitudinal row of dots or small circles as it would actually appear, it is for simplicity shown as a continuous longitudinal straight line.

Induction coil No. 1—see Figure 5. The primary consists of 3.048 metres of silk covered copper wire .71 mm. in diameter wound in one layer on a core 2.9 cm. in diameter. Insulating material is wound over and on each side of this so as to make a cylindrical core 3.13 cm. in diameter on which is wound the secondary each half consisting of 6.4 metres of silk covered copper wire .19 mm. in diameter joined to 13.41 metres of silk covered copper wire .37 mm. in diameter wound in the same sense as the primary, the thinner wire being over the primary and the thicker being beyond the ends of the primary.

Induction coil No. 2—see Figure 6. The primary j' wound on a core .6 cm. in diameter consists of 100 turns of copper wire .037 cm. in diameter insulated with single silk and coated with paraffin wax. the secondary j^2 is of copper wire [fol. 3525½] .019 cm. in diameter insulated with single silk covering and is wound over the primary commencing in the middle and in the same sense as the primary. Each half of the secondary is in layers of the following number of turns: first layer 77, second 49, third 46, fourth 43, fifth 40,

sixth 37, seventh 34, eighth 31, ninth 28, tenth 25, eleventh 22, twelfth 19, thirteenth 16, fourteenth 13, fifteenth 10, sixteenth 7, seventeenth 3, making 500 in all.

Cancelled Per Sub Spec.

Induction coil No. 3—see Figure 7. The primary consists of 3.048 metres silk covered copper wire .19 mm. in diameter and the secondary 30.48 metres long of silk covered copper wire .1 mm. in diameter wound in one layer on a core 4 cm. in diameter, the primary being in one layer outside the secondary.

Induction coil No. 4—see Figure 8. The primary consists of 3.048 metres silk covered copper wire .37 mm. in diameter wound on a core 2.9 cm. in diameter and inserted in a tube $\frac{3}{4}$ of 4 cm. external diameter on which is wound the secondary of 27.432 metres silk covered copper wire .12 mm. in diameter, the break at the middle of the secondary being over the middle of the primary.

The following tables give the adjustments, those details opposite any tune in the transmitting station table being of course used in connection with those opposite the same tune in the receiving station table.

[Matter enclosed between rules erased in copy.]

(Here follows 1 photolithograph, vide folio 3526)

Transmitting Station.

Tune	Aerial — Conductor	Transformer d d'	Inductance Number of turns of g included	Capacity in microfarads e	Length of spark in millimetres
No. 1	36.576 metres of cable	No. 1	None	.006934	3
No. 2	ditto	No. 1	45	.016395	4
No. 3	ditto	No. 2	None	.004112	3
No. 4	ditto	No. 2	100	.016849	4
No. 5	Zinc cylinder 9.144 metres long, 1.524 metres in diameter hoisted 3.048 metres above ground	No. 2	None	.001600	12.5
No. 6	30.48 metres of cable	No. 3	None	.000573	4

[fol. 3527] Receiving Station

Tune	Induction coil	Capacity in microfarads of h	h'	Inductance g' Number of turns	introduced in g^2
No. 1	No. 1	omitted	omitted	none	none
No. 2	No. 1	omitted	00004	45	none
No. 3	No. 2	0046	omitted	up to 21 may be inserted	none
No. 4	No. 2	0046	omitted	100	2 coils of 15.24 metres at each end of secondary
No. 5	No. 3	omitted	omitted	none	none
No. 6	No. 4	omitted	omitted	none	none

It will be observed that both the transmitter and the receiver are the same for tunes 1 and 2, and that when the capacity of the condenser e is varied, the two stations can be brought into tune by including 45 turns of each of the coils $g\ g'$ and by introducing a condenser h' of small capacity [fol. 3528] in parallel with the coherer T. Similarly the transformer and receiver are the same for tunes 3 and 4 and when the capacity of e is varied, the stations are tuned by including 100 turns of each of the coils $g\ g'$ and also by including the two coils g^2.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed I declare that what I claim is:

Cancelled per Sub. Spec.

1 A transmitter for electric wave telegraphy consisting of a spark producer having its terminals connected through a condenser with one circuit of a transformer the other circuit being connected to a conductor and to a capacity.

2. In a transmitter for electric wave telegraphy the combination of a transformer one circuit of which is a persistent oscillator and the other a good radiator and means for setting up oscillations in the oscillator.

3. A transmitter for electric wave telegraphy consisting of a spark producer having its terminals connected through a condenser with one circuit of a transformer the other circuit being connected to a conductor and to earth the time

period of electrical oscillations in the two circuits being the same or octaves of each other.

4. In a transmitter for electric wave telegraphy, the combination of a transformer one circuit of which is a persistent oscillator and the other a good radiator the time period of electrical oscillations in the two circuits being the same or octaves of each other and means for setting up oscillations in the oscillator.

5. A system of electric wave telegraphy in which both the transmitter and the receiver contain a transformer the time period of electrical oscillations in the four circuits of the two transformers being the same or octaves of each other.

[fol. 3529] 6. A system of electrical wave telegraphy in which both the transmitter and the receiver contain a transformer one circuit of which is a persistent oscillator and the other a good radiator or absorber of electrical oscillations all four circuits having the same time period or being octaves of each other.

Cancelled per Sub. Spec.

7. In a transmitter for electric wave telegraphy, the combination of a pair of terminals, means for producing sparks between the terminals, a transformer, connections between one winding of the transformer and the terminals, a condenser in one of the connections, a conductor, a capacity and connections between the other winding of the transformer and the conductor and capacity.

[Matter enclosed between rules erased in copy.]

Guglielmo Marconi.

Witnesses: R. B. Ransford, G. F. Warren.

[fol. 3530] GREAT BRITAIN,

England.

London, ss:

Guglielmo Marconi, the above named Petitioner, being duly sworn deposes and says that he is a Subject of the King of Italy, and resident of 18 Finch Lane, Threadneedle Street, in the City of London, England, Electrician, and that he verily believes himself to be the original, first and sole inventor of the "Improvements in apparatus

for wireless telegraphy", described and claimed in the annexed specification; that he does not know and does not believe that the same was ever known or used before his invention or discovery thereof; or patented or described in any printed publication in any country before his invention or discovery thereof; or more than two years prior to this application; or in public use or on sale in the United States for more than two years prior to this application; and that no application for patent on said improvement has been filed by him or his representatives or assigns in any country, except as follows: in Great Britain dated 26th April 1900.

Guglielmo Marconi.

Sworn to and subscribed before me this twenty sixth day of October 1900. G. F. Warren, Notary Public. (Seal.)

U. S. Revenue Stamp, 10 Cents. W. H. B. Nov. 9, 1900. (Foreign Revenue Stamps.)

[fol. 3531] 2—260.

Div. —, Room 91.

Address only "The Commissioner of Patents, Washington, D. C.," and not any official by name.

Paper No. —.

All communications respecting this application should give the serial number, date of filing, title of invention, and name of the applicant.

Department of the Interior, United States Patent Office.

Washington, D. C., Dec. 24, 1900.
Mailed Dec. 24, 1900.

Guglielmo Marconi,
Care, Betts, Betts, Sheffield & Betts,
120 Broadway, New York, N. Y.

Please find below a communication from the Examiner in charge of your application filed Nov. 10, 1900, Ser. No. 36,010, for Apparatus for Wireless Telegraphy.

C. H. DUELL,
[THOMAS EWING],*
Commissioner of Patents.

[*Words and figures enclosed in brackets erased in copy.]

Claim 1 is rejected upon the patent to Lodge, 29,505 of 1897, Telegraphy, Circuits and Systems, particular reference being had to figure 7. This patent describes a system of syntonic telegraphy on the induction system. To use the coil e as the primary of the transmitting circuit, as shown in the patent to Marconi, 586,193, July 13, 1897, Circuits and Systems, is deemed unpatentable, especially in view of the fact that in said patent statement is made that tuned circuits may be used.

As to claims 2, 4 and 6, it is required that further and clearer description be inserted in the specification as to what is meant by "persistent oscillator" and "good radiator". Until such requirement is complied with it must be held that there is insufficient basis in the specification to warrant said claims.

Claim 3 is rejected upon the British patent to Lodge, 29,505, of 1897, cited above. To have two associated tuned circuits in inductive relation to each other is deemed unpatentable; see the patent to Pupin, 640,515, Jan. 2, 1900, Circuits and Systems.

Claim 5 is also rejected upon the patent to Lodge cited above. To use step up transformers with the arrangement shown in figure 7 and step down transformers all of which are tuned, is thought to be comprehended by the disclosure of said patent.

[fol. 3532] Claim 7 is rejected upon the patent to Lodge cited above. To use such transmitting device associated with Marconi's transmitting device as disclosed in his patent No. 586,19[5]*, cited above, is deemed unpatentable.

3

C. C. DEAN,
Examiner, Div. 16.

C. D. E.

[fol. 3533] U. S. Patent Office.

In the Matter of the Application of GUGLIELMO MARCONI, for Patent for Apparatus for Wireless Telegraphy. Filed November 10, 1900. Serial No. 36,010.

July 1st.
New York, [March]* 1901.

Hon. Commissioner of Patents,
Washington, D. C.

SIR:

In the above-entitled matter, we authorize and request the cancellation of the Specification and Claims on file down to, but not including, the signatures, and the substitution of the following:

Specification.

To all whom it may concern:

Be it known that I, Guglielmo Marconi, a subject of the King of Italy, residing and having a Post-Office address at 18 Finch Lane, Threadneedle Street, in the City of London, England, Electrician, have invented certain new and useful Improvements in Apparatus for Wireless Telegraphy, of which the following is a Specification:

My invention relates to apparatus for communicating electrical signals, without wires, and by means of Hertz or electric waves

Per F. oscillations, and the object of the invention is to increase the efficiency of the system, and to provide new and simple means whereby oscilla- or electric waves

Per F. tions from a transmitting-station may be lo- one

Per F. calized, when desired, at any selected receiving-

Per F. station or stations [only]* out of a group of [fol. 3534] several receiving-stations.

(Reissue No. 11,913, dated June 4, 1901.)

In my prior United States Patent No. 586,193, I have shown and described the combination, at a transmitting station, of an oscillation-producer, such an induction-coil

[*Words and figures enclosed in brackets erased in copy.]

having one end of its secondary-coil connected to one contact of a spark-producer, and to the earth, and having the other end of the said secondary connected to the opposite contact of the spark producer and to a vertical wire or elevated plate: and I have further shown, as a receiving-station an imperfect contact connected in circuit with a vertical receiving-wire and with the earth.

According to the present invention, the system includes, the combination,

at the transmitting-station, ^ with an oscillation-transformer, of a kind suitable for the transformation of very rapidly alternating currents, of a persistent oscillator and a good radiator, one coil of said transformer being connected between the aerial wire, or plate, and the connection thereof to earth, while the other coil of the transformer is connected in circuit with a condenser, ^ a spark producer

Insert F'

an

Per F. and ^ induction-coil, (constituting the persistent oscillator) controlled by a signalling instrument; the complete system also includes at a receiving-station, an oscillation-transformer, one coil whereof is included between the aerial receiving wire and earth, constituting a good absorber of electrical oscillations, while a device responsive to electric waves, such as

Per F. ^ an imperfect contact, or a device for operating the same, is included in a circuit with the other coil of said transformer.

The system also requires as essential elements thereof, the inclusion in the lines (at both stations) from the aerial conductor to the earth, of variable inductances and the use at both stations of means for varying or adjusting the inductance of the two circuits, at each station to accord with each other. By this arrangement of apparatus, I am able [fol. 3535] to secure a perfect "tuning" of the apparatus at a transmitting-station and at one or more of a number of receiving stations.

Referring to the accompanying drawings: Fig. 1 indicates, diagrammatically, the arrangement of apparatus at a transmitting-station; Fig. 2 indicates, diagrammatically, the arrangement of apparatus at a receiving station; Figs. 3 and 4 are views, plan and side, of the preferred form of transformer at the transmitting station; Figs. 5, 6, 7 and 8, are

diagrammatic views of forms of transformers at the receiving station.

The transmitting-station is provided, under my present invention with a source *a*, of current, electri-
F. E. R. an induction
June 8, 1904 cally connected in circuit with the primary of ^
Per F. [a Ruhmkorff]* coil *c*, and with a circuit-closing key, *b*; or otherwise controlled by a signalling-instrument. In the secondary-circuit of said induction-coil, the spherical terminals, or other contacts, of a spark-
electric wave or
Per F. producer, or other ^ oscillation-producer, are included, with a shunt therefrom, in which shunt is included the primary-coil, *d*, of an oscillation-transformer, such as d^2. A condenser, *c*,—preferably one provided with two telescoping metallic tubes separated by a diaelectric, and arranged to readily vary the capacity, by being slid upon each other— is included in one connection from
induction
Per F. the ^ [Ruhmkorff]* coil to the transformer-winding, *d*.

Cancelled Per C.

A similar, or other, condenser may be included in the return connection between said parts.

The secondary-coil, *d'*, of the transformer, is connected—at
one end—to the earth, E, and at its other end
Insert Y^2 to a vertical wire, A, or an elevate plate*d*, *f* ^.
Y^2

The illustrated arrangement of parts, at a transmitting station, enables much more energy to be imparted to the [fol. 3536] radiator, *f*, the approximately-closed circuit of the primary being a good conserver, and the open circuit of the secondary being a good radiator of wave-energy. My experiments have demonstrated that the best results are obtained, at the transmitting-station, when I use a persistent-oscillator- an electrical circuit of su h a character that, if electromotive force is suddenly applied to it, and the cur-

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[*Words and figures enclosed in brackets erased in copy.]

rent then cut off, electrical oscillations are set up, in the circuit, which persist, or are maintained, for a long time in the primary-circuit, and use a good radiator (i. e., an electrical circuit which very quickly imparts the energy of electrical oscillations to the surrounding ether, in the form of waves) in the secondary circuit.

In operation, the signalling-key, *h*, is pressed, and this induction

Per F. closes the primary of the ^ [Ruhmkorff]* coil. Current then rushes through the transformer-circuit, and the condenser *c* is charged and subsequently discharges through the spark-gap. If the capacity, the inductance, and the resistance of the circuit are of suitable values, the discharge is oscillatory, with the result that alternating currents of high frequency pass through the primary of the transformer and induce similar oscillations in the secondary, these oscillations being rapidly radiated in the form of electric waves

Per Y. ^ by the elevated conductor.

For the best results, and in order to effect the selection of the station or stations whereat the transmitted oscillations are to be localized, I include, in the open secondary-circuit, of the transformer—and preferably between [fol. 3537] the radiator, *f*, and the secondary-coil, *d'*,—an inductance-coil (*g*, Fig. 1), having numerous coils, and the connection is such that a greater or less number of turns of the coil can be put in use, the proper number being ascertained by experiment.

At the receiving-stations employing my present invention, I prefer to use a receiver such as those described in my several United States Patents, Nos. 586,193; 627,650; 647,007; 647,008; 647,009 and 668,315—capable of being waves or

Per Y. effected by electrical ^ oscillations of high frequency.

Insert Y³.>

Referring to Fig. 2, *f'* indicates a plate or cylinder, not essential at either transmitter or receiver, at the upper end of an elevated conductor A, which is connected to the primary-coil *j'*, of a transformer or induction-coil, and thence to earth, E. In a shunt, around said primary, *j'*, I usually place a condenser, *h*, preferably similar, in construction and operation, to the condenser, *c*. An inductance-coil, *g'*, of

variable inductance, is interposed in the primary-circuit of the transformer, being preferably located between the cylinder, f', and the coil j', and the inductance of said coil may be adjusted, in accordance with the method described by me in my [pending Application, Serial No. ——, filed February 21st, 1901, for]* Letters Patent of the United States, No. 676,332,

Per C. ∧ to harmonize with the inductance of coil, g, at the transmitting-station Fig. 1 of the accompanying drawing) or with that of the coil or coils at one or more of the transmitting-stations included in the communicating-system.

[fol. 3538] The secondary-coil, j^2, of the transformer is preferably wound in two parts, [especially]* ∧ as described in my United States Letters Patent, No. 668,315, dated February 19th, 1901, and the outer ends of said coil are connected in certain cases, through one or more interposed inductance-coils, g^2,—preferably of variable inductance—with the terminals of a coherer, T, or other detecter of electrical oscillations. The inner ends of the split secondary-coil are connected to the plates of a condenser, j^3. A condenser, h^1, is sometimes included in a shunt around the detecter, T. B. is a battery, and R a relay, connected to the condenser j^3, and controlling a telegraphing-instrument or a printing-device. c' and c^2 are choking-coils, preventing oscillations, from the secondary, j^2, running into the battery circuit, and

Per F. thereby confining them to the ∧ [detecter]* wave responsive device.

Substitute F⁴

The four circuits—i. e., the primary and secondary circuits at the transmitting-station and the primary and secondary circuits at any one of the receiving-stations, in the communicating-system—are to be so adjusted as to make the product of the self-induction, multiplied by the capacity, the same in each case, that is to say, their electrical time period shall be the same, or octaves of each other.

[Matter enclosed between rules erased in copy.]

[*Words and figures enclosed in brackets erased in copy.]

In employing this invention to localize the transmission of intelligence at one of several receiving-stations, the time period of the circuits at each of the receiving stations is so arranged as to be different from those of the other stations. If the time-periods of the circuits [of the]* of the trans- [fol. 3539] mitting-station are varied until they are in resonance with those of one of the receiving-stations, that one alone of all of the receiving-stations will respond, provided that the distance between the transmitting and receiving stations is not too small.

The adjustment of the self-induction and capacity of any or all of the four

Per F. [the]* circuits can be made in any convenient manner, and employing various arrangements of apparatus, those shown and described herein being preferred.

In practice, I have found the following preferred details of arrangements of apparatus to work well:

The aerial conductors A, at all stations, and the conductor for the transformer-windings at the receiving-stations, are

Per C. composed of seven strands of copper wire, .889 m m in diameter. The transformer at the transmitting station may be of any of the following forms:

(1) Around a block or core, d^2, preferably a square block (say .17 meters wide) of insulating material is wound [on]* a primary-coil, d, in length .946 metres, while the secondary, d', consists of two turns, or squares, one lying on each side of the primary (see Figs. 3 and 4). The insulation of both primary and secondary consists of 1.25 m m of rubber, and 1 m m of jute, making a total thickness of 2.25 m m.

(2) A transformer, in all essentail respects similar to (1), but with a primary of 1.93

Insert B'. metres.

B'

(3) A transformer having a cylindrical core 10.16 c m. in diameter, and with a primary having ten turns wound thereon; over this, but separated by 2 m.m. of paper—or [fol. 3540] other insulant—the secondary, also of ten turns.

[Insert A.]* Insert D'.>

The inductance-coils, g and g', are, preferably, of copper wire, 6.25 m. m. in diameter, wound on a cylinder 10.64 c. m.

in diameter, with an interval of 2.28 m. m. between adjacent turns. The inductance-coils g^2, at the receiving station, are, preferably, of silk-covered copper wire, .19 m. m. diameter, wound upon cylinders 3.7 C. m. in diameter.

Various forms of induction-coils j', j^2, may be used. Figs. 5, 6, 7 and 8, show details of different forms.

The Figures show, diagrammatically, greatly enlarged longitudinal sections, not strictly to scale. Instead of showing the section of each coil or layer of wire as a longitudinal row of dots, or small circles, as it would actually appear, it is, for simplicity, shown as a continuous longitudinal straight line.

Per C. Referring to Fig. 5, the primary, $[J']^{*}_{\wedge}$ $^{j'}$, preferably consists of 3.046 metres of silk-covered
and
" " copper-wire, say, $_{\wedge}$ 71 m. m. in diameter, wound
of ebonite or other insulating material
" " in one layer on a core $_{\wedge}$ 2.9 c. m. in diameter.

Insulating material is wound over and on each side of this, so as to make a cylindrical core, say 3.13 c. m. in diameter, on which is wound the secondary, each half of which consists of 6. 4 meters of silk-covered copper-wire .19 m. m. in diameter, joined to 13.41 metres of silk-covered copper-wire, .37 m. m. in diameter, wound in the same
sense
[wire]$^{*}_{\wedge}$ as the primary, the thinner wire being over the primary and the thicker being beyond the ends thereof.

[fol. 3541] The form of induction-coil shown in Fig. 6, has a primary of one hundred turns of copper wire .037 c. m. in diameter, wound on a core, j, (2.9 c. m. in diameter), with a single silk-covering and coated with paraffin wax; the secondary j^2, is of copper wire, .019 in diameter insulated with a single silk covering, and is wound over the primary, commencing in the middle and in the same way as the primary. Each half of the secondary is in layers of the following number of turns:—first layer, 77 turns; second layer, 49 turns; third layer, 46 turns; fourth layer, 43 turns; fifth layer, 40 turns; sixth layer, 37 turns; seventh layer, 34 turns; eighth layer 31 turns; ninth layer, 28 turns; tenth layer, 25 turns; eleventh layer, 22 turns; twelfth layer, 19 turns, thirteenth layer, 16 turns; fourteenth layer, 13 turns; fifteenth layer, 10 turns; sixteenth layer, 7 turns; and seventeenth layer, 3 turns—making 500 turns in all.

A third form of induction-coil—shown in Fig. 7—has a primary of 3.048 metres of silk-covered copper-wire, .19 m. m. in diameter, and a secondary of 30.48 metres of silk-covered copper wire, .1 m. m. in diameter, wound in one layer on a core 4 c. m. in diameter, the primary being in one layer outside of the secondary.

The fourth form of induction-coil is shown in Fig. 8. Its primary consists of 3.048 metres of silk-covered copper wire, .37 m. m. in diameter, would on a core 2.9 c. m. in diameter, and inserted in a tube, j^x, of 4 c. m. external diameter, on which is wound the secondary of 27.432 metres of silk covered copper wire, .12 m. m. in diameter, the break at the middle of the secondary being over the middle of the primary.

Cancelled [Insert A^2.]* Insert C'.>

[fol. 3542] The following tables give preferred adjustments, those details opposite any tune in the transmitting station table being, of course, used in connection with those opposite the same tune in the receiving-station table.

Transmitting Station

Tune	Aerial Conductor	Transformer d, d'	Inductance Number of Turns of g included	Capacity microfarads	Length of spark in millimetres
No. 1	36.576 metres of cable	No. 1	None	.006934	3
No. 2	do	No. 1	45	.016395	4
No. 3	do	No. 2	None	.004112	3
No. 4	do	No. 2	100	.016849	4
No. 5	Zinc cylinder, 9.144 metres long, 1.524 metres in diameter, and hoisted 3.048 metres above ground	No. 2	None	.001600	12.5
No. 6	30.48 metres of cable	No. 3	None	.000573	4
No. 7	four vertical wires each 48.6 metres long connected together at	No. 4	None	.016	6

	top and bottom but kept apart throughout their length by being suspended from the arms of a wooden cross each arm of which is 4 metres long				
[fol. 3543]					
No. 8	One vertical wire 48 metres long	No. 5	None	.007	6
No. 9	One vertical wire 30·4 metres long	No. 6	None	.0026	5

Receiving Station

Tune	Induction Coil	Capacity in microfarads of k	Capacity in microfarads of k'	Inductance introduced in g' Number of turns	Inductance introduced in g^2
No. 1	No. 1	omitted	omitted	none	none
No. 2	No. 1	omitted	.00004	45	none
No. 3	No. 2	.0046	omitted	up to 21 may be inserted	none
No. 4	No. 2	.0046	omitted	100	2 coils of 15·24 metres at each end of secondary
No. 5	No. 3	omitted	omitted	None	none
No. 6	No. 4	omitted	omitted	None	none
No. 7	No. 5	omitted	omitted	none	none
No. 8	No. 6	omitted	omitted	none	none
No. 9	No. 7	omitted	omitted	none	none

It will be observed that both the transmitter and the receiver are the same for tunes 1 and 2, and that when the capacity of the condenser, c, is varied, the two stations can be brought into tune by including forty-five turns of each of the coils g, g', and by introducing a condenser, k', of small capacity, in parallel with the coherer, T. Similarly, the transmitter and receiver are the same for tunes 3 and 4, and when the capacity of c is varied, the stations are

[fol. 3544] tuned by including one hundred turns of each of the coils g and g', and by also including the coils g^2.

While I have herein shown and described details of construction and of arrangement found by me to be useful, yet I do not wish to be understood as confining my Claims thereto; obviously modifications, which are within my invention, will readily suggest themselves to skilled persons.

What I claim is:

Sub. B^2

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1. A system of electric wave telegraphy, in which both the transmitter and the receiver contain a two-circuit oscillation-transformer, the time period of electrical oscillations in the four circuits of the two transformers being the same or harmonics of each other, substantially as described.

2. A system of electric wave telegraphy, in which both the transmitter and the receiver contain a two-circuit oscillation-transformer, one circuit of which is a persistent oscillator and the other a good radiator or absorber of electrical oscillations, substantially as described.

3. A system of electric wave telegraphy in which both the transmitter and the receiver contain a two-circuit oscillation-transformer, one circuit of which is a persistent oscillator and the other is a good radiator or absorber of electrical oscillations, all four circuits having the same time period or being harmonics of each other, substantially as described.

[Matter enclosed between rules erased in copy.]

Cancelled per C

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4. In apparatus for communicating electrical signals, the combination, with an oscillation-transformer, at a transmitting station, of an induction-coil; an electric circuit containing [a]* the secondary of said coil, a condenser and the [fol. 3545] primary coil of the oscillation-transformer; a sparking-device electrically connected with the secondary of the induction-coil; and the secondary-coil of the oscillation transformer electrically connected through a variable inductance, at one end, to capacity which may be the earth

[*Words and figures enclosed in brackets erased in copy.]

and, at the other end, to an [insulated]* aerial conductor; substantially as and for the purpose described.

[Matter enclosed between rules erased in copy.]

Insert C².>

11 [9 5].* In apparatus for communicating electrical signals, the combination, with an oscillation-transformer, at a transmitting-station, of an induction-coil; an electric circuit containing the secondary of said coil, a condenser and the primary-coil of the oscillation-transformer; a producer of electric waves of high frequency

Per F. ∧ [sparking-device]* electrically connected with the secondary of the induction-coil; a signalling instrument in circuit with the primary of the induction coil; the secondary-coil of the oscillation-transformer electrically connected, at one end to capacity [which may be

Per D. the earth]* and, at the other end, to an inductance, and an aerial conductor connected to the inductance, substantially as and for the purpose described.

12 [10 6].* In apparatus for communicating electrical signals, the combination, with an oscillation-transformer, at a transmitting-station, of an induction-coil; an electric circuit containing the secondary of the said coil, a condenser and the primary-coil of the oscillation-transformer; producer of electric waves of high frequency

Per F. a ∧ [sparking-device]* connected with the secondary of the induction coil; a signalling-instrument in circuit with the primary of the induction-coil; the secondary-coil of the oscillation-transformer electrically connected, at one end, to capacity [which may be the earth],* and, at the other end, to a variable inductance, and an aerial conductor connected to the variable inductance, substantially as and for the purpose described.

[fol. 3546] Cancelled per C

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7. In apparatus for communicating electrical signals, the combination, with an oscillation-transformer, at a trans-

[*Words and figures enclosed in brackets erased in copy.]

mitting-station, of an induction-coil, an electric circuit, containing a persistent oscillator, and the secondary of the induction-coil and the primary of the oscillation-transformer; means for setting up oscillations in the oscillator; and an open-circuit, constituting a good radiator, and containing the secondary of the oscillation-transformer; substantially as and for the purpose described.

[Matter enclosed between rules erased in copy.]

[Sub. B³].* Cancelled

---

8. In apparatus for communicating electrical signals, the combination, with an oscillation-transformer, at a transmitting-station, of an electrical circuit, containing the primary of the oscillation-transformer and a persistent oscillator; a signalling-instrument controlling the oscil-ator; and an open circuit, constituting a good radiator, and containing the secondary of the oscillation-transformer and a variable inductance; substantially as and for the purpose described.

[Matter enclosed between rules erased in copy.]

Sub. D³

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11 [9].* At a station employed in wireless telegraphy, the combination, with an oscillation-transformer, of an open circuit comprising an [insulated]* aerial conductor connected with one end of a coil of the transformer; a connection from the other end of the said coil to capacity which may be the earth; a variable inductance included in said open circuit; and electrical connections from the other coil of the oscillation-transformer to an oscillation-producer or affected

Per B. to means [effected]* by electrical oscillations; substantially as and for the purpose described.

[Matter enclosed between rules erased in copy.]

[*Words and figures enclosed in brackets erased in copy.]

Cancelled per D

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12 [10].* At a station employed in wireless telegraphy, the combination, with an oscillation-transformer, of an [fol. 3547] open-circuit comprising an [insulated]* aerial conductor connected with a variable inductance; a connection from said inductance to one end of a coil of the transformer; a connection from the other end of said coil to capacity which may be the earth; and electrical connections from the other coil of the oscillation-transformer to an

affected

Per B. oscillation-producer or to means [effected]* by electrical oscillations; substantially as and for the purpose described.

[Matter enclosed between rules erased in copy.]

[Sub. B⁴].* Cancelled

---

11. At a station employed in wireless telegraphy, the combination, with an oscillation-transformer, of an open-circuit comprising an [insulated]* aerial conductor connected with a variable inductance; a connection from said inductance to one coil of the transformer; a connection from the other end of said coil to capacity which may be the earth; a shunt around said coil and containing a condenser; and electrical connections from the other coil of the oscillation-transformer to an oscillation-producer or to means effected by electrical oscillations, substantially as and for the purpose described.

[Matter enclosed between rules erased in copy.]

Cancelled per D

---

13 [12].* In a system of wireless telegraphy, the combination at a receiving station, of an oscillation-transformer, an open circuit comprising, in part, an aerial conductor connected with one end of the primary coil of the

oscillation-transformer; a connection from the

Per C. other end of the said coil to capacity [which may be the earth];* a variable inductance in said open circuit; electrical connections from the secondary coil of the oscillation-transformer to means affected by re-

ceived electrical-oscillations; and a variable inductance included in the last named electrical connection; substantially as and for the purpose described.

[fol. 3548] Cancelled Per D

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14 [13]*. In a system of wireless telegraphy, the combination, at a receiving station, of an oscillation-transformer, an open circuit comprising, in part, an aerial conductor connected with one end of the primary-coil of the oscillation-transformer; a connection from the other end of said coil to capacity which may be the earth: an inductance in said open circuit; electrical connections from the secondary-coil of the oscillation-transformer to means affected by received electrical-oscillations, an inductance included in the last-named electrical connections, and means for adjusting the inductance of one or both circuits, so as to accord with each other, substantially as and for the purpose described.

[Matter enclosed between rules erased in copy.]

19 [15 14]*. In a system of wireless telegraphy, the combination at a receiving-station, of an oscillation-transformer; an open circuit comprising, in part, an aerial conductor connected with one end of the primary-coil of the oscillation-transformer; a connection from the other end of

may

Per C. said coil to capacity [which might ^ be the earth;]* a variable inductance in said open circuit; and electrical connections from the secondary- coil of the oscillation-transformer to a receiving-instrument,

wave responsive

Per F. battery, condenser, ^ [imperfect-contact]* device and a variable inductance, substantially as and for the purpose described.

Sub D

---

16 [15]*. In apparatus for communicating electrical signals, a transmitting-station having an oscillation-transformer, an open radiating circuit comprising an aerial con-

ductor connected to one end of the secondary-coil of the oscillation-transformer, a connection from the other end of said coil to capacity [which may be the earth]*, a variable inductance in said circuit, and a persistent oscillator electrically connected [fol. 3549] in circuit with the primary-coil of the oscillation-transformer; a distant receiving-station having a oscillation-transformer, an open receiving-circuit, thereat containing an aerial conductor connected to one end of the primary-coil of the oscillation-transformer, a connection from the other end of said coil to capacity which may be the earth, a variable inductance in said circuit, and electrical connections from the secondary-coil of said oscillation-transformer to means affected by received electrical oscillations, substantially as and for the purpose described.

Per C.

[Matter enclosed between rules erased in copy.]

Cancelled Per C

---

16. In a system of electric wave telegraphy, the combination

Per B.

^ [employment]*, both at a transmitting-station and at a receiving-station, of two circuits, inductively associated with one another each of these circuits possessing capacity and inductance, and one being nearly

Per B.

constituting closed except for a spark-gap, and ^ [therefore]* a persistent oscillator, and the other circuit associated with it syntonically being an open circuit, and ^ [therefore]* a good radiator [of] ^ absorber of electric-wave energy, substantially as and for the purpose described.

" "

constituting or

[Matter enclosed between rules erased in copy.]

[Sub B']* Cancelled

---

17. In a system of electric-wave telegraphy, the employment, at a transmitting-station, of a closed circuit compris-

ing a persistent oscillator and an open circuit comprising a radiator, the product of the effected capacity and effective inductance in each of the two circuits being the same, substantially as and for the purpose described.

[Matter enclosed between rule's erased in copy.]

[Insert B^6]* Cancelled.>

Respectfully Submitted, Betts, Betts, Sheffield & Betts, Attorneys for Marconi.

[fol. 3550] UNITED STATES PATENT OFFICE, ROOM 91

In the Matter of the Application of GUGLIELMO MARCONI, for Patent for APPARATUS FOR WIRELESS TELEGRAPHY; filed November 10, 1900; serial No. 36,010.

New York, July 5th, 1901.

Hon. Commissioner of Patents, Washington, D. C.

SIR:

In the above-entitled matter, we authorize and request the following amendment of the substitute Specification, filed July 1st, 1901;

Page 8, after line 2, please insert the following:

Sub. D'. A' [Sub. B'].* Cancelled

A' "(4). The totai length of the primary d is 1.50 "metres, and it is bent round a square of insulating "material d^2, of which the side is .3048 metres long, "while the secondary d' consists of six turns or "squares, each lying on each side of the primary in "one layer. The insulation of both primary and sec- "ondary is the same as in No. 1."

Per D.

"(5). The primary consists of ten insulated wires each 1.5 metres long, wound side by side in one layer "and connected in parallel, each wire making one

"turn on a square frame, similar to that described "for transformer (4). Over the primary layer is "put a covering of paper, 1 m. m. thick, and upon "this is wound 48.64 metres of wire. The winding "is arranged in layers, the number of turns in each [fol. 3551] "successive layer being, in the first layer "(that nearest the primary), nine; in the second, "eight; in the third, seven; in the fourth, six; in the "fifth, five; in the six, two. The insulation is the same "as No. 1.

"(6) The primary consists of seven wires, wound "side by side, each wire making one turn on a square "frame as used for transformer No. 4. The seven "wires are joined in parallel and the length of each "is 1.50 metres. Over this primary layer is wound "a secondary 30.4 metres long, the winding being ar- "ranged in layers, the number of turns in the suc- "cessive layers being, in the first layer, seven turns; "in the second, six; in the third, five; in the fourth, "four."

"The transformers may be placed in an oil-bath, "especially if the turns are at all numerous."

Page 9, after the last line, please insert the following:

Per D.

A^2 "A fifth form of induction-coil may have a sec- "ondary consisting of 73.15 metres of wire wound, in "one layer, on a tube 5 cms. in diameter; said sec- "ondary being at its middle point, the wire being "12 m. m. in diameter, single silk-covered. There are "preferably two primaries, each consisting of 2.75 "metres of wire .7 m. m. in diameter wound on tubes "6.5 cms. external diameter. The two primaries are "placed symmetrically, side by side, one over each "half of secondary, and joined in parallel."

Sub. C.

"A sixth form of induction-coil, may have a sec- "ondary consisting of 48.64 metres of single silk- "covered copper-wire, .37 m. m. in diameter, wound "on a tube of 9.6 cms. diameter, in one layer, and is "cut at its middle point. Symmetrically over the

"middle portion of the secondary is wound the pri-
"mary 3.64 metres long, of wire .7 m. m. diameter,
"single silk-covered."

"A seventh form of induction-coil, may have a
"primary consisting of four wires, each 3.04 metres
"long, wound in four layers and joined in parallel,
"the layers being one under the other. The pre-
[fol. 3552] "ferred wire is .71 m. m. in diameter in-
"sulated with a single covering of silk. The second-
"ary, which is wound on a tube 3.3 cms. external
"diameter, consists of 21.24 metres of wire, .12 m. m.
"diameter, insulated with a single covering of silk.
"The secondary is divided at its middle point, and
"the primary is placed symmetrically inside of the
"secondary."

Page 11, before the paragraph commencing "It will be observed", please insert the following paragraph:

Cancelled Per C.

A' "Note. In tune No. 9, a small condenser, having
"an approximate capacity of .00008 microfarad, is
"inserted between the lower end of the receiving
"aerial conductor and the induction-coil".

Yours Respectfully, Betts, Betts, Sheffield & Betts,
Attorneys for Marconi.

[fol. 3553] 2—260

Div. —, Room 91

Address only "The Commissioner of Patents, Washington, D. C.," and not any official by name.

Paper No. —

All communications respecting this application should give the serial number, date of filing, title of invention, and name of the applicant.

Department of the Interior, United States Patent Office

Washington, D. C., August 12, 1901.
Mailed " " "

Guglielmo Marconi, c/ Betts, Betts, Sheffield & Betts, 120 Broadway, New York, N. Y.:

Please find below a communication from the Examiner in charge of your application No. 36,010, filed Nov. 10, 1900, for Apparatus for Wireless Telegraphy.

F. I. Allen [Thomas Ewing],* Commissioner of Patents.

In response to the amendments of July 3 and 8, 1901, the following action is had:

In the first paragraph of page 4 of the specification the definitions of persistent oscillators and good radiators are not sufficient. In general, a circuit which is a persistent oscillator is a poor radiator of electro-magnetic waves, and inasmuch as applicant states that his aerial circuit is the same in period as the primary circuit in which the oscillations are generated, it appears that said aerial circuit would likewise be a persistent oscillator and therefore a poor radiator. Applicant is required to further explain this feature of his invention, and accordingly claims 2, 3, 7 and 8 are objected to.

It is suggested that the word "pending" be cancelled at the end of the sixth line from the bottom on page 5.

It is asked whether the unit be the centimeter or inch used in giving the diameter of the wire as mentioned in line 15 of page 7.

[fol. 3554] J', used in the first paragraph of page 8 should be *j'*. It is thought also that in the third line of the same paragraph 71m. m. is an error.

It is thought that a circuit attuned to a certain frequency will not respond to the current of frequencies which are harmonics of the fundamental to which the circuit is attuned. Consequently, claim 1 is objected to.

Claim 11 is objected to as alternative in form, having both the oscillation producer and imperfect contact as elements in the primary circuits, whereas, by the limitation, the condenser in shunt around the primary coil limits the claim in the structure shown in figure 2, where no oscillator has been shown.

Claims 16 and 17 are not patentable inasmuch as they are drawn to an employment or use which is not comprehended in the patent statutes as patentable matter.

Claim 16 is further objectionable by the use of the phrase "and therefore the persistent oscillator" which is argumentative in form.

G. C. Dean, Examiner Div. 16.

C. D. E.

[fol. 3555] UNITED STATES PATENT OFFICE

Room 91

In the Matter of the Application of GUGLIELMO MARCONI, for Patent for Apparatus Employed in Wireless Telegraphy. Filed Nov. 10, 1900. Serial No. 36,010

December 6th
New York, [October]* , 1901.

Hon. Commissioner of Patents, Washington, D. C.

SIR:

The Examiner's letter of August 12th has been received.

We authorize and request the following amendments of the substitute Specification and Claims:

Page 7, line 26, after "metres", erase the period, and add the following:

B⁵. "and the core or block on which both primary and secondary are wound is .3048 metres wide".

Pages 8, line 4, before "with", insert the following: "wound on a cylinder 10.64 C.M. in diameter".

Same page, line 25, before "wound", please insert,

(not entered) (repetition) "joined to 13.41 metres of silk-covered copper wire, .37 m. m. in diameter.

Please substitute the following in place of the paragraph beginning "(4)", and ending" in No. 1", page 1 of the Amendment dated July 5, 1901;

[fol. 3556] Per D

B⁷. "(4). The total length of the primary *d* is 1.50 "metres, and it is bent round a square of insulating "material *d*², of which the side is .3048 metres long, "while the secondary *d'* consists of six turns or "squares, three lying on each side of the primary in "one layer. The insulation of both primary and sec- "ondary is the same as in No. 1."

[Matter enclosed between rules erased in copy.]

[*Words and figures enclosed in brackets erased in copy.]

Cancel claims 1, 2, and 3, and substitute the following:

Cancelled per C

B². "1. A system of electric wave telegraphy, in which the transmitter and the receiver each contains an oscillation-transformer, the time period of electrical oscillations in all the circuits of the transformers being the same or harmonics of each other, substantially as described.

2. A system of electric wave telegraphy, in which the transmitter and the receiver, each contains an oscillation-transformer, one circuit of which is a persistent oscillator and the other a good radiator or absorber of electrical oscillations, substantially as described.

3. A system of electric wave telegraph, in which the transmitter and the receiver each contains an oscillation-transformer, one circuit of which is a persistent oscillator, and the other a good radiator of electrical oscillations, all circuits having the same time period or being harmonics of each other, substantially as described."

[Matter enclosed between rules erased in copy.]

Cancel Claim 8, and substitute the following:

Cancelled per C

B³. "8. In apparatus for communicating electrical signals, the combination, with an oscillation-transformer, at a transmitting-station, of an electrical circuit, containing the primary of the oscillation transformer, and a condenser; a signalling instru [fol. 3557] ment controlling the oscillator; and an open circuit, constituting a good radiator, and containing the secondary of the oscillation transformer and a variable inductance, substantially as and for the purpose described."

[Matter enclosed between rules erased in copy.]

Claim 9, line 9, change "effected", to read "affected".
Claim 10, line 9, change "effected", to read "affected".
Cancel Claim 11, and substitute the following:

Cancelled per C

B⁴. "11. At a station employed in wireless telegraphy, the combination, with an oscillation-transformer, of an open circuit comprising an aerial conductor connected with a variable inductance; a connection from said inductance to one coil of the transformer; a connection from the other end of said coil to capacity which may be the earth; a shunt around said coil and containing a condenser; and electrical connections from the other coil of the oscillation-transformer to means affected by electrical oscillations, substantially as and for the purpose described."

[Matter enclosed between rules erased in copy.]

Claim 16, lines 1 and 2, erase "employment", and substitute "combination". Same Claim, line 6, erase "therefore", and substitute "constituting". Same Claim, line 8, erase "therefore", and substitute "constituting".
Cancel Claim 17, and substitute the following:

Cancelled per C

B⁵. "17. In a system of electric wave telegraphy, the combination, at a transmitting-station, of a closed circuit comprising a persistent oscillator and an open circuit comprising a radiator, the product of the effective capacity and effective inductance in each of the two circuits being the same, substantially as described.

[Matter enclosed between rules erased in copy.]
[fol. 3558] Add the following claims:

Cancelled Per C

B⁶ 18. The method of communicating intelligible signals by tuned Hertz oscillations, consisting in adjusting the product of effected inductance in the oscillation-producing circuit and in the radiating cir-

cuit at a transmitting-station of a wireless telegraph apparatus, so as to be substantially the same, substantially as described.

19. The method of communicating intelligible signals by tuned Hertz oscillations, consisting in adjusting the time periods of electrical oscillations in the oscillating-producing circuit and in the radiating circuit at a transmitting station of a wireless telegraph apparatus, so as to be the same or harmonics of each other, substantially as described.

[Matter enclosed between rules erased in copy.]

The Examiner's letter requires fuller definitions of "persistent oscillators" and "good radiators", as found on page 4 of our substitute Specification, and criticises our statement that when the primary circuit is a persistent oscillator, at the transmitting-station, the aerial-circuit is a good radiator. The Examiner apparently bases this criticism that if the time-periods of the primary and aerial circuits are the same, the aerial would be a persistent oscillator and therefore a poor radiator.

In response to this, we would state that the statement made by Mr. Marconi is correct, and is based upon the known fact that vibratory body can be set into vibration either by its fundamental note or by any harmonic. A cir- [fol. 3559] cuit attuned to a certain frequency which is a harmonic of its own, just as a violin string can be set in motion by a tuning-fork which is sounding the first harmonic. Hence, if two electrical circuits are associated with one another, one being a persistent oscillator and capable of storing up a large amount of electrical energy because it has a large capacity, this can be associated with another circuit having the same time-period of vibration but which may be more or less a good radiator according to its form. The radiative power of the circuit may be altered by suitably proportioning the aerial without changing the time-period which depends upon its capacity and self-induction. The radiative power is independent of the time-period. In point of fact, two circuits may have the same time period but very different radiative power.

An early allowance is requested.

Respectfully Submitted, Betts, Betts, Sheffield & Betts, Attorneys for Applicant.

[fol. 3560] Serial No. 36010

2—260

Div. —, Room 91

Address only "The Commissioner of Patents, Washington, D. C.," and not any official by name.

Paper No. —?

All communications respecting this application should give the serial number, date of filing, title of invention, and name of the applicant.

Rej.

Department of the Interior, United States Patent Office,
Washington, D. C.

Feb. 11, 1902.
Mailed " " "

Guglielmo Marconi, Care, Betts, Betts, Sheffield & Betts.

Guglielmo Marconi, Care, Betts, Betts, Sheffield & Betts, 120 Broadway, New York, N. Y.

Please find below a communication from the Examiner in your
charge of [the]* application [of]* filed Nov. 10, 1900, Ser. no. 36,010, for Apparatus for Wireless Telegraphy.

F. I. Allen, Thomas Ewing, Commissioner of Patents.

This case has been considered as amended Dec. 9, 1901.

Applicant's argument has been carefully considered and though difficult of interpretation by reason of grammatical defects, and also because of what seems to be a discontinuity of idea, it is correctly or otherwise interpreted by the examiner to mean that the fundamental of the aerial conductor is a harmonic of the local primary or *vice versa*, and that such a relation necessarily requires that the vibrating body of fundamental periodicity have constants such as cause it be a persistant oscillator and the aerial conductor electrical constants which make it necessarily a good radiator.

[*Words and figures enclosed in brackets erased in copy.]

The possibility of such a construction having been clearly set out on pages 7 and 8 of the Work of Hertz, by Oliver Lodge, The Electrician Company, London, 1894, and applicant's theory and explanation in the original and in the substitute specification being in accord with Lodge's statements, it is decided that the objections raised heretofore were not well taken and all further explanation is waived.

The original specification on page 2, line 28, having described the closed circuit primary as a "good conserver", it is believed that the substitute specification was not incor- [fol. 3561] rect in describing the closed circuit primary as a persistent oscillator as the two terms are synonymous.

The original specification has been carefuly compared with the substitute specification of July 3, 1901, and it is found that both describe three forms of oscillation transformers and four forms of induction coils. The amendment of July 8th inserts in the specification a description of three more transformers, namely 4, 5 and 6, and three additional induction coils, namely 5, 6 and 7, as well as a small condenser which may be inserted between the lower end of the receiving aerial and the induction coil. The amendment of Dec. 9, 1901, cancels the description of transformer 4 and inserts in lieu thereof another description of the same. The original specification describes six tunes while the substitute specification, after setting out the constants of said six tunes, adds thereto the constants of three additional ones, namely 7, 8 and 9. If the specific modifications of these transformers and inductions coils are merely special cases, clearly deducible from the principles and illustrations found in the original specification they must be held to constitute an unnecessary amplification of what is already sufficiently disclosed. If on the other hand, they have some added value or significance they involve new matter and are therefore inadmissible for that reason. It is noted that these modifications were not added until after the publication of applicant's British patent No. 7777 of 1900, about the 1st of May, 1901, which described the same.

The amendment of Dec. 6, 1901, orders an insertion after "with", line 4 of page 8, but the word "with" is not found in said line.

[fol. 3562] Page 3, lines 25 to 26, refers to a condenser similar to c which it is stated may be included in the return connection between the parts referred to in the preceding

sentence. This modification should be illustrated if the description is to be retained.

Page 5, line 22 cancel "pending".

Page 7, line 15, insert mm after .889.

Page 8, line 18, change J' to j'. Line 20, change 71 to .71. Same line, after "core" insert the material of which the core is formed.

Page 9, fifth line from the bottom, after "tube" insert the material of which the tube is formed.

The tables are indefinite because the fourth column of the first table in giving the constants of the tunes 1, 3, 5 and 6, seem to imply that there is no inductance in the circuit, whereas it is probably meant that all of the turns of g have been cut out; and because the second table in the last column thereof in giving the constants of tunes 1, 2 and 3 seem to imply the same thing.

Claims 4, 9, 10, 11, 12, 13, 14 and 15 are rendered objectionable by the argumentative phrase "capacity which may be the earth". It is not the province of the claims to explain the terms thereof, but explanation of these terms should be given in the specification. The words "which may be the earth" should be cancelled.

Claim 10 is objected to because it is alternative both in substance and in form because it covers either the transmitter or the receiver. This double meaning is given to it by the 8th line thereof.

Claims 18 and 19 cannot be considered as they are drawn to a method. Division is required under Rule 41.

The following references are cited in rejecting the claims:

[fol. 3563] British patents to

Thompson, 22020, Nov. 3, 1899.
Braun, 5104, Mch. 8, 1899;
Braun, 1862, Jan. 26, 1899;
Braun, 1863, Jan. 26, 1899.

Telegraphy, Wireless,

all of which show oscillation transformers, the primaries of which are persistent oscillators, while the secondaries are good radiators; the British patents to

Brown, 14,449, July 13, 1899.
Wilson et al., 10,153, May 13, 1899, see figure 8,

and the American patents to

Lodge, 609,154, Aug. 16, 1898,
Marconi, 627,650, June 27, 1899,
Telegraphy, Wireless,

which show that it is old to tune a receiver to a transmitter; and the patents to

Marconi, 647,007, Apl. 10, 1900;
Marconi, 647,008, Apl. 10, 1900;
Marconi, 647,009, Apl. 10, 1900;
Marconi, 668,315, Feb. 19, 1901, filed July 17, 1900,

which show that it is old to provide a receiver with an oscillation transformer, one circuit of which is a persistent oscillator and the other a good absorber of electrical oscillations.

Claim 1 is rejected on the first set of references cited because in each of the systems therein set out "the time period of *electrical oscillations* in all the circuits of the transformers" may be the same, or the oscillations of the secondaries may be harmonics of the primaries. This claim covers a very different structure from that called for by claim 3. The statement above quoted from claim 1 does not imply tuning of the circuits. By forced oscillations the time periods would be the same in any of the patents cited against the claim. The claim is further indefinite because it states that the oscillations may be the same or harmonics of each other, but it is not known whether it is [fol. 3564] meant that the secondary of the transmitter and both primary and secondary of the receiver are harmonics of the primary of the transmitter, or whether the primary and secondary of the transmitter have the same period and the primary and secondary of the receiver are harmonics of the same, or whether they are all the same.

Claim 3 correctly covers the disclosure of the specification by setting out that "all *circuits* have the same time period", which of course can only be accomplished by proportioning capacity and inductance, that is by tuning. The claim is met by the first group of references, which show the oscillation transformer &c., in view of the fact that the second group of references shows that it is old to tune a receiver to a transmitter. It is considered that it would not involve invention in view of the latter patents to tune the two circuits of the transmitter to each other, or to tune the two cir-

cuits of the receiver to each other, the two pairs being in tune. This claim is furthermore indefinite for the reason set out in connection with claim 1.

Claim 2 is rejected on the first group of references taken in connection with the four patents to Marconi last cited. The claim calls for nothing more than the use of these receivers of Marconi with the transmitters shown in the British patents to Thompson and Braun.

Claim 4 is indefinite because of the last five lines thereof. By changing the punctuation marks, that is, by changing the comma after "inductance", in the third line from the end, to a semicolon and by cancelling the comma after "end" in the same line, it is readable on figure 1. As the claim stands at present it calls for the inductance g between the secondary d' and the earth. The claim should be rewritten. [fol. 3565] Claim 7 is rejected on Thompson or the three patents to Braun cited.

Claim 8 is incomplete without the oscillator. This oscillator is merely referred to incidentally instead of being made an element of the claim. The claim, however, is rejected on the references cited against claim 7.

Claim 11 is incomplete without including positively "means affected by electrical oscillations" which as the claim stands is merely brought in by inference as an element.

Claims 16 and 17 are rejected on the references cited against claim 3.

G. C. Dean, Examiner, Div. 16.

G. K. W.

[fol. 3566] Serial No. 36010. Paper No. 7

Am'dt C. & Aff.

Filed May 1, 1902

United States Patent Office

In the Matter of the Application of GUGLIELMO MARCONI, for Apparatus for Wireless Telegraphy, Serial No. 36,010, Filed November 10, 1900

New York,
April 28th, 1902.

Hon. Commissioner of Patents, Washington, D. C.

SIR:

In the matter of the above-entitled Application, we authorize and request the following amendments to the Specification and Claims:

Page 2 of the amendment of July 5, 1901, cancel lines 24 to 32, inclusive, and substitute the following:

C". "Other forms of transformers which may be em-
"ployed by me are described and claimed in my Brit-
"ish Patent No. 7,777 of 1900".

Page 3 of said amendment of July 5, 1901, cancel lines 1 to 12, inclusive.

(Not entered repetition.)

Specification, page 8, line 5, before "with" insert "wound on a cylinder 10.64 cm. in diameter".

Page 3, lines 24, 25 and 26, cancel the sentence beginning "A similar", and ending "said parts".

Page 5, line 22, cancel "pending".

Page 7, line 15, insert "mm." after ".889".

Page 8, line 18, change "J" to read "j". Same page, [fol. 3567] line 21, change "71" to read "and 71". Same line, after the word "core", insert "of ebonite or other insulating material."

Cancel Claims 1, 2, 3, 4, 7, 8, 11, 16, 17, 18 and 19.

Renumber Claim 5 to read 9.

Renumber Claim 6 to read 10.

Renumber Claim 9 to read 11.

Renumber Claim 10 to read 12.
Renumber Claim 12 to read 13.
Renumber Claim 13 to read 14.
Renumber Claim 14 to read 15.
Renumber Claim 15 to read 16.

Claim 13 (new number), line 6, cancel "which may be the earth".

Claim 15 (new number), lines 5 and 6, cancel "which may be the earth".

Claim 16 (new number), line 6, cancel "which may be the earth".

Please insert the following Claims:

Sub D[5]

C[3]. "1. At a transmitting-station in a system of wireless telegraphy, the combination of a transformer whose secondary is connected to an open circuit including a radiating conductor at one end and capacity at the other end, and whose primary is connected to an oscillation-producing circuit which includes a condenser, the oscillation period of the two circuits being in accord with each other, substantially as described.

"2. At a transmitting-station in a system of wire-[fol. 3568] less telegraphy, the combination of a transformer whose secondary is connected to an open circuit including a radiating conductor at one end and capacity at the other end, and whose primary is connected to an oscillation-producing circuit which includes a condenser, and means for adjusting the oscillation period of the two circuits connected with the transformer to bring them into accord with each other, substantially as described.

Sub D[5]

C[3]. "3. At a transmitting-station in a system of wireless telegraphy, the combination of a transformer whose secondary is connected to an open circuit including a radiating conductor at one end and capacity at the other end, and whose primary is connected to an oscillation-producing circuit, and an adjustable

condenser located in the last named circuit, substantially as described.

"4. At a transmitting-station in a system of wireless telegraphy, the combination of a transformer whose secondary is connected to an open circuit including a radiating conductor at one end and capacity at the other end, and a variable inductance located in the said circuit, the primary of the transformer being connected to an oscillation-producing circuit which includes a condenser, substantially as described.

"5. At a transmitting-station in a system of wireless telegraphy, the combination of a transformer whose secondary is connected to an open circuit of a radiating conductor at one end and capacity at the other end, a variable inductance located in the said circuit, the primary of the transformer being connected to an oscillation-producing circuit, and an adjustable condenser located in the last-named [fol. 3569] -cuit, substantially as described.

"6. At a station employed in a system of wireless telegraphy, the combination of a transformer whose secondary is connected to an open circuit of an aerial conductor at one end and capacity at the other end, and whose primary is connected to a closed circuit which includes a condenser, the oscillation period of the two circuits being in accord with each other, substantially as described.

Sub. D[2]

6[2]. "7. At a station employed in a system of wireless telegraphy, the combination of a transformer whose secondary is connected to an open circuit including an aerial conductor at one end and capacity at the other end, and whose primary is connected to a closed circuit which includes a condenser and means for adjusting the oscillation period of the two circuits connected with the transformer to bring them into accord with each other, substa*ton*tially as described.

"8. A system of wireless telegraphy, in which the transmitting-station and the receiving-station each contains an oscillation-transformer, one circuit of

which is a persistent oscillator and the other a good radiator of electrical oscillations, the oscillation period of the circuits at the other station, substantially as described."

[Matter enclosed between rules erased in copy.]

[fol. 3570] Argument

With reference to the position of the Examiner that it would not involve invention, in view of the Patents of Marconi which describe the desirability of tuning a distant receiving instrument so as to correspond with the tune of a transmitting instrument, to tune the two circuits of the multiple-circuit transmitter to each other or to tune the two circuits of a multiple-circuit receiver to each other, we would respectfully answer as follows:

It is very plain that the necessity or desirability of tuning the two circuits of a transmitter to each other or making them accord to each other in their natural period of oscillation, is not an obvious suggestion, from prior descriptions, of desirability of tuning a transmitter to a receiver, as is seen from the fact, although the English Patent of Thompson, No. 22,020 of 1899, describes a two-circuit transmitter, yet the inventor makes not the faintest suggestion of the desirability of having the periods of oscillation accord with each other, and although Mr. Marconi himself, in his Patent No. 627,650, describes a two-circuit receiving instrument, yet he did not make any suggestion that it would be of advantage to make the periods of oscillation of the two circuits accord.

As a matter of fact, the desirability and utility of such an arrangement did not occur to him.

Practical experience has, however, demonstrated that the expedient of making the periods of oscillation of the two circuits, both of the transmitter and the receiver, accord [fol. 3571] with each other, is of very high importance; and in view of the fact that the art of wireless telegraphy is as yet commercially in its infancy, and the proper conditions for effective transmission can only be ascertained by most careful and intelligent experimentation, it would seem clear that this feature of the present invention is not one which was at all obvious to people skilled in the art, and, in fact, was not obvious to the most learned experimenters in this particular art.

We trust, therefore, that the objection will be reconsidered.

With reference to the Examiner's rejection of the Application upon reference to the British Patents to Braun and Thompson, we submit herewith an affidavit of Mr. Marconi, which shows that Dr. Braun's invention did not contemplate the possibility of bringing the two circuits at each station into accord with each other, much less the bringing of two stations into accord, each station containing two circuits. Mr. Marconi's affidavit also deals with the Examiner's rejection upon reference to the prior Marconi patents, and points out that those patents do not speak of or show the two circuits arranged to be brought into accord with each other.

An early allowance is requested.

Respectfully submitted, Betts, Betts, Sheffield & Betts, Attorneys for Applicant.

[fol. 3572]

Serial No. —

Paper No. 5

Amendment

Filed —— —, 190-

UNITED STATES PATENT OFFICE

Room 91

In the Matter of an Application of GUGLIELMO MARCONI for Apparatus for Wireless Telegraphy. Serial No. 36010. Filed November 10, 1900

UNITED STATES OF AMERICA,
Southern District of New York (ss):

Guglielmo Marconi, being duly sworn, deposes and says as follows:

I am the Applicant named in the above entitled application.

I have carefully read the letter from the United States Patent Office, under date of February 11, 1902, rejecting the claims of my Application upon reference to British Patents No. 22020 to Thompson of 1899, No. 5104 of 1899, No. 1862 of 1899 and No. 1863 of 1899, all granted to Braun, upon

British Patents 14449 of 1899 to Braun and 10153 of 1899 to Wilson, the United States Patents to Lodge 609,154, Marconi 627,650, Marconi 647,007, Marconi 647,008, Marconi 647,009 and Marconi 668,315.

The invention of my above entitled application 36019, relates to the improvement in a system of wireless telegraphy, consisting of the combination, at a station, of a transformer whose secondary is connected to an open circuit of an aerial [fol. 3573] conductor at one end, and to a capacity at the other end, and whose primary is connected to a closed circuit which includes a condenser, the oscillation period of the two circuits being in accord with each other.

I am well aware that the employment of a double circuit transmitting apparatus has been described in the British Patents of Thompson and Braun, yet it is perfectly apparent from the statements in those patents that the inventor (Dr. Braun) did not even know or understand *why* the use of double circuits, inductively connected through coils of a transformer, was advantageous. Much less did he understand that there was or could be any advantage in making the two circuits of such inductance and capacity as to have a natural period of oscillation in accord with each other.

I did not myself appreciate the necessity or desirability of such a construction at the time that I invented the two-circuit receiving apparatus described in the United States Patent No. 627,650, and the discovery made by me that the operation of the instrument was greatly improved and its capacity for transmitting and receiving messages at long distances greatly enhanced by causing the circuits to be in accord, was something which was impossible to ascertain, or even to guess at, without careful experimentation.

As a matter of fact, I did carefully experiment before I ascertained the fact, and when I had constructed trans- [fol. 3574] mitting and receiving instruments, having the above named characteristics, I found that the distance to which messages could be intelligibly transmitted was very greatly enhanced, and the distinctness of messages received over shorter distances greatly improved.

G. Marconi.

Subscribed and sworn to before me this 5th day of April, 1902. James J. Cosgrove, Notary Public, New York County. (Notarial Seal.)

[fol. 3575] 2—260

Div. —, Room 91

Paper No. —

Address only "The Commissioner of Patents, Washington, D. C.," and not any official by name.

All communications respecting this application should give the serial number, date of filing, title of invention, and name of the applicant.

Department of the Interior, United States Patent Office

Washington, D. C., June 3, 1902.
Mailed " " "

Guglielmo Marconi, Care, Betts, Betts, Sheffield & Betts, 120 Broadway, New York, N. Y.

Please find below a communication from the Examiner in charge of your application Ser. No. 36,010, for Apparatus for Wireless Telegraphy, filed Nov. 10, 1900.

F. I. Allen, [Thomas Ewing],* Commissioner of Patents.

This action is in response to the communication filed May 1, 1902.

Applicant should either complete his response to the requirement of the second paragraph of page 2 of the last office letter or give a satisfactory reason for refusing to do so. It is noted that he has cancelled only the description of induction coils 6 and 7.

Applicant should also complete his response to the requirement of the last paragraph of page 3 of the last office letter or give satisfactory reason for his refusal. In this connection present claims 9, 10, 11, 12, 14 and 16 are open to the same objection.

Claims 11 and 12 are alternative in form for the reason given in the last office letter, paragraph 1, page 4, in connection with the then claim 10, now claim 12, namely that they are capable of covering both receiver and transmitter.

Claim 15 which includes any imperfect conducting device and its accessories, is allowed.

[*Words and figures enclosed in brackets erased in copy.]

All the other claims are rejected on Tesla, 649,621, May 15, 1900, division of 645,576, Mch. 20, 1900, filed Sep. 2, 1897. On page 3, lines 113 to 125, the details of device G are given. This is an electrical oscillator comprising an [fol. 3576] alternating current generator charging a condenser and an interrupter, which is a spark gap, for discharging the same. The primary of a transformer [condenser]* is fed by this oscillation producing circuit. The secondary is connected to the ground at one end and to an elevated conductor at the other. The periods of the primary and secondary circuits are in accord with each other.

Exr.

Claims 4, 13, 14 and 16, which specify a variable inductance and means for adjusting the inductance, are not patentable over Tesla because Lodge, of record, has shown that it is old to adjust the period of a circuit by a variable inductance; and claims 3 and 5, which specify an adjustable condenser, are not patentable over Tesla because applicant has shown in his prior patent No. 627,650 that this adjustment may be produced by a variable condenser. Since it is impossible to exactly calculate the values of the electro magnetic constants of two circuits for the purpose of making their time periods agree, it is fair to assume that the electrical oscillator of Tesla must necessarily be made with an adjustable inductance or condenser, or both.

G. C. Dean, Examiner, Div. 16.

G. K. W.

[fol. 3577] Department of the Interior, United States Patent Office

Washington, D. C., Oct. 13, 1903.

Petition:

Application of G. Marconi. Serial No. 36,010

Invention: Apps. for Wireless Telegraphy

Referred to the Examiner in charge of Division 16, who is directed to file an answer on the — day of ——, which answer shall exhibit the reasons, if any, why the request of the petition hereto attached should not be granted.

F. I. Allen, Commissioner of Patents.

[*Words and figures enclosed in brackets erased in copy.]

[fol. 3578] Serial No. 36010

Paper No. 9

Petition to Revive Am'dt. D

Filed Oct. 12, 1903

Amend. D

Docket Clerk, Oct. 12, 1903. U. S. Patent Office

United States Patent Office

Room 91

In the Matter of the Application of GUGLIELMO MARCONI, for Patent for Apparatus for Wireless Telegraphy: Serial No. 36010; filed November 10, 1900

Petition to the Commissioner

New York, October 6, 1903.

To the Commissioner of Patents, Washington, D. C.

SIR:

Your petitioners aver:

First: That they are the Attorneys for the applicant above named.

Second: That said Application was filed on or about November 10, 1900.

Third: That your petitioners were informed, by Office letter bearing date the 3rd day of June, 1902, that (1) Claims 1, 2, 3, 4, 5, 6, 7, 8, 13, and 16, were met by certain references which were given; (2) that Claims 9, 10, 11 and 12 were directed to matter apparently novel; and (3) that Claim 15 was allowable.

[fol. 3579] Fourth: That the said Application is owned by Marconi's Wireless Telegraph Company, Limited, by virtue of an Assignment recorded in the United States Patent Office, on November 10, 1900, in Liber B^{82}, page 210, Transfers of Patents.

Fifth: That the points raised by the Examiner in the said letter of June 3rd 1902, were extremely technical, and it

was necessary to refer said letter to Mr. Marconi, who has had the greatest experience with those problems which deal with the prevention of interference in the receipt of messages by electrical waves or oscillations. That, at the time of the receipt of said letter of June 3rd, 1902, Mr. Marconi was not in the United States, nor did he come to America until the latter part of December, 1902, when he was in Canada, actively engaged in establishing wireless telegraphic communication between the station at Glace Bay, and the station at Poldhu, in Cornwall, and in response to a cablegram from Glace Bay, at Mr. Marconi's request, your petitioners, early in January, 1903, sent him a complete set of the papers, in connection with the Application, serial No. 36,040, including the Office letter of June 3rd, 1902. That Mr. Marconi did not arrive in the United States until about January 27th, when he was here for a very short time, in connection with the establishment of telegraphic communication, by electric waves or oscillations, between the American station at Cape Cod, and the station in Poldhu, [fol. 3580] to which task Mr. Marconi was required to give his attention almost exclusively while in America, and which he successfully accomplished; that while he was in New York City, during his visit to America aforesaid, Mr. Marconi's attention was again called, on January 27, 1903, to the matter of the Patent Office action of June 3rd, 1902, in connection with this Application No. 36040, and while he then gave some information in reply, to said letter, he found that it was absolutely necessary to postpone the filing of a complete reply to the said Patent Office letter until he could very carefully examine his records, etc., then stored in England. These records being for this reason entirely inaccessible to Mr. Marconi, delay in amending was unavoidable.

Urgent business calls in connection with installing and perfecting his system of wireless telegraphy in Europe, required Mr. Marconi to leave this country on January 31st, 1903, and he has found himself quite unable, owing to pressure of business, and to illness, to return to this country until the present time, and he has also found the demands upon his time to be so great in connection with the various stations embodying his inventions throughout the different parts of Europe, as to prevent his giving full attention to the points raised by the Examiner in said letter of June 3rd 1902, and to prepare the papers and other memoranda

necessary to point out, in detail, the differences existing between his system of wireless telegraphy, and the systems [fol. 3581] and parts of systems of the references cited against his Claims. That after Mr. Marconi's departure to Europe your petitioners wrote to Mr. Marconi, and also to Marconi's Wireless Telegraph Company, Limited, at London, England, asking them to send the required information to this country, namely on January 27th, 1903, and March 20th, 1903. That thereafter, on April 4th, 1903, your Petitioners received from said company a letter to the effect that Mr. Marconi had informed the Company that the papers referred to in our letter of January 27th to him had been dispatched. That the said papers were never received. That not having received the necessary information, your petitioners again addressed a letter to Marconi's Wireless Telegraph Company, Limited, dated May 13th, 1903, urging that the papers above referred to be furnished, and in response to a fourth letter, dated June 5th, 1903, your petitioners were in receipt of a cablegram dated July 3rd, 1903, stating that Mr. Marconi has been ill, but that it is hoped to send the papers on July 20th.

That on August 21, 1903, certain papers were received, but no remarks from Mr. Marconi.

That Mr. Marconi was in New York from September 28th, 1903, to October 3rd, 1903, and then was information from him available.

Fifth: That until the receipt of the papers and the information referred to, your petitioners were unable to file a complete and full response to the Examiner's letter of June 3rd, 1902.

[fol. 3582] That thereafter your petitioners have carefully considered the questions involved, and have prepared and amendment and argument which covers fifteen full-sized typewritten pages, and is completely responsive to the last Office action, and is annexed hereto.

Wherefore your petitioners request that the said Application, serial No. 36010, be revived as a pending Application, and that the Examiner in charge thereof be instructed to reopen the same and enter the amendment hereto annexed.

Respectfully, Betts, Betts, Sheffield & Betts.

While it is believed the foregoing petition and the appended affidavit are sufficient of themselves to warrant the

revival of this application, attention is respectfully directed to the fact that applicant's British patent No. 7777 of 1900 will absolutely preclude the assignees of this valuable invention from filing a new application.

Respectfully, Thos. E. Robertson, Assoc. Attorney.

[fol. 3583] City, County and Southern District of New York, ss:

Louis Frederick Holbrook Betts being duly sworn, deposes and says: I am a member of the firm of Betts, Betts, Sheffield and Betts, Attorneys for Guglielmo Marconi, in the matter of the above entitled Application.

Referring to the papers filed in connection with said Application, it will be seen that the last action of the Patent Office, dated June 3rd, 1902, raised certain questions extremely technical, and which required to be referred to a person technically and practically skilled in the art of wireless telegraph, by the employment of Hertzian waves, or electrical oscillations, which is an entirely novel art, of which little is known as to the practical realization, and the theory of which is still unsettled, and more especially was it necessary to refer to such a skilled person, the question of the likeness of the systems of Lodge and of Tesla, when used separately, or when employed together, and it therefore became absolutely necessary, in order to file a complete response to the Examiner's letter, to refer these matters to Mr. Marconi, who has had the greatest experience with the delicate problems of wireless telegraphy, and who has succeeded in solving many of these problems only after the most painstaking efforts, and after having devised many new forms of apparatus and combinations of apparatus. [fol. 3584] Inasmuch as the Application, No. 36010 especially deals with the problem of preventing interference in the receipt of messages by electrical waves or oscillations, to which question Mr. Marconi has given the most careful and practical study, it was decided to await his arrival in this country before submitting the questions raised by the Examiner's letter to him.

Mr. Marconi did not come to the United States, after the receipt of the Patent Office letter of June 3rd, 1902, until the end of January, 1903, on which occasion his time and atten-

tion were almost exclusively devoted to the establishment of electrical communication between the American station at Cape Cod, and the station at Poldhu, in Cornwall, and to the development of his new receiver, which employs a varying magnetic field for assisting the receipt of electrical oscillations. When Mr. Marconi was in New York, and at all available in connection with his Application No. 36010, the Examiner's letter of June 3rd, 1902, was submitted to him, in connection with the other papers relating to said Application, and was very carefully considered, but Mr. Marconi found himself unable to completely reply to said letter until he could examine his records and data, then stored at London. Inasmuch as he was then called to England, in connection with the operation and protection of his stations in European countries, he requested that he be informed by your petitioners, as to the papers and information necessary to be furnished, in connection with said Application, [fol. 3585] No. 36010, and this was done on January 27th, and later on on March 20th, our firm wrote to Mr. Marconi, and to the Marconi's Wireless Telegraph Company, Limited urging that the information referred to, together with the papers, be sent as soon as possible, and in reply our firm received a letter, on April 11th, 1903, to the effect that Mr. Marconi had informed the Company that the affidavits referred to in our letter of January 27th had been dispatched by the Notary. These affidavits were never received. After waiting a reasonable time for the receipt of these papers which were deemed necessary in connection with the Application No. 36010, we again wrote to the Marconi's Wireless Telegraph Company, Limited, on May 13th, 1903, urging that these papers should be furnished to us, and, in response to a fourth letter, dated June 5th, 1903, we were in receipt of a cablegram, dated July 3rd, 1903, that Mr. Marconi has been ill, and this is the reason why the papers were not sent in response to our last letters.

That thereafter, on August 21st, 1903, we received certain papers, but no remarks from Mr. Marconi. That thereafter, Mr. Marconi was in New York from September 28th to October 3rd, 1903, and then was information from him available. That we thereafter prepared an amendment and argument in reply to the last office action upon the application in question, which amendment, with the argument relating thereto, covers fifteen large typewritten

[fol. 3586] pages, and is completely responsive to the last office action.

It is evident, therefore, that the filing of an amendment in response to the official action of June 3rd, 1902 has been prevented by circumstances beyond the control of the inventor, the owners of the patent, and the attorneys for applicant.

L. F. H. Betts.

Sworn to and subscribed before me this 6th day of October, 1903. Francis White Proscher, Notary Public, Queens Co. Cert. filed in New York County. (Notarial Seal.)

[fol. 3587] United States Patent Office

Room 91

In the Matter of the Application of Guglielmo Marconi, for Patent for Apparatus for Wireless Telegraphy, Serial No. 36,010, filed November 10, 1900

[Amend. D.]

New York, October 6, 1903.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

Replying to Office action of June 3, 1902, we authorize and request the following amendments of the substituted Specification and Claims:

Cancelled per E

Specification, page 3, line 10, after "station", add "Fig. 9 is a view, similar to Fig. 2, showing the employment of a condenser in the earth connection of the receiving apparatus".

Page 5, after "communicating-system", last line of said page, please add: "A condenser, X (Fig. 9) may be inserted in the open circuit of the receiving-station, between the coil f' and the capacity E".

Page 6, after line 23, please insert the following:

"If preferred, the oscillation-radiating conductor and the oscillation-receiving conductor, or either, may be connected [fol. 3588] to any suitable capacity instead of being directly earthed. On certain rocky islands, it has been found impossible to make what telegraph engineers call a good earth or ground connection, but the apparatus has worked well in such places when, instead of a ground connection, a large metallic surface (plates of zinc, of about 400 square feet surface, were found useful) placed on the surface of the rocks, has been utilized."

[Matter enclosed between rules erased in copy.]

Cancel the amendment dated July 5, 1901, also the correction thereof contained in our Amendment dated December 6, 1901, and substitute the following:

D[1] "Various forms of transformers, etc., which may be employed by me are described in my British Patent No. 7,777 of 1900."

Page 10, cancel the description of details of tune No. 7, in the tables relative to the Transmitting-station.

Page 11, cancel the description of details of tunes 7, 8 and 9, in the tables relative to the Receiving station.

Cancel Claims 1, 2, 3, 4, 5, 6, 7 and 8, and substitute the following:

D[2] "1. At a station employed in a wireless telegraph system, a signalling-instrument comprising an induction-coil, the secondary circuit of which includes a [fol. 3589] condenser discharging through a means which automatically causes oscillations of the desired frequency; an open circuit electrically connected with the oscillation-producer aforesaid and a variable inductance included in the open circuit, substantially as and for the purpose described.

"2. At a station employed in a wireless telegraph system, an oscillation-receiving conductor, a variable inductance connected with said conductor; a wave responsive device electrically connected with said

conductor and in circuit with a condenser, substantially as and for the purpose described.

D² "3. At a station employed in a wireless telegraph system, a signalling instrument comprising an induction coil, the secondary circuit of which includes a condenser discharging through a means which automatically causes oscillations of the desired frequency, and the primary circuit of which includes a generator; means for varying the primary circuit; an open circuit electrically connected with the oscillation-producer aforesaid, and a variable inductance included in the open circuit, substantially as and for the purpose described.

Substitute F⁵

"4. At a transmitting-station employed in a wireless telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating conductor at one end and capacity at the other end, and whose primary is connected to a condenser-circuit discharging through [fol. 3590] a means which automatically causes oscillations of circuit and the open circuit being in electrical resonance with each other, substantially as described.

D² "5. At a transmitting-station employed in a wireless telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating conductor at one end and capacity at the other end, and whose primary is connected to a condenser-circuit discharging through a means which automatically causes oscillations of the desired frequency, such condenser-circuit and the open circuit being in electrical resonance with one another; an induction-coil, the secondary winding of which includes the condenser aforesaid, a source of energy included in the primary winding of said coil, and means for varying the circuit of said primary winding, substantially as described.

[Matter enclosed between rules erased in copy.]

"6. At a transmitting-station employed in a wireless telegraph system, the combination of a trans-

former whose secondary is connected to an open circuit including a radiating conductor at one end and capacity at the other end, and whose primary is connected to a condenser-circuit discharging through a means which automatically causes oscillations of the desired frequency, and means for adjusting the oscillation period of each of the two circuits connected with the transformer to bring them into accord with each other, substantially as described.

Substitute F[6]

"7. At a transmitting-station employed in a wireless telegraph system, the combination of a trans- [fol. 3591] former whose secondary is connected to an open circuit including a radiating conductor at one end and capacity at the other end, and whose primary is connected in series with an adjustable condenser, and a means which automatically causes oscillations of the desired frequency, substantially as described.

[Matter enclosed between rules erased in copy.]

D[2] "8. At a transmitting-station employed in a wireless telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating conductor at one end and capacity at the other end, a variable inductance being included in said circuit [said circuit]* and whose primary is connected to a condenser-circuit discharging through a means which automatically causes oscillations of the desired frequency, substantially as described.

"9. At a transmitting-station employed in a wireless telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating conductor at one end and capacity at the other end, a variable inductance being included in said circuit, and whose primary is connected in series with an adjustable condenser and with a means which automatically causes oscilla-

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* [Words enclosed in brackets erased in copy.]

dions of the desired frequency, substantially as described.

"10. A system of wireless telegraphy, in which the transmitting-station and the receiving station each contains an oscillation-transformer, one circuit of which is an open circuit and the other a closed circuit, the two circuits at each station being in elec-
[fol. 3592] trical resonance with each other and in
D² electrical resonance with the circuits at the other station, substantially as described."

Renumber Claim 9 to read 11, and cancel "which may be the earth", line 10 of said Claim.

Renumber Claim 10 to read 12, and cancel "which may be the earth", lines 9 and 10 of said Claim.

Cancel Claim 11, and substitute the following:

D³ "13. At a receiving-station employed in a wireless telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a variable inductance being included in said circuit, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and a condenser in circuit with the wave-responsive device, substantially as described.

"14. At a receiving-station employed in a wireless telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a wave-responsive device electrically connected with the other winding of the oscillation-
[fol. 3593] transformer, and means for adjusting the two transformer circuits in electrical resonance with each other, substantially as described.

D⁴ "15. At a receiving-station employed in a wireless telegraph system, the combination of an oscillation transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation receiving conductor at one end and capacity at the other end, a condenser located in said circuit between the coil and the capacity, a wave-

responsive device electrically connected with the other winding of the oscillation-transformer, and means for adjusting the two transformer circuits in electrical resonance with each other, substantially as described.

"16. At a receiving-station employed in a wireless telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, an adjustable condenser in a shunt connected with the open circuit and around said transformer-coil, a wave-responsive device electrically connected with the other coil of the oscillation-transformer, and means for adjusting the two transformer circuits in electrical resonance with each other, substantially as described.

"17. At a receiving-station employed in a wireless telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil [fol. 3594] of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and means included in each of said transformer-circuits, for adjusting said circuits in electrical resonance with each other, substantially as described.

D[3] "18. At a receiving-station employed in a wireless telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end, and capacity at the other end, a variable inductance being included in said open circuit, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and a variable inductance included in circuit with the wave-responsive device, substantially as described.

Cancel Claims 12, 13 and 14.

Renumber Claim 15 to read 19, and cancel "which may be the earth", line 6 of said Claim.

Cancel Claim 16 and substitute the following:

D[1] "20. In a system of wireless telegraphy, a transmitting-station containing an oscillation-transformer, the primary of which is connected to a condenser-circuit discharging through a spark-gap which auto-
electric waves
[fol. 3595] matically causes [oscillations]* ^ of the desired frequency, the secondary of said transformer connected to an open circuit including a radiating-conductor, and with a capacity and a coil for charging the condenser aforesaid; a receiving-station containing an oscillation-transformer, the primary of which is connected with an oscillation-receiving conductor and with a capacity, a wave-responsive device connected with the secondary of said transformer, and a receiving-instrument connected with the wave-responsive device, all in combination with means for bringing the four transformer-circuits, two at each station, into electrical resonance with each other, substantially as described.

Cancelled per E

"21. The method of communicating intelligible signals by tuned electrical oscillations, consisting in adjusting the electrical resonance in the oscillation-producing circuit, at a transmitting-station of a wireless telegraph system, so as to accord with the electrical resonance of the radiating-circuit at said station, substantially as described.

"22. The method of communicating intelligible signals by tuned electrical oscillations, consisting in adjusting the time periods of such oscillations in the oscillation-producing circuit and in the radiating-circuit, at a transmitting-station of a wireless telegraph apparatus, so as to be the same or harmonics of each other, substantially as described."

[fol. 3596] Argument

The formal objections of the Office are met by the changes in the Specification.

Cancelled E

[A new figure (Fig. 9) has been added to the drawings.]*

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* [Words enclosed in brackets erased in copy.]

The Claims as now drawn differentiate the present invention from that of Tesla, especially in respect to the apparatus for automatically producing electrical oscillations of desired frequency. In the Tesla Patents cited by the Examiner, the oscillation-producing connections and devices are vaguely described, but are not illustrated. Apparently, they comprise a transformer whose primary was discharged through a condenser and through a *mechanically-operated* break.

Mr. Marconi, on the other hand, discharges the primary throught the condenser circuit and through a sparkgap which *automatically* produces oscillations of desired frequency.

Tesla does not show or describe any means for adjusting the resonance of the two transformer circuits at the transmitting stations.

The apparatus described in the cited Tesla Patents can have no value as references, since they are not workable in wireless telegraphy, and will not work over even 1 100 part of the distance to which oscillations can be sent by Marconi apparatus of the same dimensions.

[fol. 3597] The object apparently aimed at by Tesla, in the cited Patents, is to transmit electrical currents of high potential by conduction through the high and rarified stratum of air, and he states, clearly (in Patent No. 649,621, lines 73, etc., page 2) "that the phenomenon here involved is one of true conduction and not to be confounded with the phenomena of electrical radiation".

Mr. Marconi's apparatus is one for propagating and utilizing radiant energy, and his system of wireless telegraphy depends upon the detection, at a distant station, of these radiated waves, in such a way as to vary the local circuit of apparatus at such station.

Mr. Tesla's apparatus is one for propagating electrical oscillations at the station, conducting them (by the air) to a distance station, and utilizing the same for light, heat or power, independent of local generators. For this, he requires (page 5, patent 645,576) that the terminals at each station shall be elevated so as to maintain a "moderate" height of 35,000 feet above sea level.

Mr. Marconi has sent oscillations more than three thousand miles, using terminals of only 250 feet.

The arrangement of apparatus figured and described in Tesla's U. S. Patent No. 645,576, dated March 20, 1900, is radically different in function from that shown in Marconi's U. S. Application Serial No. 36010.

In the above mentioned patent, Tesla describes in detail an oscillation transformer the secondary circuit of which [fol. 3598] consists of a flat helical coil of wire generally of considerable length; in some cases he says it would be 50 *miles* in length. The primary circuit was to consist of a few turns concentric with the secondary circuit. He furthermore states that the primary circuit is to be traversed by the discharges of a condenser and the secondary circuit then becomes a seat of high frequency high pressure electromotive forces. It is important to notice that in the specification of Tesla No. 645,576 and in other correlated specifications by Tesla, not one word is said about the application of this oscillation transformer to the production of *electric waves*. Tesla's idea clearly is that he can transmit electric energy through rarefied air; for example, through the upper strata of the atmosphere, if he can introduce into one part of this rarefied air high frequency electric currents, and as he says *conduct* electricity from one place to the other. He proposes to place at two localities oscillation transformers of the kind described to connect one end of each secondary circuit to the earth and the other end to an aerial of insulated wire. At the transmitting end he proposes to set up oscillations of high frequency and high electromotive force, and at the receiving end to draw off in some way not explained in detail the alternating current which has been transmitted through the rarefied atmosphere from the transmitter.

Now this process has no resemblance whatever to the process which is conducted by Marconi's apparatus. In this latter case the transmitter is definitely arranged with the object of throwing off from the radiating wire elec- [fol. 3599] tric or Hertzian waves. Tesla's object is to inject into the upper atmosphere high frequency electric currents and to *conduct* them by means of the rarefied air to the distant place. Tesla never mentions in his specifications the words Hertzian waves or electric waves; his invention is concerned with a totally different process, and his appliances are unsuited for Hertzian wave generation.

Tesla does not mention as important that the primary and secondary circuits of his oscillator should be so ad-

justed as regards inductances and capacity that the product of the two for each circuit is the same. It is true he says the results are "particularly satisfactory" when the primary Coil A^1 with its secondary Coil C^1 at the receiving end is adjusted to vibrate in synchronism with the transmitting Coil A C. (See lines 40-45, page 4, No. 645,576). But this rough statement does not supply the information which Marconi gives.

Again, Marconi describes in great detail the particular shapes and sizes of the oscillation transformers at the transmitting and receiving ends and the other details as to the capacities which are alone effective in enabling him to construct an apparatus for Syntonic Hertzian Wave Telegraphy.

Tesla is not even original in the form of his oscillator. The flat spiral coils which he uses are merely a reproduction of Knockenhauer's spirals figured in nearly every text book on Physics.

Hence we can say as follows:

[fol. 3600] (i) Tesla has never applied his oscillator to the special production of Hertzian waves, but always for the production of high frequency electric currents which he proposes to *conduct* through the air.

(ii) Tesla's flat coil oscillator is not suitable for the production of Hertzian waves, and especially unsuitable for their absorption and reception.

(iii) He gives no explicit instruction for the tuning of all four circuits of the transmitting and receiving oscillation transformers.

On the other hand Marconi sets out:

(i) With the definite idea of producing a practical syntonic Hertzian Wave telegraphy, and this he has practically achieved. He does not operate by means of *Conduction* through rarefied air, but by means of Hertzian Waves produced in the ether.

(ii) He gives explicit details of the oscillation transformers which are quite different in form from Tesla's, and also defines the rules by which Syntonism is secured, by adjusting the capacity and inductance of four different circuits.

Tesla's apparatus taken as a whole is not the equivalent of Marconi's. It could not perform the same duty and if set up exactly as Tesla describes, Syntonic Hertzian Wave telegraphy could not be conducted by it. Hence if it is not equivalent, it is not anticipatory.

The so-called Tesla oscillator is an air core induction [fol. 3601] coil devised for a particular purpose by Tesla. The Marconi oscillation transformer is a quite different form of induction coil devised for transforming oscillations of Hertzian Wave frequency.

There is, therefore, no use of a Tesla Oscillator by Marconi, but only a use of scientific principles, some of which are applied by Tesla for one purpose and some by Marconi for another.

The notion that any sort of transformer with two coils on it, in fact, any air-core transformer can take the place of Marconi's special coils, is quite a fallacy.

An allowance of the Claims is now requested.

Respectfully submitted, Betts, Betts, Sheffield & Betts, Attorneys for Marconi.

[fol. 3602] United States Patent Office

Room 91

Patent Office, Oct. 12, 1903. Div. 16. Filed

In the Matter of the Application of GUGLIELMO MARCONI, for Patent for Apparatus for Wireless Telegraphy; Serial No. 36,010; Filed November 10, 1900

New York, October 6th, 1903.

Hon. Commissioner Patents, Washington, D. C.

SIR:

Please recognize, Thomas E. Robertson, of 605 Seventh Street, Washington, D. C., as our Associate Attorney, in the matter of the above-entitled Application.

Yours respectfully, Betts, Betts, Sheffield & Betts, Attorneys for Marconi.

[fol. 3603] Paper No. 10

U. S. Patent Office, Oct. 15, 1903

Mailed

Department of the Interior, United States Patent Office

Washington, D. C., October 15, 1903.

In the matter of the application of GUGLIELMO MARCONI, for patent for Apparatus for Wireless Telegraphy, filed November 10, 1900, Ser. No. 36,010

Examiner's Statement

This is a petition to revive the above entitled application which became abandoned June 3, 1903, by reason of failure to prosecute the same within one year from the date of the last official action, which was June 3, 1902.

Annexed to the petition is an affidavit by one of the attorneys substantiating the statement of facts alleged by the petition to constitute a showing of unavoidable delay.

These facts are that because of the technical nature of the invention it was necessary to submit the questions raised by the last office letter to Marconi, who was not in the country when the letter of June 3, 1902, was received, and who did not arrive here until the latter part of December, 1902.

No attempt has been made to account for the seven months delay intervening between the receipt of the last office letter and Marconi's arrival in this country. In this connection attention is called to ex parte McElroy, 101 O. G. 2823, in which it was decided that the *delay* must be [fol. 3604] unavoidable and not merely that a *certain portion of the delay* must be unavoidable.

Early in Janaury, 1903, Marconi, who was then at Glace Bay, cabled the attorneys for the record of the application, which was sent to him. Marconi was too busy evidently to attend to the matter until his arrival in the United States on January 27, 1903, at which time he gave the attorneys partial information, but found it necessary to postpone filing a complete reply to the last office letter until he could examine his records in England.

The necessity for consulting these records was apparently caused by the citation of two patents to Tesla, which in the

opinion of the Examiner discloses the invention presented in this application. These patents show in the drawings purely diagrammatic and conventional representations of certain apparatus known for many years as the "Tesla oscillator". Apparently Marconi did not make any serious attempt to find out what these patents really did disclose because he has amended his claims in such a way that they are still readable upon the Tesla patents. This will be hereinafter more fully explained.

Marconi left this country on January 31, 1903, and owing to pressure of business found himself unable to prepare the necessary instruction to his attorneys.

On March 20, 1903, nine and one-half months after the date of the last letter, the attorneys called on the Marconi Company for the necessary information.

On April 4, 1903, ten months after the date of said office letter, the attorneys received a communication from the Company stating that Marconi said he had already sent the papers required. These papers were never received.

On May 13, 1903, eleven months after the date of said [fol. 3665] office letter, the attorneys addressed a letter, which should certainly have been a cablegram, to the Marconi Company urging that the papers be sent and on June 5, 1903, twelve months after the date of said office letter, another such request was sent to said Company.

It would seem that some action based on the partial information obtained from Marconi January 27, 1903, might have been submitted by the attorneys between May 13 and June 3, 1903, that would have saved the case from abandonment.

On July 3, 1903, thirteen months after said office letter, a cablegram was received by the attorneys stating that Marconi had been ill, but hoped to send the papers July 20, 1903.

On August 21, 1903, fourteen and one-half months after the date of said office letter, the desired papers were received, but were accompanied by no remarks from Marconi.

On October 3, 1903, sixteen months after said office letter, Marconi was in New York and then information was received from him.

This petition was then presented on October 13, 1903, sixteen months and ten days after the date of the last office letter and was accompanied by a fifteen page amendment alleged to be completely responsive to the last office action and presumably based on the information imparted by

Marconi to his attorneys. This amendment will be hereinafter more fully described.

Although Marconi alleges that he was so busy with business matters requiring his entire attention, that he was unable to give any of his time to the prosecution of this application, he has nevertheless found time to file four applications for letters patent in this office, namely, 132,974, [fol. 3606] November 28, 1902; 141,398 and 141,399, February 2, 1903; and 172,617, September 10, 1903.

It is by no means unusual that an active inventor is too busy perfecting his inventions and filing applications for later improvements, to devote much of his time to the prosecution of his applications already filed, but such a condition of affairs, it is thought, does not constitute the unavoidable delay mentioned by statute as prerequisite to the revival of an abandoned application.

At this point reference is made to applicant's co-pending application serial number 82,856, filed November 19, 1901. In answer to the rejection of June 21, 1902, the attorneys found it possible to prepare and submit an elaborate amendment although the invention involved matters of technical difficulty of much the same order as those involved in this application.

On October 7, 1903, in said application an affidavit was submitted by Prof. J. A. Fleming, the retained expert of the Marconi Company, explaining certain theoretical matters on which additional information is asked by a previous office letter.

It would seem that the services of this expert were just as available to the Marconi Company in this application as they were in application serial number 82,856 although no attempt apparently was made to call them into requisition when it was found that Marconi was not available.

In view of the foregoing it is thought that the affidavit of the attorneys fall far short of the showing of unavoidable delay covering the entire period contemplated by R. S. 4894 and by Rule 172 as construed by the Commissioner of Patents in the following cases:

[fol. 3607] Ex parte Klenha, 28 O. G., 1272.
Ex parte Pratt, 39 O. G., 1349.
Ex parte Murray, 56 O. G., 1060.
Ex parte McPhil, 56 O. G., 1060.
Ex parte Raeymaekus, 60 O. G., 1749.
Ex parte Heine, 64 O. G., 1006.

It has been the Examiner's practice, however, to overlook much in showings of delay in similar cases where the amendment submitted with the petition has been such as to put an application in condition for allowance without further action on the part of the office and in such cases his favorable recommendations have heretofore been accepted by the Commissioner.

In order to ascertain if such treatment could be accorded in the present case a careful examination has been made of the amendment submitted with this petition. As a result of such examination the following report is made:

Many of the claims are not patentable over Tesla, 645,576, and 649,621, of record, the amendment designed to overcome said reference as well as Marconi's pretended ignorance of the nature of a "Tesla oscillator" being little short of absurd. Ever since Tesla's famous lecture on alternating currents of high frequency delivered before the American Institute of Electrical Engineers in 1891, and repeated in 1892 before the Institute of Electrical Engineers and the Royal Institution, London, the Societe Internationale des Electriciens and the Societe Francaise de Physique, Paris, which lectures have been widely published in all languages, —the term "Tesla oscillator" has become a household word on both continents.

Anyone who has read such elementary text books on physics as are used in the ordinary high school or in the first [fol. 3608] year of a technical college course knows what this term means. Marconi evidently knew in 1897, because he is quoted by Della Riccia in the Rivista di Artiglieria e Genio, Vol. 2, 1898, page 343, as having said that he employed such oscillator and also an Elihu Thomson oscillator in certain early experiments at Dover, but that the results were not so good as those obtained by using an ordinary induction coil.

The Tesla oscillator as a means for generating currents of high frequency and high tension for use in wireless telegraphy was first patented by Dr. Braun (see British patent 1862 of 1899, published January 27, 1900, or Swiss patent, 18577, published November 30, 1899, or German patent, 111,578, filed October 14, 1898).

Braun did not tune the transmitting wire to the period of the oscillator but this is clearly described in the Tesla patents of record (see page 4, 645,576 and the last three lines

of page 1 down to the first ten lines of page 2 of 649,621, see also claims 5, 7, 9 and 10.)

On page 4, of 645,576 it is said that "the primary and secondary circuits in the transmitting apparatus being carefully synchronized, * * *". The term "synchronized" as applied to two circuits is synonymous with the term "tuned". In 649,621 at the point above indicated and elsewhere it is clearly stated that the elevated conductor is so designed and adjusted that the point of maximum potential is coincidental with the end of the wire, that is, the transmitting wire is equal to a quarter wave length of the disturbance in the circuit and consequently of the radiated wave.

This means nothing more nor less than tuning the elevated conductor to the Tesla oscillator, (which is any closed circuit containing a spark-gap, a condenser and an inductance,) inductively associated with said vertical wire. Au-
[fol. 3609] thority for this statement may be found in three papers dealing with the theoretical aspects of electrical oscillations and electro magnetic waves, namely:

Ascoli in "Electricista", Rome, August 1897.

Slaby in "Electrician", London, April 25 and May 2, 1902.

Fessenden in "Transactions Amer. Inst. Elec. Engr." December, 1899.

Tuning a closed persistently oscillating circuit with the vertical transmitting wire as well as the advantages resulting therefrom has been described by Pupin in the paper presented before the American Institute, December, 1899, and by Fessenden in patents 706,735 and 706,736, August 12, 1902, where the closed persistently oscillating circuit is *conductively* connected with the open oscillator or good radiator i. e., the transmitting wire, and the same thing has been disclosed by Stone in patents Nos. 714,756 and 714,831, wherein the closed and open circuits are *inductively* connected.

The amendment does, indeed, cancel much of the new matter that has been injected into this case since it was filed but on the other hand more new matter is sought to be added by said amendment. Specifically the amendment to page 5 after the last line thereof specifying that a condenser X may be inserted in the open circuit between the coil j' and the earth E is not justified by the original dis-

closure and is, in fact, an idea borrowed from Stone's patent 737,179, August 25, 1903,—see Fig. 2.

The new figure illustrating this construction is without justification.

The amendment to page 6, line 23, referring to the use of the "artificial ground" is new matter and is an idea taken from Fessenden's patent 706,746, August 12, 1902.

[fol. 3610] These features have not been claimed and thus according to the settled practice the amendment would not have been entered if presented during the regular prosecution of the case because an amendment cannot be entered in part, (ex parte Stern, 59 MS. Dec. 254).

The proposed amendment presents a number of apparatus claims and two method claims (claims 21 and 22). Therefore this amendment, if presented during the regular prosecution of the case, would have resulted in an immediate requirement of division and, as decided in ex parte Tichirner, 97 O. G., 187, the business of the office would in such case be best facilitated by refusing to enter the amendment.

As decided in ex parte Morrison 99 O. G., 2969, such an amendment would not have been entered even if presented when the case was alive on the last day of the year allowed by law for the prosecution of the case, in order to save it from abandonment.

It is thus apparent that the amendment accompanying this petition is not even of such character that it may be entered, much less put the case in condition for allowance, and that therefore there is not the same reason for overlooking the deficiencies of the showing made to account for the delay that might exist were the amendment one which would put this case in condition for allowance.

The associate attorney has presented a brief argument to the effect that failure to revive this case will work irreparable injury to the assignees because Marconi's British patent No. 7777 of 1900 filed April 26, 1900, operates as a bar to a new application for what he calls "this valuable invention".

It is true that said British patent as well as other foreign patents so operates and it is true that this is a valuable [fol. 3611] invention, but, in the opinion of the Examiner, the references above cited and also numerous other references, some of which are hereinafter set forth, effectually dispose of the idea that this is a valuable *application*, however valuable may be the invention disclosed therein, be-

cause any patentable claims which this application will support in view of the state of the art must necessarily be of the most limited character.

Some of these references, above referrred to, which disclose a closed persistently oscillating circuit known as the D'Arsonval or the Oudin oscillator (a modification of the Tesla oscillator) inductively associated with an open or radiating circuit attuned thereto for the purpose of transmitting electro magnetic signal waves, are

L'Industrie Electrique, Paris, =156, June 25, 1898, page 363.

L'Electrician, Paris, Vol. XVI, =406, October 8, 1898, page 235 and especially page 237, paragraph 2, second column.

Notice General sur les Curants de Haute Frequence et de Haute Tension, published by E Ducretet, 75 Rue Claude-Bernard, October, 1898, pages 9, 14-16.

La Telegraphie Hertzienne Sans Fil, Ducretet, November-December, 1898, page 5.

La Telegraphie Sans Fil.—Grafligny, published by Barnerd and Co., Paris, January 1, 1900, Fig. 40, 153.

La Revue Scientifique et Industrielle de l'Annee, Annees 1898-1899, by Breton, published by Barnerd & Co., Paris, 1900, p. 35.

It is therefore recommended that this petition be denied.

Very respectfully, Wm. A. Kinnan, Actg. Examiner, Division XVI. G. K. W.

[fol. 3612] Serial No. 36,010

Paper No. 11

Supplemental Petition and Proposed Amendment A E
Filed Oct. 24, 1903

Amend E

United States Patent Office

Room 91

In the Matter of the Application of Guglielmo Marconi for Patent for Apparatus for Wireless Telegraphy Serial No. 36,010. Filed November 10, 1900.

Before the Commissioner of Patents by Petition

City and County of New York,
Borough of Manhattan, ss:

Louis Frederic Holbrook Betts, being duly sworn, deposes and says:

I am the Louis Frederic Holbrook Betts who has heretofore made an affidavit in this matter, verified October 6, 1903, and I have read the recommendation of the Examiner that the petition to revive the above entitled application be denied.

In the first place, I desire to point out that the Examiner is in error in stating that Mr. Marconi "did not arrive here until the latter part of December, 1902", if by "here" the Examiner means the United States. It is distinctly pointed out in the petition, and in my affidavit, that Mr. Marconi arrived in Canada in December, 1902, but did not arrive in New York until the 27th day of January, 1903. Therefore it was not possible to confer with Mr. Marconi until the 27th of January, 1903, on which very day we did promptly bring this matter to his attention.

The Examiner then states that, "No attempt has been [fol. 3613] made to account for the seven months' delay intervening between the receipt of the last Office letter and Marconi's arrival in this country."

And the Examiner calls attention to *Ex Parte McElroy*, 101, O. G., 2823.

Deponent does not believe that this case is applicable to the present case, because in the McElroy case it appeared

that it had been "the practice" of the applicant to postpone the amending of his applications until the last few weeks before the time limit expired, and that when in this instance he was about to amend his application he was stricken with typhoid fever, and therefore could not do so, and *by reason of this practice* the Commissioner held that the first eleven months delay was "intentional," and therefore that the delay was unavoidable because only a "certain portion of the delay" had been explained away.

This "*practi*" of waiting eleven months before making an amendment has not been adopted or followed by this applicant, as I will now point out.

The application was filed November 7th, 1900. It was rejected December 24th. It was amended July 1, 1901. It was again rejected August 12, 1901. Again it was amended on December 6, 1901. Amended April 28, 1902, and again rejected on June 3, 1902.

The last amendment was filed six weeks after rejection.

Considering the fact that the applicant resides more than [fol. 3614] 3000 miles away from his attorneys, it necessitates consultation with him by letters back and forth, often several letters to prepare a single amendment.

If, however, it is thought that it is necessary to explain the reason for not acting on this case between the 3rd day of June, 1902, and the 27th day of January, 1903, deponent, upon information and belief, states as follows; basing his information upon communication, from the Marconi Company, and upon statements in the public prints as to the movements of Mr. Marconi.

Mr. Marconi was not, unless for very brief periods of time, in a position to take up the amendment of his application and could not be visited by his attorneys.

In the early part of July, 1902, Mr. Marconi was called to Italy to make experiments in wireless telegraphy for the Italian Government upon the Italian war-ship "Carlo Alberto," which had been furnished to him by the Italian Government for this purpose. He left London, as I am informed, very hurriedly for this purpose, sailing first to Gibraltar and afterwards to Spezzia.

During this time, he succeeded, as I was informed, in transmitting messages, by his wireless system, between England and Gibraltar, and subsequently successfully transmitted one or more wireless messages from England direct to Spezzia, in the gulf of Genoa. This latter achievement

was considered, at the time, a marvelous event, as it involved transmission across Europe. These experiments occupied, [fol. 3615] as I believe, a number of weeks, and after completing the same, he was invited by the Czar of Russia to come to Cronstadt, Russia, and was permitted by the Italian Government to go there upon the same war-ship, "Carlo Alberto." He accordingly sailed for Russia, and during this trip was successful in transmitting messages from England to Cronstadt. For this achievement, as I was informed, he was decorated at the time, by the Czar of Russia, with an Order.

We were informed that it was hoped that he would return to England in September, 1902, and that he would then proceed immediately to Cape Breton, Canada, but he was unable to do so. It was always, however, represented to us that he was coming to this country soon. He did not arrive, however, in Cape Breton, until December, 1902, and during all of the time from June to December was only temporarily in England, as we were informed. That Mr. Marconi came to this country as early as feasible is, we think, sufficiently indicated by the fact that he came on the "Carlo Alberto," which had been placed at his service for the purpose, and he was, naturally, anxious not to keep that ship longer than absolutely necessary, she being under orders to sail for Venezuela as soon as she could be spared from his experiments.

It thus appears that from June 3, 1902, until Mr. Marconi arrived in Canada, he was more than 3000 miles away from his attorneys, being for the most part of the time in the Mediterranean and Baltic Seas, conducting experiments on the above mentioned Italian war-ship, and therefore it is [fol. 3516] submitted to your Honor that the first part of the delay has been satisfactorily shown to have been unavoidable, as well as that of the last part of the whole period.

The Examiner states that "it would seem that some action, based on the partial information obtained from Marconi January 27, 1903, might have been submitted by the attorneys between May 13th and June 3, 1903, that would have saved the case from abandonment." We can hardly suppose that the Examiner recommends or approves of the practice of making a merely formal and insufficient reply to an Office letter, and one known to be insufficient at the time of making it, especially when, as in this case, detailed and accurate information on which to base what

was believed to be an adequate reply, was promised in a short time.

The only information which Mr. Marconi gave us on January 27, 1903, was a very brief verbal one, and as Mr. Marconi informed us that upon his return to England he would send us a full written report, after he had consulted with his documents there, we had no records to go by to formulate an amendment between May 13, 1903, and June 3, 1903, as suggested by the Examiner. The verbal information which Mr. Marconi did give us on January 27, 1903, was not sufficiently clear or well enough understood by us to have answered the last Office action.

It is submitted that Mr. Marconi's attorneys, in view of [fol. 3617] the facts above set forth, and in view of the facts set forth in my former affidavit, had every reason to expect that they would have received, long before the year's time elapsed, sufficient information from Mr. Marconi to amend the case in response to the last Office letter, and that the delay in the case arose from the exceptional circumstances of Mr. Marconi's absence from England, engaged in experiments in perfecting his wireless system, and the inevitable and unexpected delays in coming to this country, and in putting his attorneys in possession of his statements which grew out of those exceptional occupations.

L. F. H. BETTS.

Sworn to before me this 22nd day of October, 1903.

JAMES J. COSGROVE,

(NOTARIAL SEAL). *Notary Public,*
New York County.

[fol. 3618] UNITED STATES PATENT OFFICE.
Room 91.

In the matter of the Application of Guglielmo Marconi, for Patent for Apparatus for Wireless Telegraphy. Serial No. 36,010. Filed November 10th, 1900.

New York, October 24, 1903.

Hon. Commissioner of Patents, Washington, D. C.

SIR:

We transmit herewith a supplemental showing, duly verified, in the matter of the petition to revive the above entitled application.

In order to remove any portions of the amendment of October 6th, 1903, (filed with the original showing and petition) which may be considered objectionable on the ground that said amendment cannot be entered because, in the Examiner's opinion, it contains new matter and also contains method as well as apparatus claims, it is hereby requested that the following amendment may be made to the aforesaid amendment of October 6th, 1903.

Cancel the last eleven lines of page 1 of the amendment dated October 6th, 1903.

[fol. 3619] Cancel the first eight lines of page 2 of said amendment.

Cancel claims 21 and 22 on page 9 of said amendment.

Cancel the second paragraph on page 10 of said amendment, said paragraph reading as follows:

"A new Figure (Fig. 9) has been added to the drawings."

Respectfully submitted,

BETTS, BETTS, SHEFFIELD & BETTS,

Attorneys for Marconi.

[fol. 3620] Paper No. 12

U. S. Patent Office, Oct. 26, 1903, Mailed

Department of the Interior, United States Patent Office

Washington, D. C., October 26, 1903.

IN THE MATTER OF THE APPLICATION OF GUGLIELMO MARCONI, FOR PATENT FOR APPARATUS FOR WIRELESS TELEGRAPHY. FILED NOVEMBER 10, 1900. SER. NO. 36,010.

Before the Commissioner by Petition

Examiner's Statement

On October 12, 1903, a petition was filed to revive the above entitled application, which became abandoned June 3, 1903, under R. S. 4894; on October 15, 1903, the Examiner submitted an answer recommending that the petition be denied; and on October 24, 1903, an additional affidavit was filed in support of the petition of October 12th. In view of this affidavit the following answer is respectfully submitted.

The additional affidavit sets up an argument and a statement of alleged facts, based on the information and belief

of one of the attorneys, as to Marconi's movements between June 3, 1902, and the latter part of December, 1902, said facts, so alleged on information and belief, being intended to show that the delay existing between the aforesaid dates was an unavoidable delay.

The facts submitted in this additional affidavit, in the Examiner's opinion, merely serve to emphasize the position [fol. 3621] taken by him in his answer of October 15th, namely, that Marconi was unable to attend to his Patent Office business by reason of other business interests.

What Marconi's other business interests were is immaterial and the fact that he was successful in his business, as repeatedly emphasized by the attorney in both original and supplemental showings evidently for the purpose of strengthening his case, is irrelevant and incompetent.

It was held in ex parte Smith, 101 O. G., 1369, that the plea of "other business engagements" was not sufficient to account for the delay which resulted in the abandonment of an application under R. S. 4894.

In ex parte Beecher, 101 O. G., 1132, "unavoidable delay" was defined as meaning "circumstances beyond the control of the applicant".

From the spirit of these adjudications it would seem that Marconi's successes should not be given such consideration as would make up for the deficiencies in a showing of unavoidable delay. If Marconi had failed to transmit messages from Poldhu to Spezzia and had not been honored by the Czar of Russia, the showing submitted by the attorney would be entitled to just as much consideration.

It seems that ex parte McElroy, 101 O. G., 2823, cited in the Examiner's answer of October 15th as authority for holding that a showing of unavoidable delay must cover the entire period, has been objected to by the attorney as not on all fours with the present case. Attention is, therefore, respectfully called to the following decisions of the Commissioner of Patents, which show that the uniform and [fol. 3622] settled practice of the office under Rule 72 has been to require "a showing of facts covering the entire period" in order to warrant the revival of an abandoned application:

Ex parte Root, 40 O. G., 811.
Ex parte Fenno, 52 O. G., 1665.
Ex parte Edison, 56 O. G., 1061.

Ex parte Murray, 56 O. G., 1060.
Ex parte Clarke, 61 O. G., 286.
Ex parte Heine, 64 O. G., 1006.
Ex parte Warren, 96 O. G., 2410.

It has been maintained that this case should be revived because Marconi's British patent No. 7777 of 1900, will bar the filing of a new application for the subject matter disclosed in this case. Not only said British patent but also Belgian patent No. 152,840 and French patent, No. 308,204, and it is believed other foreign patents for the same invention, will bar such new application, and this very fact furnishes additional reason why the application should not have been permitted to become abandoned.—ex parte Pietzner, 103 O. G., 2171.

The proposed amendment submitted with the supplemental affidavit of October 24, 1903, removes the objection to the proposed amendment of October 12, 1903, in that it cancels therefrom the method claims and the new matter referred to in the Examiner's answer of October 15, 1903, but the amendment of October 12th as amended is not such as would put this case in condition for allowance.

No reason is seen for favorably recommending this petition.

Very respectfully,

WM. A. KINNAN,
Acting Examiner, Division XVI.

G.K.W.

[fol. 3622] Serial No. 36010.

Paper #13

Filed Nov. 4, 1903

Docket Clerk, Nov. 4, 1903, U. S. Patent Office

United States Patent Office

In the Matter of the Application of GUGLIELMO MARCONI for a Patent for Apparatus for Wireless Telegraphy: Filed November 10, 1900; Serial No. 36,010

Before the Commissioner, by Petition

Brief on Behalf of Marconi

This is a petition filed by the Attorneys for Marconi, that this Application be revived as a pending Application.

under the provisions of the Statutes of the United States.

On October 12, 1902, this petition was filed, and on October 15th the Examiner submitted an answer, recommending that the petition be denied. Thereupon, under date of October 24th, we submitted an additional affidavit, in the nature of a supplemental affidavit, and under date of October 26th, the Examiner has held that "no reason is seen for favorably recommending this petition."

The one-year time limit provided by the statute expired on June 3, 1903.

In the petition as filed on October 12th, it was shown that Marconi did not arrive in the United States from abroad, [fol. 3624] until the 27th day of January, 1903. The petition supported by a duly verified affidavit, explains in detail the several attempts, beginning on the day he arrived, January 27th, 1903, which the attorneys made to secure sufficient information from him about this highly technical invention, to completely and satisfactorily answer the last office action of June 3, 1903.

It was shown that not only was one attempt made, but several attempts were made between January, 1903, and June of the same year, although Marconi was not in this country at any time between those dates, except from the 27th to the 31st of January, 1903. It is further shown that when this application was called to his attention in January, 1903, Marconi stated that he was unable to fully and completely answer this office letter until he had consulted some documents which were then in England.

In view of the many attempts made to secure information to amend this case between January and June, 1903, it is satisfactorily explained why the amendment was not filed during this period, and therefore the Examiner's statement of October 15th makes no criticism as to the sufficiency of the excuse for non-action after January, 1903, except that the Examiner suggests that "some action on the partial information obtained from Marconi on January 27, 1903, might have been submitted by the attorneys between May 13th and June 3, 1903, that would have saved the case from abandonment.

[fol. 3625] We can hardly suppose that the Examiner recommends or approves of the practice of making a piecemeal reply to an Office letter, and one known to be in the nature of a piecemeal reply, and insufficient at the time of

making it, especially when, as in this case, detailed and accurate information on which to base what was believed to be an adequate reply, was promised in a short time.

The only information which Mr. Marconi gave us on January 27, 1903, was a very brief verbal one, and as Mr. Marconi informed us that upon his return to England he would send us a full written report, after he had consulted with his documents there, we had no records to go by to formulate an amendment between May 13, 1903, and June 3, 1903, as suggested by the Examiner. The verbal information which Mr. Marconi *did* give us on January 27, 1903, was not sufficiently clear or well enough understood by us to have answered the last Office action.

The Examiner, in his letter of October 26th, practically admits that the delay from January to June of 1903 was "unavoidable".

But the Examiner, in his letter of October 5th, recommends that "the petition be denied", because it had not *then* been shown that the delay in filing the amendment from June of 1902, to January of 1903, was "unavoidable" [fol. 3626] on the authority of ex parte McElroy, 101 O. G. 2823.

We therefore filed a supplemental showing as to where Mr. Marconi was during the period between June of 1902 and January of 1903, when he first arrived in this country, although we did not believe, and do not believe now, that the decision in the McElroy case is applicable to the present case.

This supplemental showing is contained in an affidavit, duly verified under date of October 22*th*.

It shows that Marconi was not in the United States from the time of the last office action, June 3, 1902, until January of 1903.

Marconi was, therefore, unavailable for consultation.

It was further shown that early in July, 1902, Mr. Marconi left England, where the present owners of this Marconi application reside, and went to Italy, where he was engaged in conducting important experiments upon the Italian war-ship "Carlo Alberto," which had been loaned him by the Italian Government for that purpose. It was further shown that these experiments lasted for several weeks in the Mediterranean Sea, upon this war-ship, and that thereafter, Mr. Marconi sailed up the Baltic Sea upon this same

war-ship to Cronstadt, Russia, still continuing his experiments, which lasted sometime in addition.

The Examiner, in his letter of October 26th, has criticised [fol. 3627] this showing as to Marconi's movements during this period, as immaterial and irrelevant, because the Examiner claims that "Marconi was unable to attend to his patent office business by reason of his other business interests."

It is submitted that this showing is both material and relevant. It is material and relevant because it explains where Mr. Marconi was during the Summer and early Autumn of 1902, and shows that Mr. Marconi was more than 3000 miles away from his attorneys, and also shows that he was many hundreds of miles away from the owners of his patent. He was, therefore, unavailable during this period for consultation.

It is also shown in the supplemental affidavit that Mr. Marconi was expected by his attorneys to come to the United States early in the Fall of 1902, but that he was delayed from time to time by this important business, and that he only returned to England for a very short time after completing his experiments on the "Carlo Alberto" in the Baltic Sea, and then sailed for Canada upon the same Italian war-ship, which was still being loaned him by the Italian Government to continue his experiments while crossing the Atlantic, and that he arrived on this war-ship in Canada about December of 1902.

While, therefore, Mr. Marconi was on this war-ship conducting his experiments in the Mediterranean Sea, the Baltic Sea, and the Atlantic Ocean, it is only fair to say that he was "unavoidably" prevented from taking action. [fol. 3628] It is submitted, therefore, that not only has it been shown that the delay from January to June, of 1903, was "unavoidable," but also that the delay from June, 1902, until January of 1903, was also "unavoidable".

The Examiner practically claims that during this first period of the year's time, Mr. Marconi should have given up conducting his experiments for the Italian Government, on the "Carlo Alberto," for the purpose of attending to his Patent Office business.

This is what the Examiner's contention amounts to.

It is not believed that this is sound.

While it may be true that where an inventor resides in the vicinity or near his attorneys and is engaged in *ordinary*

mercantile business, that an excuse of "other business engagements" as a reason for not attending to his Patent Office matter, is not a good excuse, yet where, as in the present case, it is shown that the inventor resides more than 3000 miles away from his attorneys and that during the period of time in question he was conducting experiments for the Italian Government, a different and more reasonable view of the facts should be taken. The rule certainly does not contemplate any obligation by the applicant to travel hundreds of miles during the first part of the period for action and come from foreign countries when there was every reasonable expectation, and a continuing expectation, that his business abroad would allow him ample time after it was finished to take the required action.

We submit that the decisions which the Examiner cites in his letter of October 26th do not apply to this case.

[fol. 3629] In ex parte McElroy, 101 O. G. 2823, it was held that the delay was not "unavoidable" because it had been shown that it was the "*practice*" of the applicant to *only* amend his applications within the last week or two of the time limit, and that in this case he was unable to do so because he had been stricken during this last week or two with typhoid fever. The Commissioner therefore held that the delay was "intentional."

The McElroy case does not apply to the present case. First, because it is shown that it has not been the "practice" of this applicant to amend his applications only within the last week or two of the time limit (the last amendment having been made about two months after official action); and second, because it has been shown that the attorneys made repeated efforts to obtain sufficient knowledge to amend this case during the whole last six months of the time limit, the first being made five months before the year's time expired.

In ex parte Root, 40 O. G. 811, it appeared that only twelve days before the time limit had elapsed, the attorneys made a *single* effort to have this case amended, which was unsuccessful. This effort consisted in writing a letter to another lawyer in Washington. The Commissioner said:

"The writing of this note and its failure to come into Mr. M. F. Halbeck's hands at an earlier date, constitute the *sole* reason presented to bring the case within the statute for reinstatement of applications abandoned for want of prosecution. * * * It is therefore a case in which the

entire period of two years is allowed to expire without any attempt at definite action." (Italics ours).

This case is no precedent, therefore, for the Marconi case: first, because the engagements and absence from home were exceptional and because here the attorneys made not one, but several attempts; and second, because these attempts were not made during the last week or two of the time limit [fol. 3630] but at least as early as five or six months before the time limit expired.

Ex parte Fenno, 52 O. G. 665 was a case following the decision in ex parte Root, and the only showing in this case was that during the last *month* of the time limit, the applicant was in such a bad financial condition that he was unable to pay for an amendment being filed. The Commissioner says:

"It is true that he states that in April, 1890, he was short of money and had hard work to get what he needed; but there is no showing as to what his financial condition was during the preceding twenty-three months. Ex parte Root, C. D. 1887, 81."

Here again was a case where no effort was made until the time limit was about to expire and then the showing was that only a single effort was made.

Such is not the situation, as we have pointed out, in the present instance.

Ex parte Edison, 56 O. G. 1061, likewise follows ex parte Root, since the only showing in the Edison case was that during the time limit the attorney once wrote to the Patent Office for a copy of a previous action and the Commissioner held that this letter of Edison's attorney was not an "action" as required by the statutes.

Ex parte Murray also follows ex parte Root. In the Murray case it did not appear that the attorneys had *ever* attempted during the two years' period to amend the case or to get sufficient information from the applicant to amend the case.

[fol. 3631] Such is not the situation in the case at hand.

In ex parte Clarke, 61 O. G. 286, the petition was denied because "the delay has been more than *four* years, and applicant only accounted for one." Furthermore, it did not appear that even during this one year, either applicant or the attorney had endeavored to amend the case or secure

such information as would have enabled the attorney to amend the case.

Ex parte Heine, 64 O. G. 1006, merely follows ex parte Root, which we have shown is clearly distinguishable from the present case.

Ex parte Warren, 96 O. G. 2410, was another case where the applicant's attorneys waited until within a week or two of the time limit before filing a proper amendment or took an appeal. The Commissioner states:

"By *intentionally* postponing proper action until the last of the time allowed, the attorneys assumed the risk of accidents, mistakes, or other circumstances which might then prevent action." (Italics ours)

It is shown in the Marconi case that the attorneys did *not* wait until the last of the time limit, but at least five months prior to that time endeavored to get from the inventor such information as would enable them to properly amend the case, but that the inventor was unable to give this information, and that during the succeeding five months not one, but several additional attempts were made to secure this information."

[fol. 3632] We have shown, therefore, that not one of the cases cited by the Examiner is applicable to the case at bar.

We have further shown that not only was the delay during the last six months of the year "*unavoidable*," but that the delay during the first six months as well, was "*unavoidable*."

Apparently, the supplemental showing which we have made has somewhat altered the Examiner's opinion as to the equities of this case, because in his first letter of October 15th, he recommended that the "petition be denied," while in his letter of October 26th, the Examiner merely states that "no reason is seen for favorably recommending this petition."

It is respectfully submitted, therefore, that in view of the detailed showing now presented in this case as to the efforts made to amend the case, and as to the whereabouts of the inventor, Marconi, during the whole period of the year's time, that the petition to revive this application should be granted.

Respectfully submitted,

BETTS, BETTS, SHEFFIELD & BETTS,

Attorneys for Marconi.

New York, October 30, 1903.

[fol. 3633] Serial No. 36,010, Paper No. 14. Notice of Commr's Decision. Dated 190.

E. E. G.

Department of the Interior,
United States Patent Office

Washington, D. C., December 3, 1903.

In the Matter of the Application of GUGLIELMO MARCONI.
Apparatus for Wireless Telegraphy. Filed Nov. 10, 1900.
Serial No. 36,010.

Petition That Applicant be Held Not to be Abandoned.

SIR:

You are hereby informed that the above petition has been denied by the Commissioner. Please find enclosed herewith a copy of the decision.

By direction of the Commissioner:

Very respectfully,

C. M. IRELAN,
Chief Clerk.

F.

Guglielmo Marconi,
c/o Thos. E. Robertson,
605 Seventh St.,
Washington, D. C.

[fol. 3634] M. H.

Serial No. 36,010. Paper No. 14.

Commr's Decision.

Recorded Vol. 78, page 119.

United States Patent Office.

Ex parte GUGLIELMO MARCONI.

Apparatus for Wireless Telegraphy.

Petition.

Application filed November 10, 1900, No. 36,010.

Messrs. Betts, Betts, Sheffield & Betts and Mr. T. E. Robertson for applicant.

This is a petition for a ruling that the above-entitled application is not abandoned, notwithstanding the fact that no action was taken in prosecution thereof for more than one year. It is contended that the delay in prosecution was unavoidable.

The last office action was dated June 3, 1902, and no reply was received until this petition was filed on October 12, 1903.

The facts relied upon as showing that the delay was unavoidable are set forth in two affidavits by one of the attorneys. It is said that the examiner's letter raised certain technical questions, which Marconi himself could best answer and that:

"it was decided to await his arrival in this country before submitting the questions raised by the examiner's letter to him."

It is said further that Marconi did not, in fact, come to this country until January 27, 1903, at which time the papers in the case were submitted to him and he then gave the at- [fol. 3635] torneys some information but not enough to enable them to make a completely responsive action in the case. It is said that Marconi found it necessary to consult certain records in London before he could furnish all of the

information necessary. Marconi then left this country for Europe, and thereafter the attorneys wrote two letters to his company asking for information and the papers. On April 11, 1903, they received a letter from the company saying that the "affidavits" had been despatched, but they were never received. Two more letters were written to the company, and on July 3rd a cablegram was received, saying that Marconi was ill and that the papers could not be forwarded at once. On August 21st the papers were received, but were accompanied by no remarks or explanation by Marconi. Marconi was in New York from September 28th to October 3rd, and the information desired was then available.

This showing attempts to excuse the failure of the attorneys to act by the statement that it was necessary to consult the inventor, but no effort whatever was made to consult the inventor for seven months after the office action. He was consulted in January, 1903, however, and assuming that he was the one then called upon to act, there is no satisfactory explanation why he did not furnish the information desired. The suggestion is made that he was very busy upon other matters which he seems to have regarded as more important, but this is not a sufficient excuse for inaction. It does not appear that he was any more busy then than at any other time. It appears merely that he was a busy man, and by choice devoted his attention to other matters instead of this. The cablegram as to Marconi's illness was after the application was abandoned, and there- [fol. 3636] fore it does not appear that the illness had anything to do with the failure to act within the year.

After the examiner had answered this petition, the attorney presented a supplemental affidavit, attempting to explain the inaction for the first seven months of the year fixed by law for action. It was there said:

"Mr. Marconi was not, unless for very brief periods of time, in a position to take up the amendment of his application and could not be visited by his attorneys."

It is said that in July, 1902, Marconi went to Italy, and a few weeks later to Russia, and expected to return to England and then go to Canada in September, 1902. He did not, in fact, reach Canada until December, 1902, and ar-

rived in this country on January 27, 1903. The attorneys were awaiting his arrival in this country, and say:

"It was always, however, represented to us that he was coming to this country soon."

The movements of Marconi before coming to this country might be pertinent if they were what prevented the attorneys from communicating with him, but that does not appear to have been the case. No effort seems to have been made to communicate with him. It seems clear that the consultation might have been conducted by correspondence and that in fact seems to have been the intention after the interview of January 27, 1903.

The year allowed by law for action is ample, and it is only under very exceptional circumstances that a delay for a longer period is justified. The mere plea that the inventor was busy upon other matters and did not have time to devote to the case under consideration, cannot be accepted as a showing that the delay for such a long time was unavoid-[fol. 36,37] able. The word "unavoidable" in the statute means more than that to act would have been inconvenient.

Since the delay in this case is attempted to be explained on the ground that Marconi did not furnish the necessary information, it cannot be held that the delay was unavoidable, in the absence of a showing by him of good reasons why he did not furnish the information.

The petition is denied.

F. I. ALLEN,
Commissioner.

December 2, 1903.

[fol. 3638] Serial No. 36010

Paper No. 15

Request for Rehearing

aff.

Filed February 24, 1904

Docket Clerk, Feb. 24, 1904. U. S. Patent Office.

United States Patent Office

In the Matter of the Application of Guglielmo Marconi, for Patent for Apparatus for Wireless Telegraphy, Serial No. 36,010. Filed November 10, 1900.

New York, February 19, 1904.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

This Application was rejected on the 3rd day of June, 1902. On the 12th day of October, 1903, petition was filed asking that the Application be declared a pending Application under the authority vested in your Honor, by the provision of Section 4894 of the Revised Statutes.

On December 2, 1903, this petition was denied, in the absence of a verified showing by Marconi himself.

We respectfully ask for a re-consideration of the foregoing petition in view of the supplemental showing contained in the affidavits of Guglielmo Marconi, L. F. H. Betts and T. E. Robertson, filed herewith.

Respectfully submitted,

BETTS, BETTS, SHEFFIELD & BETTS,

Attorneys for Applicant.

[fol. 3639] In the United States Patent Office

In Reapplication of Guglielmo Marconi, Serial No. 36,010. Filed November 10, 1900. Apparatus for Wireless Telegraphy.

London, England, ss:

Guglielmo Marconi, being duly sworn, deposed and says:

I am the applicant in application for United States Letters Patent Serial No. 36,010, filed November 10, 1900, for apparatus for wireless telegraphy.

In the latter part of the year 1901, and early in the year 1902, I was in America, and at that time succeeded in transmitting signals from Poldhu in Cornwall, to St. John's, Newfoundland by my system of wireless telegraphy, and satisfied myself that it was possible to transmit messages on a commercial scale. Early in 1902 I was, however, compelled to return to England, but it was my intention to return to America as soon as possible for the purpose of installing a station for the commercial transmission of signals across the Atlantic Ocean, which station was to be installed at Cape Breton, Nova Scotia to connect with our station at Poldhu, Cornwall, on the one hand, and with a station at Cape Cod, U. S. A., on the other hand. As time went on, it became more and more important to the interests of my various companies, that this long distance transmission station should be established, and I was con-

[fol. 3640] stantly urged to return to America for this and other purposes connected with my interests in America, and particularly in the United States. I was constantly expecting to make this trip to America, but it became necessary to postpone my departure from time to time.

In June, 1902, an opportunity presented itself to obtain the use of the "Carlo Alberto", a ship of the Italian Navy, for the purpose of carrying out tests of my system, and I determined to make use of this opportunity to make tests of long distance transmission over land and sea. Accordingly and on the 18th day of June, 1902, I commenced my experiments on the "Carlo Alberto" round the Coast of England, which were continued uninterruptedly between this ship and a number of my stations, i. e. Poldhu, The Lizard, Poole, Niton, etc., until the 6th July.

On the 6th July I left Dover on the "Carlo Alberto" for Cronstadt, carrying out experiments during the entire voyage, and on 22nd July I sailed from Cronstadt to England, where I arrived on August 1st. All the time from August 1st to the 24th I was busily engaged in experiments preparatory to another voyage on the "Carlo Alberto". It had been my intention to sail from there to America, for the purpose of installing the long distance transmission station there, but decided to return first to the Mediterranean, and on August 25th, 1902, I sailed from England for the Mediterranean on the "Carlo Alberto", with the intention of returning to England about the first week in September, and of proceeding from there to Cape Breton, and after establishing communication between Cape Breton and Poldhu, to proceed to Cape Cod, U. S. A.

I am informed and believe that my representatives in [fol. 3641] America were notified of this change of plans. During all of the time that I was carrying on these tests on the "Carlo Alberto", I was steaming from place to place, and often, on account of the uncertainty of my movements, it was impossible for correspondence to reach me.

These experiments in the Mediterranean occupied my time until the 20th day of September when I returned to England, and on the 20th day of October, 1902, I sailed from England for Cape Breton, arriving there on the 31st day of October, 1902. From that time on, I was constantly expecting to leave Cape Breton, for New York City, and I am informed and believed that certain important matters which demanded my attention in New York, were postponed from time to time, pending my arrival. The experiments at Cape Breton occupied a longer time than I had anticipated, and I did not leave there for New York until the 14th day of January, 1903. In the meantime I received at Cape Breton a letter from my attorneys, Messrs. Betts, Betts, Sheffield & Betts, bearing date of January 3rd, 1903, asking for certain information which they desired in regard to my application serial No. 36,040, for the purpose of making an amendment in that application, and of overcoming the objections urged thereto by the Examiner in the United States Patent Office. On January 10, 1903, I telegraphed to Messrs. Betts, Betts, Sheffield & Betts, to send me copies of the papers in this case, and under date of January 10th they mailed these copies to me, and they were duly received at Cape Breton.

On examining these papers, I discovered that I would be unable to answer the questions presented by the Action of the Patent Office, dated June 3rd, 1902, without resort to my papers stored in London, and for this reason I postponed any report on this application until I should arrive in New York City.

[fol. 3642] I arrived in New York City about January 23, 1903, and remained there several days, during which time I consulted with my attorneys, Messrs. Betts, Betts, Sheffield & Betts, and I discussed with Mr. L. F. H. Betts, of that firm, this application serial No. 36,010, and I promised to send to him the information which was necessary, upon my return to London, and upon my examination of the papers stored there. At this time I requested Mr. Betts to write a letter to me, in London setting forth exactly the papers and information which were necessary in connection with this application, in order that I might prepare such papers in London. Upon my arrival in London, it became absolutely necessary for me to give my attention to pressing matters in connection with the development of my inventions in wireless telegraphy. Mr. Betts had written the letter which I had asked for, under date of January 27, 1903, and I took advantage of the first opportunity to prepare the papers asked for in that letter, and prior to April 4, 1903, I prepared and despatched to Messrs. Betts, Betts, Sheffield & Betts, the necessary papers. These papers were left in the hands of the Notary to be sent to Messrs. Betts, Betts, Sheffield & Betts, about the end of March or the beginning of April 1903. On April 4, 1903, I received a telegram from the Marconi Wireless Telegraph Company, Limited, of London, asking me if the papers in this case had been prepared and sent, and I informed Marconi's Wireless Telegraph Company, Limited, that these papers had been sent, and I am informed and believe that this information was imparted to Messrs. Betts, Betts, Sheffield & Betts, by that Company.

On the 22nd day of May 1903, a letter was received, bearing date May 13, 1903, from Messrs. Betts, Betts, Sheffield & Betts, by Marconi's Wireless Telegraph Company, Limited, [fol. 3643] of London, stating that these papers had never been received and asking that they be sent to them immediately. At that time I was in Italy, at Pisa, where I had been ordered by Dr. Mazzoni, of Rome, for a recupera-

tive rest, in order that I might recover from an illness from which I had suffered since about April 20th. At this time I was unable to attend to any business matters whatever. On my return to England, in May, 1903, I had not recovered from my previous illness, and was, by doctor's orders, again confined to bed for a week or ten days. In fact, during the two months from about the middle of April to about the middle of June, 1903, I was not only incapacitated by illness, from attending to patent business, but was, much to my own inconvenience and that of my companies prevented from attending to many other urgent matters of business.

As soon as I was able to attend to this matter, and in the month of August, 1903, I forwarded to Messrs. Betts, Betts, Sheffield & Betts, papers which I believed would be sufficient to meet their requirements. Thereafter, I arrived in New York City, on September 28, 1903, and remained there until October 3, 1903, and at this time the full information was given to Messrs. Betts, Betts, Sheffield & Betts, and I am informed and believe that the necessary amendment was immediately filed by them.

GUGLIELMO MARCONI.

February, 1904.

[SEAL.]

G. F. WARREN,
Notary Public.

[NOTARIAL SEAL.]

(Foreign Revenue Stamps.)

[fol. 3644] Consulate-General of the United States of America for Great Britain & Ireland at London

I, Richard Westacott Acting Consul-General of the United States of America at London, England do hereby make known and certify to all whom it may concern that George Frederick Warren who hath signed the annexed Certificate, is a Notary Public, duly admitted and sworn and practising in the city of London, aforesaid, and that to all facts by him so done full faith and credit are and ought to be given in Judicature and thereout.

In Testimony Whereof, I have hereunto set my hand and affixed my Seal of Office at London aforesaid, this Third day of February in the year of our Lord One Thousand Nine Hundred and Four.

[SEAL.] RICHARD WESTACOTT,
Acting Consul-General.

[CONSULAR SEAL.]

[fol. 3645] United States Patent Office

In re Application of Guglielmo Marconi No. 36,010. Filed Nov. 10, 1900. Apparatus for Wireless Telegraphy

STATE OF NEW YORK,
County of New York, ss:

Louis Frederick Holbrook Betts, being duly sworn, deposes and says:

I am a member of the firm of Betts, Betts, Sheffield & Betts, attorneys for Guglielmo Marconi in the above-entitled application.

When I received the Office action bearing date of June 3, 1902, in the above-entitled application, I had been informed and believed that it was Mr. Marconi's intention to come to America for the purpose of establishing a long-distance transmission station at Cape Breton, Nova Scotia, and also for the purpose of establishing a station at Cape Cod, Massachusetts, and I was aware that he was being urged to come to America for this purpose, at the earliest possible moment, since it was of considerable importance to the interests of the Marconi Wireless Telegraph Company of America that this long-distance station should be installed. I was also aware that Mr. Marconi intended to visit New York at the time of his contemplated trip to this country, and that there were many matters awaiting [fol. 3646] his consideration in New York, and I believed that Mr. Marconi was likely to leave England for this country at any time. During the early part of July, 1902, it came to my knowledge that Mr. Marconi had left England for Cronstadt, Russia, for the purpose of carrying out certain experiments on the "Carlo Alberto", in the Baltic Sea, a ship belonging to the Italian Navy, and loaned to Mr.

Marconi by the Italian Government. It was expected in America that as soon as Mr. Marconi completed his experiments he would sail for America for the purpose of establishing a long-distance transmission station.

On the 21st day of August, 1902, a letter was addressed to this office by Mr. H. Cuthbert-Hall, Managing Director of Marconi's Wireless Telegraph Company, Ltd., of London, which letter was duly received, and with this letter was received a copy of a letter bearing date of August 16, 1902, addressed to the Marconi Wireless Telegraph Company of America, which letter contained the following information:

"You may possibly have learned from announcements in the press that Mr. Marconi is going to the Mediterranean next week on the 'Carlo Alberto', and will probably take the opportunity of making further experiments with the Poldhu Station over land and sea combined.

"We have thought that you might be surprised that any engagement should now be entered into which tends further to postpone the proposed trans-Atlantic transmission. This engagement has, however, been entered into in the interests not only of this Company, but of all the Marconi Companies. * * *

"* * * It is hoped that he" (Mr. Marconi) "will return to England about the first week in September; he will then proceed to Cape Breton, and after communication has been established between that Station and Poldhu, he will then go on to Cape Cod and start the service there".

This letter, though it informed me that Mr. Marconi [fol. 3647] would not be in this country so early as I had expected, led me to believe that he would be available for a personal interview not later than the 1st of October, 1902, and it also informed me that he would be, in the meantime, traveling from place to place on the "Carlo Alberto," and I knew that it would be practically impossible to communicate with him, or to secure any technical information from him.

Mr. Marconi did not, in fact, complete these experiments on the "Carlo Alberto" and leave England for Cape Breton until the middle of October, but during all the time from the 1st of June until he actually sailed from England it was represented to us that he was about to come to this country, and we knew that he was steaming from place to

place on the "Carlo Alberto", and that it was well nigh impossible to communicate with him.

Mr. Marconi did not arrive at Cape Breton until about the 1st of November, 1902. I am informed and believe that the exact date was the 31st day of October, 1902. In my affidavit, executed the 22nd day of October, 1903, in support of the petition to revive this application, I stated that Mr. Marconi did not arrive in Cape Breton until December, 1902. This date should have been "until November, 1902", and the date December, 1902, was included in my prior affidavit by mistake.

My partner, Mr. Frederic H. Betts, was at this time a director in the Marconi Wireless Telegraph Company of America, of which Company Mr. Marconi was, and still is, also a director, and in order to show that our office was kept informed as to Mr. Marconi's movements, and that [fol. 3648] we had good reason to expect him in New York immediately, I will state that the regular meeting of the Board of Directors of the Marconi Wireless Telegraph Company of America was postponed on October 28, 1902, for a period of two weeks, in the expectation that Mr. Marconi would be in this country at the end of that time.

Under date of November 13, 1902, we received a letter as follows:

New York, November 13, 1902.

Frederic H. Betts, Esq.,
120 Broadway, City.

DEAR SIR:

The regular meeting of the Board of Directors of Marconi Wireless Telegraph Company of America which was postponed on October 28th, 1902, for the farther period of two weeks, or pending the arrival of Mr. Marconi, was not held November 11th, 1902, there being no quorum.

It is now desired that the Directors consent to a further postponement of the said meeting for three weeks, pending the arrival of Mr. Marconi in New York.

Yours respectfully,

MARCONI WIRELESS TELEGRAPH
COMPANY OF AMERICA,
By C. J. STEEDMAN,
Secretary and Treasurer."

Under date of November 28, 1902, we received a second letter, as follows:

"November 28, 1902.

Frederic H. Betts, Esq.,
120 Broadway, City.

DEAR SIR:

By telegram dated November 23d, we are advised that Mr. Marconi will be detained at Glace Bay until about the 6th prox. Kindly signify on enclosed postal whether you prefer that the meeting of the Board of Directors be further adjourned until, say, December 9th, or indefinitely postponed to be held upon special call on Mr. Marconi's arrival here.

Yours very truly,
MARCONI WIRELESS TELEGRAPH
CO. OF AMERICA,
By J. BOTTOMLEY,
Secretary."

The information contained in these letters was communicated to me, and being thus in almost weekly expectation of the arrival of Mr. Marconi in New York, and believing, [fol. 3649] as I did, that it was of the utmost important that the very technical questions presented by the Patent Office action of June 3, 1902, should be discussed at a personal interview with Mr. Marconi, because of his peculiar knowledge of the subject-matter involved, I did not, at this time, write to Mr. Marconi asking for this information. In fact, during the time from June, 1902 to January, 1903, it appeared that Mr. Marconi would be in New York City about as soon as it would be possible to communicate with him by letter, because, since he was abroad travelling on the "Carlo Alberto", I knew that letters to him would necessarily be very greatly delayed and would perhaps not reach him at all, and after he arrived at Cape Breton he expected to leave there at any moment.

However, in view of the repeated postponements of his departure from Cape Breton, I finally wrote to him there, under date of January 5, 1903, asking him for the desired information in regard to this Application No. 36,010, although we still had six months to amend the same. On

January 10, 1903, I received from him a telegraphic request for copies of the papers in this case, as follows:

"Glace Bay N. S. Jan. 10.

Mirage New York

Send set papers 36010 addressed to Cape Cod station.

Marconi."

These copies were sent to him the same day, with a letter reading as following:

"January 10, 1903.

Guglielmo Marconi, Esq.,

Cape Cod Station, Marconi's Wireless Tel. Co., Ltd.,

Cape Cod, Mass.

DEAR SIR:

Your telegram of January 10th from Glace Bay, has been received.

In accordance therewith, we send to you herewith complete set of papers in the matter of your Application No. 36,010.

[fol. 3650] "Will you please let us have your views in relation to this case at your earliest convenience.

Yours very truly,

B., B., S. & B."

About the middle of January, Mr. Marconi finally left Cape Breton for Cape Cod, and arrived there, as I am informed and believe, on January 16th, and on January 23rd, he arrived in New York City. He remained here several days, and at that time discussed with me this application No. 36010, and informed me that he would not be able to furnish the desired information without consulting his papers stored in London. I accordingly reduced to writing a statement of the information and papers which we desired, in the form of a letter to Mr. Marconi, bearing date of January 27, 1903. This letter was dispatched to Mr. Marconi, on January 27, 1903.

Later, on March 20th, our firm wrote *both* to Mr. Marconi and to Marconi's Wireless Telegraph Company, Ltd., urging that the information referred to, together with the papers, be sent as soon as possible. These letters read as follows:

"Guglielmo Marconi, "March 20, 1903.

c/o Marconi's Wireless Tel. Co., Ltd.

18 Finch Lane, London, England.

DEAR SIR:

Referring to your United States Application, serial No. 36,010 (for tuning the circuits at both the transmitting and receiving stations), you will recollect that, when you were here, we called your attention to the fact that the Examiner had rejected your Claims on the Tesla United States Patents, on the ground that you used the Tesla form of oscillator in connection with your wireless telegraph system. At that interview, you gave us, offhand, some of the reasons which distinguish your apparatus from that of Tesla, and you were to send us more information on this point. Accordingly, we asked you in our letter of January 27, 1903 (see page 4), to give us a full explanation, in detail, of the radical difference between your system and Tesla's.

[fol. 3651] "We have not heard from you in connection with this matter, and should be pleased to receive your views at the earliest day. The Application should be hurried as much as possible, having remained pending in the Patent Office for two and a half years. Another reason why this matter should be disposed of now, is that the Patent Office Examiner has, in connection with Dr. Fleming's Application, raised the point that he also uses the Tesla oscillator. Dr. Fleming, of course, uses your form, and the same reasons given in connection with your Application No. 36,010, will also be pertinent in connection with the reply to be filed in Dr. Fleming's case.

"If unable to send the desired information now, will you kindly indicate when you hope to do so.

Yours very truly,

BETTS, BETTS, SHEFFIELD & BETTS,

W. H. B."

"March 20, 1903.

"Marconi's Wireless Telegraph Co., Ltd.
18 Finch Lane, London, England.

DEAR SIRS:

Referring to Mr. Marconi's Applications Nos. 36,010 and 82,856, for United States Patents, and which have been pending since November, 1900, and November, 1901, respectively, we wrote to Mr. Marconi under date of January 27, 1903 (see copy of letter enclosed), asking him to consider certain positions taken by the Examiner in the United States Patent Office, in reference to the second-named Ap-

plication, and to send us an affidavit by himself, and possibly one by Dr. Fleming, pointing out fully the theory of operation of the apparatus of said Application, and also distinguishing the oscillator employed by him from that described by Tesla in the United States Patent sent with our letter. We now enclose a copy of the said Tesla Patent.

"We have not heard from Mr. Marconi in response to our letter, and are very anxious that the matters referred to should have early attention. Will you please, therefore, ask Mr. Marconi, at his earliest convenience, to give our letter of January 27, 1903, his complete considera'ion, and to have his views, as well as those of Prof. Fleming, sent to us in the form of affidavits.

"There is need for haste in prosecuting both of said Applications, especially in the case of No. 82,856, in which we may be able to file certain claims, somewhat broadly covering the employment of a single aerial with a plurality of transmitting or receiving branches connected thereto, thus bringing on an Interference which will decide priority of invention as between Mr. Marconi and other claimants.

Kindly acknowledge receipt of this letter.

Yours truly,

BETTS, BETTS, SHEFFIELD & BETTS,

W. H. B."

[fol. 3652] These were the only letters we wrote to either of these parties on that date, and in reply we received, on or about April 11th, the following letter:

"London, 4th April, 1903.

Messrs. Betts, Betts, Sheffield & Betts,
120 Broadway, New York.

DEAR SIRS:

In connection with your letter of March 20th I have this morning wired to Mr. Marconi who is at present at Poldhu, asking him if the affidavits sent with your letter of Jan. 27th had been attended to and returned. Mr. Marconi wires in reply "Yes affidavits despatched by Notary".

Yours faithfully,

MARCONI'S WIRELESS TELEGRAPH CO., LTD.,
HENRY W. ALLEN,
Secretary & Asst. Manager."

These papers or affidavits were never received by us.

After waiting a reasonable time for the receipt of these papers, which were necessary in connection with Application No. 36,010, we again wrote to Marconi's Wireless Telegraph Company, Ltd., on May 13, 1903, in which we said:

"May 13, 1903.

"Marconi's Wireless Telegraph Company, Ltd.,
18 Finch Lane, London, England.

GENTLEMEN:

Referring to our two letters to Mr. Marconi under date of March 20th, and to our letter to your Company of the same date, will you please let us know when we may expect to have the affidavits or statements by Mr. Marconi relative (1) to the differences between the Marconi system and the Tesla system, and (2) relative to the system which employs one aerial for the reception or transmission of several messages simultaneously.

"As we wrote you at that time, two of Mr. Marconi's United States Applications are being held up awaiting these affidavits or reports, and we are also delaying action in the matter of the two applications filed on behalf of Prof. Fleming.

Yours very truly,

BETTS, BETTS, SHEFFIELD & BETTS,
W. H. B."

[fol. 3653] And again, in a fourth letter, dated June 5, 1903, we wrote as follows:

"June 5, 1903.

Marconi's Wireless Telegraph Company, Limited,
18 Finch Lane, London, England.

DEAR SIRS:

Referring to our two letters dated March 20, 1903, to Mr. Marconi, and our letter of the same date to you, we have not received the affidavits, arguments or instructions referred to therein.

As we have already stated, the two applications of Mr. Marconi and the two applications of Prof. Fleming, are

being held up until we receive the information requested in said letters.

Will you please have the answers to said letters forwarded to us as soon as possible?

Yours very truly,

BETTS, BETTS, SHEFFIELD & BETTS,

W. H. B."

In answer we received the following cablegram, dated July 3, 1903:

"July 3, 1903.

Mirage, New York.

"Affidavits Multiple Patents Delayed by Marconi's illness. Hope to send twentieth.

"HALL".

Upon receipt of this information, that Mr. Marconi had been ill, we took immediate steps to prepare a petition to the Commissioner of Patents, asking that he declare that the case had not become abandoned, since we believed that the delay in the case was such a delay as the Commissioner would be warranted in declaring "unavoidable", under the provisions of section 4894 of the Revised Statutes.

On July 8th, this petition, accompanied by an affidavit executed by myself, was forwarded to our representative in Washington, Mr. Thomas E. Robertson, of No. 605 Seventh Street. In a letter of July 9th, Mr. Robertson stated that this petition must be accompanied by an amendment, since the Commissioner of Patents had declared that he had no power to grant such a petition unless it was accompanied by an amendment. It was impossible for us to prepare this amendment without the necessary information from Mr. [fol. 3654] Marconi, and we were therefore compelled to await the arrival of the necessary papers.

On August 29, 1903, we received certain papers, but no remarks from Mr. Marconi. These papers did not convey sufficient information to enable us to make a full and complete response to the Office action of June 3rd. We were aware that Mr. Marconi intended to be in New York sometime during the month of September, 1903. Mr. Marconi was first in New York from September 28th to October 3rd, and we then secured from him the desired information. We thereupon prepared an amendment and argument in

reply to the last Office action on this application, which amendment, with the argument relating thereto, covers fifteen large typewritten pages, and is completely responsive to the last Office action. This amendment was forwarded to Mr. Robertson, in Washington, on October 6, 1903, and on October 12th the amendment and petition were filed in the Patent Office.

On December 2, 1903, the Commissioner of Patents denied this petition, and a copy of his decision was received by us on December 3rd. On December 5th we forwarded to Marconi's Wireless Telegraph Company, Ltd., at London, a copy of this decision, together with a copy of the petition, affidavits and brief, and asking that they ascertain if Mr. Marconi could make a satisfactory showing to explain the delay on his part, which delay the Commissioner of Patents had, in his decision, remarked upon as fatal to the petition. In this letter to the Marconi Company we also asked for further instructions in regard to this case. Under [fol. 3655] date of December 30, 1903, Mr. Marconi wrote us in regard to this application, saying that he would prepare a statement showing that the papers which he sent us in April, 1903, were the papers which we desired for use in this application, and also showing that he was unable to attend to business on account of illness during a considerable portion of the Spring of 1903. This statement was forwarded to us under date of January 6, 1904, and was received by us in due course. On January 22nd we forwarded to Mr. Marconi a letter accompanied by a draft form of affidavit which we desired him to execute, and which was based on the information contained in his statement. This affidavit, duly executed, was received by us on the 15th day of February, 1904.

L. F. H. BETTS.

Subscribed and sworn to before me this 29th day of February 1904.

[SEAL.] JAMES COSGROVE,
Notary Public,
New York Co.

[NOTARIAL SEAL.]

[fol. 2656] In the United States Patent Office

In Re Application of Guglielmo Marconi, Serial No. 36,010. Filed November 10, 1900. Apparatus for Wireless Telegraphy.

District of Columbia,
County of Washington, ss:

Thomas E. Robertson, of Washington, in the District of Columbia, being duly sworn, deposes and says:

On the 9th day of July, 1903, I received from Messrs. Betts, Betts, Sheffield & Betts, of 120 Broadway, New York City, a petition, accompanied by a verified showing of Mr. L. F. H. Betts, for the revival of the above entitled application of G. Marconi; that this petition was forwarded to me with instructions to file in the Patent Office; that as no amendment accompanied the petition, I consulted the Law Clerk of the Patent Office regarding the matter and was informed that no matter how good the reasons for revival, the Commissioner invariably rules that under the law he has no power to revive any case in which an amendment is not presented;

That in view of the interview with the Law Clerk, the petition, with its verified showing, was not filed, but on the same day (July 9, 1903) I replied to the attorneys in [fol. 3657] fact informing them that an amendment would have to be filed with the petition.

A few days after this, on July 17, I received a letter from the attorneys in fact acknowledging the receipt of my letter and stating that they would re-forward the petition, with the amendment, as soon as the information arrived which they were expecting from Mr. Marconi who was then in Europe.

THOS. E. ROBERTSON.

Subscribed and sworn to before me this 24th day of February, 1904.

WM. H. DeLACY,
Notary Public.

[NOTARIAL SEAL.]

[fol. 3658]

Paper No. 16

Serial No. 36010

Brief

Filed March 3, 1904

Docket Clerk, U. S. Patent Office, Mar. 3, 1904

United States Patent Office

In the Matter of Application of Guglielmo Marconi. Serial No. 36,010. Filed November 10, 1900. For Improvements in Apparatus for Wireless Telegraphy.

Brief on Request for Reconsideration of Petition to Revive

Hon. Commissioner of Patents,
Washington, D. C.

SIR:

This Application was rejected on the 3rd day of June, 1902. On the 12th day of October, 1903, a petition was filed, asking that the case be declared a pending application, under the authority vested in your Honor by the provisions of section 4894 of the Revised Statutes.

On December 2, 1903, this petition was denied on the ground that the attorneys made no attempt to consult the inventor for seven months after the rejection, and on the ground that when the inventor was consulted he failed to reply, and has failed to explain why he did not reply.

We ask for a reconsideration of this decision, in view of the additional showing contained in the affidavits of Mr. [fol. 3659] Marconi and Mr. L. F. H. Betts, attached to the request for reconsideration.

We believe that if the exact circumstances which controlled the proceedings in this case are presented to your Honor, as they present themselves to us, your Honor will be satisfied that the delay was "unavoidable" in the sense in which that term is used in section 4894 of the Revised Statutes.

From a consideration of section 4894 of the Revised Statutes, and of the decisions interpreting that section, and particularly of the decisions rendered by your Honor, we believe that it will be held that this application is not

abandoned, if it can be shown that during the whole period from June 3, 1902, to June 3, 1903, the applicant, and his attorneys, were using such diligence in the prosecution of this application as is generally used and observed by prudent and careful business men in relation to their most important affairs, and that the failure to file the amendment within the year was caused by happenings beyond the control of the applicant or his attorneys (Ex parte Pratt, C. D. 1887, p. 32; Ex parte Hiene, C. D. 1893, p. 196; Ex parte Stuckgold, 106 O. G., p. 544).

We believe that such a showing can be made, and is made, by the affidavits accompanying the request for reconsideration.

In the decision of December 2, 1903, your Honor said:

[fol. 3660] "This showing attempts to excuse the failure of the attorneys to act, by the statement that it was necessary to consult the inventor, but no effort whatever was made to consult the inventor for seven months after the Office Action."

Your Honor further, referring to the supplemental affidavit filed, and the showing therein of the movements of Mr. Marconi during the Summer and Fall of 1902, said:

"The movements of Mr. Marconi before coming to this country might be pertinent if they were what prevented the attorneys from communicating with him, but that does not appear to have been the case. No effort seems to have been made to communicate with him. It seems clear that the consultation might have been conducted by correspondence and that in fact seems to have been the intention after the interview of January 27, 1903."

We believe that the affidavits attached to the request for reconsideration will show that Mr. Marconi's movements were exactly what prevented his attorneys from communicating with him.

On the 18th day of June, 1902, Mr. Marconi began his experiments on the "Carlo Alberto," and from that time to the 1st of November, he was continuously occupied with these experiments. We were aware that he was traveling from place to place, at sea, and that communications addressed to him had very slight chance of reaching their destination.

It is true that Mr. Marconi twice returned to England during the time from June to November of 1902. It is also true that if letters had been addressed to him there they might have reached him, provided they had been held by the Marconi Company, Limited, pending his arrival, and not forwarded to him, and so followed him from place to place.

His attorneys, however, had been led to believe, and did believe, that as soon as Mr. Marconi arrived in England [fol. 3661] he would immediately sail for America. This was certainly Mr. Marconi's intention when he left England on the "Carlo Alberto." Influenced by this belief, his attorneys felt that it would be useless to address a communication to him in London, since they supposed that such a communication would, at best, be handed to him as he was about to sail for this country, and would, therefore, not secure for them the desired information any sooner than such information would be secured by awaiting his arrival in New York.

It thus appears that the most expeditious, as well as the most satisfactory, way to communicate with Mr. Marconi was to await his arrival in New York.

Acting on this information, and using their best judgment, his attorneys refrained from writing to Mr. Marconi. They did not, of course, at any time suppose that the delay would extend over more than a week or so.

The attorneys watched with considerable interest the subsequent postponements of Mr. Marconi's arrival in New York, but each time his arrival was postponed it still appeared that he would leave for New York before a letter could reach him.

Finally, alarmed by the repeated postponements, his attorneys wrote him, in January, 1903, at Cape Breton, with the results set forth in the affidavits attached to this request.

It thus appears that during the whole time from June, 1902, to January, 1903, there was no period in which this case was put aside and intentionally delayed.

[fol. 3662] It is submitted that the affidavits show that during this period, the attorneys for Mr. Marconi, though they did not actually write any letter in this case, were, nevertheless, exercising the greatest care and diligence in its prosecution, because the case was under constant consideration and everything was being done that the most careful person would do in the prosecution of his most important

business affairs. The attorneys for Mr. Marconi were at all times in possession of information which indicated to them that the most expeditious procedure possible was to await the arrival of Mr. Marconi in New York.

In the decision of December 2nd, and discussing the conduct of Mr. Marconi, your Honor said:

"He was consulted in January, 1903, however, and assuming that he was the one then called upon to act, there is no satisfactory explanation why he did not furnish the information desired. The suggestion is made that he was very busy upon other matters which he seems to have regarded as more important, but that is not a sufficient excuse for inaction. It does not appear that he was any more busy than at any other time. It appears merely that he was a busy man, and by choice devoted his attention to other matters instead of this."

The affidavits filed in connection with this petition show that Mr. Marconi left this country after the 27th of January, 1903. He could not have arrived in London earlier than the 4th of February. Prior to the 4th of April he had prepared and despatched the papers necessary in this case. It is thus seen that these papers were prepared within two months.

It is *now* shown that Mr. Marconi did actually act in this case, two months before the year elapsed, but his efforts came to naught as we never received the papers Mr. Marconi sent.

[fol. 3663] When it is considered that it was necessary for Mr. Marconi to look up records, and to prepare carefully drawn papers, in connection with this very technical subject, and when it is further remembered that this period was one in which the wonderful developments of wireless telegraphy, due to the efforts of Mr. Marconi, were in their most active stage; that Mr. Marconi was engaged in attending to the numerous experiments which were being carried on under his direction, over all Europe and in America and was also necessarily giving his personal attention to the organization of commercial companies to carry on the practical development of his system; and that, as the foremost figure in this new art, his personal services were demanded by many large interests, it is not believed that it can be said that he was negligent in requiring the space of two months to prepare these papers.

In view of this showing, it is not believed that your Honor will hold that in thus delaying for so short a time the forwarding of these papers, Mr. Marconi was guilty of negligence.

It must be remembered that Mr. Marconi had until the 3rd of June to amend his application. We do not, of course, contend that this would justify him in *intentionally* postponing action, but in preparing these papers within two months, Mr. Marconi certainly gave the matter as much attention as a prudent and careful business man would give to his most important business affairs.

[fol. 3664] These papers, which were despatched early in April, did not reach their destination; they were lost in transmission in some manner which has never been, and probably can never be, accounted for.

During the period immediately following the despatch of these papers by Mr. Marconi, when he supposed they were on their way to his attorneys and would arrive in due course, and his attorneys, relying on the information contained in the letter received April 19, 1903, in reply to their letter of March 20, 1903, also supposed that these papers were on their way and would arrive in due course, certainly no one can be blamed for negligence.

The attorneys for Marconi waited for these papers until May 13th, and again wrote to England urging that the papers be despatched immediately.

In the decision of December 2nd, your Honor said:

"The cablegram as to Marconi's illness was after the application was abandoned and thereafter (therefore) it does not appear that the illness had anything to do with the failure to act within the year."

It is believed that the affidavits *now* filed with this request show that Mr. Marconi's illness begun in the middle of April and thus prevented the filing of the amendment within the year.

The letter from the attorneys, of May 13th, was received by Marconi's Wireless Telegraph Company, Limited, on May 22nd. At that time Mr. Marconi was ill in Italy and unable to attend to business, and he did not recover sufficiently to attend to business until the middle of June. In the meantime, or on June 3rd, the year allowed by law, terminated.

[fol. 3665]

It is believed that it has been shown that during this whole year everything had been done to forward the prosecution of this case that could in reason be asked. The case had been under constant consideration by the persons interested in its prosecution. All of these persons were certainly aware of the important interests involved, and were using the greatest care to see that these interests were properly and adequately protected.

The repeated and unexpected postponements of Mr. Marconi's visit to America, caused the postponement of a ion for seven months, but these postponements could not have been anticipated and there was no reason to suppose that the delay would be of any such length.

The fact that Mr. Marconi could not furnish the desired information without consulting his records in London, caused a further unexpected and unavoidable postponement of action.

Notwithstanding all this, papers were prepared which, but for their loss in the mail, would have made it possible to amend the case within the year.

Finally, at the very end of the year, when the loss of the papers was discovered, Mr. Marconi was incapacitated by a serious illness, and it became impossible to make the necessary amendment.

[fol. 3666] Immediately after the expiration of the year, on June 5, 1903, the attorneys for Marconi wrote a further letter to Marconi's Wireless Telegraph Co., Ltd., to ascertain why the necessary papers had not been sent. In reply to this letter they received a cablegram, dated July 3, 1903, saying that Mr. Marconi had been ill and that for this reason the papers had not been sent. The attorneys for Marconi then immediately took steps to protect his rights by preparing a petition, asking your Honor to declare that the case was not abandoned.

This petition was sent to Mr. Thomas E. Robertson, of 605 7th Street, Washington, on July 8th, and the attorneys for Marconi were informed by him that the petition must be accompanied by an amendment. They were, therefore, compelled to await the receipt of the information from Mr. Marconi.

On August 21, 1903, certain papers were received from Mr. Marconi, but these papers were insufficient to enable his attorneys to make the necessary amendment, and they were

compelled to await his arrival in New York, in the latter part of September, 1903. Upon his arrival, he was consulted in regard to this application, and on October 12th the proper amendment and petition were filed.

It will be noticed that the second time Mr. Marconi undertook to prepare these papers, it again required a period of two months. Even at this time, when Mr. Marconi knew that the papers should be furnished immediately, it was impossible for him to prepare them in less time.

[fol. 3667] On December 2nd, your Honor's decision, denying the petition, was rendered, and a copy of this decision was sent to Mr. Marconi by the first steamer leaving New York. Mr. Marconi immediately replied with a statement in regard to his illness during the period from the middle of April to the middle of June, 1903, and instructing his attorneys to ask for a reconsideration of the petition, in view of the additional showing which he could make, and which your Honor had indicated, in the last paragraph of the decision of December 2nd, was necessary.

Mr. Marconi's attorneys, by the next steamer, sent to him an outline of the affidavit desired, and he immediately drew up the necessary affidavit and returned it to his attorneys, by whom it was received on the 15th day of February 1904. The affidavit, together with a supplemental affidavit of Mr. Betts, and a request for reconsideration, were forwarded to Washington on February 20th.

In the prosecution of this application, the failure to file the necessary amendment was undoubtedly caused by a loss of papers in the mail, that is, by an accident beyond the control of the applicant, and unavoidable.

There have been a number of cases in the history of the Patent Office, and even during your Honor's administration, in which failure to file the necessary amendment has been caused directly by an unavoidable accident occurring near the end of the period allowed by law, and in which cases it has been held that the delay was not "unavoidable" within [fol. 3668] the meaning of that term as used in section 4894 of the Revised Statutes.

In each of these cases, however, there has been some period through the year in which the application was deliberately laid aside with the intention of postponing action for some purpose or other, or else, the actions which were taken by the applicant have not been bona fide attempts to further the prosecution of the applications.

In the present case, there has never been any such period of intentional delay, and there has never been taken any action which was not a bona fide attempt to further the prosecution.

We have been unable to find any case which has been held to be abandoned where there has been, during the whole year, a bona fide attempt to amend the application as soon as possible.

It is believed that it has been shown that in this case there has been such a bona fide attempt.

Favorable action on the petition is respectfully asked.

Respectfully submitted,

BETTS, BETTS, SHEFFIELD & BETTS,

Attorneys for Marconi.

Dated, New York, February 29, 1904.

[fol. 3669]

Letter No.

E. E. G.

Department of the Interior, United States Patent Office,

Washington, D. C. March 29, 1904.

Serial No. 36,010, Paper No. 17

Notice of Comm'rs decision, Dated ——— 190—.

Petition for Reconsideration of Question of Abandonment

In the matter of the Application of Guglielmo Marconi, Apparatus for Wireless Telegraphy; Filed Nov. 10, 1900, Serial No. 36,010.

Sir:

You are hereby informed that the above petition has been granted by the Commissioner. Please find enclosed herewith a copy of the decision.

By direction of the Commissioner:

Very respectfully,

C. M. IRELAN,

Chief Clerk.

F

Guglielmo Marconi,
c/o Thos. E. Robertson
605 Seventh St.,
Washington, D. C.

[fol. 3670] M. H.

Serial No. 36,010, Paper No. 17, Comm'rs decision—Recorded Vol. 79, Page 209, United States Patent Office.

Ex parte Guglielmo Marconi.

Apparatus for Wireless Telegraphy.

Petition.

Application filed November 10, 1900, No. 36,010.

Messrs. Betts, Betts, Sheffield & Betts and Mr. T. E. Robertson for applicant.

This is a petition for a reconsideration of the question of abandonment of the above-entitled application.

In the decision dated December 2, 1903, it was held that the application must be regarded as abandoned in the absence of a more complete showing of the reasons for the delay than that included in the affidavits then filed. The present petition is supported by an affidavit of the inventor and by affidavits of one of the principal attorneys and an associate.

It appears that the inventor was traveling during many months immediately after the last office letter, and that it was difficult to communicate with him. By reason of the character of the invention, it was necessary for the attorneys to obtain his advice and assistance in replying to the examiner's action, and since he was constantly expected to come to this country, the attorneys postponed action until his arrival. Various circumstances interfered with his plans to visit this country, and his visit was postponed from [fol. 3671] time to time. When he did arrive, in January, 1903, he was consulted about this application, but found it necessary to refer to his papers in London before giving his instructions. This was five months before the year allowed by law expired. Upon returning to London the inventor prepared the papers, giving his attorneys instructions, and left them with a notary early in April, 1903, to be forwarded, but they were never received by the attorneys. It is not clear what became of them. For two months after April 15, 1903, the inventor was incapacitated for business by illness, and although the attorneys were active in seeking the

information to be used as the basis for a reply to the examiner's action, the inventor was unable to furnish it. Upon his recovery, he again prepared his instructions to his attorneys and forwarded the papers to them, and upon a second trip to this country gave them oral advice. Responsive action was then taken in the case.

Under all of the circumstances, it must be held that reasonable diligence was exercised in preparing a response to the last office action and that the delay was unavoidable.

The petition is granted.

F. I. ALLEN,
Commissioner.

March 28, 1904.

[fol. 3672] 2—260

Div. XVI, Room 109

Paper No. 18

C. E. N.

Address only "The Commissioner of Patents, Washington, D. C.," and not any official by name.

All communications respecting this application should give the serial number, date of filing, title of invention, and name of the applicant.

Department of the Interior, United States Patent Office,
Washington, D. C.

March 31, 1904.
Mailed " " "

G. Marconi,
c/ T. E. Robertson,
605 7th Street,
Washington, D. C.

Please find below a communication from the Examiner in charge of [the]* your application [of]* 36,010, filed November 10, 1900, for Apparatus for Wireless Telegraphy.

F. I. ALLEN,
THOMAS EWING,
Commissioner of Patents.

[*Words and figures enclosed in brackets erased in copy.]

This application having been revived by the Commissioner, applicant's amendment of October 12, 1903, has been entered as corrected by his amendment of October 24, 1903. The following action is taken:

The claims are all allowed except claims 4, 5, 6 and 7, which are rejected on the patent to Stone, 714,756, December 2, 1902, application filed February 8, 1900.

Stone shows in Fig. 5 a transformer M whose secondary L_2 is connected to an open circuit including a radiating conductor V at one end and a capacity E at the other and whose primary L_1 is connected to a condenser circuit discharging through a spark gap, viz., the circuit C s L_1 L. These circuits are in "electrical resonance with each other",—see lines 16-20, page 2. It is not stated how the elevated conductor is given a natural period equal to that of the oscillations impressed upon it but it is well-known by all skilled in this art that this may be accomplished by adjusting the length of the elevated conductor, thereby adjusting the distributed capacity and the distributed inductance of the same until the natural period of such conductor is equal to the [fol. 3673] natural period of the condenser circuit C sL_1 L. =36,010.

[fol. 3673] When this is done "the frequency impressed upon the elevated conductor" is "the same as the natural period or fundamental of such conductor", to quote from the Stone patent.

Applicant discloses another means whereby the same result may be effected, viz., by including a "variable inductance" in the elevated conductor. All claims which include this element are considered allowable over the Stone patent.

In regard to claim 7 it may be said that Stone states that the operator at each station may at will adjust his apparatus in such way as to place himself in communication with any other station (page 4, lines 28-36) and that he also states that this result may be effected by making the coil L of the condenser circuit adjustable (page 6, lines 76-81). Inasmuch as the period of an oscillating circuit depends upon the capacity of the condenser in the same way that it depends upon the inductance of the coil, it is held that it is not patentable to make the condenser e of applicant's oscillating circuit adjustable for the same purpose as Stone makes the coil L of his oscillating circuit adjustable.

Claims 4, 5, 6 and 7 will be allowed if amended by inserting the words *a variable inductance and* after the word "including" in line 3 of each claim.

In claim 8, line 6, the words "said circuit" are repeated and should be canceled.

CAMPBELL,
Examiner, Division XVI.

G. K. W.

[fol. 3674] Patent Office, Jun. 1, 1904, Div. 16. Filed

Mail Room, May 31, 1904, U. S. Patent Office

Serial No. 36010

Paper No. 19

Amend't F

Filed May 31, 1904

United States Patent Office

In Re Application of Guglielmo Marconi, Serial No. 36,010, for Apparatus for Wireless Telegraphy, Filed November 10, 1900

Amendment

New York,
May 28, 1904.

Hon. Commissioner of Patents,
Washington, D. C.

Sir:

We authorize and request the following amendment of the Specification of this Application:

In line 10 of page 1, after "tions," insert "or electric waves."

In line 12, same page, after "oscillations", insert "or electric waves."

In line 13, same page, before "selected", insert "one."

In line 1 of page 2, cancel "only."

In line 19 of same page, insert before "a spark producer", the words

F'. "a producer of Hertzian oscillations or electric waves shown in the form of."

In the same line, insert "an" before "induction coil."

Same page, at the end of line 24, insert "a device responsive to electric waves, such as."

In line 13 of page 3, change "Ruhmkorff" to "induction."

In line 17, same page, insert before "oscillation producer," the words electric wave or."

In lines 23 and 24 of same page, substitute "induction" for "Ruhmkorff."

[fol. 3675] After the end of line 28 of same page, insert

F². "It is obvious that instead of the induction coil and associated parts for producing the electric waves or oscillations, I may use any other proper means for producing such waves or oscillations, such, for instance, as a generator of alternating electric currents."

In line 15 of page 4, substitute "induction" for "Ruhmkorff."

In line 23, same page, after "radiated," insert "in the form of electric waves."

5

Exr. In line 10 of page [4]*, ^ before "oscillations", Insert "waves or."

Before the paragraph beginning in line 11 of page 5, insert a paragraph as follows:

F³. "As a responder to electric waves, I may use at the receiving station any of the now well known forms of such devices such as those which depend for their action on the reduction of the resistance of a metallic microphone by the action of electric waves, or 'coherers', one form of which is disclosed in my patent No. 586,193; or I may employ one which depends for its action on the increase of the resistance of the device under the influence of the electric waves, or 'anti-coherers', such as described by Branly in 'La Lumiere Electrique' of June 13, 1891; or I may use those which depend upon the action of an electric

[*Words and figures enclosed in brackets erased in copy.]

wave as a magnetizing or demagnetizing agency, such as I have disclosed in my application No. 132,974, filed November 28, 1902; or I may use various other well known devices such as the electrolytic, electro-[fol. 3676] thermal, electromagnetic or electro-dynamic responders."

In lines 22, 23 and 25 of page 5, cancel "pending application, serial No. — filed February 21, 1901, for "and insert after "United States," "No. 676,332," unless this has *already been done*.

In line 15 of page 6, change "detector" to "wave responsive device."

On the same page, cancel the paragraph beginning at line 16 and ending in line 23, and substitute therefor the following:

F⁴. "The capacity and self-induction of the four circuits—i. e., the primary and secondary circuits at the transmitting station and the primary and secondary circuits at any one of the receiving stations, in a communicating system—are each and all to be so independently adjusted as to make the product of the self-induction multiplied by the capacity, the same in each case, or multiples of each other, that is to say, the electrical time periods of the four circuits are to be the same, or octaves of each other."

On page 7, line 7, cancel "the" and substitute "any or all of the four."

Cancel claims 4 and 5 and substitute therefor the following:

F⁵. "4. In a system of syntonic wireless telegraphy, a circuit so arranged as to form a persistent oscillator, a circuit so formed as to constitute a good radiator in inductive relation thereto, means for inducing in the oscillator circuit electric undulations of a predetermined period, and means for attuning the natural [fol. 3677] period of vibration of each of said circuits to the period of the undulations so induced.

F⁶. 5. An element of an apparatus employed in a system of telegraphy by electric waves or oscillations of high frequency, comprising a conductor elevated at

one end and connected to capacity at the other end, said conductor including a variable inductance and an element having appreciable capacity."

In claim 6, line 8, insert "each of" before "the two circuits."

Cancel claim 7 and substitute therefor:

F[6]. "7. An element of an apparatus employed in a system of telegraphy by electric waves or oscillations of high frequency, comprising an open circuit so arranged as to constitute a radiator of such waves or oscillations, and means for varying at will the natural period of vibration of the said circuit."

In claim 11, lines 5 and 6, cancel "sparking device" and substitute "producer of electric waves of high frequency."

In claim 12, line 5, cancel "sparking device" and substitute "producer of electric waves of high frequency."

In claim 19, line 9, cancel "imperfect contact" and substitute "wave responsive."

In claim 20, line 5, cancel "oscillations" and substitute "electric waves."

[fol. 3678] Remarks

The claims now presented, all include an elevated conductor, or a circuit which is a good radiator of electric waves or oscillations, and means for adjusting the tune of such elevated conductor or radiating circuit. It is believed that the Examiner recognizes the fact that the Stone Patent does not show such an arrangement, and an early allowance is requested.

Respectfully submitted,

BETTS, BETTS, SHEFFIELD & BETTS,

Attorneys for Applicant.

(Here follow 2 photolithographs, side folios 3679-3680)

10744

A.

Serial No. 36010

2—181.

Division.

Letters should be addressed to
Commissioner of Patents,
Washington, D. C.

DEPARTMENT OF THE INTERIOR,

U. S. Patent Office.

Washington, D. C., June 1, 1904.

Guglielmo Marconi, Assor.

c. T. S. Robertson,

City

SIR:—Your APPLICATION for a patent for an IMPROVEMENT IN

Apparatus for Wireless Telegraphy

Filed Nov. 10, 1900, has been examined and ALLOWED.

The final fee, **Twenty Dollars**, must be paid, and the Letters Patent bear date as of a day not later than SIX MONTHS from the time of this present notice of allowance.

If the final fee is not paid upon that period the patent will be withheld, and your only relief will be by a renewal of the application, with additional fees, under the provisions of Section 4897, Revised Statutes. The Office aims to deliver patents upon the day of their date, and on which their term begins to run; but to do this properly applicants will be expected to pay their final fees at least TWENTY DAYS prior to the conclusion of the six months allowed them by law. The printing, photolithographing, and engrossing of the several patent parts, preparatory to final signing and sealing, will consume the intervening time, and such work will not be done until after payment of the necessary fees.

When you send the final fee you will also send, DISTINCTLY AND PLAINLY WRITTEN, the name of the INVENTOR, and TITLE OF INVENTION AS ABOVE GIVEN, DATE OF ALLOWANCE (which is the date of this circular), DATE OF FILING, and, if assigned, the NAMES OF THE ASSIGNEES.

If you desire to have the patent issue to ASSIGNEES, an assignment containing a REQUEST to that effect, together with the FEE for recording the same, must be filed in this Office on or before the date of payment of final fee.

After issue of the patent uncertified copies of the drawings and specifications may be purchased at the price of 5 cents each. The money should accompany the order. Postage stamps will not be received.

Respectfully,

F. I. Allen,

Commissioner of Patents.

After allowance, and prior to payment of the final fee, applicants should carefully scrutinize the description to see that their statements and language are correct, as mistakes not incurred through the fault of the office, and not affording legal grounds for reissues, will not be corrected after the delivery of the letters patent to the patentee or his agent.

IN REMITTING THE FINAL FEE GIVE THE SERIAL NUMBER AT THE HEAD OF THIS NOTICE.

If payment is made by check or draft, the credit allowed is subject to the collection of the same.

$ 20- RECEIVED
JUN 9 1904 S
CHIEF CLERK.U.S.
PATENT OFFICE.

2—327.

40741

MEMORANDUM

OF

FEE PAID AT UNITED STATES PATENT OFFICE.

(Be careful to give correct Serial No.)

Serial No. 36,010 , *1900*

INVENTOR:

GUGLIELMO MARCONI

PATENT TO BE ISSUED TO

As Assigned.

NAME OF INVENTION, AS ALLOWED:

Apparatus for Wireless Telegraphy.

DATE OF PAYMENT:

June 9th, 1902.

FEE:

Final $20.00

DATE OF FILING:

Nov. 10, 1900

DATE OF CIRCULAR OF ALLOWANCE:

June 1, 1904.

The Commissioner of Patents will please apply the accompanying fee as indicated above.

Thos E. Robertson

Attorney.

SEND PATENT TO

Attorneys.

9—1846

[fol. 3681] Serial No. 36,010

C.R.

Department of the Interior, United States Patent Office,
Washington, D. C.

June 9, 1904.

Guglielmo Marconi, Assor.,
℅ Thos. E. Robertson,
605 7th St.,
Washington, D. C.

SIR:

You are informed that the final fee of Twenty Dollars has been received in your application for Improvement in Apparatus for Wireless Telegraphy.

Very respectfully,

F. I. ALLEN,
Commissioner of Patents.

No. 763,772. PATENTED JUNE 28, 1904.

G. MARCONI.

APPARATUS FOR WIRELESS TELEGRAPHY.

APPLICATION FILED NOV. 10, 1900.

NO MODEL.

Fig. 1.

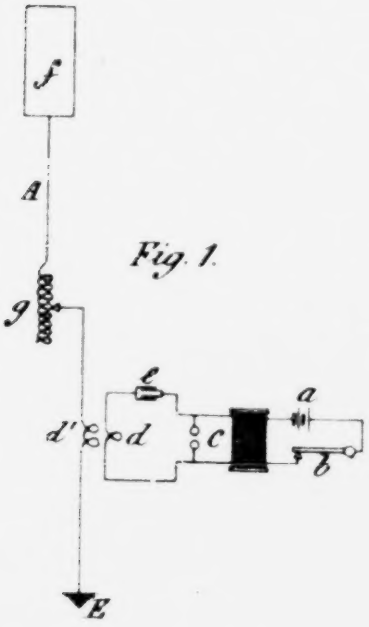


Fig. 2.

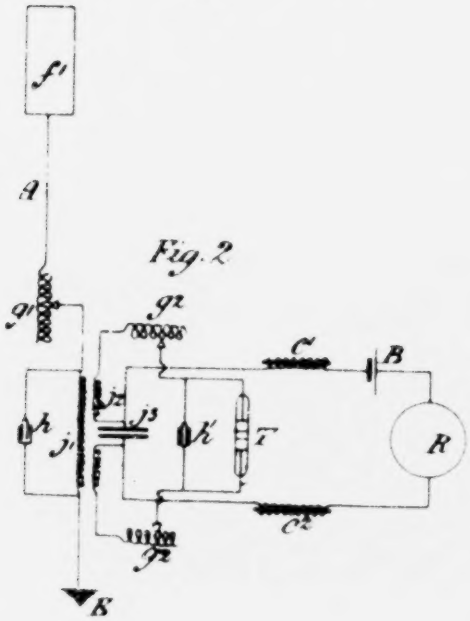


Fig. 3.

Fig. 4.

Fig. 5.

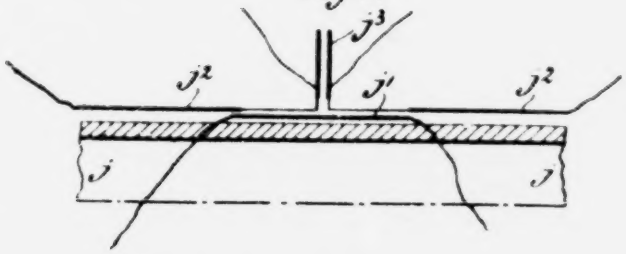


Fig. 6.

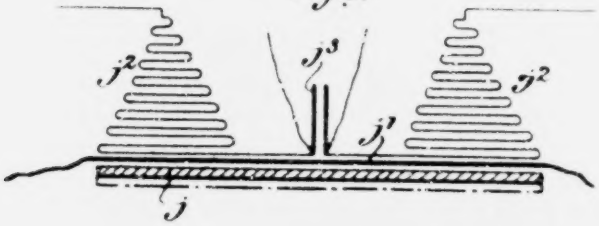


Fig. 7.

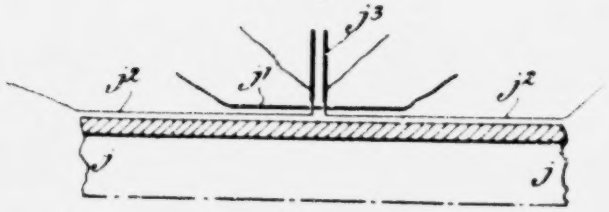
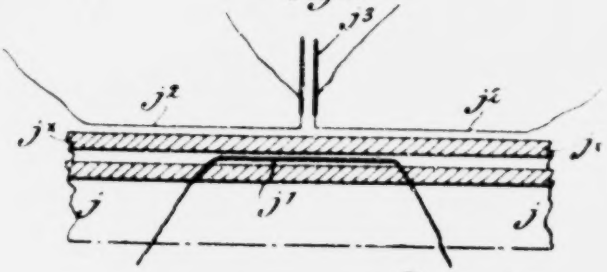


Fig. 8.



Witnesses

Inventor

GUGLIELMO MARCONI, By

Bates Batts Hayford & Dix

HIS ATTORNEYS

UNITED STATES PATENT OFFICE.

GUGLIELMO MARCONI, OF LONDON, ENGLAND, ASSIGNOR TO MARCONI'S WIRELESS TELEGRAPH COMPANY, LIMITED, OF LONDON, ENGLAND.

APPARATUS FOR WIRELESS TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 763,772, dated June 28, 1904.

Application filed November 10, 1900. Serial No. 36,010. (No model.)

To all whom it may concern:

Be it known that I, GUGLIELMO MARCONI, electrician, a subject of the King of Italy, residing and having a post-office address at 18 Finch Lane, Threadneedle street, in the city of London, England, have invented certain new and useful Improvements in Apparatus for Wireless Telegraphy, of which the following is a specification.

My invention relates to apparatus for communicating electrical signals without wires and by means of Hertz oscillations or electric waves; and the object of the invention is to increase the efficiency of the system and to provide new and simple means whereby oscillations or electric waves from a transmitting-station may be localized when desired at any one selected receiving station or stations out of a group of several receiving-stations.

In my prior United States patent No. 586,193 (Reissue No. 11,913, dated June 4, 1901) I have shown and described the combination at a transmitting-station of an oscillation-producer, such as an induction-coil, having one end of its secondary coil connected to one contact of a spark-producer and to the earth and having the other end of the said secondary connected to the opposite contact of the spark-producer and to a vertical wire or elevated plate, and I have further shown at a receiving-station an imperfect contact connected in circuit with a vertical receiving-wire and with the earth. According to the present invention the system includes at the transmitting-station the combination, with an oscillation-transformer of a kind suitable for the transformation of very rapidly alternating currents, of a persistent oscillator, and a good radiator, one coil of said transformer being connected between the aerial wire or plate and the connection thereof to earth, while the other coil of the transformer is connected in circuit with a condenser, a producer of Hertzian oscillations or electric waves shown in the form of a spark-producer, and an induction-coil (constituting the persistent oscillator) controlled by a signaling instrument. The complete system also includes at a receiving-station an oscillation-transformer one coil whereof is included between the aerial receiving-wire and earth, constituting a good absorber of electrical oscillations, while a device responsive to electric waves, such as an imperfect contact or a device for operating the same, is included in a circuit with the other coil of said transformer. The system also requires as essential elements thereof the inclusion in the lines (at both stations) from the aerial conductor to the earth of variable inductances and the use at both stations of means for varying or adjusting the inductance of the two circuits at each station to accord with each other. By this arrangement of apparatus I am able to secure a perfect "tuning" of the apparatus at a transmitting-station and at one or more of a number of receiving-stations.

Referring to the accompanying drawings, Figure 1 indicates diagrammatically the arrangement of apparatus at a transmitting-station. Fig. 2 indicates diagrammatically the arrangement of apparatus at a receiving-station. Figs. 3 and 4 are views, plan and side, of the preferred form of transformer at the transmitting-station. Figs. 5, 6, 7, and 8 are diagrammatic views of forms of transformers at the receiving-station.

The transmitting-station is provided under my present invention with a source *a* of current electrically connected in circuit with the primary of an induction-coil *c* and with a circuit-closing key *b* or otherwise controlled by a signaling instrument. In the secondary circuit of said induction-coil the spherical terminals or other contacts of a spark-producer or other electric-wave or oscillation producer are included with a shunt therefrom, in which shunt is included the primary coil *d* of an oscillation-transformer, such as *d'*. A condenser *e*, preferably one provided with two telescoping metallic tubes separated by a dielectric and arranged to readily vary the capacity by being slid upon each other, is included in one connection from the induction-coil to the transformer-winding *d*. The secondary coil *d'* of the transformer is connected (at one end) to the earth E and at its other end to a vertical wire A or an elevated plate *f*.

It is obvious that instead of the induction-

coil and associated parts for producing the electric waves or oscillations I may use any other proper means for producing such waves or oscillations—such, for instance, as a generator of alternating electric currents.

The illustrated arrangement of parts at a transmitting-station enables much more energy to be imparted to the radiator *f*, the approximately closed circuit of the primary being a good conserver and the open circuit of the secondary being a good radiator of wave energy. My experiments have demonstrated that the best results are obtained at the transmitting-station when I use a persistent oscillator—an electrical circuit of such a character that if electromotive force is suddenly applied to it and the current then cut off electrical oscillations are set up in the circuit which persist or are maintained for a long time in the primary circuit and use a good radiator—*i. e.*, an electrical circuit which very quickly imparts the energy of electrical oscillations to the surrounding ether in the form of waves—in the secondary circuit.

In operation the signaling-key *b* is pressed, and this closes the primary of the induction-coil. Current then rushes through the transformer-circuit and the condenser *c* is charged and subsequently discharges through the spark-gap. If the capacity, the inductance, and the resistance of the circuit are of suitable values, the discharge is oscillatory, with the result that alternating currents of high frequency pass through the primary of the transformer and induce similar oscillations in the secondary, these oscillations being rapidly radiated in the form of electric waves by the elevated conductor.

For the best results and in order to effect the selection of the station or stations whereat the transmitted oscillations are to be localized I include in the open secondary circuit of the transformer, and preferably between the radiator *f* and the secondary coil *d*, an inductance-coil *g*, Fig. 1, having numerous coils, and the connection is such that a greater or less number of turns of the coil can be put in use, the proper number being ascertained by experiment.

At the receiving-stations employing my present invention I prefer to use a receiver such as those described in my several United States Patents, Nos. 586,193, 627,650, 647,007, 647,008, 647,009, and 668,315, capable of being affected by electrical waves or oscillations of high frequency.

As a responder to electric waves I may use at the receiving-station any of the now well-known forms of such devices, such as those which depend for their action on the reduction of the resistance of a metallic microphone by the action of electric waves or "coherers," one form of which is disclosed in my Patent No. 586,193, or I may employ one which depends for its action on the increase of the resistance of the device under the influence of the electric waves or "anticoherers," such as described by Branly in *La Lumiere Electrique* of June 13, 1891, or I may use those which depend upon the action of an electric wave as a magnetizing or demagnetizing agency, such as I have disclosed in my application Serial No. 132,974, filed November 28, 1902, or I may use various other well-known devices, such as the electrolytic, electrothermal, electromagnetic, or electrodynamic responders.

Referring to Fig. 2, *f'* indicates a plate or cylinder (not essential at either transmitter or receiver) at the upper end of an elevated conductor A, which is connected to the primary coil *j'* of a transformer or induction-coil and thence to earth E. In a shunt around said primary *j'* I usually place a condenser *h*, preferably similar in construction and operation to the condenser *c*. An inductance-coil *g'* of variable inductance is interposed in the primary circuit of the transformer, being preferably located between the cylinder *f'* and the coil *j'*, and the inductance of said coil may be adjusted in accordance with the method described by me in my Letters Patent of the United States No. 676,332 to harmonize with the inductance of coil *g* at the transmitting-station, Fig. 1 of the accompanying drawings, or with that of the coil or coils at one or more of the transmitting-stations included in the communicating system.

The secondary coil *j''* of the transformer is wound in two parts, preferably as described in my United States Letters Patent No. 668,315, dated February 19, 1901, and the outer ends of said coil are connected in certain cases through one or more interposed inductance-coils *g''*, preferably of variable inductance, with the terminals of a coherer T or other detector of electrical oscillations. The inner ends of the split secondary coil are connected to the plates of a condenser *j''*. A condenser *h'* is sometimes included in a shunt around the detector T. B is a battery, and R a relay connected to the condenser *j''* and controlling a telegraphing instrument or a printing device. *c'* and *c''* are choking-coils preventing oscillations from the secondary *j''* running into the battery-circuit and thereby confining them to the wave-responsive device.

The capacity and self-induction of the four circuits—*i. e.*, the primary and secondary circuits at the transmitting-station and the primary and secondary circuits at any one of the receiving-stations in a communicating system—are each and all to be so independently adjusted as to make the product of the self-induction multiplied by the capacity the same in each case or multiples of each other—that is to say, the electrical time periods of the four circuits are to be the same or octaves of each other.

In employing this invention to localize the

transmission of intelligence at one of several receiving-stations the time period of the circuits at each of the receiving-stations is so arranged as to be different from those of the other stations. If the time periods of the circuits of the transmitting-station are varied until they are in resonance with those of one of the receiving-stations, that one alone of all of the receiving-stations will respond, provided that the distance between the transmitting and receiving stations is not too small.

The adjustment of the self-induction and capacity of any or all of the four circuits can be made in any convenient manner and employing various arrangements of apparatus, those shown and described herein being preferred. In practice I have found the following preferred details of arrangements of apparatus to work well: The aerial conductors A at all stations and the conductor for the transformer-windings at the receiving-stations are composed of seven strands of copper wire .889 millimeters in diameter. The transformer at the transmitting-station may be of any of the following forms:

1. Around a block or core d', preferably a square block—say .17 meters wide—of insulating material is wound a primary coil d in length .946 meters, while the secondary d' consists of two turns or squares, one lying on each side of the primary. (See Figs. 3 and 4.) The insulation of both primary and secondary consists of 1.25 millimeters of rubber and one millimeter of jute, making a total thickness of 2.25 millimeters.

2. A transformer in all essential respects similar to 1, but with a primary of 1.93 meters and the core or block on which both primary and secondary are wound, is .3048 meters wide.

3. A transformer having a cylindrical core 10.16 centimeters in diameter and with a primary having ten turns wound thereon; over this, but separated by two millimeters of paper or other insulant, the secondary, also of ten turns.

Various forms of transformers, &c., which may be employed by me are described in my British Patent No. 7,777 of 1900.

The inductance-coils g and g' are preferably of copper wire 6.25 millimeters in diameter, wound on a cylinder 10.64 centimeters in diameter, with an interval of 2.28 millimeters between adjacent turns. The inductance-coils g^3 at the receiving-station are preferably of silk-covered copper wire .19 millimeter diameter wound upon cylinders 3.7 centimeters in diameter.

Various forms of induction-coils j'' j^3 may be used. Figs. 5, 6, 7, and 8 show details of different forms. The figures show diagrammatically greatly-enlarged longitudinal sections not strictly to scale. Instead of showing the section of each coil or layer of wire as a longitudinal row of dots or small circles, as it would actually appear, it is for simplicity shown as a continuous longitudinal straight line.

Referring to Fig. 5, the primary j'' preferably consists of 3.046 meters of silk-covered copper wire, say, and seventy-one millimeters in diameter wound in one layer on a core of ebonite or other insulating material 2.9 centimeters in diameter. Insulating material is wound over and on each side of this, so as to make a cylindrical core, say, 3.13 centimeters in diameter, on which is wound the secondary, each half of which consists of 6.4 meters of silk-covered copper wire .19 millimeter in diameter joined to 13.41 meters of silk-covered copper wire .37 millimeter in diameters wound in the same sense as the primary, the thinner wire being over the primary and the thicker being beyond the ends thereof.

The form of induction-coil shown in Fig. 6 has a primary of one hundred turns of copper wire .037 centimeters in diameter wound on a core j (2.9 centimeters in diameter) with a single silk covering and coated with paraffin-wax. The secondary j^3 is of copper wire .019 in diameter, insulated with a single silk covering, and is wound over the primary, commencing in the middle and in the same way as the primary. Each half of the secondary is in layers of the following number of turns: first layer, seventy-seven turns; second layer, forty-nine turns; third layer, forty-six turns; fourth layer, forty-three turns; fifth layer, forty turns; sixth layer, thirty-seven turns; seventh layer, thirty-four turns; eighth layer, thirty-one turns; ninth layer, twenty-eight turns; tenth layer, twenty-five turns; eleventh layer, twenty-two turns; twelfth layer, nineteen turns; thirteenth layer, sixteen turns; fourteenth layer, thirteen turns; fifteenth layer, ten turns; sixteenth layer, seven turns; and seventeenth layer, three turns, making five-hundred turns in all.

A third form of induction-coil (shown in Fig. 7) has a primary of 3.048 meters of silk-covered copper wire .19 millimeter in diameter and a secondary of 30.48 meters of silk-covered copper wire .1 millimeter in diameter wound in one layer on a core four centimeters in diameter, the primary being in one layer outside of the secondary.

The fourth form of induction-coil is shown in Fig. 8. Its primary consists of 3.048 meters of silk-covered copper wire .37 millimeter in diameter wound on a core 2.9 centimeters in diameter and inserted in a tube j^4 of four centimeters external diameter, on which is wound the secondary of 27.432 meters of silk-covered copper wire .12 millimeter in diameter, the break at the middle of the secondary being over the middle of the primary.

Other forms of transformers which may be employed by me are described and claimed in my British Patent No. 7,777 of 1900.

The following tables give preferred adjustments, those details opposite any tune in the transmitting-station table being of course used in connection with those opposite the same tune in the receiving-station table:

Transmitting-Station.

Tune	Aerial conductor	Transformer *d d'*	Inductance number of turns of *g* included	Capacity microfarads *e*	Length of spark in millimeters.
No. 1	38.578 meters of cable	No. 1.	None.	.0[illegible]984	3
No. 2	do	No. 1.	45	.016888	4
No. 3	do	No. 2.	None.	.004112	3
No. 4	do	No. 2.	100	.010849	4
No. 5	Zinc cylinder 9.144 meters long, 1.524 meters in diameter, and hoisted 8.048 meters above ground.	No. 2.	None.	.021600	12.5
No. 6	30.48 meters of cable.	No. 2.	None.	.000873	4

Receiving-Station.

Tune	Induction-coil.	Capacity in microfarads of—		Inductance introduced in—	
		A.	A'	*g'*. Number of turns.	*g*³.
No. 1.	No. 1.	Omitted.	Omitted.	None.	None.
No. 2.	No. 1.	Omitted.	.0[illegible]04	45	None.
No. 3.	No. 2.	.0046	Omitted.	Up to 21 may be inserted.	None.
No. 4.	No. 2.	.0046	Omitted.	100	2 coils of 15.24 meters at each end of secondary.
No. 5.	No. 3.	Omitted.	Omitted.	None.	None.
No. 6.	No. 4.	Omitted.	Omitted.	None.	None.

It will be observed that both the transmitter and the receiver are the same for tunes 1 and 2 and that when the capacity of the condenser *e* is varied the two stations can be brought into tune by including forty-five turns of each of the coils *g g'* and by introducing a condenser *k* of small capacity in parallel with the coherer T. Similarly the transmitter and receiver are the same for tunes 3 and 4, and when the capacity of *e* is varied the stations are tuned by including one hundred turns of each of the coils *g* and *g'* and by also including the coils g^3.

While I have herein shown and described details of construction and of arrangement found by me to be useful, yet I do not wish to be understood as confining my claims thereto. Obviously modifications which are within my invention will readily suggest themselves to skilled persons.

What I claim is

1. At a station employed in a wireless-telegraph system, a signaling instrument comprising an induction-coil, the secondary circuit of which includes a condenser discharging through a means which automatically causes oscillations of the desired frequency; an open circuit electrically connected with the oscillation-producer aforesaid and a variable inductance included in the open circuit, substantially as and for the purpose described.

2. At a station employed in a wireless-telegraph system, an oscillation-receiving conductor, a variable inductance connected with said conductor; a wave-responsive device electrically connected with said conductor and in circuit with a condenser, substantially as and for the purpose described.

3. At a station employed in a wireless-telegraph system, a signaling instrument comprising an induction-coil, the secondary circuit of which includes a condenser discharging through a means which automatically causes oscillations of the desired frequency, and the

primary circuit of which includes a generator; means for varying the primary circuit; an open circuit electrically connected with the oscillation-producer aforesaid, and a variable inductance included in the open circuit, substantially as and for the purpose described.

4. In a system of syntonic wireless telegraphy, a circuit so arranged as to form a persistent oscillator, a circuit so formed as to constitute a good radiator in inductive relation thereto, means for inducing in the oscillator-circuit electric undulations of a predetermined period, and means for attuning the natural period of vibration of each of said circuits to the period of the undulations so induced.

5. An element of an apparatus employed in a system of telegraphy by electric waves or oscillations of high frequency, comprising a conductor elevated at one end and connected to capacity at the other end, said conductor including a variable inductance and an element having appreciable capacity.

6. At a transmitting-station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating-conductor at one end and capacity at the other end, and whose primary is connected to a condenser-circuit discharging through a means which automatically causes oscillations of the desired frequency, and means for adjusting the oscillation period of each of the two circuits connected with the transformer to bring them into accord with each other, substantially as described.

7. An element of an apparatus employed in a system of telegraphy by electric waves or oscillations of high frequency, comprising an open circuit so arranged as to constitute a radiator of such waves or oscillations, and means for varying at will the natural period of vibration of the said circuit.

8. At a transmitting-station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating-conductor at one end and capacity at the other end, a variable inductance being included in said circuit, and whose primary is connected to a condenser-circuit discharging through a means which automatically causes oscillations of the desired frequency, substantially as described.

9. At a transmitting-station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating-conductor at one end and capacity at the other end, a variable inductance being included in said circuit, and whose primary is connected in series with an adjustable condenser and with a means which automatically causes oscillations of the desired frequency, substantially as described.

10. A system of wireless telegraphy, in which the transmitting-station and the receiving-station each contains an oscillation transformer, one circuit of which is an open circuit and the other a closed circuit, the two circuits at each station being in electrical resonance with each other and in electrical resonance with the circuits at the other station, substantially as described.

11. In apparatus for communicating electrical signals, the combination, with an oscillation-transformer, at a transmitting-station, of an induction-coil; an electric circuit containing the secondary of said coil, a condenser and the primary coil of the oscillation-transformer; a producer of electric waves of high frequency electrically connected with the secondary of the induction-coil: a signaling instrument in circuit with the primary of the induction-coil; the secondary coil of the oscillation-transformer electrically connected, at one end to capacity and, at the other end, to an inductance, and an aerial conductor connected to the inductance, substantially as and for the purpose described.

12. In apparatus for communicating electrical signals, the combination, with an oscillation-transformer, at a transmitting-station, of an induction-coil; an electric circuit containing the secondary of the said coil, a condenser and the primary coil of the oscillation-transformer; a producer of electric waves of high frequency connected with the secondary of the induction-coil; a signaling instrument in circuit with the primary of the induction-coil; the secondary coil of the oscillation-transformer electrically connected, at one end, to capacity and, at the other end, to a variable inductance, and an aerial conductor connected to the variable inductance, substantially as and for the purpose described.

13. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a variable inductance being included in said circuit, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and a condenser in circuit with the wave-responsive device, substantially as described.

14. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and means for adjusting the two transformer-circuits in electrical resonance with each other, substantially as described.

15. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a condenser located in said circuit between the coil and the capacity, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and means for adjusting the two transformer-circuits in electrical resonance with each other, substantially as described.

16. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, an adjustable condenser in a shunt connected with the open circuit and around said transformer-coil, a wave-responsive device electrically connected with the other coil of the oscillation-transformer, and means for adjusting the two transformer-circuits in electrical resonance with each other, substantially as described.

17. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and means included in each of said transformer-circuits, for adjusting said circuits in electrical resonance with each other, substantially as described.

18. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a variable inductance being included in said open circuit, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and a variable inductance included in circuit with the wave-responsive device, substantially as described.

19. In a system of wireless telegraphy, the combination at a receiving-station, of an oscillation-transformer; an open circuit comprising, in part, an aerial conductor connected with one end of the primary coil of the oscillation-transformer; a connection from the other end of said coil to capacity; a variable inductance in said open circuit; and electrical connections from the secondary coil of the oscillation-transformer to a receiving instrument, battery, condenser, wave-responsive device and a variable inductance, substantially as and for the purpose described.

20. In a system of wireless telegraphy, a transmitting-station containing an oscillation-transformer, the primary of which is connected to a condenser-circuit discharging through a spark-gap which automatically causes electric waves of the desired frequency, the secondary of said transformer connected to an open circuit including a radiating-conductor, and with a capacity and a coil for charging the condenser aforesaid; a receiving-station containing an oscillation-transformer, the primary of which is connected with an oscillation-receiving conductor and with a capacity, a wave-responsive device connected with the secondary of said transformer, and a receiving instrument connected with the wave-responsive device, all in combination with means for bringing the four transformer-circuits, two at each station, into electrical resonance with each other, substantially as described.

GUGLIELMO MARCONI.

Witnesses:

R. B. RANSFORD,

G. F. WARREN.

ABANDONED

Revived Mch 29, 1904

178.--~~TELEGRAPHY~~,
~~Telegraphs: Circuits & Systems.~~

1 9 0 0

C O N T E N T S:

1 Application / papers.

1. Rej. Dec. 24, 1900.
2. Ltr Spec July 3, 1901
3. Amendt c. July 8, 1901
4. Letter. Aug. 12, 1901
5. Amendt & Ltr. Aug 8, 1901
6. Rej Feb. 11, 1902.
7. Amendt & Affd. May 1, 1902
8. Rej June 3, 1902
9. Ltr Prop Amendt & Affd. Oct. 12, 1903
9 1/2. Amdt. Claims of Affy Oct. 12, 1903
10. Examiner's Answer Oct 15, 1903.
11. Appeal Petition and proposed Amendt Oct 24, 1903
12. Examiner's Ans. Oct. 26- 1903.
13. Brief for Appellant Nov. 4 1903
14. Commr's Decision Dec. 2- 1903.
15. Argument for Appellant Jan. 6 24, 1904
16. Brief for Petitioner Jan. 3 1904
17. Commr's Decsn Mch 29 '04
18. Rej. Mar. 31- 1904.
19. Amendt & Affy May 31, 1904
20.
21.
22.
23.

T I T L E:

Improvement in Apparatus for Wireless Telegraphy.

No. 763,772. PATENTED JUNE 28, 1904.

G. MARCONI.

APPARATUS FOR WIRELESS TELEGRAPHY.

APPLICATION FILED NOV. 10, 1900.

NO MODEL.

Fig. 1.

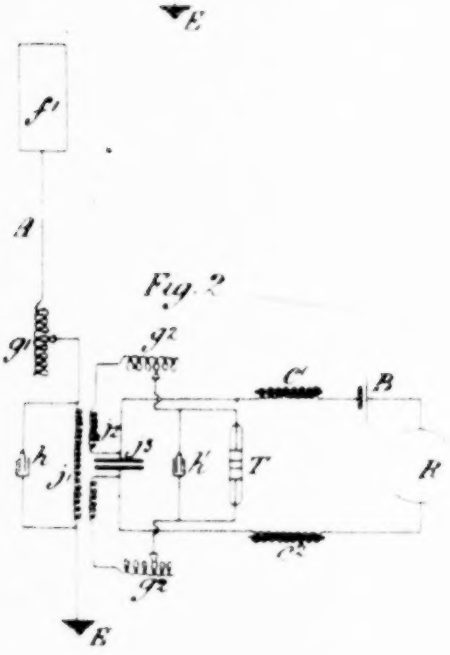


Fig. 2.

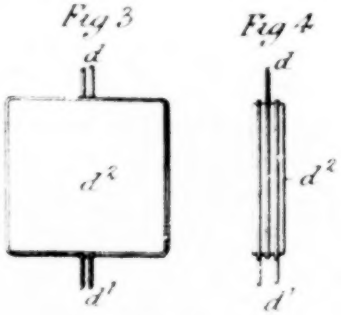


Fig. 3.

Fig. 4.

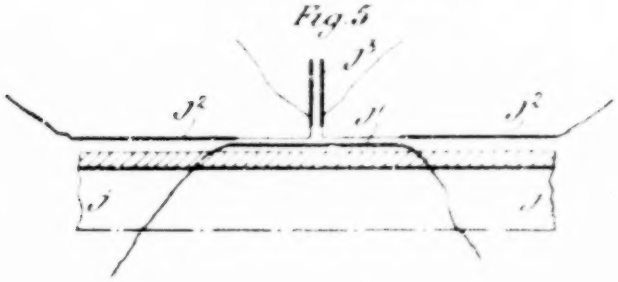


Fig. 5.

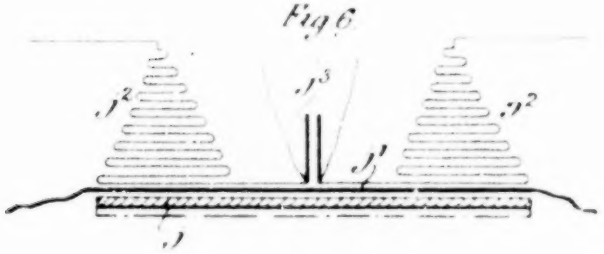


Fig. 6.

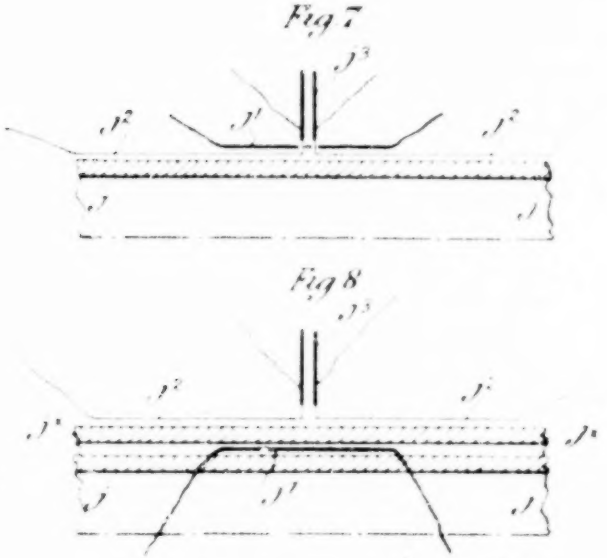


Fig. 7.

Fig. 8.

Witnesses.

Inventor.

GUGLIELMO MARCONI.

Bakewell & Hoffman & Watts

Witnesses
A. M. Perkins
E. A. Beach

Inventor
Guglielmo Marconi
By his Attorneys
Pierce Dodge & Wright

UNITED STATES PATENT OFFICE.

GUGLIELMO MARCONI, OF LONDON, ENGLAND, ASSIGNOR TO THE WIRELESS TELEGRAPH AND SIGNAL COMPANY, LIMITED, OF SAME PLACE.

APPARATUS EMPLOYED IN WIRELESS TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 627,650, dated June 27, 1899.

Application filed January 5, 1899. Serial No. 701,251. (No model.)

To all whom it may concern:

Be it known that I, GUGLIELMO MARCONI, electrician, a subject of the King of Italy, residing at 28 Mark Lane, in the city of London, England, have invented certain new and useful Improvements in Apparatus Employed in Wireless Telegraphy, of which the following is a specification.

In the specification of a former patent granted to me, No. 586,193, I described a receiver in which the ends of an imperfect contact in a local circuit were connected one to earth and the other to an insulated conductor.

According to this invention the conductor is no longer insulated, but is connected to a capacity, which may be the earth, through the primary of an induction-coil, while the ends of the imperfect contact are connected to the ends of the secondary one of the connections, being through a condenser.

The induction-coil preferably consists of a few turns of insulated wire. Over or under this first winding, which constitutes the primary, is wound a secondary winding, which constitutes the secondary.

In order to obtain the best effects, it is essential that the induction-coil should be of very thin wire. It is desirable that the primary and secondary windings of the coil should be close to each other and that the windings of each should be in a single layer. It is desirable that the induction-coil should be in tune or syntony with the electrical oscillation transmitted, the most appropriate number of turns and most appropriate thickness of wire varying with the length of wave of the oscillation transmitted.

The capacity of the condenser on the connection between the imperfect contact and the secondary of the coil should be varied (in order to obtain best effects) if the length of wave is varied.

It is desirable that the conductor connected should offer a large surface, and therefore the use of such materials as broad wire-netting in lieu of wire is desirable. It is also desirable to employ thick conductors or netting or its equivalents at the transmitting end. The introduction of the coil in the conductor not only improves the signals, but also prevents to a great extent any interference due to atmospheric influences, as any atmospheric electricity collected by the aerial conductor escapes to earth through the primary of the coil, thus preventing a charge from accumulating and discharging itself through the imperfect contact. Any stray interference can be further minimized by substituting a suitable capacity for the earth.

I have used a condenser of about one-fourth microfarad capacity for the above purpose.

Figure 1 is a diagram of the arrangement I prefer. Fig. 2 shows a modification. Fig. 3 shows the induction-coil.

In Fig. 1, A is a long conductor suspended in the air by insulators, and E is a connection to earth or other suitable capacity. B is a local battery, and R is a relay working a signaling or other instrument. p is the primary of the induction-coil or transformer, which is inserted between A and E. k is a condenser placed across the sensitive imperfect contact and the secondary winding of the induction-coil or transformer. c c^2 are choking-coils, their object being to prevent the oscillations generated in the winding p^2 from running into the battery connections at b and d, which would weaken the effect of the oscillations on the sensitive imperfect contact T.

Fig. 2 shows a somewhat similar arrangement, which, however, does not give such good results as Fig. 1. In this case the condenser k is omitted.

I have obtained good results by employing an induction-coil or transformer constructed as follows: The primary p of the said induction-coil or transformer is wound on a glass tube f about .635 centimeter in diameter. The said primary winding consists of two parallel windings of two hundred turns each of copper wire .012 centimeter in diameter insulated by a single covering of silk. The resistance of these two windings in parallel is about 3.1 ohms. The secondary winding p^2 of the induction-coil or transformer consists of about eight hundred turns of a similar but thinner wire .005 centimeter in di-

ameter wound over or under the primary winding. The resistance of the secondary winding is about one hundred and forty ohms.

The condenser K, which I preferably use, is composed of six tin-foil or copper plates connected to each terminal, each plate being five centimeters by three centimeters, the plates being insulated by paraffined paper .017 centimeter thick.

When using the above-described induction-coil or transformer, I employ as insulated conductor at each station a conductor formed of seven strands of about one-millimeter-diameter copper wire one hundred and forty feet long, the top of the conductor being one hundred and twenty feet from the ground. In some cases I use in lieu of the above-described conductor a galvanized-iron netting about two feet broad and one hundred and thirty feet long, the top of the netting being about one hundred and ten feet above the ground. In the latter case I obtain good results when using an induction-coil or transformer constituted as follows: secondary winding of three hundred and seventy-five turns of copper wire .005 centimeter in diameter insulated with one covering of silk, and wound on a glass tube .777 centimeter in diameter. Over this is wound the primary winding of one hundred and seventy-five turns of a similar wire .012 centimeter in diameter. The resistance of the primary winding is about 7.1 ohms and that of the secondary about 79 ohms.

What I claim is—

1. In a receiver for electrical oscillations, the combination of an imperfect electrical contact, a local circuit through it, an induction-coil, a capacity, a conductor connected to one end of the primary of the coil, a connection between the other end and the capacity, connections between the ends of the imperfect contact and the ends of the secondary of the coil and a condenser in one of the latter connections.

2. In a receiver for electrical oscillations, the combination of an imperfect electrical contact, a local circuit through it, a local battery and relay included in the local circuit, choking-coils respectively included in said circuit between the terminals of the imperfect electrical contact and the battery and relay, an induction-coil, a capacity, a conductor connected to one end of the primary of the coil, a connection between the other end and the capacity, connections between the ends of the imperfect contact and the ends of the secondary of the coil, and a condenser in one of the latter connections.

3. In a receiver for electrical oscillations, the combination of an imperfect electrical contact, a local circuit through it, an induction-coil, the primary and secondary of which consist of a single layer only, a capacity, a conductor connected to one end of the primary of the coil, a connection between the other end and the capacity and connections between the ends of the imperfect contact and the ends of the secondary of the coil.

4. In a receiver for electrical oscillations, the combination of an imperfect electrical contact, a local circuit through it, an induction-coil, the primary and secondary of which consist of a single layer only, a capacity, a conductor connected to one end of the primary of the coil, a connection between the other end and the capacity and connections between the ends of the imperfect contact, the ends of the secondary of the coil and a condenser in one of the latter connections.

5. In a receiver for electrical oscillations, the combination of an imperfect electrical contact, a local circuit through it, an induction-coil, the primary and secondary of which consist of a single layer only, and in which the primary consists of a number of parallel wires connected at their ends, a capacity, a conductor connected to one end of the primary of the coil, a connection between the other end and the capacity and connections between the ends of the imperfect contact and the ends of the secondary of the coil.

6. In a receiver for electrical oscillations, the combination of an imperfect electrical contact, a local circuit through it, an induction-coil, the primary and secondary of which consist of a single layer only, and in which the primary consists of a number of parallel wires connected at their ends, a capacity, a conductor connected to one end of the primary of the coil, a connection between the other end and the capacity and connections between the ends of the imperfect contact, the ends of the secondary of the coil and a condenser in one of the latter connections.

7. In a receiver for electrical oscillations, the combination of an imperfect electrical contact, a local circuit through it, an induction-coil, the primary and secondary of which are both of wire not exceeding one-fiftieth of a centimeter in diameter, a capacity, a conductor connected to one end of the primary of the coil, a connection between the other end and the capacity and connections between the ends of the imperfect contact and the ends of the secondary of the coil.

8. In a receiver for electrical oscillations, the combination of an imperfect electrical contact, a local circuit through it, an induction-coil, the primary and secondary of which are both of wire not exceeding one-fiftieth of a centimeter in diameter, a capacity, a conductor connected to one end of the primary of the coil, a connection between the other end and the capacity and connections between the ends of the imperfect contact, the ends of the secondary of the coil and a condenser in one of the latter connections.

GUGLIELMO MARCONI.

Witnesses:
ROBERT B. RANSFORD,
JOHN H. WHITEHEAD.

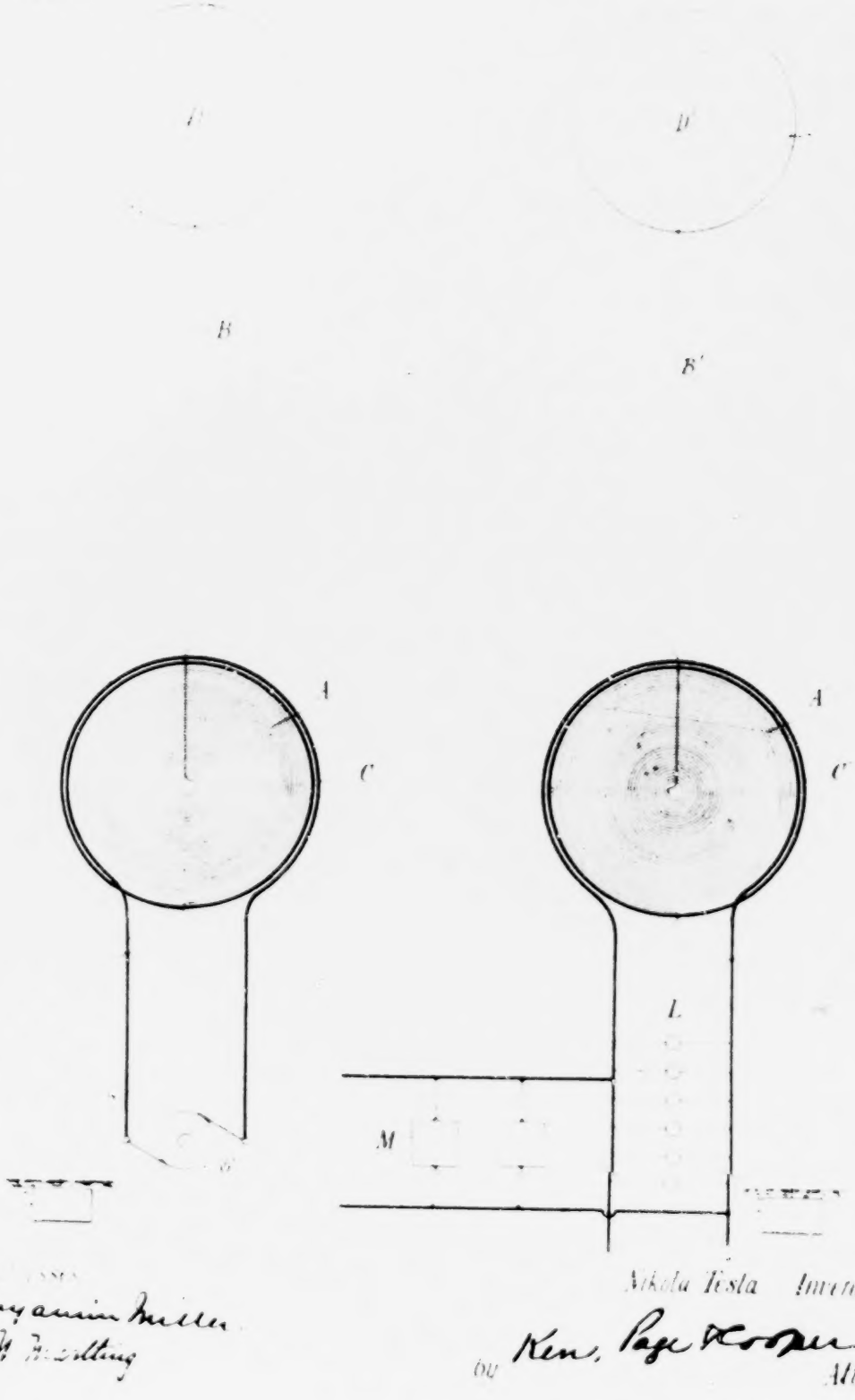
No. 649,621. Patented May 15, 1900.

N. TESLA.

APPARATUS FOR TRANSMISSION OF ELECTRICAL ENERGY

Application filed Feb. 16, 1900.

No Model.



Witnesses:
Benjamin Miller
G. W. Breckenridge

Nikola Tesla Inventor
by Kerr, Page & Cooper
Attys

UNITED STATES PATENT OFFICE.

NIKOLA TESLA, OF NEW YORK, N. Y.

APPARATUS FOR TRANSMISSION OF ELECTRICAL ENERGY.

SPECIFICATION forming part of Letters Patent No. 649,621, dated May 15, 1900.

Original application filed September 2, 1897, Serial No. 650,343. Divided and this application filed February 19, 1900. Serial No. 5,780. (No model.)

To all whom it may concern:

Be it known that I, NIKOLA TESLA, a citizen of the United States, residing at the borough of Manhattan, in the city of New York, county and State of New York, have invented certain new and useful Improvements in Apparatus for the Transmission of Electrical Energy, of which the following is a specification, reference being had to the drawing accompanying and forming a part of the same.

This application is a division of an application filed by me on September 2, 1897, Serial No. 650,343, entitled "Systems of transmissions of electrical energy," and is based upon new and useful features and combinations of apparatus shown and described in said application for carrying out the method therein disclosed and claimed.

The invention which forms the subject of my present application comprises a transmitting coil or conductor in which electrical currents or oscillations are produced and which is arranged to cause such currents or oscillations to be propagated by conduction through the natural medium from one point to another remote therefrom and a receiving coil or conductor at such distant point adapted to be excited by the oscillations or currents propagated from the transmitter.

This apparatus is shown in the accompanying drawing, which is a diagrammatic illustration of the same.

A is a coil, generally of many turns and of a very large diameter, wound in spiral form either about a magnetic core or not, as may be desired. C is a second coil formed by a conductor of much larger size and smaller length wound around and in proximity to the coil A.

The apparatus at one point is used as a transmitter, the coil A in this case constituting a high-tension secondary, and the coil C the primary, of much lower tension, of a transformer. In the circuit of the primary C is included a suitable source of current G. One terminal of the secondary A is at the center of the spiral coil, and from this terminal the current is led by a conductor B to a terminal D, preferably of large surface, formed or maintained by such means as a balloon at an elevation suitable for the purposes of transmission. The other terminal of the secondary A is connected to earth, and, if desired, to the primary also, in order that the latter may be at substantially the same potential as the adjacent portions of the secondary, thus insuring safety. At the receiving-station a transformer of similar construction is employed; but in this case the longer coil A' constitutes the primary, and the shorter coil C' the secondary, of the transformer. In the circuit of the latter are connected lamps L, motors M, or other devices for utilizing the current. The elevated terminal D' connects with the center of the coil A', and the other terminal of said coil is connected to earth and preferably, also, to the coil C' for the reasons above stated.

The length of the thin wire coil in each transformer should be approximately one-quarter of the wave length of the electric disturbance in the circuit, this estimate being based on the velocity of propagation of the disturbance through the coil itself and the circuit with which it is designed to be used. By way of illustration, if the rate at which the current traverses the circuit including the coil be one hundred and eighty-five thousand miles per second then a frequency of nine hundred and twenty-five per second would maintain nine hundred and twenty-five stationary waves in a circuit one hundred and eighty-five thousand miles long and each wave would be two hundred miles in length.

For such a low frequency, which would be resorted to only when it is indispensable for the operation of motors of the ordinary kind under the conditions above assumed, I would use a secondary of fifty miles in length. By such an adjustment or proportioning of the length of wire in the secondary coil or coils the points of highest potential are made to coincide with the elevated terminals D D', and it should be understood that whatever length be given to the wires this requirement should be complied with in order to obtain the best results.

It will be readily understood that when the above-prescribed relations exist the best conditions for resonance between the transmit-

ting and receiving circuits are attained, and owing to the fact that the points of highest potential in the coils or conductors A A' are coincident with the elevated terminals the maximum flow of current will take place in the two coils, and this, further, necessarily implies that the capacity and inductance in each of the circuits have such values as to secure the most perfect condition of synchronism with the impressed oscillations.

When the source of current G is in operation and produces rapidly pulsating or oscillating currents in the circuit of coil C, corresponding induced currents of very much higher potential are generated in the secondary coil A, and since the potential in the same gradually increases with the number of turns toward the center and the difference of potential between the adjacent turns is comparatively small a very high potential impracticable with ordinary coils may be successively obtained.

As the main object for which the apparatus is designed is to produce a current of excessively-high potential, this object is facilitated by using a primary current of very considerable frequency; but the frequency of the currents is in a large measure arbitrary, for if the potential be sufficiently high and the terminals of the coils be maintained at the proper elevation where the atmosphere is rarefied the stratum of air will serve as a conducting medium for the current produced and the latter will be transmitted through the air, with, it may be, even less resistance than through an ordinary conductor.

As to the elevation of the terminals D D', it is obvious that this is a matter which will be determined by a number of things, as by the amount and quality of the work to be performed, by the condition of the atmosphere, and also by the character of the surrounding country. Thus if there be high mountains in the vicinity the terminals should be at a greater height, and generally they should always be at an altitude much greater than that of the highest objects near them. Since by the means described practically any potential that is desired may be produced, the currents through the air strata may be very small, thus reducing the loss in the air.

The apparatus at the receiving-station responds to the currents propagated from the transmitter in a manner which will be well understood from the foregoing description. The primary circuit of the receiver—that is, the thin wire coil A'—is excited by the currents propagated by conduction through the intervening natural medium from the transmitter, and these currents induce in the secondary coil C' other currents which are utilized for operating the devices included in the circuit thereof.

Obviously the receiving-coils, transformers, or other apparatus may be movable—as, for instance, when they are carried by a vessel floating in the air or by a ship at sea. In the former case the connection of one terminal of the receiving apparatus to the ground might not be permanent, but might be intermittently or inductively established without departing from the spirit of my invention.

It is to be noted that the phenomenon here involved in the transmission of electrical energy is one of true conduction and is not to be confounded with the phenomena of electrical radiation which have heretofore been observed and which from the very nature and mode of propagation would render practically impossible the transmission of any appreciable amount of energy to such distances as are of practical importance.

What I now claim as my invention is—

1. The combination with a transmitting coil or conductor connected to ground and to an elevated terminal respectively, and means for producing therein electrical currents or oscillations, of a receiving coil or conductor similarly connected to ground and to an elevated terminal, at a distance from the transmitting-coil and adapted to be excited by currents caused to be propagated from the same by conduction through the intervening natural medium, a secondary conductor in inductive relation to the receiving-conductor and devices for utilizing the current in the circuit of said secondary conductor, as set forth.

2. The combination with a transmitting coil or conductor having its ends connected to ground and to an elevated terminal respectively, a primary coil in inductive relation thereto and a source of electrical oscillations in said primary circuit, of a receiving conductor or coil having its ends connected to ground and to an elevated terminal respectively and adapted to be excited by currents caused to be propagated from the transmitter through the natural medium and a secondary circuit in inductive relation to the receiving-circuit and receiving devices connected therewith, as set forth.

3. The combination with a transmitting instrument comprising a transformer having its secondary connected to ground and to an elevated terminal respectively, and means for impressing electrical oscillations upon its primary, of a receiving instrument comprising a transformer having its primary similarly connected to ground and to an elevated terminal, and a translating device connected with its secondary, the capacity and inductance of the two transformers having such values as to secure synchronism with the impressed oscillations, as set forth.

4. The combination with a transmitting instrument comprising an electrical transformer having its secondary connected to ground and to an elevated terminal respectively, and means for impressing electrical oscillations upon its primary, of a receiving instrument comprising a transformer having its primary similarly connected to ground and to an elevated terminal, and a translat-

ing device connected with its secondary, the capacity and inductance of the secondary of the transmitting and primary of the receiving instruments having such values as to secure synchronism with the impressed oscillations, as set forth.

5. The combination with a transmitting coil or conductor connected to ground and an elevated terminal respectively, and means for producing electrical currents or oscillations in the same, of a receiving coil or conductor similarly connected to ground and to an elevated terminal and synchronized with the transmitting coil or conductor, as set forth.

6. The combination with a transmitting instrument comprising an electrical transformer, having its secondary connected to ground and to an elevated terminal respectively, of a receiving instrument comprising a transformer, having its primary similarly connected to ground and to an elevated terminal, the receiving-coil being synchronized with that of the transmitter, as set forth.

7. The combination with a transmitting coil or conductor connected to ground and to an elevated terminal respectively, and means for producing electrical currents or oscillations in the same, of a receiving coil or conductor similarly connected to ground and to an elevated terminal, the said coil or coils having a length equal to one-quarter of the wave length of the disturbance propagated, as set forth.

8. The combination with a transmitting coil or conductor connected to ground and to an elevated terminal respectively, and adapted to cause the propagation of currents or oscillations by conduction through the natural medium, of a receiving-circuit similarly connected to ground and to an elevated terminal, and of a capacity and inductance such that its period of vibration is the same as that of the transmitter, as set forth.

9. The transmitting or receiving circuit herein described, connected to ground and an elevated terminal respectively, and arranged in such manner that the elevated terminal is charged to the maximum potential developed in the circuit, as set forth.

10. The combination with a transmitting coil or conductor connected to ground and to an elevated terminal respectively of a receiving-circuit having a period of vibration corresponding to that of the transmitting-circuit and similarly connected to ground and to an elevated terminal and so arranged that the elevated terminal is charged to the highest potential developed in the circuit, as set forth.

NIKOLA TESLA.

Witnesses:
PARKER W. PAGE,
MARCELLUS BAILEY.

DEFENDANT'S EXHIBIT M-6 4093

No. 797,169. PATENTED AUG. 15, 1905.

F. BRAUN.

SPACE TELEGRAPHY.

APPLICATION FILED FEB. 6, 1899.

Fig. 1

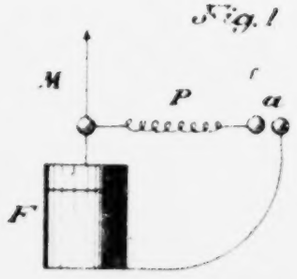
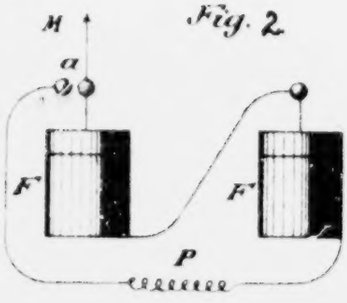


Fig. 2



Witnesses
O. F. Taber
G. W. Breck

Inventor
Ferdinand Braun
By Philip Kelp. Sawyer
Attys

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UNITED STATES PATENT OFFICE.

FERDINAND BRAUN, OF STRASSBURG, GERMANY.

SPACE TELEGRAPHY.

No. 797,169. Specification of Letters Patent Patented Aug. 15, 1905

Application filed February 6, 1899. Serial No. 704,805.

To all whom it may concern.

Be it known that I, FERDINAND BRAUN, a subject of the German Emperor, and a resident of Strassburg, Alsace, German Empire, have invented a new and useful Improvement in Space Telegraphy, of which the following is a specification.

My invention relates to the transmission of electric signals without connecting-wires and comprises the improvements hereinafter described.

Electrical vibrations, although similar in their physical nature, may be classified for practical purposes into three groups. The first group includes vibrations which are created by the relative mechanical movements of magnets, coils, wires and so on. These are exemplified in the well-known ordinary alternating currents, as used for electric light and transmission of power. Their frequency will obviously be limited by the physical conditions of machinery.

A second group of electrical vibrations consists of oscillations which are produced by the discharge of Leyden jars, or condensers, with or without inductance-coils in circuit. The frequency of these oscillations, which is considerably higher than the frequency of the former group, can be calculated by well-known relations between capacity and inductance.

A third group of vibrations or oscillations is that first studied experimentally by the late Dr. Hertz, and in the production of these the capacity and inductance are not obtained by means of specially-provided Leyden jars, or condensers, and inductance-coils, but the capacity and inductance of ordinary conductors are used.

Hitherto the attention of inventors, occupied with the transmission of signals without the use of connecting-wires, by means of Hertzian or electromagnetic ether waves, has been principally confined to the use of such waves produced by the oscillations of the last-mentioned group, and one object has been to increase the frequency of these waves as much as possible. This is exemplified by the use of the Righi transmitter. For the transmission of such short waves it is essential, however, that the transmitting and receiving stations should be, so to speak, visible to each other; as stated by Hertz in one of his earlier papers concerning the transmission of electromagnetic ether waves and by subsequent experiments, it has been shown, that various material objects, such as sails, smoke, trees, buildings and the like, interposed between the two stations, weaken or in some cases entirely prevent communication between them. My invention is intended to obviate this inconvenience and I do this by making use of electrical oscillations belonging to the second group above mentioned which have only a small frequency compared with the frequency of the oscillations of the third group. By this means, owing to the greater length of the waves produced, these latter are able to pass through conductors if these are but of moderate thickness. Furthermore, obstacles in the path of waves will not project such sharply-defined shadows, the waves passing around them in a manner similar to that which sound-waves pass round obstacles. Another advantage in using slower vibrations or oscillations is that their potential and amplitude, and thereby the energy transmitted, are more easily increased. When the higher-frequency waves are used, produced by the oscillations of the third group above mentioned, there is a certain length of spark which must not be exceeded if the circuit is required to excite vibrations or oscillations; otherwise the vibrations or oscillations would be damped too much; but this means that the effective potential is limited, which, if oscillations of the second group are used either does not occur, or can be very easily avoided.

I have found by experiments that the oscillations produced by the discharge of Leyden jars of usual size in a circuit having moderate inductance, are very convenient for the purpose of transmitting signals.

In carrying out my invention, I make use of the well-known upwardly-projecting transmitting-wire, and receiving-wire connected to the coherer in the receiving-station. It is well understood in the art that the function of the former wire, which projects upwardly and to a considerable height, is to spread out or radiate the electromagnetic ether waves through the air, and of the latter wire to collect these waves and to conduct them to the coherer.

As the object of my invention is to use the waves created by the oscillations produced by the discharge of Leyden jars or other condensers, it is essential for my invention that the transmitting-wire be so related to the oscillation-circuit containing the Leyden jars that oscillations will be created in the transmitting-wire by the oscillations in said circuit. For this purpose the transmitting-wire

3701

is in accordance with the present invention connected conductively to the oscillation-circuit, as illustrated diagrammatically in the drawings.

A form of appanatus in which the transmitting-wire is not conductively connected to the oscillation-circuit but is inductively connected thereto is described and claimed in my application Serial No. 157,728, filed May 18, 1903, as a division of this application.

An oscillation-circuit comprising a Leyden jar or condenser and spark-gap, with or without an inductance-coil, is, and for a long time has been, well known to be a persistently-oscillating circuit, or a circuit in which its electrical equilibrium having once been disturbed, vibrations or oscillations continue for a considerable length of time. In other words, this circuit is a source of maintained or sustained electrical oscillations. This circuit I have likened to a "reservoir of energy," a portion of which is radiated from the transmitting-wire for every oscillation until there is no more energy left and the circuit ceases to vibrate.

In order that my invention may be clearly understood, I have shown in the accompanying drawings by way of example, some arrangements of circuits for transmitting signals by means of the electric oscillations above described.

Figure 1 illustrates diagrammatically a transmitting apparatus constructed in accordance with the invention. Fig. 2 shows a modified arrangement of the same.

In Fig. 1 a Leyden jar indicated at F has its inner and outer coatings connected through the spark-gap *a*, a coil P of small self induction or inductance being included in the oscillation-circuit which increases the normal inductance of such circuit. The inner coating is connected to the transmitting-wire M. It is well understood that the transmitting-wire may be of any suitable size. The jar is charged in the usual manner by means of an influence-machine, inductorium or other suitable means.

In place of one jar, two or more can be used connected in parallel or series. Fig. 2 for example shows two jars arranged in series, or as commonly called in "cascade."

The invention is not limited to the precise arrangements of circuits shown in the drawings, as these can be varied very considerably, and electric oscillations of low frequency suitable for transmitting signals according to my invention can be produced in various other ways.

Leyden jars have been used heretofore in connection with wireless telegraphy, but never before have the oscillation-circuits been conductively connected to the transmitting-wires so that the oscillations in said circuits create oscillations in the transmitting-wires which latter create and cause to radiate therefrom electromagnetic ether waves.

What I claim is—

1. In a transmitter for wireless telegraphy, the combination with an oscillation-circuit containing a condenser, of a transmitting-wire connected conductively with said circuit, substantially as and for the purpose stated.

2. In a transmitter for wireless telegraphy, the combination with an oscillation-circuit containing a condenser and a spark-gap, of a transmitting-wire connected conductively with said circuit, substantially as and for the purpose stated.

3. In a transmitter for wireless telegraphy, the combination with an oscillation-circuit containing a condenser and an inductance means for increasing the normal inductance of said circuit, of a transmitting-wire connected conductively with said circuit, substantially as and for the purpose stated.

4. In a transmitter for wireless telegraphy, the combination with an oscillation-circuit containing a condenser and a spark-gap and an inductance means for increasing the normal inductance of said circuit, of a transmitting-wire connected conductively with said circuit, substantially as and for the purpose stated.

5. In a transmitter for wireless telegraphy, a transmitting-wire provided with a spark-gap, a condenser connected across the spark-gap, and a source of electrical energy connected to the terminals of the spark-gap.

6. In a transmitter for wireless telegraphy, a transmitting-wire provided with a spark-gap, a condenser connected across the spark-gap, and a source of periodically-varying electromotive force connected to the terminals of the spark-gap.

7. In a transmitter for wireless telegraphy, a transmitting-wire provided with a spark-gap, a plurality of condensers connected across the spark-gap, and a source of periodically-varying electromotive force connected to the terminals of the spark-gap.

8. In a transmitter for wireless telegraphy, a transmitting-wire connected conductively with a closed oscillation-circuit.

9. In a transmitter for wireless telegraphy, a transmitting-wire connected conductively with a persistently-oscillating circuit.

10. In a system of wireless telegraphy, a transmitting-wire connected conductively with a source of persistent electrical oscillations.

11. In a system of wireless telegraphy, means for radiating electromagnetic waves of low frequency, comprising a transmitting-wire conductively connected with a source of persistent low-frequency electric oscillations.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

FERDINAND BRAUN.

Witnesses:
FRITZ NIESS,
MAX ADLER.

DEFENDANT'S EXHIBIT N-6

No. 797,544. PATENTED AUG. 15, 1905.

F. BRAUN.

SPACE TELEGRAPHY.

APPLICATION FILED MAY 18, 1903.

Fig. 1.

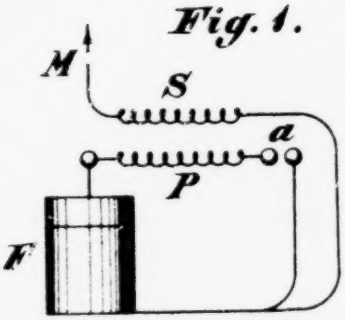
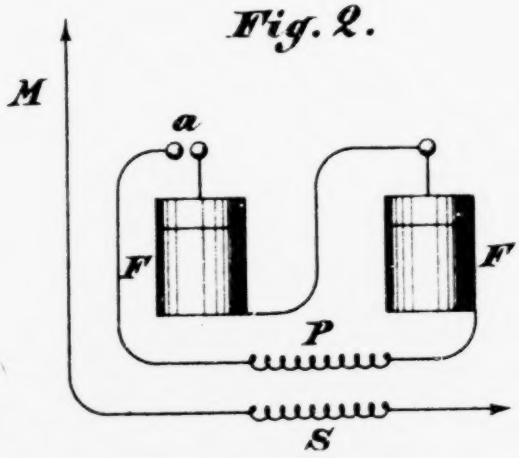


Fig. 2.



Witnesses:
G. M. Copeland
Finis D. Moorman

Inventor
Ferdinand Braun
by Philip Lawrence Roberts
Atty.

3702a

UNITED STATES PATENT OFFICE.

FERDINAND BRAUN, OF STRASSBURG, GERMANY.

SPACE TELEGRAPHY.

No. 797,544. Specification of Letters Patent. Patented Aug. 15, 1905.

Original application filed February 6, 1899. Serial No. 704,605. Divided and this application filed May 18, 1903. Serial No. 157,728.

To all whom it may concern:

Be it known that I, FERDINAND BRAUN, a subject of the German Emperor, and a resident of Strassburg, Alsace, German Empire, have invented a new and useful Improvement in Space Telegraphy, of which the following is a specification.

My invention relates to the transmission of electric signals without connecting-wires and comprises the improvements hereinafter described.

The invention is a part of that for which an application, Serial No. 704,605, was filed by me February 6, 1899. In said application the advantage is shown which is arrived at by using Hertzian or electromagnetic ether-waves of lower frequency than the Hertzian and Righi waves mainly used before, and said application shows and describes the use of oscillations produced by the discharge of a Leyden jar or condenser with or without an inductance-coil in the oscillation-circuit, and a transmitting-wire conductively connected to the oscillation-circuit so that oscillations in said circuit create oscillations in the transmitting-wire, which latter create and cause to radiate therefrom electromagnetic ether-waves. This divisional application relates to apparatus in which the transmitting-wire is inductively connected with the oscillation-circuit.

An oscillation-circuit comprising a Leyden jar or condenser and spark-gap, with or without an inductance-coil, is, and for a long time has been, well known to be a persistently-oscillating circuit, or a circuit in which, its electrical equilibrium having once been disturbed, vibrations or oscillations continue for a considerable length of time. In other words, this circuit is a source of maintained or sustained electrical oscillations. This circuit I have likened to a "reservoir of energy," a portion of which is radiated from the transmitting-wire for every oscillation until there is no more energy left and the circuit ceases to vibrate.

The invention is illustrated by the accompanying drawings by way of example.

Figure 1 shows diagrammatically a transmitting apparatus according to the present invention. Fig. 2 illustrates a modification thereof.

In Fig. 1, F is a Leyden jar preferably of the usual size. An oscillation-circuit is provided containing said Leyden jar F, an air-gap *a* and the primary P of a suitable transformer, which primary coil will also act as an inductance-coil. One end of the secondary S of this transformer is connected to any point of the oscillation-circuit, as for example between the air-gap and the outer coating of the Leyden jar, and the other end to the upwardly-extending transmitting-wire M. By dimensioning properly the Leyden jars, the transformers, the coils &c. the most favorable results will be obtained.

In Fig. 2 an oscillation-circuit is provided containing two Leyden jars connected in series for reducing the capacity, and a primary coil P of a transformer, which also acts as an inductance-coil. One end of the secondary coil of the transformer S is connected with the transmitting-wire M, and the other end is shown prolonged and ending in an arrow to indicate that it may be prolonged by adding a suitable length of insulated wire or connected to some other suitable capacity area.

The use of the electric connection by means of a transformer between the oscillation-circuit and the transmitting-wire enables the potential to be obtained which is most fit for the production of electromagnetic waves. Experience has shown that transformed oscillations are very useful. Experience has shown also that the action of oscillating energy can be essentially increased by the invention, so that it is possible to overcome longer distances than it has been before.

The invention is not limited to the precise arrangements of circuits shown in the drawings, as these can be varied considerably. Therefore I do not limit myself to the particular arrangements shown, but

What I claim is—

1. In a transmitter for wireless telegraphy, the combination with an oscillation-circuit containing a condenser and the primary of a transformer, of a transmitting-wire connected with the secondary of the transformer, the other end of said secondary being connected to one plate of said condenser.

2. In a transmitter for wireless telegraphy, the combination with an oscillation-circuit

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containing a condenser and the primary of a transformer, of a transmitting-wire connected with the secondary of the transformer, the other end of said secondary being connected to a capacity area other than earth and having no direct connection with earth.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

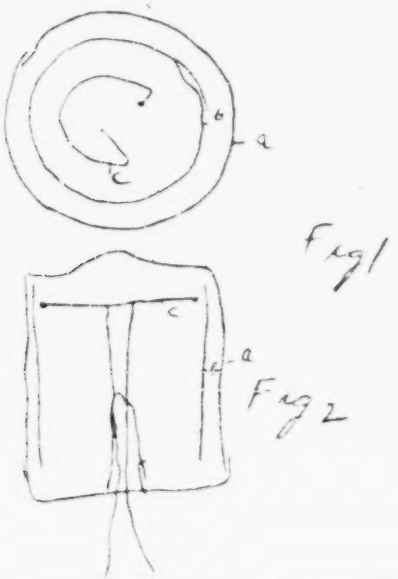
FERDINAND BRAUN.

Witnesses:
JONATHAN TEFFNECK,
STEVEN BRANDER.

3703

DEFENDANT'S EXHIBIT Q 6

Sketch made by Weagant at R. 1542



DEFENDANT'S EXHIBIT S-6

another instance of what was well known, the enormous use that medical skill and science was in promoting sympathetic relations between Europeans and Orientals. A medical man could set aside politics and religion, and establish himself in communication with the people of the country in a way which no one else could. It was a remarkable fact that they should be that evening in the centre of London, listening with interest to an account of a wild country in the centre of Asia. Could there be a stronger instance of the immense width of the English dominion and English interests? We had very strong interests in Afghanistan; it was not exactly within our frontiers; but its frontiers we had undertaken to protect, the line having been laid down by agreement between the two great European powers, which were both making for themselves empires in Asia—England and Russia. It was for that reason that those who sat at home, safe behind their sea-washed barriers, were responsible for the maintenance of the frontier, and the welfare of people at such a distance. There was no doubt the Amir was one of the most powerful and successful monarchs, perhaps, in Asia, and his was one of those curious kingdoms which had been left standing, notwithstanding the agglomerations of the great empires of Russia, China, Persia, and India. The people of Afghanistan were an agglomeration of tribes, but beyond that they were an assemblage of free men who, like ourselves, considered liberty one of the noblest gifts. They had always fought gallantly against the foreigner, and were determined, if possible, to have their country for themselves. We could all sympathise with people of that sort, and for that reason he cordially echoed the wish the Chairman had expressed that we should use every exertion to preserve the liberties of the Afghan people, and maintain its independence and integrity.

Colonel E. T. THACKERAY, R.E., C.B., V.C., said, one interesting feature of Afghanistan was the system of subterranean canals, or underground channels, which were made for connecting together the shafts sunk wherever water was expected to be found. Some of these canals were carried to a length of about 20 miles. These canals were supposed to have been originated by King Hushung, who was also supposed to have built the seven great cities of Afghanistan, besides Kabul. Earthquakes were extremely common in that country.

A vote of thanks to Mr. Gray for his interesting paper was carried unanimously, and briefly acknowledged.

FOREIGN & COLONIAL SECTION.

Tuesday, February 20, 1894; Sir ALBERT KAYE ROLLIT, LL.D., M.P., Vice-President of the Society, in the chair.

The paper read was "The Arts and Industries of Belgium, and the Antwerp Exhibition, 1894," by Edouard Séve.

The paper and discussion will be printed in the next number of the *Journal*.

TWELFTH ORDINARY MEETING.

Wednesday, Feb. 21, 1894; Sir RICHARD WEBSTER, Q.C., M.P., Chairman of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Kent, Walter G., 199, High Holborn, W.C.
Niven, David Coats, Oriental Gas Company, Calcutta.
Walker, Ernest Octavius, C.I.E., Brook-hill-house, Teignmouth, Devon.
Walton, Joseph, Zetland-buildings, Middlesbrough.
Williamson, S. H., Mayor of Worcester

The following candidate was balloted for and duly elected a member of the Society:—

Bruff, Charles Clarke, Coalport, Shropshire.

The paper read was—

ELECTRIC SIGNALLING WITHOUT WIRES.

BY W. H. PREECE, C.B., F.R.S.

What is electricity? Few venture to reply boldly to this question, first, because they do not know; secondly, because they do not agree with their neighbours, even if they think they know; thirdly, because their neighbours do not agree among themselves, even as to what to apply the term. The physicist applies it to one thing, the engineer to another. The former regards his electricity as a form of ether, the latter as a form of energy. I cannot grasp the concept of the physicist, but electricity as a form of energy is to me a concrete fact. The electricity of the engineer is something that is generated and supplied, transformed and utilised, economised and wasted, meted out and paid for. It produces motion of matter, heat, light, chemical decomposition, and sound; while these effects are reversible, sound, chemical decomposition, light, heat, and motion reproduce those effects which are called electricity.

Faraday's immortal researches, Clerk-Maxwell's prophetic investigations, and Hertz's convincing experiments, have definitely and conclusively proved the existence of one medium throughout all space, called the

JUN 6 1933

ether, through which waves of energy, called radiations, are propagated with the same velocity, but in different forms and with different frequencies, although all of the same character. At one end of the scale we have actinic disturbances producing photographic impressions; at the other end of the scale electric waves producing electromagnetic disturbances while the intermediate radiations give light and heat. Actinic waves are extremely minute and number many millions per second, electric waves are very long and may number only hundreds per second. Like light waves, they are propagated in straight lines, they obey the laws of reflection, they are refracted, they are subject to interference, and they may be even polarised.

We have to consider electric waves to-night, and I want to show you how we are gradually, by patient plodding, creeping along towards the period when I hope we shall be able to make real practical use of such electromagnetic disturbances.

If we take a conductor through which a rapidly alternating current is being supported by any means, it throws the ether which surrounds it into oscillations. Energy is thus radiated away in electric waves. These electric waves spread out in all directions, as do waves of light, and if they fall on similar conductors properly placed and sympathetically prepared, these waves of energy are transformed back again into alternating currents which give evidence of their presence. Their presence is indicated by a telephone if the frequency of the alternating currents is brought within the range of the ear. Hertz and his followers experimented with waves of much shorter length, and with sparks in air, but all my experiments have been made with telephones and with waves comparable in frequency with those of sound.

The prime source of energy has been either a steam-engine or a galvanic battery. This has produced, by suitable machinery, rapidly intermittent or alternating currents, which have been transmitted through a primary circuit. At some distance away from this circuit there has been a secondary telephone circuit, and between these two circuits the only connecting medium has been the ether, which has been thrown into electric oscillation, and it has been across this space that I have been signalling without wires. In all cases, the primary currents were of such a frequency as to produce a musical note in the telephones fixed in the secondary circuit, which could easily be read, if sent in the dots and dashes of the Morse code.

Signalling through space is very fascinating. I have now for ten years been steadily investigating the subject. In 1884, messages sent through insulated wires, buried in iron pipes in the streets of London, were read upon telephone circuits erected on poles 80 feet away on the housetops. It was imagined this must have been due to accidental connections, or to earths, or to any other cause but the true one, namely, electromagnetic induction, or the influence which one conductor conveying currents exercises on another parallel to it, when separated by a dielectric, or by mere space, that is, by the ether.

It is very difficult to convert the human mind from one mode of thought to another. We have been so trained to regard currents of electricity as something flowing in one complete unbroken circuit, that their temporary condition as waves of energy in space is difficult to realise. One irresistibly endeavours to trace them to earth conduction, to leakage, to contact, or to some more well-known cause. Ten years of unremitting experiment have, however, proved the effects I am bringing before you to be due, primarily, to radiation, and not to conduction.

In 1885, a very exhaustive series of experiments was made for me by Mr. A. W. Heaviside, in the neighbourhood of Newcastle, to find out how far the distance between the wires affected the results. Ordinary telegraph working currents produced disturbances at a distance of 2,000 feet, while effects on parallel lines of telegraph, 10½ miles apart, between Durham and Darlington, were perceptible. Distinct speech was carried on through a distance of one quarter of a mile. We even obtained indications of current between the east and west coasts, 40 miles apart, but these observations were vitiated by conduction through the large network of telegraph wires between those two places. I brought the subject before the British Association at their meeting in Birmingham in 1886. The district between Gloucester and Bristol, along the banks of the River Severn, was then selected, where for a length of 14 miles, and at an average distance apart of 4·5 miles, no intermediate disturbing conductors existed. I was able to experiment with complete metallic circuits, the return wires passing far inland, in the one case through Monmouth, and, in the other, through Stroud. Weak disturbances were detected. These experiments

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were repeated, with more experience and greater success, in 1889. Similar experiments were conducted along the valley of the Mersey. A new trunk line of copper wires that was being erected between London and the coast of North Wales was then experimented upon, and some interesting results were obtained in the district between Shrewsbury and Much Wenlock, and between Worcester and Bewdley.

An admirable series of experiments were made for me in the same year, by Mr. Gavey near Porthcawl, in South Wales. There we have a wide expanse of sand well covered by the tide and giving the opportunity to observe the effects in water as well as in air. Squares of insulated wire, 1,200 yards long, were laid side by side at various distances apart, and smaller squares were suspended above each other on scaffold poles. The effects were observable equally in air and water. The results were absolutely conclusive that we were working with the so-called electro-magnetic induction, and all subsequent experience has confirmed this conclusion.

These further experiments were brought before the British Association at Manchester in 1887.

Thus the theory of the thing had been thoroughly threshed out, and it only waited for some convenient opportunity to give it a practical test.

When the Royal Commission to inquire into electric communication between the shore and lighthouses and light vessels was appointed in June, 1892, the question was started. Here was the opportunity. My proposal to test this means of communication in a practical way was submitted by the Postmaster-General to the Treasury. The expenditure was sanctioned, and the experiment made. The results were submitted by me to the Electric Congress which was held in Chicago in August in 1893.

The Bristol Channel proved a very convenient locality to test the practicability of communicating across a distance of three and five miles. Two islands, the Flat Holm and the Steep Holm, lie off Penarth and Lavernock Point, near Cardiff, the former having a lighthouse upon it. On the shore two copper wires weighing 400 lbs. per mile, forming one conductor, were suspended on poles for a distance of 1,267 yards, the circuit being completed by the earth. Experience justified the assumption that the earth acts as a conductor, and that it practically replaces the fourth side of the rectangle used in the previous experiments. We have not yet determined the actual position of the resultant line of this earth side, but further experiments are being made. On the sands at low water mark, 600 yard from this primary circuit and parallel to it, two ordinary gutta-percha covered copper wires and one bare copper wire were laid down, their ends being buried deep in the ground by means of bars driven in the sand.

One of the gutta-percha wires was lashed to an iron wire to represent a cable. These wires were periodically covered by the tide which rises here at springs to 33 feet. On the Flat Holm, 3·1 miles away, another gutta-percha covered copper wire was laid for a length of 600 yards.

There was also a small steam launch having on board several lengths of gutta-percha covered wire. One end of such a cable, half a mile long, was attached to a small buoy, which acted as a kind of float to the end, keeping the wire suspended upon or near the surface of the water while the launch slowly steamed ahead against the tide. It was paid out and picked up in several positions between the primary circuit and the islands.

The apparatus used on shore was a 2 horse-power portable Marshall's steam-engine, working a Pike and Harris's alternator, sending 192 complete alternations per second at a voltage of 150, and of any desirable strength up to a maximum of 15 ampères. These alternating currents were broken up into Morse signals by a suitable key and sent along the primary circuit. The signals received on the secondary circuit produced sound and were read on a pair of telephones—the same instruments being used for all the experiments.

The object of the experiments was not only to test the practicability of signalling between the shore and the lighthouse, but to differentiate the effects due to earth conduction from those due to electromagnetic induction, and to determine the effects in water.

It was possible to trace, without any difficulty, the region where the signals ceased to be perceptible from currents, due to earth conduction, and where they commenced to be solely due to electric waves. This was found by allowing the paid-out cable, suspended near the surface of the water, to sink. Near the shore, no difference was perceptible, whether the cable was near the surface or lying on the bottom, but a point was reached where all sounds ceased as the cable sank, but were recovered again when the cable came to the surface.

The total absence of sound in the submerged cable rather surprised me, and it leads to the conclusion, either that the waves of energy are dissipated in the sea water, or else that they are reflected away from the surface of the water like rays of light. I believe implicitly in the latter explanation. Subsequently, experiments on the sands in the Conway Estuary showing the relative transparency of air and water to these electric waves, tend to support the latter deduction, for if waste of energy took place in the water, the difference would be more marked than was actually found to be the case. It was 6 per cent. only. As it is, we have ample evidence that the electric waves are transmitted to considerable distances through water, though how far remains to be found out.

There was no difficulty in communicating between the shore and Flat Holm. Messages were read. Mr. Gavey, who was making the experiment on the island, wrote me, "There was then a somewhat lengthened pause, due to a slight derangement of the machinery on the mainland, but at 2 p.m. I heard clearly and distinctly the following, 'Here Haskayne' (one of his assistants) 'with a message from Mr. Preece for Mr. Gavey.'" I was in London that day. "Then followed the announcement of the sad and sudden death of Mr. Graves, which cast a gloom over the success of the experiment. It seemed an extraordinary fact, that the first readable message transmitted for such a distance by such means should announce the death of the head of the Technical Department."

The distance between the two places was 3½ miles. The attempt to speak between Lavernock and Steep Holm was not so successful. The distance was 5¾ miles, but though signals were perceptible, conversation was impossible. There was distinct evidence of sound, but it was impossible to differentiate the sounds into Morse signals. We were just on the limit of audibility, and we were using our available maximum power. If either line had been longer, or the primary currents stronger, we should have spoken as was done at Flat Holm.

As the laws governing these effects were by no means so clear and conclusive as such probing and enquiring deserved, Mr. Gavey and Mr. Kempe conducted for me a very careful series of experiments near Frodsham, on the estuary of the Dee, which was found to be a more convenient locality than Conway, and the very satisfactory results obtained will shortly be published. The [illegible] so clear that, given the [illegible] which it is desired to communicate, [illegible] mere matter of calculation to show what [illegible] to be done. It would be quite easy to [illegible] between France and England, or [illegible] Straits of Dover.

There happens to be a very convenient [illegible] accessible loch in the highlands—Loch Ness [illegible] —forming part of the route of the Caledonian Canal between Inverness and Hanoaver—having a line of telegraph on each side of it. Five points on each side of this loch were taken and so arranged that any fractional length of telegraph wire on either side could be taken for trial. Ordinary, and not special apparatus was employed, sending messages, as before, by Morse signals, and speaking by telephone across a space of one and a quarter miles was found practical, and in fact, easy. Indeed, the sounds were so loud, that they were found sufficient to form a call for attention.

The following apparatus was in use on each side of the loch for the transmission of Morse signals.—A set of batteries consisting of [illegible] dry cells, giving a maximum voltage of [illegible] rapidly revolving rheotome which broke [illegible] current into a musical note; a Morse key by which these musical notes could be transformed into Morse signals; resistance coils and ampères meters to vary the primary current; two bell telephones joined in multiple arc to act as receivers. For the transmission of actual speech simple granular carbon microphones, known as the Dieckert's, were used as transmitters, and a current of 2 ampères was maintained through these and two Bell telephones in circuit with the line wire.

Any lingering fear that earth conduction had principally to do with these results was removed by making the earth's terminals on the primary circuit at one end at Inverness nine miles away, and at the other end in two directions in a parallel glen about six miles away. The early experiments of 1897, in the valley of the Severn, had placed this question of earth interference beyond the region of doubt, but earth conduction, as a main factor in the results, is still believed in by critics. The function performed by the earth has been thoroughly developed in the Frodsham experiments, and will be discussed subsequently.

One very interesting fact observed at Loch Ness was that there was one particular frequency in the primary circuit that gave a decided maximum effect upon the telephones in the secondary circuit. This proves the pre-

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sence of resonance, and is, of itself, a fact sufficient alone to prove the effects as being due to the transformation of electric waves into electric currents.

It is well known that every telephone has one particular note—the natural note of the disc—to which it responds better than to any other, but this resonant effect far exceeded in magnitude any difference due to the natural pitch of the disc. It was not the natural note.

Conversation by telephone, though possible, was not however practical. Still, it is something to have transmitted speech by electricity across an air space of 1½ miles. We had this curious condition, that at some intermediate point the energy of the human voice was found side by side in two different forms—sonorous vibrations in the air, and electric waves in the ether.

There is now no difficulty in communicating with outlying islands if the conditions are favourable. The Northern Commissioners of Lights are anxious to establish electrical communication with the Muckle Flugga Lighthouse, at the extreme north of the Shetland Islands, but the place is so inaccessible that, though the conditions are favourable and signalling without wires is possible and simple, it would be more prudent to adopt the more expensive plan of a submerged cable. I would rather inaugurate the system nearer home, where it could be watched, nursed, and improved. Anyhow, it is something to be able to report that we have now acquired a practical system of signalling across space without the necessity of using wires.

Although this short paper is confined to a description of a simple practical system of communicating across terrestial space, one cannot help speculating as to what may occur through planetary space. Strange, mysterious sounds are heard on all long telephone lines when the earth is used as a return, especially in the calm stillness of night. Earth currents are found in telegraph circuits, and the Aurora Borealis lights up our northern sky when the sun's photosphere is disturbed by spots. The sun's surface must, at such times, be violently disturbed by electrical storms, and if oscillations are set up and radiated through space, in sympathy with those required to affect telephones, it is not a wild dream to say that we may hear on this earth a thunderstorm in the sun.

If any of the planets be populated with beings like ourselves, having the gift of language and the knowledge to adapt the great forces of Nature to their wants, then if they could oscillate immense stores of electrical energy to and fro in telegraphic order, it would be possible for us to hold commune by telephone with the people of Mars.

DISCUSSION.

Mr. PREECE, in answer to a question, stated that the experiments described were performed during the severe weather of last week, and that the wind had no effect upon the results.

Mr. W. GRANVILLE said he was not yet converted to the belief that the effects described were produced by induction, or radiation through space, and not by conduction or leakage; but there was one test which would decide the question. An induced current was only capable of producing a temporary action, whereas a current set up by conduction remained permanent as long as the primary current acted. When, in 1842, Professor Morse bridged a river in America by a somewhat crude method, resembling that shown on the diagram, the apparatus then used was only capable of responding to currents of a certain duration, certainly not to those of such small duration as would be produced by induction. Somewhat later Mr. Preece succeeded in bridging the Solent by a similar method, and he took it the instruments then in vogue were such as would only respond practically to currents of somewhat long duration; and there, again, there was simply the effect of conduction. Some years ago, in conjunction with the late Mr. Willoughby Smith, he had the satisfaction of carrying out a series of experiments at Yarmouth, where they succeeded in communicating from the shore to a small boat about a quarter of a mile off by means of two earth plates carried out to sea, but remaining at a distance of a quarter mile from the boat. Those signals were clearly produced by conduction, for they placed a galvanometer in the circuit, and found that, just as long as the battery current remained on, was it deflected, so that the result could not possibly be produced by induction. There had also been experiments by the Telegraph Construction and Maintenance Company, with a view to communicating with lighthouses; and at Alum Bay they communicated with the Needles through a non-continuous cable, bridging a distance of some 60 yards. In that case, a vibrator and telephone was first tried, but afterwards they substituted for it an ordinary galvanometer; and there they ascertained that the effect was produced by a permanent current, and, therefore, by conduction. With regard to the distance one could signal by means of induction through air, it was found, as the result of a large number of experiments, that if they took two spirals similar to those on the table, the sound fell off very rapidly, as the distance increased, and that with a very strong battery current

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it was impossible to bridge a greater distance than about 100 yards. The same result was noticeable in the experiment shown that evening. He therefore must remain unconverted until Mr. Preece was able to inform them of the fact that he had placed a galvanometer in the circuit.

Mr. ALEXANDER SIEMENS said Mr. Preece had the great advantage over most of those present that he had conducted experiments on this most interesting subject, while they had not. He understood him to say that in one of his experiments he used two metallic circuits, so that there could be no doubt as to their being real induction, and not conduction currents which he was dealing with. There was one point to which particular attention should be called, viz., that in one case he had succeeded in calling up the other party. In some of the experiments the difficulty was that you had, by means of a boat, or in some other way, to fix the time at which the experiment was going to be made, in order that the man at the other side might be on the watch, but, in communicating with a lighthouse, it was very important to be able to call to your correspondent when you wanted him. If it was necessary, first, to send an ordinary telegram to say you were going to send a message, you might as well send it all at once. No doubt this method of signalling would be much further developed in the able hands in which it was, and a good deal might be expected from it in future.

Major-General FESTING, F.R.S., said he did not quite gather whether the result of the experiments in the Bristol Channel was to show that the two wires would respond to each other if they were both in the water. He understood that they would, if they were both in the air, or both in the water, but that if one were in the air and the other in the water, they would not.

Lieut.-Col. CUNNINGHAM, R.E., said Mr. Preece seemed to lay great stress on the fact that this inductive effect took place through the ether, and that it would probably take place equally in a vacuum. All the experiments were made across water, but he did not catch whether the wires were on both sides up in the air, or on one side in the air, and on the other in the water. He would also ask if there was any advantage in the long wires being parallel to each other, and further, what was the function of the cable paid out by the steam-launch.

Mr. CHARLES BRIGHT said it was a question at a recent meeting of the Society whether submarine cables or land lines were preferable, and the majority of speakers seemed in favour of land lines. He did not agree in that, but these experiments of Mr. Preece's seemed to point to another method of getting out of the difficulty in cases where a submarine cable was not sufficiently durable, as for instance for communication between lightships and the shore, owing to the continual chafing of the cable on the bottom and against the moorings. In conclusion, he would ask those studying this subject in future to change the title, and he did so in the interest of shareholders and cable contractors, who might think their occupation was gone. It was not really telegraphing without wires, because it appeared that considerable lengths of wire were necessary.

Mr. PREECE, in reply, said he was sorry Mr. Granville should have suggested that he was such a poor electrician as not to have tried the experiment he suggested. One of the first experiments he ever took part in was in the year 1853, when he assisted Mr. Lindsay in endeavouring to communicate across rivers by means of conduction currents. They made a tank to represent a river, and produced very capital results. He had often experimented in that direction, and, as Mr. Granville said, they succeeded in communicating across the Solent, through a broken cable from Hurst Castle, by means of those currents. He did not suppose anybody—unless it were Mr. Granville himself, or Mr. W. Smith—had devoted more attention to conduction currents through water or earth than he had. But there was as much difference between communicating by current through the air and by means of radiation as there was between having a room illuminated by electricity and taking hold of a red-hot poker. All his experiments had been verified by some such system as that adopted on Loch Ness, or by the use of metallic circuits, as was done in London, and also on the Severn and Conway lines. It was quite impossible to conceive that when you had two coils in the air, which were kept wide apart, that there could be any earth action of any sort. Mr. Granville drew attention to the fact that with the two coils he had shown, the sound diminished very rapidly as they were separated. That was so with coils, but if, instead of coils, the wires had been stretched out in straight lines, the distance through which you could communicate increased with the length of the wire; so that if Mr. Granville could communicate with coils 100 yards apart, the probability was that if the same wire had been stretched out straight the distance would have increased to a mile or more. Mr. Siemens had called attention to an important point. The one great difficulty in the earlier experiments was that there was no means of calling attention, but at Loch Ness the sound was so loud at 1¼ mile distance that it amounted to a call. The loudness was simply dependent on the materials and means used. With regard to the effects in air and in water on the South Wales coast, and also in the Conway estuary, the sounds were all reproduced in water as well as in air. When the conditions were the same, the effect would be the same. At Lavernock Point, the wires were on 20 feet

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poles on the top of a cliff about 70 feet above high-water mark; in this case the electric waves did not pass through the water, they struck the water at a very low angle, which was probably for those waves the angle of total reflection, and the absence of any effect when the cable was sunk, was to him a proof that the waves did not penetrate the water. Had the primary wires been under water there would have been an effect on the submerged cable. He had not experimented in a vacuum, but always either in air or water. How far the air or water took any part in the transmission he could not say, but he had no doubt that the effects would all be traced to the same agency as operated in the case of light and heat, viz., the oscillations of the ether. It was essential to the effect that the wires should be parallel. If the wire on the Flat Holm were perpendicular to the one on Lavernock point he did not think any effect would be produced. The whole theory had been worked out; it was rather complicated and difficult, but he hoped before long to be in a position to write another paper on it. The object of the cable from the launch was first of all to see how far the effects of the earth currents extended, and where the effect of radiation alone appeared. They found that close in shore it made no difference whether the wire was on the surface or submerged, but when they got to a certain distance the difference between the effect of flotation and submersion became evident, and at length submersion caused the effect to disappear entirely. They experimented in that way inland as well as at sea, and inland they were able to plot out the earth currents; they had been plotted, not only there, but for Liverpool, London, and several other places. The object of having the cable suspended was to endeavour to differentiate between the radiations which were evident on the surface, and the earth currents which must have been evident on the surface as well as at the bottom of water. He must admit that the title of the paper was somewhat misleading, but he hoped he had made amends in the concluding particulars in which he had referred to hearing a thunderstorm in the sun, and that he had established some claim to the 300,000 francs which were now lying somewhere in Paris, having been offered as a premium to the man who first showed how to communicate with the inhabitants of Mars.

The CHAIRMAN, in proposing a hearty vote of thanks to Mr. Preece, said the paper had been to him quite a revelation as to matters of which he had hardly ventured to dream as possible. He thought the objection to the title of the paper was rather hypercritical, because ordinary people always understood telegraphing by wire as meaning through the wires going from one station to the other, and these parallel wires not connected would rather be looked upon as the sending and receiving instruments. He hoped, therefore, that the same name would be adhered to in any further development of the subject. He was interested in Mr. Granville's observations, but he, at once, thought of the answer which Mr. Siemens gave as being probably the correct one, and that where there were two complete insulated metallic circuits, the effects could not be due to leakage. He could not help thinking, also, having regard to what was known about induced currents, that the fact that no appreciable current was apparent in the receiving wire when it was perpendicular to the sending wire, would seem to indicate that the effect was produced by radiation or induction. He hoped on some future occasion they would have the privilege of hearing from Mr. Preece of the further development of this subject; one branch of it at least deserved further investigation, and that was the suggestion that the electric waves were reflected from the surface of the water. It was obvious that that would account for the fact that there was no apparent transmission from air to water, or from water to air, while at the same time there was transmission when both wires were either in air or in water. Possibly, also, the theory that the medium of transmission was what was understood as ether, was capable of further investigation.

The vote of thanks was carried unanimously, and the meeting adjourned.

Correspondence.

MODERN DEVELOPMENT OF ILLUSTRATED JOURNALISM.

MR. JOHN LEIGHTON, F.S.A., writes:—Mr. Townsend seems to have ignored the early stages of process, where the artist became his own engraver, and laid his own lines before photography and chemistry engraved them for him. I well remember that it was early in the forties that one of the Fourdriniers—a son of the inventor of the paper-making machine—had a method that he called gypsograph, it was a drawing with a point made through a surface of plaster down to a plate, and into which lines a stereotype cast entered, producing a relief block, that when bold was effective. Then there was the *Procédé Comte* by which many handsome works were done in Paris, and one has only to instance *L'Art pour tous* and the very large natural history subjects by Karl Bodmer, of Barbeson, that were first published in "*L'Illustration*" to see how the artist's touch was maintained, as in an etching. Then, again, there was "*La Vie Moderne*," an imitation of "*The Graphic*," only it was all process. A system that I employed in my "Suggestions in Designs," consisting of 1,100 designs, done in Paris by the Frères Comte and published about 1878, and printed on a tint, in a belief that it would defy photographic reproduction,

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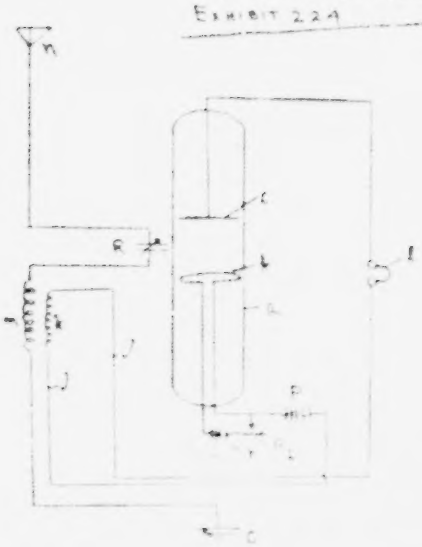
DEFENDANT'S EXHIBIT V 6

Sketch made by Lofting at R 2070

LOFTING DIAGRAM OF
REPARATION OF CLAIMANT'S
EXHIBIT 224



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DEFENDANT'S EXHIBIT W 6

Sketch made by Loftin at R. 2097

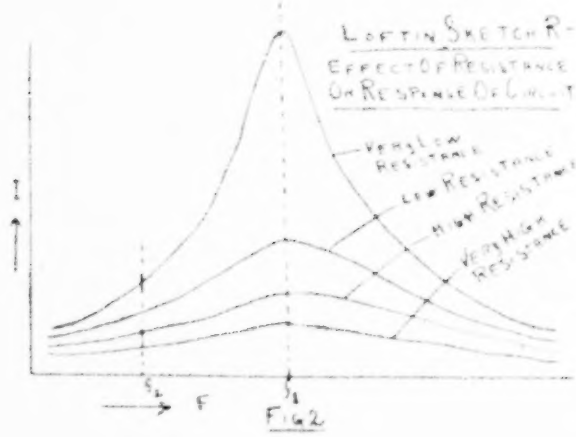


FIG 2

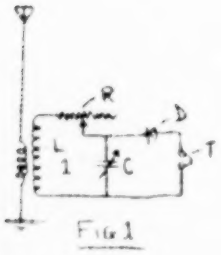


FIG 1

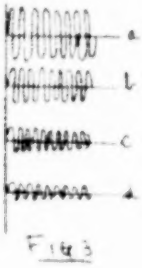


FIG 3

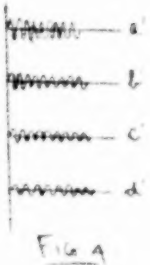
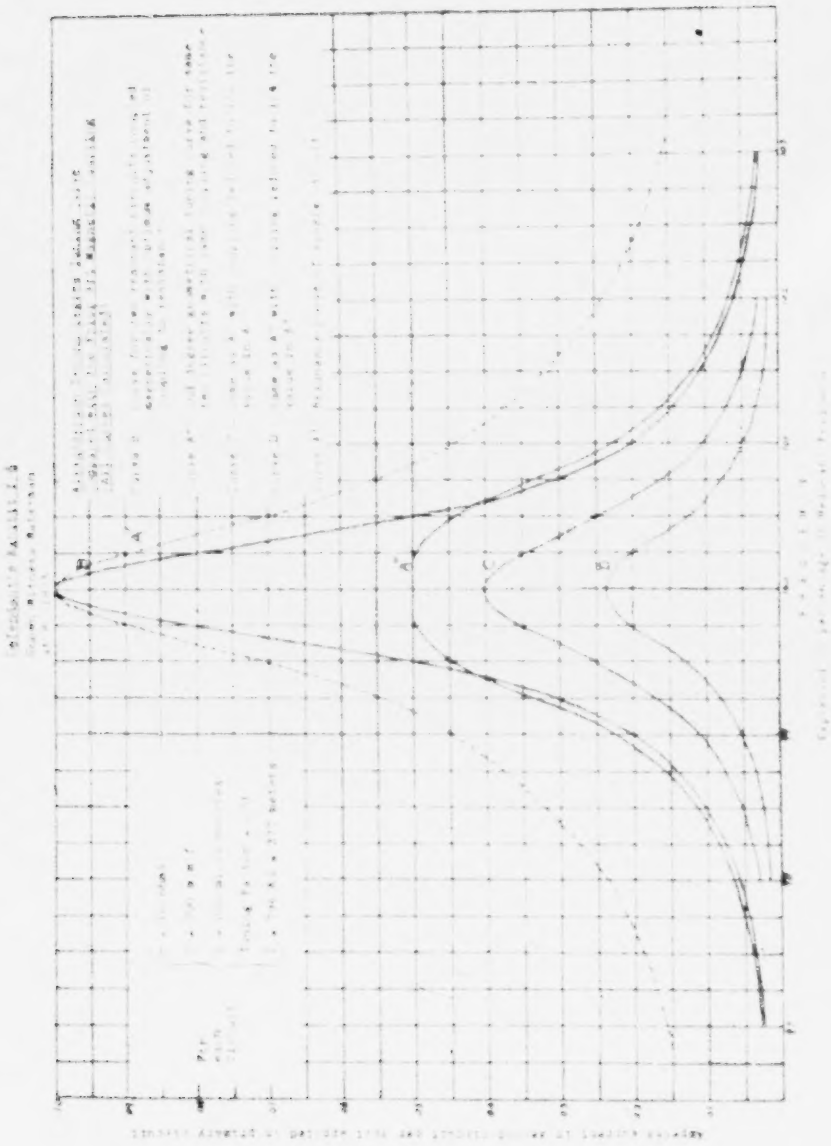


FIG 4

DEFENDANT'S EXHIBIT Y-6

Shown witness Waterman at R. 1973



DEFENDANT'S EXHIBIT Z-6

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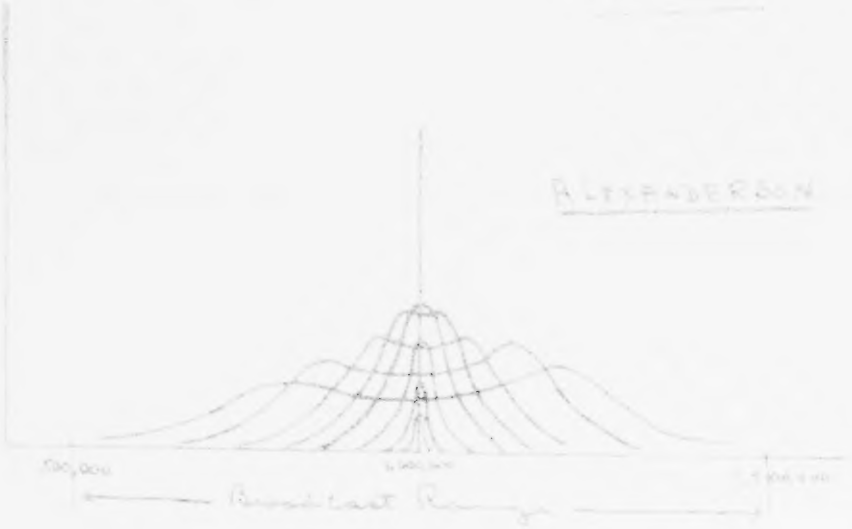
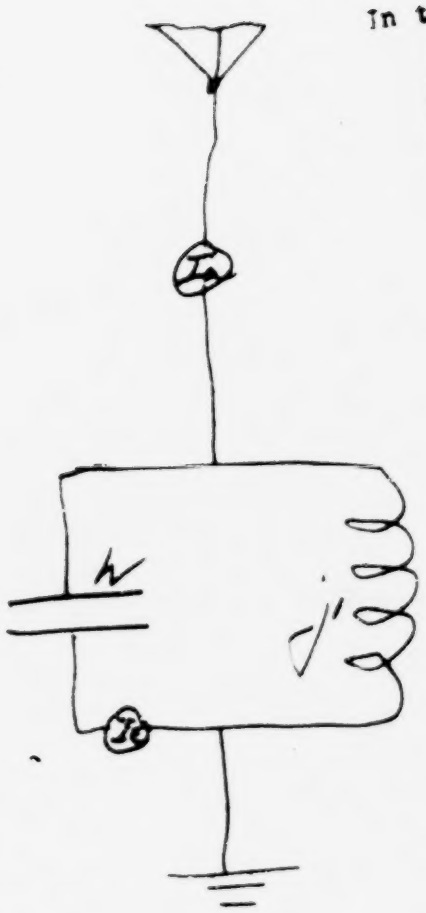
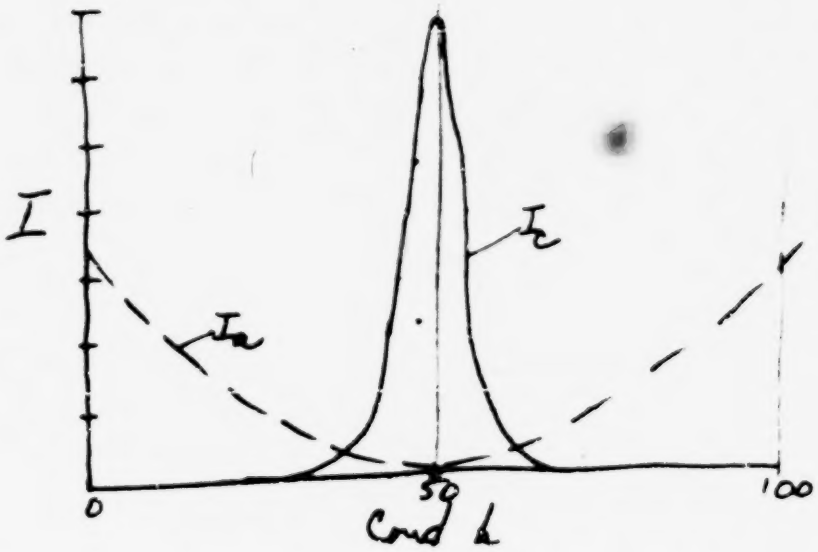
Dist. of N.J.
Identified



Defendant's Ex. JJ

Marconi v. U.S.
In the United States Court of Claims
No. 33,642
EXHIBIT
DEFENDANT'S SUPPORT NO. 1
DATE 6-1-39
ROBERT W. COOPER, C.S.R.
LAW REPORTER

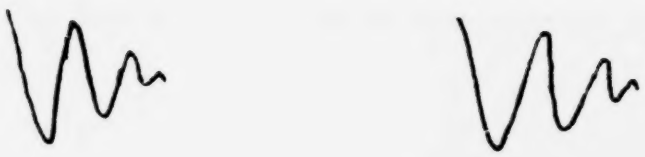




Defendant's Exhibit MM

EXHIBIT
NO. MM
DATE 6/30/36
Edward W. Cooper, C. S. R.
LAW REPORTER

Ant Charging Circuit



Ant Circuit

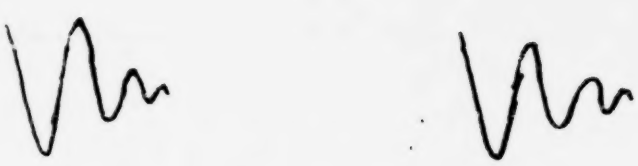
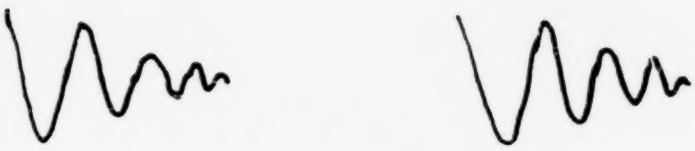


Fig 1 Fessenden.

Closed Circuit



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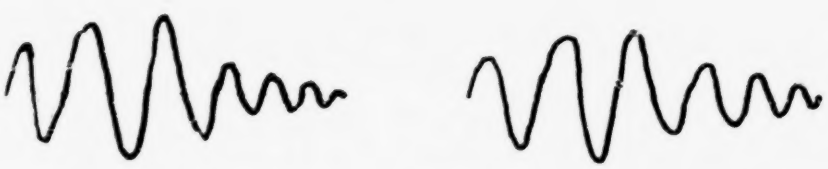
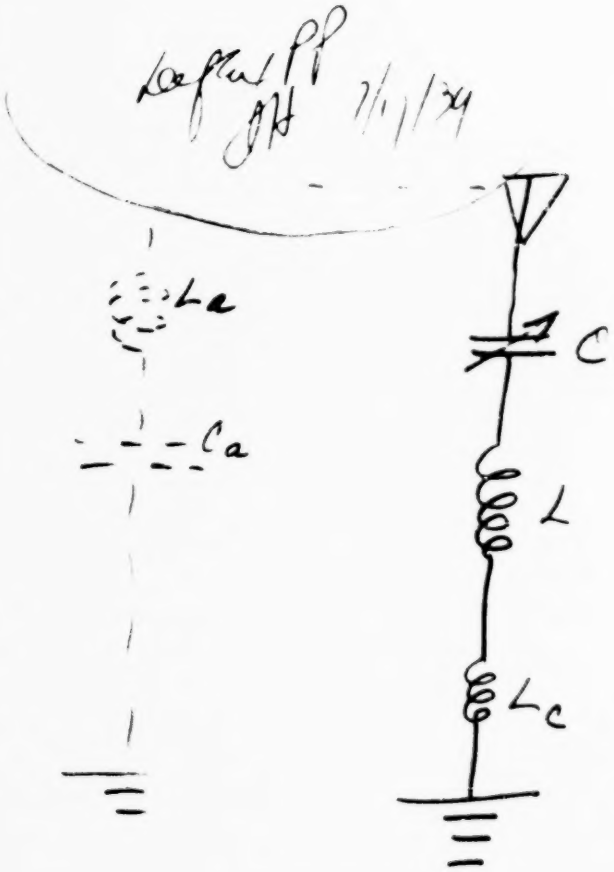


Fig 2 Marconi

Defendant's Exhibit PP



$$L_e = L + L_a + L_c$$

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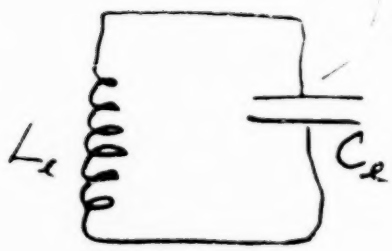
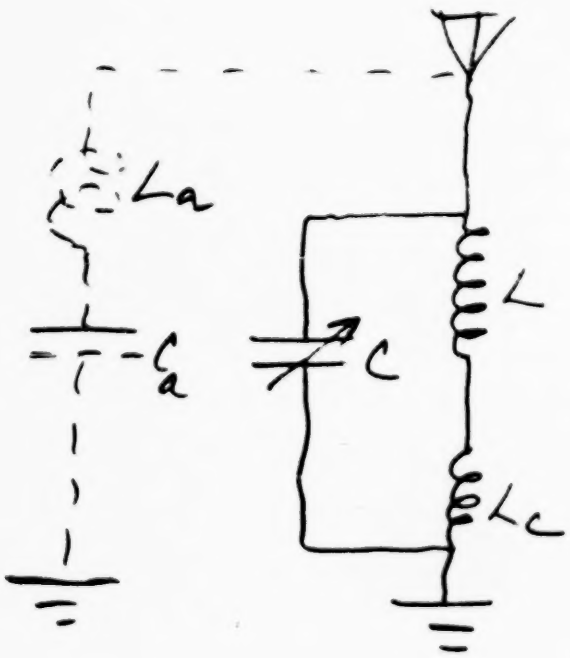
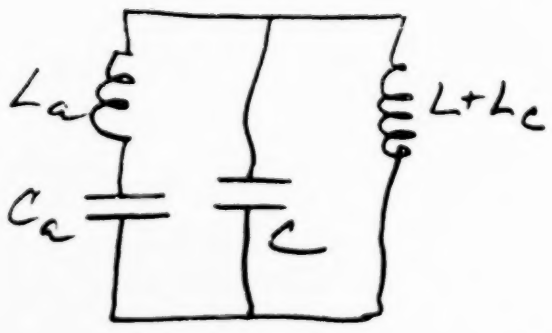


Equiv. Simple Circuit





Equiv. Simple Circuit

DEFENDANT'S EXHIBIT BBB

BBB

MARCONI ANTENNA CIRCUIT "TUNES"

MARCONI TRANSMITTER		MARCONI RECEIVER			
Tune No.	Approx. W/L meters:	Overall W/L	W/L ~~if h omitted~~ of series circuit $f'g'hE$ alone	Substantially constant, non-varied, second resonance wave-length of Marconi receiver (that of wheel circuit hj_1 with antenna and load coil as dead-end)	Resonance frequency of Wheel circuit hj_1 alone
1	205	205.7	----	----	----
2	302	302.1	----	----	----
3		142.3 (g'=0)	142.3	1628	1640
		166.4 (g'= 10)	166.4	1631	2640
	199	199.2 (g' = 21)	199.3	1634	1640
4	364	364.1 (g' = 100)	364.6	1641	1640
5	-	This tune is series only, h omitted as in tune 1			
6	-	This tune is series only, h omitted as in tune 1			

Marconi Wireless Telegraph Co. of America
Dept. [illegible]
DBB

Interf. 37353743 Deft's Ex. FFF

Sept. 2, 1924. 1,507,016

L. DE FOREST

RADIOSIGNALING SYSTEM

Filed Sept. 23, 1915 2 Sheets-Sheet 1

Fig 1

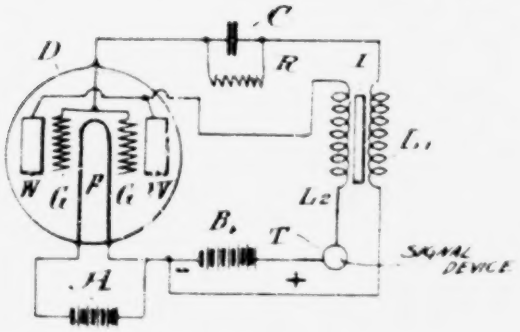
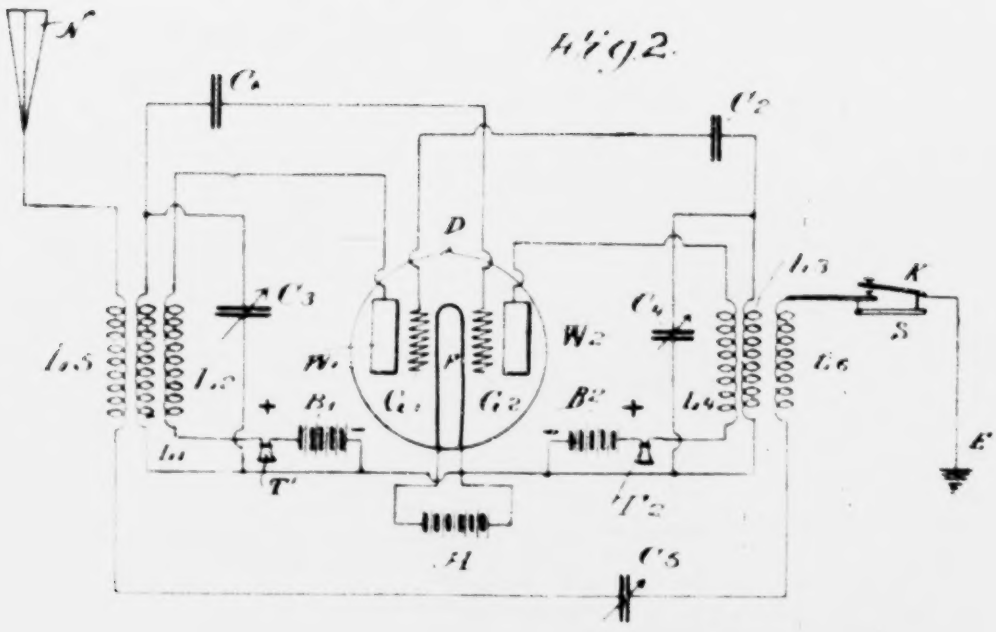


Fig 2



Inventor:
Lee de Forest
By his Attorney
Samuel E. Darby

Sept. 2, 1924. 1,507,016

L. DE FOREST

RADIOSIGNALING SYSTEM

Filed Sept. 23, 1915 2 Sheets-Sheet 2

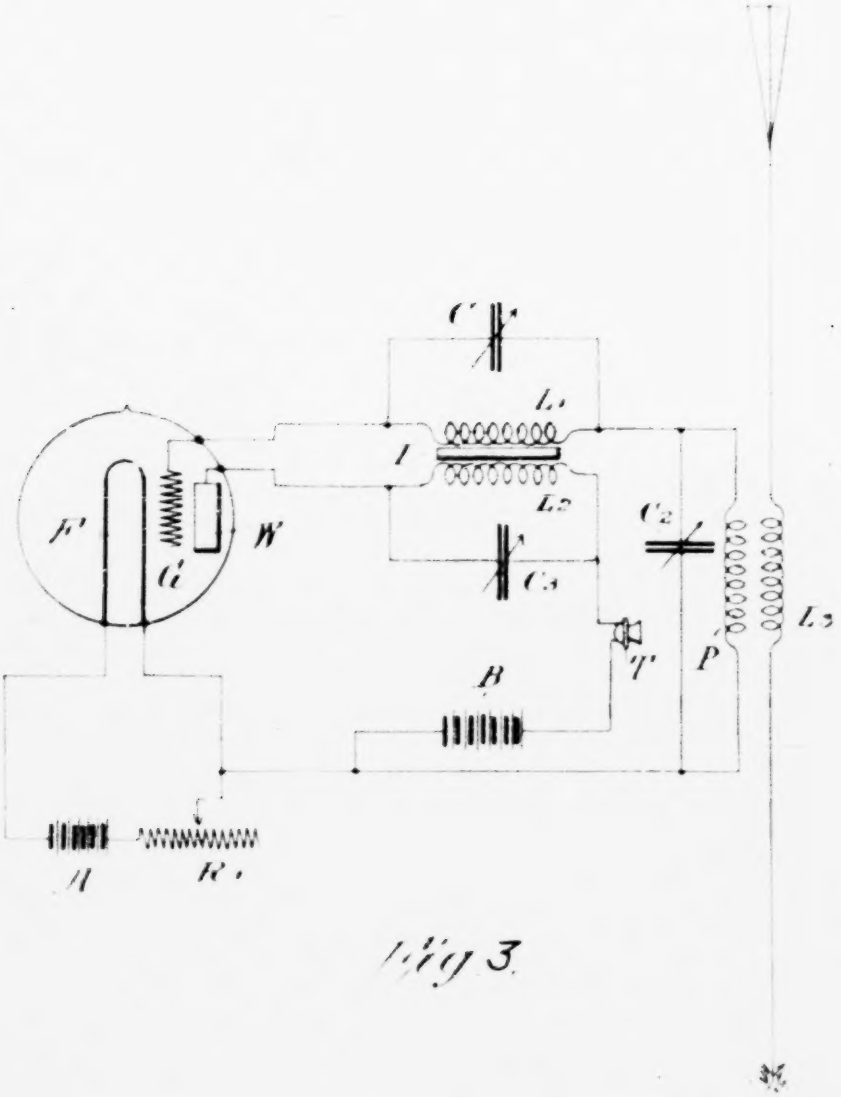


Fig 3.

Inventor:
Lee de Forest
By his Attorney
Samuel E. Darby

3737

Patented Sept. 2, 1924.

1,507,016

UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y., ASSIGNOR TO DE FOREST RADIO TELEPHONE AND TELEGRAPH COMPANY, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

RADIOSIGNALING SYSTEM.

Application filed September 23, 1915. Serial No. 52,176.

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, residing in the city of New York, county of Bronx and State of New York, have made a certain new and useful Invention in Radiosignaling Systems, of which the following is a specification.

This invention relates to radio signaling systems.

The object of the invention is to provide a radio signaling system which is simple and efficient in operation.

Further objects of the invention will appear more fully hereinafter.

The invention consists substantially in the construction, combination, location and relative circuit arrangements all as will be more fully hereinafter set forth, as shown in the accompanying drawing and finally pointed out in the appended claims.

Referring to the drawing, Figs. 1, 2, 3, all show various circuit arrangements embodying my invention.

In accordance with my present invention, I propose to employ an evacuated vessel with hot and cold electrodes therein, known as the audion, together with suitable circuit connections to cause the audion to operate as a generator of undamped oscillations, and to so arrange the circuit connections to cause the audion to operate as a generator of undamped oscillations, and to so arrange the circuit connections referred to so as to allow such a generator to also be employed as a detector. The underlying principle of my present invention as will be more fully described, is the association, preferably by inductive coupling means, of the circuits of the cold electrodes of the audion.

In Fig. 1 I have shown a simple circuit arrangement for accomplishing the objects of my invention wherein D is the exhausted vessel, F the hot or filament electrode, and A is the battery for heating the same in the usual and well known manner and controlled by the resistance R_1 as shown in Fig. 4, if desired. G designates the grid or "input" electrodes and W the wing or "output" electrodes. Preferably, and as shown, though I do not desire to be limited in this respect, the wing and grid electrodes are arranged in pairs, both grids and both wings being connected in parallel. The input electrodes G are connected to one side of the filament F by a circuit including therein one coil of a transformer L_1. The output electrodes W are likewise connected to the filament F by a circuit including the coil L_2 of the transformer, and the usual source of voltage such as battery B or other direct current source with its positive terminal connected to the cold electrodes W through the telephone or signal indicating device T, as shown.

In series with the grid or input electrodes G and in the circuit thereof I propose to place a stopping condenser C, and to shunt around this condenser a high and preferably non-inductive resistance R, of from 25,000 to 100,000 ohms.

The transformer whose coils are L_1 L_2 may be a "telephone transformer" as shown, with the coils having several thousands turns each surrounding an iron core I, in which case the system will oscillate at "audio" or low frequencies, or the windings may contain only a few hundreds of turns each, of several milli-henries inductance, and the coils more or less spatially separated or "loosely coupled" in which case the system will oscillate at high or "radio" frequencies.

In the first case, that is, when the system is oscillating in "audio" frequencies the system becomes a "siren" and will generate powerful telephonic currents having a clear musical note heard in the telephone receiver T. The pitch of this note can be varied by altering the inductance of either of the coils L_1 L_2 in any well known manner, or by altering their coupling as by withdrawing from the transformer the iron core I, or by varying the distributed capacity of the winding or the spatial relation of the windings, or the capacity of the condenser C, the value of the resistance R, or the potential of the battery B, or the brightness of the filament F in any manner well known in the art.

When such an oscillating system as shown in Fig. 1, is employed for generating radio frequencies, the capacity of the ordinary telephone wires leading to the telephone receiver or signaling device T is usually sufficient to form a by-path around the high impedance and high resistance of this device. The impedance of source B to the

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radio frequency oscillations, I have found to be insufficient to materially dampen the same. My invention as defined in the claims is not to be limited in this respect however, for other expedients will readily suggest themselves to those skilled in the art.

If the system described is to be employed as a generator of high frequency oscillations for transmission purposes the signal device T may be a trans-mitter if desired. An alternative arrangement is shown in Fig. 2 wherein a key indicated at K is inserted in the antenna earth system. As it is obvious that my invention applies to either transmitting or receiving systems, I wish it to be understood that by the term "signal device," as used throughout the specification, I mean broadly either a transmitter or a receiver of signals.

When an audion with its cold electrodes associated or inter-linked as shown, is used as a receiving system its ordinary sensitiveness as a detector is many times increased by virtue of the "kick back" or progressively amplifying effect of the received signal impulses.

In Fig. 2 I have illustrated a "compound audion" containing two insulated grid members G_1 and G_2, and two insulated wing members W_1 and W_2, each of the four electrodes being connected to the filament F by a circuit containing inductances L_1, L_3, L_2, and L_4, respectively. The coils L_1, L_2, may be inductively associated as shown, and likewise inductances L_3, L_4, may be inductively associated, so as to allow reaction of the one upon the other in each pair.

As shown, I prefer to associate the grid nearest one wing with the current of the wing lying furthest away, usually on the opposite side of the filament, as thereby I find that the reaction of the circuits upon each other is the most violent. Each wing W_1 W_2, has, preferably, its own source of electro motive force as indicated at B_1, B_2, respectively, although I am not to be limited in this respect as it is obvious that a common source may be employed. In the circuit of the sources B_1 and B_2, I employ telephone receivers T_1, T_2, preferably, one receiver for each ear of the operator. I employ the usual stopping condensers C_1 and C_2 in the circuits of the grids G_2 and G_1, respectively, and the variable capacities C_3 and C_4, shunted around the coils L_1, L_3, to render the grid circuits oscillatory. The coils L_1, L_2, and L_3, L_4 of the two oscillating circuits are associated inductively or otherwise to the same antenna-earth system comprising the usual elements N, L_5, C_5, L_6, and E, as shown, whether the arrangement be used for receiving or transmitting signals.

When using the arrangement shown in Fig. 2, as a generator of alternating currents the sources of the wing currents, B_1 and B_2, respectively, should be of high voltage, as for example, direct current generators of from 600 to 1200 volts.

In the antenna-earth system, I show a transmitting key K connected directly therein. I also employ a hand operated switch S shunted around the same to cut the key K out when the system is used as a receiving system. The periodicities of the oscillating circuits L_1, C_3 and L_3, C_4, should be made the same, or nearly the same by properly adjusting their respective capacities or inductances. If the natural rates of oscillation of these two circuits are not quite the same, beats or interferences are set up in the antenna, resulting in a harmonic variation of amplitudes of the radiated wave train which may be of practical value when signaling to receiving stations where the receiver can give audible responses only to interrupted or intermittent trains of waves.

It will be noted that in accordance with my invention, the connection of the terminals of the wing and grid coils is important. I have found that the oscillations set up are much more intense when one end of one of these coils is connected to the grid or plate as the case may be, than when the opposite end of that coil is thus connected. In other words, by reversing coil L_2 relative to coil L_1, the oscillations set up may be found to be much more intense than before such reversal of connections. The principle here involved is that the phase of the two pulsating currents in the coils L_1 and L_2, shall be so displaced relative to each other that a positive charge or surge upon the wing electrodes shall be next followed by a negative charge or surge upon the grid, the effect of this being that thereby an increase of current through the coil L_2 to the wing results in a succeeding increase in the resistance of the gas path between the wing and the filament electrodes, and conversely, a diminution in the current from the wing to the filament electrodes results in a succeeding decrease in the resistance of the path. It is by these means that one circuit is enabled to react upon the other so that successively increasing pulsations are set up in the two associated circuits until the losses by resistance, leakage and load, are equal to the increment of energy supplied from the battery or source B B_1, B_2 whereupon a stable condition of oscillation or pulsation is attained.

In Fig. 3 I have shown a modified arrangement wherein the wing and grid circuits are inductively associated as in Fig. 1, through coils L_1 and L_2 around which are shunted capacities C and C_3, respectively. In this arrangement I prefer to associate the grid circuit with the antenna earth circuit through inductance L_5 of the antenna

system. In this instance I shunt a capacity C_2 around the inductance P as shown. The core I is also used in coupling between the oscillating circuits of the cold electrodes, and the reaction effect is secured between these circuits as hereinbefore described.

It will be understood that many other circuit arrangements will readily occur to those skilled in the art without departing from the broad scope of my invention as defined in the claims. Therefore, having set forth the objects and nature of my invention, and having shown and described various embodiments thereof, what I claim as new and useful and of my own invention and desire to secure by Letters Patent, is,—

1. In a radio signaling system, an evacuated vessel including hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, separate circuits connecting each of the cold electrodes to the hot electrode, said circuits being inductively associated.

2. In a radio signaling system, an evacuated vessel containing hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, separate oscillating circuits connecting each of said cold electrodes to said hot electrode, said circuits being inductively associated.

3. In a radio signaling system, an evacuated vessel including hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, separate circuits connecting each of the cold electrodes to the hot electrode, said circuits being inductively associated, and an antenna system associated with said circuits.

4. In a radio signaling system, an audion including hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, separate circuits connecting each of said cold electrodes to said hot electrode, and means to set up successively increasing pulsations in said circuits, and an antenna system inductively associated with said circuits.

5. In a radio signaling system, an audion including hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, separate oscillating circuits connecting each of the cold electrodes to said hot electrode, said circuits being inductively coupled and an antenna system inductively associated with said coupling.

6. In a radio signaling system, an evacuated vessel containing hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, separate circuits connecting each of said cold electrodes with said hot electrode, said circuits being inductively associated, a source of electromotive force and a signaling device being included in one of said circuits.

7. In a radio signaling system, an evacuated vessel containing hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, circuits connecting each of said cold electrodes with said hot electrode, said circuits being inductively coupled, a source of electromotive force and a signaling device being included in one of said circuits and an antenna system inductively associated with said coupling.

8. In a radio signaling system, an evacuated vessel containing hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, circuits connecting each of said cold electrodes with said hot electrode, said circuits being associated, a source of electromotive force and a signal indicating device being included in one only of said circuits and an antenna system associated with said circuits, and means for operating said radio signaling system as a transmitting station.

9. In a radio signaling system, an evacuated vessel containing hot and cold electrodes therein, circuits connecting each of said cold electrodes with said hot electrode, said circuits being inductively associated, a source of electromotive force and a signal indicating device being included in one of said circuits and an antenna system associated with said circuits, and means for operating said signaling system as a receiving station.

10. In a radio signaling system, an audion including hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, separate circuits connecting each of said cold electrodes to said hot electrode, said circuits being inductively associated with each other.

11. In a radio signaling system, an evacuated vessel containing a hot electrode and a plurality of grid electrodes and a plurality of wing electrodes, circuits connecting each of said grid electrodes and said wing electrodes with said hot electrode, the circuits of the grid electrodes being inductively associated with the circuits of the wing electrodes.

12. In a radio signaling system, an evacuated vessel containing a hot electrode and a plurality of grid electrodes and a plurality of wing electrodes, circuits connecting each of said grid electrodes and said wing electrodes with said hot electrode, the circuits of the grid electrodes being associated with the circuits of the wing electrodes respec-

tively, and a signal indicating device included in each of the circuits of said wing electrodes.

13. In a radio signaling system, an evacuated vessel containing a plurality of wing electrodes and a plurality of grid electrodes, a filament electrode interposed between said grid electrodes and between said wing electrodes, circuits connecting each of said wing and grid electrodes with said filament electrode, the circuits of said grid electrodes being inductively associated with the circuits of said wing electrodes respectively.

14. In a radio signaling system, an evacuated vessel, containing a plurality of wing electrodes and a plurality of grid electrodes, a filament electrode interposed between said grid electrodes and between said wing electrodes, circuits connecting each of said wing and grid electrodes with said filament electrode, the circuit of each of said grid electrodes being inductively associated with the circuit of said wing electrode on the opposite side of said filament electrode.

15. In a radio signaling system, an evacuated vessel containing a plurality of wing electrodes, and a plurality of grid electrodes, a filament electrode interposed between said grid electrodes and between said wing electrodes, circuits connecting each of said wing and grid electrodes with said filament electrode, the circuits of said grid electrodes being inductively coupled with the circuits of said wing electrodes respectively.

16. In a radio signaling system, an evacuated vessel containing a plurality of wing electrodes and a plurality of grid electrodes, a filament electrode interposed between said grid electrodes and between said wing electrodes, circuits connecting each of said wing and grid electrodes with said filament electrode, the circuits of said grid electrodes being inductively coupled with the circuits of said wing electrodes respectively, and an antenna system inductively associated with said coupling.

17. In a radio signaling system, an evacuated vessel containing a plurality of wing electrodes, and a plurality of grid electrodes, a filament electrode interposed between said grid electrodes and between said wing electrodes, circuits connecting each of said wing and grid electrodes with said filament electrode, the circuits of said grid electrodes being inductively coupled with the circuits of said wing electrodes respectively, the circuit of each of said grid electrodes being inductively coupled with the circuit of said wing electrode on the opposite side of said filament.

18. In a radio signaling system, an evacuated vessel containing a plurality of wing electrodes, and a plurality of grid electrodes, a filament electrode interposed between said grid electrodes and between said wing electrodes, circuits connecting each of said wing and grid electrodes with said filament electrode, the circuits of said grid electrodes being inductively coupled with the circuits of said wing electrodes respectively, the circuit of each of said grid electrodes being inductively coupled with the circuit of said wing electrode on the opposite side of said filament, and an antenna system inductively associated with each said coupling.

19. In a system for generating oscillations, a work circuit, and means for generating and transmitting the generated oscillations comprising an oscillatory circuit having two electrodes in an exhausted receptacle, and a second circuit inductively coupled thereto having a conducting body interposed between said electrodes.

20. In a system for generating oscillations, a work circuit, and means for generating and transmitting the generated oscillations comprising an oscillatory circuit having two electrodes, a second circuit inductively coupled thereto and having a conducting body interposed between said electrodes.

21. In a system for generating oscillations, a work circuit, and means for generating and transmitting the generated oscillations comprising an oscillatory circuit having two electrodes, a second circuit inductively coupled thereto and having a conducting body interposed between said electrodes and means for varying the frequency of the produced oscillations.

22. In a system for generating oscillations, a work circuit, and means for generating and transmitting the generated oscillations comprising an oscillatory circuit having two electrodes means for producing a flow of current between said electrodes and a second circuit inductively coupled with the first circuit and having a conducting body interposed between said electrodes.

23. In a system for generating oscillations, a work circuit, and means for generating and transmitting the generated oscillations comprising an oscillatory circuit having two electrodes means for producing a flow of current between said electrodes and a second oscillatory circuit inductively coupled with the first oscillatory circuit and having a conducting body interposed between said electrodes.

24. The method of generating alternating currents which consists in causing current to flow in one of two inductively coupled circuits, and varying the flow of current in the first circuit by impressing the potential induced in the second circuit upon a conducting body interposed between two electrodes in the first circuit.

25. Means for producing sustained electrical oscillations comprising an oscillatory circuit having two electrodes in an exhaust-

ed receptacle and a second circuit coupled thereto having a conducting body interposed between said electrodes.

26. Means for producing sustained electrical oscillations comprising an oscillatory circuit having two electrodes, a second circuit coupled thereto having a conducting body interposed between said electrodes, and means for varying the frequency of the produced oscillations.

27. Means for producing sustained electrical oscillations comprising an oscillatory circuit having two electrodes, means for producing a flow of current between said electrodes, and a second circuit coupled with the first having a conducting body interposed between said electrodes.

28. The method of producing electrical alternating currents which consists in causing current to flow in one of two coupled circuits and varying the flow of current in the first circuit by impressing the potential induced in the second circuit upon a conducting body interposed between two electrodes in the first circuit.

29. In a system for generating electrical oscillations, a work circuit, and means for generating and transmitting the generated oscillations to said work circuit comprising an evacuated vessel having a hot electrode, a cold plate electrode and a cold grid electrode, said cold electrodes being electrically associated with each other, and a source of current for the hot electrode.

30. The method of producing high frequency alternating currents, which consists in causing current to flow in one of two associated circuits and varying the flow of current in the first circuit by impressing a charge induced in the second circuit upon an element in the space between the electrodes respectively included in said second circuit.

31. Means for generating high frequency oscillations, including an evacuated vessel having separated wing, grid and filament electrodes therein, circuits for said electrodes, and a source of current supply having its terminals respectively connected to two of said electrodes and operating to generate oscillations in one of said electrode circuits.

32. The combination with a work circuit and means for generating and transmitting the generated alternating currents to said work circuit, comprising an evacuated vessel having a hot and a plurality of cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, means to supply current to said electrodes, and circuit connections between said electrodes.

33. The combination with a work circuit and means for generating and transmitting the generated alternating current to said work circuit, comprising an evacuated vessel having a hot and a plurality of cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, a circuit connection between the cold electrodes, and means for impressing an electromotive force in the space between the cold and hot electrodes, and means to supply current to the hot electrode.

34. The combination with a work circuit and means for generating and transmitting the generated alternating currents to said work circuit, comprising an evacuated vessel having a hot and a plurality of cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, a circuit connection between the cold electrodes, a circuit connection between one of the cold electrodes and one side of the hot electrode, a source of current included in said last-mentioned circuit connection, and means for supplying current to the hot electrode.

35. A work circuit and means for generating and transmitting the generated oscillations to said work circuit, comprising an audion and its associated circuits.

36. The combination with a work circuit and means for generating and transmitting the generated oscillations to said work circuit, comprising an evacuated vessel having filament, grid and plate electrodes therein, means to supply current to said electrodes, and circuit connections between said electrodes.

37. In a system for generating electrical oscillations, an evacuated vessel having a hot electrode, a cold plate electrode and a controlling electrode, circuits connected to said cold plate electrode and said controlling electrode, respectively, and coupled with each other, and a source of current for the hot electrode.

38. The combination with a translating device, of means for generating and transmitting to said device the generated oscillations, comprising an evacuated vessel having filament, grid and plate electrodes, means to supply current to said electrodes, and circuit connections between said electrodes.

39. Means for producing sustained electrical oscillations, comprising an oscillatory circuit having two electrodes, one of said electrodes comprising an incandescent filament, a second circuit coupled to said oscillatory circuit and having a controlling grid electrode for regulating the discharge between said two electrodes.

40. Means for producing electrical oscillations comprising an oscillatory circuit having two electrodes, one of said electrodes comprising an incandescent filament, a second circuit coupled thereto having a con-

trolling grid electrode associated with said electrodes, and means for varying the frequency of the produced oscillations.

41. The method of producing electrical oscillations with an incandescent filament thermionic discharge device having two coupled circuits each connected to the incandescent filament thereof, which consists in causing current to flow in one of the said two coupled circuits and varying the flow of current in said first circuit by impressing the potential induced in the second circuit upon a controlling grid electrode regulating the current flow in the first circuit.

In testimony whereof I have hereunto set my hand in the presence of a subscribing witness, on this 18th day of September, A. D., 1915.

LEE DE FOREST.

Witness:
S. E. DARBY.

DEFENDANT'S EXHIBIT UUF 4121

Sept. 2, 1924. 1,507,017

L. DE FOREST

WIRELESS TELEGRAPH AND TELEPHONE SYSTEM

Filed March 20, 1914 2 Sheets-Sheet 1

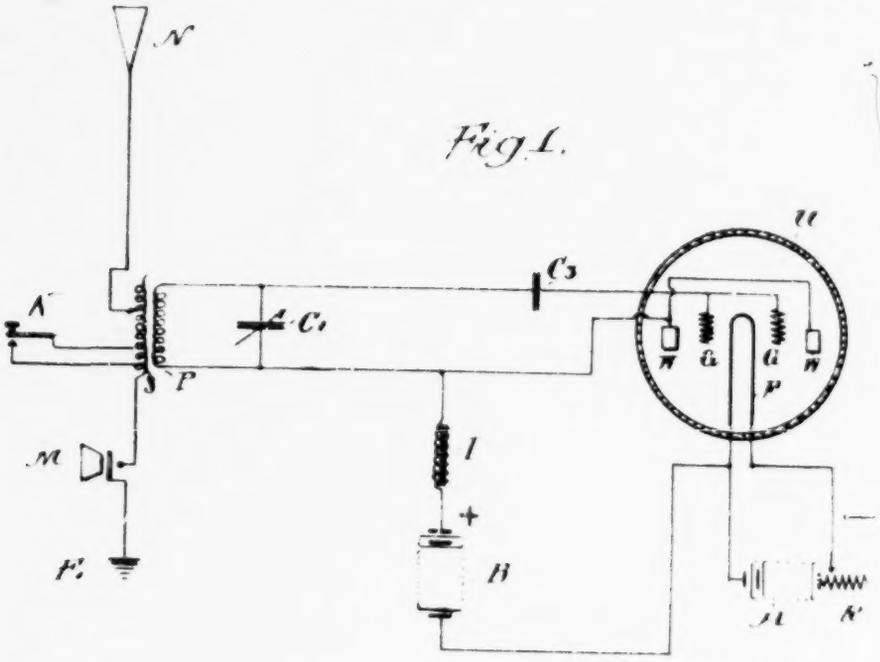

Fig. 1.

Fig. 5

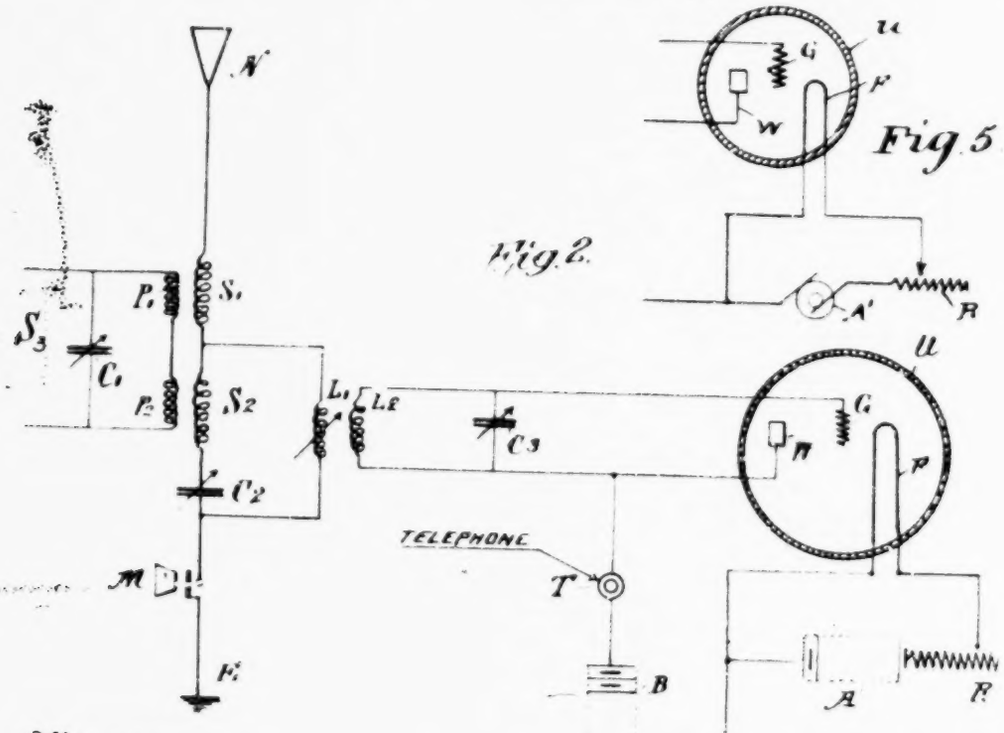

Fig. 2.

Witnesses:
J. F. Daily, Jr.
W. L. Daily.

Inventor
Lee de Forest
By his Attorney
Samuel G. Darby

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Sept. 2, 1924. 1,507,017

L. DE FOREST

WIRELESS TELEGRAPH AND TELEPHONE SYSTEM

Filed March 20, 1914 2 Sheets-Sheet 2

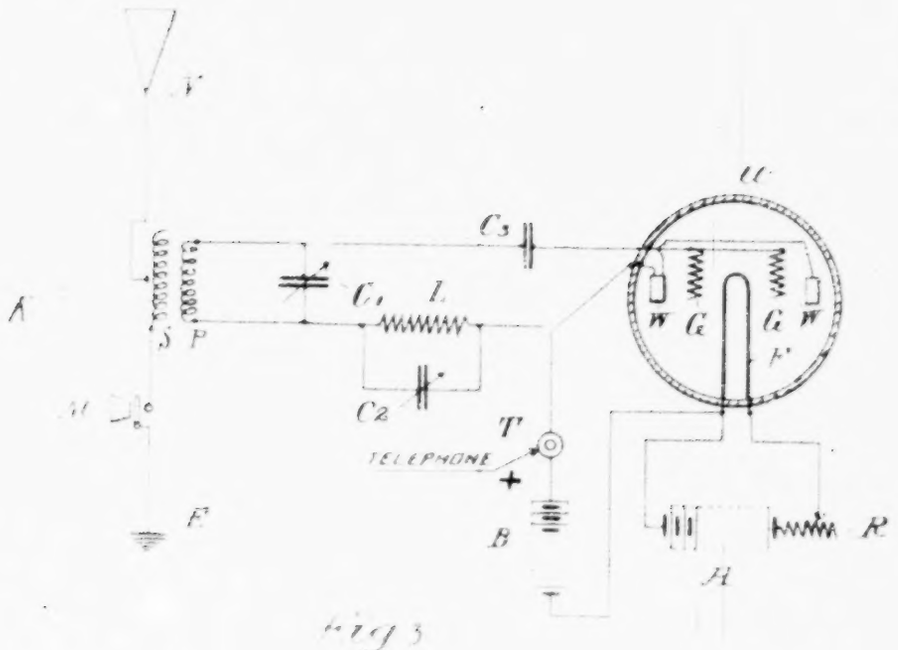

Fig 3

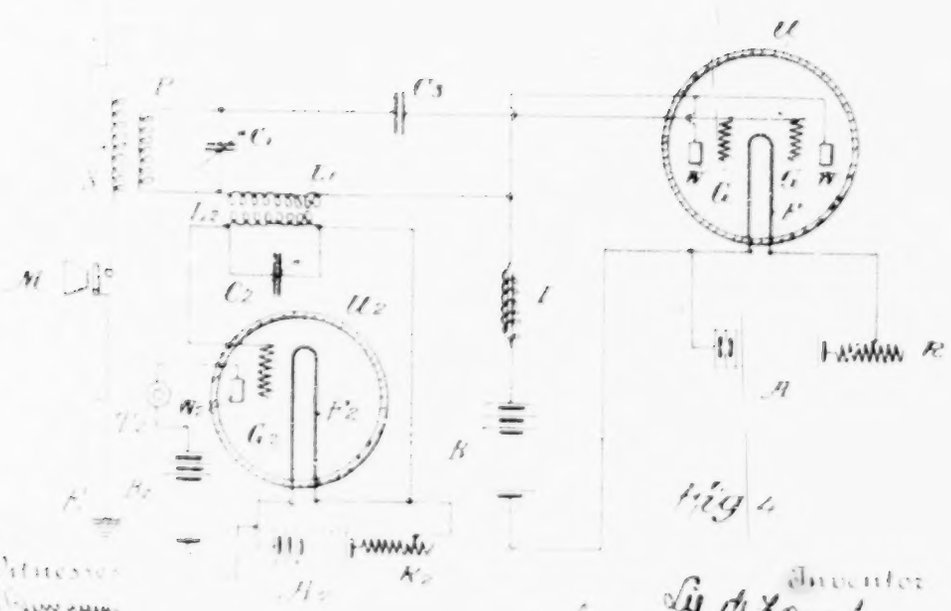

Fig 4

Witnesses

Inventor

Patented Sept. 2, 1924.

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1,507,017

UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y., ASSIGNOR TO RADIO TELEPHONE & TELEGRAPH COMPANY, A CORPORATION OF DELAWARE.

WIRELESS TELEGRAPH AND TELEPHONE SYSTEM.

Application filed March 20, 1914. Serial No. 825,984.

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, residing at New York, in the county and State of New York, have made a certain new and useful Invention in Wireless Telegraph and Telephone Systems, of which the following is a specification.

This invention relates to wireless telegraph and telephone systems.

The object of the invention is to provide a wireless telegraph and telephone system which is simple and efficient and wherein provision is made for duplex operation whether for telegraphing or telephoning.

A further object is to provide a more perfect generator of high frequency oscillations of uniform amplitude.

A further object is to provide a system of the nature referred to employing an oscillation generator which combines detector functions with its functions as a generator and to utilize the combined functions thereof for duplex operation.

Other objects will appear more fully hereinafter.

The invention consists substantially in the construction, combination, location and relative arrangements of parts all as will be more fully hereinafter set forth, as shown in the accompanying drawings, and finally pointed out in the appended claims.

Referring to the drawings,—

Fig. 1 is a circuit diagram showing one arrangement embodying my invention wherein the device serves as a generator of continuous oscillations.

Fig. 2 is a circuit diagram showing an arrangement whereby the receiver is not affected by the energy being radiated from the home antenna.

Fig. 3 is a circuit diagram showing an arrangement wherein the same device serves as an oscillation generator and a detector.

Fig. 4 is a similar view showing a modified arrangement wherein a detector separate from the oscillation generator is employed.

Fig. 5 is a similar view of a modified form of detector employed in accordance with my invention.

In the drawing N designates the antenna for transmitting and receiving. Adjustably connected in the antenna circuit is an inductance S. The antenna circuit is connected to earth or other capacity E, and, where the apparatus is to be used for telephonic communication the antenna includes a microphone transmitter M. Where the apparatus is to be used for telegraphing a Morse telegraph key K is bridged across a portion of the inductance S. The inductance S is in the form of a coil with which is inductively associated, preferably in loose coupled relation, an inductance coil P, one terminal of which is connected to auxiliary or cold grid electrodes G, G, arranged within an evacuated bulb or vessel U. The other terminal of coil P is connected to the cold plates or electrodes W also arranged within the bulb U. Connected across the terminals of coil P is a variable capacity C_1. In series with the coil P and electrodes G, I place a blocking condenser C_3, and if desired, (see Fig. 3), in series with the coil P and electrode plates W, I place an inductance coil L, across the terminals of which is connected a variable capacity C_2. Contained in the bulb U is a hot electrode F, which is, in the form shown, a filament or glower, to which current is supplied from any convenient source indicated at A, the current supply being regulated by a rheostat R.

As above indicated the current source A may be of any desired form, such for instance as a battery, direct current generator, or an alternating current generator. Where an alternating current generator is employed, as indicated in Fig. 5, the frequency, for wireless telephone operation, should be above that of the essential frequencies of voice sounds, say fifteen hundred cycles per second, or higher. For wireless telegraph work the frequency of the generator may be very much lower, for example, five hundred per second.

A telephone receiver T is connected on one side in series with the plate electrodes W, and on the other side in series with the filament F. In circuit with the telephone T, is a source of current supply indicated at B, as a battery, the purpose of which is to impress an electro-motive-force between the cold plate electrodes W, and the filament F.

By reason of the arrangement above de-

scribed the device U with its associated electrodes and filaments and their associated circuits and connections, becomes a generator of alternating or pulsating electric currents or continuous oscillations of high frequency in the circuit of coil P, the frequency of which depends upon the spatial relation of the electrode members contained therein, the value of the electro motive force impressed across the electrodes, and the amount of inductance and capacity included in or associated with the circuit of said coil. In the arrangement shown in Fig. 3 the frequency of such oscillations may be varied by varying the capacity of condensers C_1 or C_2.

By reason of the relation of coils P and S, the oscillations in the circuit of coil P are impressed upon the antenna-earth system and with a natural period of oscillation in the antenna-earth system the same as that of the oscillations in the circuit of primary coil P.

The amplitude of the oscillations induced in the antenna earth system as above described may be varied by and in accordance with sound waves falling upon the microphone transmitter M, in the usual manner. Similarly, a telegraph key associated in the antenna earth system may serve to control the emission of wave trains in accordance with the telegraphic code, if desired, and as shown, if the key K is associated with the antenna-earth system in such a manner as to short circuit a portion of the inductance S, the wave length of the emitted wave trains may be altered in a manner well understood in the art.

It will be seen that, in the arrangement shown in Fig. 3, the device U, with its associated electrodes and filament and circuit arrangement therefore combines within itself the functions of a source of continuous oscillations and also those of a detector, like the audion detector, and its detector functions are in no way impaired by its simultaneous operation as an oscillation generator. Incoming electro-magnetic signals influence the circuits of the electrodes G and W, and produce an alteration in the conducting qualities of the medium between the plate and grid electrodes, and consequently any received signals when attuned to the proper wave length will be heard in the receiver T, during the pauses between the signals being made by the operation of the key K, or between the words spoken into the microphone transmitter M. By this simple arrangement, as described, I am enabled to secure duplex operation whether for telegraphing or telephoning, employing the same apparatus for transmitting and receiving.

It is obvious that provision may be made to protect the telephone receiver T in case large amounts of current are to pass across the space in the bulb U. Any suitable means may be employed for this purpose, as, for instance the usual high resistance telephone receiver may be employed, which, if desired, may be coupled to the circuit containing the battery B, electrodes W and filament F, in any suitable or well known manner.

In Fig. 4 I have shown an arrangement wherein a detector device independent of and separate from the oscillation generator is employed. In this arrangement I employ for the detector an evacuated bulb U_2 with a filament F_2, and a grid G_2 and a plate W_2 similar to corresponding parts above described with reference to bulb U, the filament circuit being supplied with current from a current source A_2, controlled by a rheostat R_2, the plate W_2 constituting one terminal of a circuit which contains the telephone receiver T_2 and current source B_2, the other terminal of said circuit being connected to one side of the filament circuit. One terminal of another circuit is connected to the grid G_2, the other terminal of said circuit being connected to the other side of the filament F_2. This last mentioned circuit is inductively associated with the oscillating circuit which contains the coil P, as for instance, through the coils L_1 L_2, the latter being shunted by a variable capacity C_2. By means of the variable condenser C_2 this secondary system can be accurately attuned to the frequency of the received oscillations. It is obvious that this secondary receiver circuit may be associated with the antenna earth system, or with the circuit of coil P, in any other suitable or well known manner.

Any suitable means may be employed to supply the necessary inertia to the circuit of battery B, such, for instance, as by including an impedance coil I, in said circuit.

Fig. 2 shows a "balanced antenna circuit" associated with the source of the oscillations S, and its inductances and capacity so proportioned relative to the capacity of the antenna itself that the total effect of the oscillations from the source S upon the receiver transformer L_1 L_2 is neutralized while at the same time impulses received on the antenna N, preferably of a slightly different frequency from that of the oscillations from S, are clearly received in the properly attuned receiving circuit L_2 C_3 and transmitted to the audion detector U and translated there into telephone currents in the circuit T B in the well known manner.

I am unable at the present time to give a complete explanation of the theory of action of the apparatus when operating as a generator. I have discovered, however, as hereinabove stated, that a system constructed as shown and described and energized from a suitable current source, becomes the seat of continuous high frequency oscilla-

tions. Undoubtedly the phenomena involved depends upon the effect of successively applied charges or surges of potential upon the grid and plate elements and having the power to effect momentarily the conductivity of the medium between the filament and plate electrodes in such manner that the current variations in the grid filament circuit produce corresponding variations in the plate filament circuit which are fed back to the grid filament circuit to add their effects to the initial variations, which latter, thus reinforced, create and form greater variations in the plate filament circuit which are, in turn, fed back to the grid filament circuit to still further amplify the variations in that circuit, and so on. The energy of the variations of each circuit reacts upon and increases that of the other circuit until a maximum sustained alternating current is finally produced, whose frequency can be controlled by varying the electrical constants of the associated circuits. In other words, the amplifying action incident to the feeding back of energy from the one circuit to the other increases until oscillations are produced which, once set up are self-perpetuating, analogous to the "whistling" or surging action observed when a telephone receiver and microphone transmitter, connected together in the same or coupled circuits, are so placed as to react one on the other mechanically and electrically.

From the foregoing description it will be observed that in its broad scope my invention lies in the discovery that when suitably connected and associated an audion becomes a generator of oscillating, alternating or pulsating electric currents which may be utilized for any purpose for which such currents are desired, and I have succeeded in securing remarkable results in the practical use and operation of an oscillation generator of this character particularly when applied to the generator of high frequency oscillations.

It is obvious that the principles of my invention may be embodied in various other arrangements, and that various changes in the details might readily occur to those skilled in the art, and still fall within the spirit and scope of my invention.

But having now set forth the objects and nature of my invention, and arrangements embodying the principles thereof, what I claim as new and useful, and of my own invention, and desire to secure by Letters Patent, is,—

1. In a system for generating electrical oscillations, a work circuit, and means for generating and transmitting the generated oscillations to said work circuit comprising an evacuated vessel having a hot electrode, a cold plate electrode and a cold grid electrode, an oscillating circuit, one side of said circuit being connected to the grid electrode and the other side to the plate electrode, and means for impressing an electromotive force in the space between the hot electrode and the plate electrode.

2. In a system for generating electrical oscillations, a work circuit, and means for generating and transmitting the generated oscillations to said work circuit comprising an evacuated vessel having a hot electrode, a cold plate electrode and a cold grid electrode, interposed between the hot and cold plate electrode, a source of current for the hot electrode, an oscillating circuit connecting said cold electrodes, and means for impressing an electromotive force between said hot electrode and said cold plate electrode.

3. In a system for generating electrical oscillations a work circuit, and means for generating and transmitting the generated oscillations to said work circuit including an evacuated vessel having hot and cold electrodes therein, circuits for said electrodes, one of said circuits being a series oscillating circuit and connected between said cold electrodes, and means for impressing an electromotive force in the space between two of said electrodes.

4. In a system for generating electrical oscillations a work circuit, and means for generating and transmitting the generated oscillations to said work circuit including an evacuated vessel having hot and cold electrodes therein, circuits for said electrodes, one of said circuits being a series oscillating circuit and connected between said cold electrodes, means for impressing an electromotive force in the space between two of said electrodes, and a telephone associated with one of said circuits.

5. Means for producing high frequency oscillations for transmission comprising a transmitting circuit associated therewith, an oscillatory circuit having two cold electrodes in an exhausted receptacle and a second circuit having a conducting electrode within said receptacle, one of said oscillating circuit electrodes being interposed between the other two, and means for impressing an electromotive force between one of said cold electrodes and said conducting electrode.

6. Means for producing high frequency oscillations for transmission comprising a transmitting circuit associated therewith, an oscillatory circuit having two cold electrodes, a conducting electrode, one of said cold electrodes being interposed between the other two, a circuit connection between the conducting and one of the cold electrodes, and means for varying the frequency of the produced oscillations.

7. Means for producing high frequency oscillations for transmission comprising a transmitting circuit associated therewith, an oscillatory circuit having two cold elec-

trodes a second circuit including a current source and a conducting electrode one of said cold electrodes being interposed between the other two electrodes and means for controlling flow of current through the space between said electrodes.

7. Means for generating high frequency oscillations for transmission including a transmitting circuit associated therewith, an evacuated vessel containing hot and cold electrodes, and a series oscillation circuit connecting said cold electrodes and a source of power associated with said circuit.

8. Means for generating high frequency oscillations for transmission including an evacuated vessel, a circuit including a transmitting circuit associated therewith, a current source and having its terminals within and sealed and separated from each other, and an oscillatory circuit including a conducting body interposed between said terminals.

10. The combination with a work circuit, and means for generating and transmitting the generated alternating currents to said work circuit, comprising an evacuated vessel having a hot and a plurality of cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, inductance and capacity connected between the cold electrodes, means for impressing electro-motive force in the space between one of the cold electrodes and the hot electrode, and means for supplying current to the hot electrode.

11. The combination with a work circuit, and means for generating and transmitting the generated alternating currents to said work circuit, comprising an evacuated vessel having a hot and a plurality of cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrode, an oscillating circuit connecting the cold electrodes, means for impressing an electro-motive force in the space between the cold and hot electrodes and means for supplying current to the hot electrode.

12. An audion having a plurality of grid electrodes, a plurality of wing electrodes, a hot electrode, a series oscillating circuit associated with the grid and wing electrodes, and means for impressing an electro-motive force between the wing and hot electrodes.

13. In a radio signaling system an evacuated vessel having separate electrodes therein, and circuit connections [illegible] to constitute a combined generator of high frequency oscillations and detector of high frequency oscillations.

14. In a radio signaling system an evacuated vessel having separate electrodes therein, and circuit connections [illegible] to constitute a combined generator of high frequency oscillations and a detector for received high frequency oscillations, and an antenna system associated therewith.

15. In a radio signaling system, an evacuated vessel including hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrodes, circuits connecting each of said cold electrodes to said hot electrode, and means to set up successively increasing potentials in said circuits.

16. In a radio signaling system, an evacuated vessel containing hot and cold electrodes therein, circuits connecting each said cold electrode with said hot electrode, said circuits being associated, a source of electro-motive force, and a signal indicating device being included in said circuits, and an antenna system associated with said circuits, and means for operating said signaling system as either a transmitting or a receiving system.

17. In a radio signaling system, an audion including hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrodes, circuits connecting each of said cold electrodes to said hot electrode, and means to cause said circuits to react upon each other.

18. In a radio signaling system, an audion including hot and cold electrodes therein, said cold electrodes being located at relatively different distances from said hot electrodes, circuits connecting each of said cold electrodes to said hot electrode, said circuits being associated to react upon each other.

19. In an electrical system, an evacuated vessel, hot and cold grid and plate electrodes therein, a circuit connecting each of said cold electrodes with said hot electrode, said circuits being associated to react upon one another.

20. In an electrical system, an evacuated vessel, a hot electrode within said vessel, cold grid and plate electrodes associated therewith, a circuit connecting each of said cold electrodes with said hot electrode, said circuits and electrodes being so associated that electrical variations in either circuit produce electrical variation in the other circuit.

21. In an electrical system, an audion including a hot electrode, a plate electrode and controlling electrodes, circuits connecting the plate electrode and controlling electrode with said hot electrode, and means for causing variations in the circuit of the plate electrode to react upon the controlling electrode.

In testimony whereof I have hereunto set my hand in the presence of the subscribing witnesses, on this 10th day of March A. D. 1914.

LEE DE FOREST.

Witnesses:
S. POWER CLEVELAND,
W. A. DARBY.

[fol. 3751] IN THE SUPREME COURT OF THE UNITED STATES,
OCTOBER TERM, 1942

No. 369

STIPULATION—Filed Jan. 5, 1943

It is hereby stipulated and agreed by and between counsel for the respective parties herein, subject to the approval of the Court, as follows:

(1) That the following and only the following exhibits shall be printed or reproduced for use on the argument of the above-entitled cause:

Plaintiff's exhibits: Nos. 7; 19; 20; 21; 22; 34; 35; 36; 46; 53; 59; 60; 69; 72; 74; 75; 77; 78 (1913 edition; Figs. 29a, 31, 33, 62, and 89; 1915 edition: Figs. 84 and 88); 79; 80; 84; 87; 91 (Figs. 36 and 37); 92 (Figs. 1, 3, 4, 6, 9, and 61; and page 110); 95; 99; 102; 103; 106; 107; 108; 109; 110; 111; 112; 113; 114; 116; 120′ (Interdepartmental Radio Board Preliminary Report); 120″ (Stone Canadian Society Lecture); 121′ (Stone U. S. Patent No. 767,984); 121″ (Interdepartmental Radio Board's Letter of April 16, 1921); 122; 142; 150; 151; 157; 158; 159; 160; 171; 203 (Fig. 45); 205 (Fig. 218; 211; 223; 225; 227; 228; 229; 230; 241; 242; 243; 244; 246; 248 (Figs. 2, 3, 4, and 5); 250; [fol. 3752] 258; 259; 260; 261; 262; 263; 264; 265; 266; 268; 269; 270; 273; 274; 275; 276; 282; 287; 289; 290; 298; 300; 301; 302; 315; 317; 318; 319; 322; 323; 324; 325; 326; 327; 335; 343; 344; 347; 348; 349; 363; 364; Waterman's Drawings Nos. 1, 2 and 3; 410; 413A; 419; 420; 440; 441; 453; 454; 455; 462; 472; 477A. (Note that 477A is the same as part of the April 6, 1942 findings of the Court of Claims and appears at page 142 of the printed record.)

Defendant's exhibits: Nos. A; B; C; D; I; J; K; L; M; N; O; P; S; T; U; V; W; X; Z; A-1; B-1; C-1; D-1; E-1; F-1; G-1; H-1; I-1; J-1; K-1; L-1; M-1; N-1; P-1; T-1; A-2; B-2; C-2; E-2; F-2; M-2; O-2; P-2; Q-2; R-2; U-2; V-2; W-2; X-2; Y-2; Z-2; A-3; B-3; D-3; E-3; F-3; G-3; H-3; I-3; K-3; N-3; P-3; Q-3; R-3; B-4; E-4; J-4; R-4; S-4; Z-4; A-5; B-5; C-5; D-5; E-5; F-5; G-5; N-5; O-5; Q-5; S-5; T-5; U-5; V-5; W-5; X-5; B-6; L-6; M-6; N-6; Q-6; S-6; V-6; W-6; Y-6; Z-6; JJ; KK; LL; MM; PP; BBB and UUU. (As to KK, it will be sufficient to note

that it is the same as Defendant's Exhibit U-2 to be reproduced. As to LL, Fessenden patent 706,735, it will be sufficient to reproduce it as part of Plaintiff's Exhibit 171 and note that LL is the same as such part of Exhibit 171.

(2) Whereas, through inadvertence, page 73 of plaintiff's exhibit No. 92 was included in the transcript of record certified to this Court from the Court of Claims herein instead of page 75 thereof, it is farther stipulated and agreed that the annexed copy of Fig. 62 of said exhibit (the same being a part of said page 75) shall be reproduced as a part of the record herein in lieu of Fig. 60 (which was a part of the erroneously-included page 73 of the said exhibit); and it is further stipulated and agreed [fol. 3753] that said Fig. 62 of said exhibit was a part of the printed record that was before the Court of Claims herein, and that certification thereof is therefore hereby waived.

Dated: December 31, 1942.

Richard A. Ford, Abel E. Blacknar, Jr., Counsel for Petitioner. Charles Fahy, Solicitor General of the United States. Clifton V. Edwards, Special Assistant to the Attorney General.

[fol. 4133] IN THE SUPREME COURT OF THE UNITED STATES,
OCTOBER TERM, 1942

No. 369

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA

v.

UNITED STATES

STIPULATION AND ADDITION TO RECORD—Filed March 29, 1943

It is hereby stipulated between the respective parties by their attorneys, this Honorable Court consenting, that the attached reproduction of Defendant's Exhibit P-1 is a true copy of the said translation as it appeared in the printed record in the Court of Claims proceedings as to which certiorari has been granted, the illustrations in said attached reproduction having been inadvertently omitted in the transcript of record certified to this Court.

It is stipulated that the attached copy may be considered with like force and effect as though it were included in the printed transcript at the place designated, and that copies of said attached translation including the drawings may be substituted in lieu of the copy of said translation now appearing in Volume V, pages 3515-3518.

Dated March 23, 1943.

Abel E. Blacknar, Jr., Counsel for Petitioner.
Charles Fahy, Solicitor General of the United States.

1 DEFENDANT'S EXHIBIT P 1

(Translation of Defendant's Exhibit O-1). Physikalische Zeitschrift--Oct. 20, 1904, pp. 680-81. [1]Translation of Wehnelt article.

A Wehnelt (Erlangen), in Reference to the exit of Negative Ions from Incandescing Metallic Oxids and Phenomena Connected Therewith"

In a treatise with the same heading in Vol. 14, pp. 425–468 of the Annalen der Physik (1904) I have set forth a series of experiments and measurements which showed that certain metallic oxids, and in fact, especially the oxids of the earth alkali metals in an incandescing state, both under atmospheric pressure and also in a vacuum, emit numerous negative ions. (electrons)

[1] Read in Division 2 on the 21st of Sept. Exhaustive literary references are to be found in Annalen der Physik Vol. 14, p. 425 etc. 1904.

[1a] Vorgetragen in Abteilung 2 am 21 Sept. Ausführliche Litteraturangaben befinden sich Annalen der Physik 14, 425 etc. 1904.

In intimate connection with this quality stands the fact also discovered by me, that the cathode drop in a glimmer charge completely disappears on glowing oxid cathodes even under the deepest pressures, provided that the current density (current strength per square centimeter of incandescing oxid surface) remains below a value depending upon the temperature and increasing with this. That current density at which a cathode drop begins to show I have called the limit current density. It attains, under high incandescence of the oxid, values up to three amperes.

I wish today to first bring before you some experiments which explain that which has been said above, and then to show you a practical application of incandescing oxid cathodes.

Emission of Negative Ions by Incandescing Metallic Oxids.—A glass tube R (Fig. 1), exhausted to a moderate extent contains a brass cylinder C in the axis of which there is situated a thin platinum wire D covered with CaO. The wire can be heated to high temperatures by the current of two accumulators A. If I connect the wire D with the one pole, the cylinder C through a galvanometer G with the other pole, of a source of current B, then there only flows a current through the tube if D is connected with the negative pole of B. The experiment shows consequently that only negative ions are emitted from the incandescing oxid.

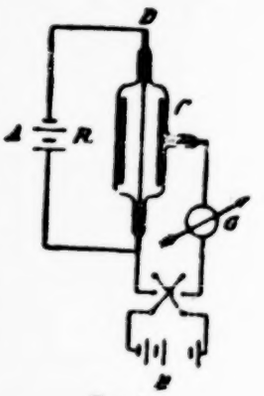

FIG. 1.

If I take another tube, which is otherwise exactly similar, but which contains a platinum wire carefully cleaned, and heat the same to the same temperature as previously the wire covered with CaO, then the current is under an equally high negative charge of the wire only exceedingly weak, and in fact, only about 1/1000 of that in the former experiment.

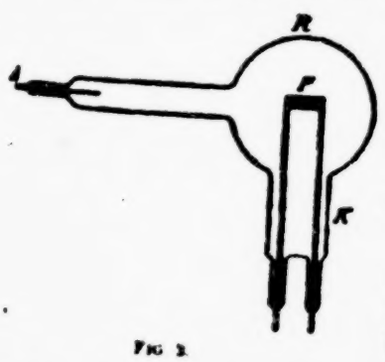

FIG. 2.

Incandescing Metallic Oxids as Cathodes in Discharge Tubes.—The tube R (Fig. 2) contains as cathode K a platinum sheet P covered with CaO which can be electrically heated red hot, and as an anode an iron wire A. The surface of the incandescing metallic used cathode amounting to several square centimeters, allows of sending through the tube considerable current strengths, even under deep pressures without there being present a cathode drop.

Since the anode drop constantly amounts to about 20 volts and the drop on the positive cells under strong currents and low pressures, as special measurements have shown, amounts to only one to two volts per centimeter, I can, by using the light conductor of

220 volts potential, send through the tube (Fig. 2) currents of several amperes strength. The incandescing oxid cathodes furnish us consequently with a means of investigating the processes in the positive column with any gas whatever and under any pressures however deep, up to very high current strengths. The remarkable brightness of the positive strata under high current strength promises to be serviceable to the spectro-analytical investigation of gas spectra. Quartz windows on the tube would also make the ultra violet portion of the light of the strata accessible to investigation.

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Weak Cathode Rays.—If we exceed the limit current density either by increasing the current strength or decreasing the temperature of the incandescing oxid cathode, then we can impart to the cathode drop any desired value, and consequently produce cathode rays of any desired velocity.

The tube, Fig. 3, contains as cathode K a small platinum sheet P upon which there is located a small speck of calcium oxid.

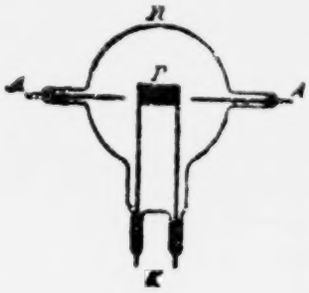

FIG. 3

A brass rod A serves as anode. If the sheet P is electrically brought to a glowing heat and the electrodes A, K, by throwing in a suitable resistance are connected with the light conductor of 220 volts potential, then the entire current goes only through the calcium oxid coating on the cathode sheet P, since here the cathode drop is much lower than on the clean platinum sheet, whereby there proceeds an intensely blue cathode beam of rays from the coating. By changing the temperature of the platinum sheet, there can be imparted to the cathode rays then any desired velocity, and this can then be measured according to well-known methods.

Application of Discharge Tubes with Glowing Metal Oxid Cathodes in Practice.—If in an exhausted discharge tube R (Fig. 4[1]) we push one or several metallic electrodes A close to the glowing metallic oxid electrode K (platinum sheet P covered with CaO) then the discharge potential, if A is anode and K is cathode, amounts to only about twenty volts. If we reverse the direction of current so that now A is cathode and K is anode, the discharge potential now amounts to some thousands of volts, since under deep pressures the cathode drop on metals takes on exceedingly high values. If, therefore, we connect the electrodes A and K with an alternating source of current, the potential of which lies below the value which the cathode drop on the metallic electrode A has, then the tube acts as an electric valve, in that it allows to pass through only one phase of the alternating current. The tube (Fig. 4) can consequently serve for the purpose of transforming alternating current into pulsating direct current.

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[1] The cathode K is assumed to be turned 90° as regards the plane of the picture.

The maximum current strength to be sent through the tube (valve ...e depends as follows, from what has been said above, upon the ... of the glowing oxid surface. The efficiency of the valve tube ...ends upon the working potential employed, and ... rases with this, since the tube up to the strongest ...wable current strength, entirely independent of ... absorbs always only 20 volts potential. In ...plying a working potential of 120 volts alternating ...rent, taking into consideration the consumption ... watts for heating of the metal oxid cathode, the ...ciency of the valve tube amounted to about 65%. By using the well-known Graetz system of con... both phases of the alternating current can ...tilized. By using three metallic anodes, we ... as with a Hewitt transformer, also transform rotary current into ...ating direct current.

Fig. 4

Discussion

SUPREME COURT OF THE UNITED STATES

OCTOBER TERM, 1942

No. 369

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA,

Petitioner,

vs.

THE UNITED STATES.

PETITION FOR WRIT OF CERTIORARI TO THE COURT OF CLAIMS AND SUPPORTING BRIEF.

ABEL E. BLACKMAR, JR.,
RICHARD A. FORD,
Counsel for Petitioner.

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Argument	14
Point I. The Court of Claims, in holding that claims 1, 2, 3, 6, 8, 10 to 14, and 17 to 20 of Marconi patent No. 763,772 were invalid, has rendered a decision in conflict with the decisions of the Circuit Court of Appeals for the Ninth Circuit and the United States District Courts for the District of Washington and for the Eastern District of New York, on the same question and on substantially the same evidence, in Marconi Wireless Telegraph Company of America v. Kilbourne & Clark Manufacturing Co. (265 Fed. 644, affirming the decision of the Washington District Court, 239 Fed. 328), and in Marconi Wireless Telegraph Company of America v. National Electric Signalling Co. (273 Fed. 813), respectively	14
Point II.—The Court of Claims, in holding that claims 1 and 37 of Fleming patent No. 803,684 were not infringed, and in failing to hold that these claims were valid, has rendered a decision in conflict with the decision, rendered on the same questions and on substantially the same evidence, of the Circuit Court of Appeals for	

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the Second Circuit, in Marconi Wireless Telegraph Company of America v. DeForest Radio Telephone & Telegraph Co. (243 Fed. 560, affirming 236 Fed. 942), and the two subsequent decisions of the United States District Court for the Southern District of New York in the same case (memorandum opinion of July 11, 1917, not reported, and 261 Fed. 393) 21

Point III. The Court of Claims, in limiting petitioner's compensation, for the use by respondent of upwards of $40,000,000 worth of radio apparatus during the accounting period, to less than $80,000 plus additional compensation measured by interest), has rendered a decision which, in view of the prior recognized fundamental position of petitioner's patents in the radio art and in view of the proposed award to petitioner by the Interdepartmental Radio Board of upwards of $1,250,000, has resulted in a failure of justice as between the United States and one of its citizens 26

Point IV. The Marconi patent No. 763,772 was valid as to claims 1, 2, 3, 6, 8, 10 to 14, and 17 to 20 thereof, and the subject matter of said claims was used by respondent 27

A. Said claims of the patent were valid 27

B. The above-mentioned claims of the Marconi patent were infringed 29

Point V. The Fleming patent No. 803,684 was valid as to claims 1 and 37 thereof and the subject matter of said claims was used by respondent 30

A. The patent was infringed 30

B. The Fleming patent was valid 32

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SUPREME COURT OF THE UNITED STATES
OCTOBER TERM, 1942

No. 369

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA,

Petitioner,

vs.

THE UNITED STATES.

PETITION FOR WRIT OF CERTIORARI TO THE COURT OF CLAIMS.

To the Honorable the Chief Justice and Associate Justices of the Supreme Court of the United States:

Your petitioner, Marconi Wireless Telegraph Company of America, respectfully prays for a writ of certiorari, directed to the Court of Claims of the United States, to review the interlocutory and final judgments of that court rendered in this action on November 4, 1935,[1] and April 6, 1942,[2] respectively. The transcript of record in the case is being filed herewith in accordance with Rule 41 of this Court.[3]

[1] Findings and opinion reported in 81 C. Cls. 671.

[2] Not yet reported. The Findings of Fact, Conclusion of Law, and Opinion of the Court will be found at Court R., pp. 117-182.

[3] The record, as filed in this Court, includes a portion ("Other parts" R., pp. 2313-2522) which was included at respondent's request. This portion of the record is not material to the issues raised by this petition; it will be material to the case only in the event that respondent files a petition with respect to the Findings of the court below that claim 16 of Marconi patent No. 763,772 was valid and infringed.

I.

Summary Statement of Matter Involved.

Petitioner, at the time of instituting the present action, was the owner, among many other United States Letters Patent, of a reissued patent to Guglielmo Marconi, No. 11,913, the original of which had issued July 13, 1897; a patent to Sir Oliver Lodge, No. 609,154, which issued August 16, 1898; another patent to Marconi, No. 763,772, which issued June 28, 1904; and a patent to Sir John Ambrose Fleming, No. 803,684, which issued November 7, 1905. Each of these patents covered inventions in the then infant field of wireless or radio communication.

This action was brought by petitioner in the Court of Claims of the United States under the Act of Congress of June 25, 1910[4] (U. S. Code, Title 35, Section 68), to recover compensation for the use, by the respondent, the United States, of apparatus embodying the subject matter of one or more of the four patents above-mentioned. The original petition, filed July 29, 1916, claimed compensation in the sum of $1,000,000.

On July 1, 1918, the Act of June 25, 1910, was amended to permit the recovery of compensation where the subject matter of a patent had been used *or manufactured* by *or for* the United States; the amendment also took away the patent owner's right to seek compensation from parties who supplied the Government with infringing apparatus. Thereafter, the patentee's sole remedy was by suit against the United States in the Court of Claims for the recovery of his reasonable and entire compensation. *Richmond Screw Anchor Co.* v. *United States*, 275 U. S. 331, 343. In view of the changes in the statute and of the greatly increased use of wireless apparatus by the respondent as a result of

[4] Printed, as amended July 1, 1918, at page 37, *infra*, as Appendix A.

the World War of 1916-1918, petitioner filed, on May 21, 1919, a Supplemental Petition (Court R., pp. 1-6) claiming $5,000,000 additional compensation. The period covered by the claim extends from July 29, 1910, to the dates of expiration of the Marconi reissue and Lodge patents, and, as to the other two patents, to November 20, 1919, the date when petitioner assigned the patents to a third party, the claim against respondent being, however, reserved to petitioner.

The subject matter of the Marconi reissue patent (Plaintiff's Exhibit 19, included in exhibits certified as incorporated by reference in the 1935 findings of the court below; offered "Other parts" R. p. 190), as petitioner considered that it should be construed, was an elevated aerial or antenna for radio communication, one end of which was connected to the earth, or "grounded". The subject matter of the Lodge patent (Plaintiff's Exhibit 20, included in the exhibits incorporated in the findings of the court below; offered "Other parts" R. p. 190) was the insertion in the antenna circuit, of a radio transmitter or receiver or both, of an inductance coil (coil of wire) for the purpose of "tuning" the antenna circuit • • • *i. e.*, making it selectively responsive to a particular, desired wavelength or frequency. The subject matter of the second Marconi patent, No. 763,772 (Plaintiff's Exhibit 21, included in the exhibits incorporated in the findings of the court below; offered "Other parts" R. p. 190-1) was the utilization, at a radio transmitting or receiving station or both, of two circuits (one an "open" or antenna circuit, and the other a "closed" circuit), the two circuits being coupled to each other and both of them being tuned to the same wavelength or frequency. The subject matter of the Fleming patent (Plaintiff's Exhibit 22, included in the exhibits incorporated in the findings of the court below; offered "Other parts" R. p. 191) was a vacuum tube ("valve") for use with

radio, the tube containing a filament ("cathode"), adapted to be heated to incandescence, and another electrode or element ("cold" electrode or "plate"), the filament and plate being connected together by a circuit outside of the tube.[5]

Copies of the Marconi patent No. 763,772 and of the Fleming patent are annexed hereto for the convenience of the Court.

The four patents upon which petitioner's claim was based were the fundamental patents of the radio art and it was upon their disclosures that substantially all of the subsequent marvelous development of that art has been built.[6]

The Marconi reissue patent had been sustained by the District Courts for the Eastern and Southern Districts of New York.[7] The Court of Claims held that it had not been infringed (Court R. p. 117).

The Lodge patent has been sustained by all courts which have passed upon it, including the court below. The Court of Claims held that it was valid and infringed (Court R. p. 117) and has awarded to petitioner, for respondent's use of the subject matter thereof from March 8, 1913, to August 16, 1915, compensation amounting to $34,827.70 (plus additional compensation measured by interest) (Court R. p. 135).

The Marconi patent No. 763,772 had been held valid and infringed by the District Court for the Eastern District of

[5] This is the "Fleming valve" which was several times referred to by this Court in *DeForest Radio Co. v. General Electric Co.*, 283 U. S. 664. See, for example, this Court's references to "Fleming, the inventor of the Fleming valve" and to the Fleming patent above referred to, at page 680 of 283 U. S.

[6] Respondent's Interdepartmental Radio Board recognized that all four of these patents were fundamental (see brief, p. 12 *infra*).

[7] *Marconi Wireless Telegraph Co. of America* v. *National Electric Signalling Co.* 213 Fed. 815; *Same* v. *DeForest Co.*, 138 Fed. 657.

New York;[8] it had also been held valid, but not infringed, by the District Court for the District of Washington in a decision which was affirmed by the Circuit Court of Appeals for the Ninth Circuit.[9] Both of these decisions were rendered after strenuously contested trials, most of the testimony, in the latter case at least, having been taken in open court. The corresponding British Marconi patent had been twice sustained by the High Court of Justice, Chancery Division;[10] and the corresponding French patent had been sustained by the Civil Tribunal of the Seine.[11] The Court of Claims, however, on testimony taken before an Examiner, held that all claims in issue of the patent were invalid, except claim 16 (a very limited claim) which was held valid and infringed (Court R. p. 117).[12]

The Fleming patent had been held valid and infringed, after a strenuously contested trial in open court, by the District Court for the Southern District of New York, in a decision which was affirmed by the Circuit Court of Appeals for the Second Circuit.[13] The District Court also held, on a

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[8] *Marconi Wireless Telegraph Co. of America* v. *National Electric Signalling Co.*, 213 Fed. 815. No appeal was taken, the defendant taking a license (Plaintiff's Exhibit 360, included in exhibits incorporated in the findings of the court below; offered "Other parts" R., p. 2101).

[9] *Marconi Wireless Telegraph Co. of America* v. *Kilbourne & Clark Mfg. Co.*, 265 Fed. 644, affirming 239 Fed. 328; decree, Pltf's Exh. 364 ("Other parts" R., pp. 2500-3, offered "Other parts" R., p. 2103).

[10] *Marconi* v. *British Radio Tel. & Tel. Co.*, (1911) 27 T. L. R. 274, 28 R. P. C. 181; the Judgment is Plaintiff's Exhibit 7 ("Other parts" R., pp. 1600-1640; offered "Other parts" R., p. 186). *Marconi* v. *Helsby Wireless Telegraph Co.*, (1914) 30 T. L. R. 688; 31 R. P. C. 399; the Judgment is Plaintiff's Exhibit 35 ("Other parts" R., pp. 1642-7; offered "Other parts" R., p. 202).

[11] *Societe Marconi* v. *Societe Generale, etc.*, Pltf's Exh. 36 ("Other parts" R., pp. 1648-1708; offered "Other parts" R., p. 202).

[12] Commissioner Johns, who reported on the issues of validity and infringement of petitioner's patents, had heard none of the testimony.

[13] *Marconi Wireless Telegraph Co. of America* v. *DeForest Radio Tel. & Tel. Co.*, 243 Fed. 560 affirming 236 Fed. 942.

contested motion to extend the decree, that certain additional apparatus infringed the Fleming patent (Pltf's Exh. 171; "Other parts" R. pp. 2104-5; offered "Other parts" R. p. 1346); and, after a trial in open court on Supplemental Bill, that still other apparatus also infringed the patent (261 Fed. 393). The Court of Claims, on testimony taken before an Examiner,[4] held that the patent had not been infringed, and indicated, in its opinion, that it considered the patent invalid (although not actually holding it invalid). (Court R. pp. 117, 165).

Although the patents have expired, the petitioner corporation has been kept alive for the purpose of prosecuting the present action in order to secure for its former stockholders a recovery for respondent's use of these important patents,—the claim against respondent being petitioner's sole remaining asset. (See Special Findings of Fact of the court below of November 4, 1935, Nos. VI and VII, together with the documents incorporated therein by reference; Court R. pp. 9-11.)

The present petition seeks a review of the decision of the Court of Claims only with respect to the Marconi patent No. 763,772 and the Fleming patent No. 803,684. As the Marconi reissue patent expired July 13, 1914, and as respondent's use of wireless apparatus up to that date was relatively small, no review is sought of the decision of the court below with respect to that patent.

As a result of the decision of the Court of Claims, petitioner, the owner of the four fundamental patents in the radio art (all previously sustained by courts of the United States), has been awarded less than $80,000 (plus additional compensation measured by interest) for respondent's purchase or manufacture and use, during the period covered by the claim, of upwards of $40,000,000 worth of radio

[4] See footnote 12, above.

apparatus.[15] We respectfully submit that this constitutes a substantial failure of justice for reasons set forth in our supporting brief (see p. 26, *infra*).

II.

The Questions Presented.

The questions presented are as to the validity and infringment of claims 1, 2, 3, 6, 8, 10 to 14, and 17 to 20 of the Marconi patent No. 763,772 and of claims 1 and 37 of the Fleming patent No. 803,684.

III.

Reasons Relied On for the Allowance of the Writ of Certiorari.

(1) Because the Court of Claims, in finding that the Marconi patent No. 763,772 was invalid as to claims 1, 2, 3, 6, 8, 10 to 14, and 17 to 20, and in failing to find that these claims were infringed by the apparatus described in its Special Findings of Fact XLVI, XLVIII, XLIX, and L of November 4, 1935, rendered a decision in conflict with the decisions of the Circuit Court of Appeals for the Ninth Circuit and the United States District Courts for the District of Washington and for the Eastern District of New York, on the same question and on substantially the same evidence, in *Marconi Wireless Telegraph Company of America* v. *Kilbourne & Clark Manufacturing Co.* (265 Fed. 644, affirming the decision of the Washington District Court, 239 Fed. 328), and in *Marconi Wireless*

[15] Other parts of R., p. 1957. The Interdepartmental Radio Board recommended to Congress that petitioner be awarded over $1,250,000 as compensation for respondent's use of the subject matter of the Lodge patent, the Marconi patent No. 763,772, and the Fleming patent (see brief, p. 20, *infra*).

Telegraph Company of America v. *National Electric Signalling Co.* (213 Fed. 815), respectively.[16]

(2) Because the Court of Claims, in finding that claims 1 and 37 of the Fleming patent No. 803,684 were not infringed and in failing to find that these claims were valid, rendered a decision in conflict with the decisions of the Circuit Court of Appeals for the Second Circuit and the United States District Court for the Southern District of New York, on the same question and on substantially the same evidence, in *Marconi Wireless Telegraph Company of America* v. *DeForest Radio Telephone & Telegraph Co.*[17] (243 Fed. 560, affirming the decision of the District Court, 236 Fed. 942); *Same* v. *Same* (memorandum opinion of the District Court; "Other parts" R., pp. 2104-5); and *Same* v. *Same* (261 Fed. 393, S. D., N. Y.).

(3) Because the Court of Claims, in limiting petitioner's compensation, for the use by respondent of upwards of $40,000,000 worth of radio apparatus during the accounting period, to less than $80,000 (plus additional compensation measured by interest), has rendered a decision which, in view of the prior recognized fundamental position of petitioner's patents in the radio art and in view of the proposed award to petitioner by the Interdepartmental Radio Board of upwards of $1,250,000, has resulted in a failure of justice as between the United States and one of its citizens.

[16] *The National Electric Signalling Co.* decision was followed by the District Court for the Southern District of New York, on a contested preliminary injunction motion, in *Marconi Wireless Telegraph Company of America* v. *DeForest, etc., Co.*, 225 Fed. 65; this decision was affirmed by the Circuit Court of Appeals for the Second Circuit, 225 Fed. 373. (See also Plaintiff's Exhibit 345, "other parts" R., pp. 2473-7; offered "Other parts" R., p. 2094).

[17] This decision was followed by the District Court for the District of Delaware, on a contested motion for a preliminary injunction, in *Marconi Wireless Telegraph Company of America* v. *Radio Audion Co.*, 278 Fed. 628.

WHEREFORE, your petitioner respectfully prays that a Writ of Certiorari be issued out of and under the seal of this Honorable Court, directed to the Court of Claims of the United States, commanding that court to certify and send to this Court on a day to be designated, a full and complete transcript of the record and all proceedings in this cause, in so far as the same are material to the errors herein assigned, to the end that this cause may be reviewed and determined by this Court; that the judgment of the Court of Claims of the United States be reversed in so far as errors therein have been assigned by your petitioner; and that petitioner be granted such other and further relief as may seem proper.

Dated, August 31, 1942.

ABEL E. BLACKMAR, JR.,
RICHARD A. FORD,
Counsel for Petitioner.

BRIEF IN SUPPORT OF PETITION FOR WRIT OF CERTIORARI.

Opinions of the Court Below.

The 1935 opinion of the Court of Claims of the United States on the issues of validity and infringement of the patents in suit is reported at 81 Ct. Cls. 741.

The 1942 opinion of the said court on the accounting proceeding is not yet reported, but will be found in the printed record at page 157.

Jurisdiction.

1. The final judgment of the Court of Claims, now sought to be reviewed, was rendered April 6, 1942 (Court R., p. 182).

2. By an order of the Chief Justice of this Court, dated May 21, 1942, petitioner's time to file its petition for writ of certiorari was extended to September 4, 1942.

3. The judgment was rendered in an action to recover compensation for the use or manufacture by or for the respondent, the United States, of apparatus embodying the subject matter of four letters patent of the United States; the action was brought under the Act of June 25, 1910, as amended July 1, 1918 (U. S. Code, Title 35, Section 68).

4. The jurisdiction of this Court is invoked under Sections 3 and 8 of the Act of February 13, 1925, as amended by the Act of May 22, 1939 (U. S. Code, Title 28, Sections 288 and 350).

5. Some of the cases believed to sustain the jurisdiction are:

Wilson & Co. v. *United States*, 311 U. S. 104;
United States v. *Pelzer*, 312 U. S. 399;
American Chicle Co. v. *United States*, — U. S. —, 86 L. Ed. 1106;
Standard Refrigerator Co. v. *Winters*, 280 U. S. 30;
Toledo Pressed Steel Co. v. *Standard Parts*, 307 U. S. 350;
Honolulu Oil Co. v. *Halliburton*, 306 U. S. 550.

Statement of the Case.

The facts, so far as this application is concerned, are stated in the petition. We wish, however, to add the following:

Both Senatore Guglielmo Marconi and Sir Ambrose Fleming, patentees of the two patents involved in this application, were widely recognized in the radio art as having made contributions of great value to the development thereof. Their patents which were involved before the Court of Claims in the present suit cover these contributions.

The two Marconi patents covered the fundamental features which made it possible for him to be the first to transmit intelligible messages across the Atlantic Ocean and which resulted in his becoming known as the "father of wireless". His position in the art of wireless telegraphy was recognized by Congress, when, on April 13, 1938,[1] it authorized and directed the Secretary of the Interior to grant permission to the Marconi Memorial Foundation, Inc., for the erection on public grounds of the United States in the District of Columbia, of a memorial "to the late Guglielmo Marconi, inventor of an apparatus for

[1] This was after the Court of Claims had held the Marconi reissue patent not infringed and all the broad claims of the second Marconi patent invalid.

wireless telegraphy", by the American people (Public Resolution No. 86, 75th Congress).[19]

Fleming likewise initiated, by the disclosure of the invention of his patent here in suit, a tremendous advance in the wireless art. His two-element tube or "valve" was the foundation upon which DeForest built his three-element tube or "audion" which opened up a multitude of new and unsuspected possibilities and which, in various improved forms, is in practically universal use to-day.

These facts have been judicially recognized not only in this country, but, as to the subject matter of Marconi patent No. 763,772, in England and France (see the cases referred to at page 5 of the Petition).

The fundamental character of petitioner's patents here in suit was also recognized by respondent's Interdepartmental Radio Board (the functions of which are described at pages 19-20, *ante*). The representative, on that Board, of the Department of Justice, said, before a Congressional committee, that "Those four patents are all fundamental."[20]

In considering these patents, it should be borne in mind that, as they expired considerably more than six years ago, no further claim for infringement of either of them can hereafter be made by petitioner or its assignee, either against respondent or anyone else.

Specification of Errors.

The errors which petitioner will urge, if the writ of certiorari is granted, are that the Court of Claims of the United States erred:

1. In holding that claims 1, 2, 3, 6, 8, 10 to 14, and 17 to 20 of Marconi patent No. 763,772 were invalid;

[19] A copy of the Resolution is appended hereto at page 37, *ante*, as Appendix B.

[20] Pltf's Ex. 122, [illegible] R., Vol. III, p. 1072.

2. In holding that the subject matter of said claims lacked invention;

3. In holding that the subject matter of said claims, or certain of them, was anticipated in the prior art;

4. In failing to hold that said claims of Marconi patent No. 763,772 involved invention, that they covered new and useful subject matter, and that Marconi was the first inventor of the subject matter thereof;

5. In failing to hold that said claims were valid;

6. In failing to make the ultimate finding of fact that said claims of Marconi patent No. 763,772 were infringed by the apparatus described in the Special Findings of Fact of the Court of Claims, Nos. XLVI, XLVIII, XLIX, and L, of November 4, 1935 (81 C. Cls. 705-710);

7. In failing to enter a judgment awarding to petitioner compensation for the manufacture and use by and for the respondent of apparatus utilizing the subject matter of claims 1, 2, 3, 6, 8, 10 to 14, and 17 to 20 of Marconi patent No. 763,772;

8. In failing to hold that claims 1 and 37 of Fleming patent No. 803,684 involved invention, that they covered new and useful subject matter, and that Fleming was the first inventor of the subject matter thereof;

9. In failing to hold that said claims of the Fleming patent were valid;

10. In holding that said claims of Fleming patent No. 803,684 were not infringed by the apparatus described in the Special Findings of Fact of the Court of Claims, Nos. LXXV, LXXVI, LXXVIII, and LXXIX, of November 4, 1935 (81 C. Cls. 735-740);

11. In failing to hold that said claims of the Fleming patent were infringed by the apparatus described in said find-

ings Nos. LXXV, LXXVI, and LXXIX, and that claim 1 of said patent was infringed by the apparatus described in said finding No. LXXVIII;

12. In failing to enter a judgment awarding to petitioner compensation for the manufacture and use by and for the respondent of apparatus utilizing the subject matter of claims 1 and 37 of Fleming patent No. 803,684.

Summary of Argument.

The various points or propositions which are set forth under the following captions summarize the argument.

ARGUMENT.

Point I.

The Court of Claims, in holding that claims 1, 2, 3, 6, 8, to 10, 14, and 17 to 20 of Marconi patent No. 763,772 were invalid, has rendered a decision in conflict with the decisions of the Circuit Court of Appeals for the Ninth Circuit and the United States District Courts for the District of Washington and for the Eastern District of New York, on the same question and on substantially the same evidence, in Marconi Wireless Telegraph Company of America v. Kilbourne & Clark Manufacturing Co. (265 Fed. 644, affirming the decision of the Washington District Court, 239 Fed. 428), and in Marconi Wireless Telegraph Company of America v. National Electric Signalling Co. (213 Fed. 815), respectively.

Prior to the decision of the Court of Claims, the Marconi patent No. 763,772 and the corresponding British and French patents had been sustained as valid by all courts to which that question had been presented.

The first decision, in point of time, was that of Mr. Justice Parker of the High Court of Justice, Chancery Di-

vision. Its judgment was delivered February 21, 1911.[21] Justice Parker held that Marconi's British patent No. 7,777 of 1900 (plaintiff's exhibit 34, included in exhibits certified as incorporated by reference in the court's findings; offered "Other parts" R. p. 202), corresponding to his patent here in suit No. 763,772, was valid and infringed, the invention covered thereby "producing an entirely new and useful result" ("Other parts" R. Vol. III, p. 1631).

In December, 1912, the Civil Tribunal of the Seine held that Marconi's corresponding French patent (No. 305,060; plaintiff's exhibit 142, "Other parts" R. Vol. IV, p. 2009; offered "Other parts" R. p. 532) was valid and infringed.[22] That court called the invention "a wonderful conquest" and said that "the Marconi patent stands out as an unassailable monument until new discoveries are made" ("Other parts" R. Vol. III, pp. 1663, 1690; see also "Other parts" R. Vol. III, pp. 1705-6).

The first decision in this country on Marconi patent No. 763,772, here in suit, was that of Judge Veeder in the *National Electric Signalling Co.* suit above referred to (213 Fed. 815). In that case, decided in 1914, the patent was held valid and infringed, Judge Veeder stating (213 Fed. 848) that Marconi had overcome the difficulties existent in prior art arrangements, and that:

> "In combination with the increased available energy in the transmitter, the distance over which messages could be sent was enormously increased. With this apparatus Marconi communicated across the Atlantic in 1901, and the claims in issue constitute the essential

[21] The judgment in this case, *Marconi* v. *British Radio Tel. Co.*, is reported in (1911) 27 T. L. R. 274, 28 R. P. C. 181; a copy is in evidence as plaintiff's exhibit 7 ("Other parts" R., Vol. III, pp. 1600-1640; offered "Other parts" R., p. 186).

[22] A translation of the judgment in this case, *Societe Marconi* v. *Societe generale, etc.*, is in evidence as plaintiff's exhibit 36, "Other parts" R., Vol. III, pp. 1648-1708; offered "Other parts" R., p. 202.

features of apparatus which has since made possible communication over a distance of 6,000 miles. It is used in more than 1,000 installations by Marconi, and is admittedly an essential feature of the wireless art as at present known and practiced."

Judge Veeder also referred to the subject matter of this Marconi patent as a "conspicuous advance in wireless telegraphy". (213 Fed. 858.)

Judge Veeder's decision was followed, on motion for preliminary injunction, by the District Court for the Southern District of New York in *Marconi Wireless Telegraph Co. of America* v. *De Forest, etc., Co.*, 225 Fed. 65. This decision was affirmed by the Circuit Court of Appeals for the Second Circuit (225 Fed. 373).

In July, 1914, the High Court of Justice, Chancery Division (Mr. Justice Eve), again held that Marconi's British patent No. 7,777 of 1900 was valid and infringed.[3]

In December, 1916, Marconi's American patent was again held valid, this time by the District Court for the District of Washington in the *Kilbourne & Clark Mfg. Co.* case above referred to (239 Fed. 328). Although the court there held that the patent had not been infringed, yet the decree (dated July 16, 1917) specifically held that Marconi patent No. 763,772 is "good and valid in law as to claims 1, 2, 3, 6, 8, 10, 11, 12, 13, 14, 16, 17, 18, 19, and 20" and that "Marconi was the first, true, original and sole inventor of the inventions described in said Letters Patent and claimed in the said claims" (plaintiff's Exhibit 364, ~~"Other parts"~~ Exhibit R., Vol. IV, pp. 2504-2; offered "Other parts" R., p. 2103). This District Court stated that what Marconi did "was a feat accomplishment" and that the ideas involved in the

[3] The judgment in this case, *Marconi* v. *Helsby Wireless Telegraph Co.*, is reported in (1914) 30 T. L. R. 633, 31 R. P. C. 399; a copy is in evidence as plaintiff's exhibit 35 (~~"Other parts"~~ Exhibit R., Vol. III, pp. 1642-7, offered "Other parts" R., p. 202).

patent "have proven of great value to the world." (239 Fed. 335, 342.)

The defendant, in the *Kilbourne & Clark* case, took a cross appeal from the adjudication of validity of the Marconi patent; on this appeal, the Circuit Court of Appeals for the Ninth Circuit considered the question of validity (see 265 Fed. 644, 661) and affirmed the degree of the District Court upholding the patent. In this respect, the Court of Claims was in error in stating (81 C. Cls. 762) that the validity of the Marconi patent was not passed upon in the *Kilbourne & Clark* case.[24]

In the face of this formidable array of decisions holding the Marconi patent valid, the Court of Claims, although stating in its 1937 Special Finding XLIV herein (81 C. Cls. 705) that

> "The invention of patent #763772 went into wide use in the United States and elsewhere. Apparatus embodying the invention of #763772 was employed in the first transatlantic radio signalling",

nevertheless held the patent invalid.

All of the prior art relied upon by the respondent in the present case with respect to this Marconi patent was admittedly involved in one or another of the prior American suits based on that patent (respondent's expert Loftin, "Other parts" R., p. 1068). For example, Marconi's prior patent No. 627,650 was discussed by Judge Veeder in the *National Electric Signalling* case, 213 Fed. 815, 859-860; the corresponding British patent was also discussed by Mr. Justice Parker ("Other Parts" R., Vol. III, p. 1609). The Tesla patent No. 645,576 was also discussed by Judge Veeder (213 Fed. 855-7) as well as by the French court ("Other Parts"

[24] Even though the Marconi patent was held not infringed in the *Kilbourne & Clark* case, the adjudication of validity "stands as an adjudication of one of the issues litigated." *Electrical Fittings Corp.* v. *The Thomas & Betts Co.*, 307 U. S. 241.

R., Vol. III, pp. 1685-1690). And the alleged 1899 correspondence between Stone and Baker was in evidence in the *Kilbourne & Clark* case and quoted, in part, in the opinion of the District Court (239 Fed. 339).

The prior American decisions were rendered after strenuously contested trials in which some or all of the testimony was taken in open court. In the Court of Claims, on the other hand, all of the testimony on the issues of validity and infringement was taken before an Examiner, usually a Notary Public; even the Commissioner who made the report on validity and infringement had heard none of the testimony.

Of course, the accomplishment of a patentee is measured by the advance made by him over the sum of human knowledge available at the time he made his invention. It is therefore important to appreciate that the decisions in all of the prior cases were rendered at a much earlier stage of the radio art, *i. e.*, at a time when the point of view of the witnesses, especially of the experts, more nearly reflected the point of view existent at the time the invention was made. The decision of the Court of Claims was rendered some thirty-five years after Marconi made the invention covered by his patent No. 763,772, after the phenomenal development of the art that started about 1916 as a result of the incentive of the World War of 1914-1918, and after years of advanced and intensive study and research which naturally made the original advances in the art seem, by comparison, simple and obvious. In other words, by 1935, when the first decision below was rendered, it had become extremely difficult, if not impossible, to recapture the point of view of 1900, whereas, in 1911-1916, when the prior decisions were rendered, comparatively little advance had been made in the art and the work of Marconi and other early inventors could be more easily seen in its true perspective. That which was made to the court below to appear, in 1935, to

have been obvious in 1900, did not appear to at least four courts, in 1911-1916, to have been obvious. Petitioner submits that this fact alone should lead this Court to scrutinize the decision of the Court of Claims in a review of this case.

In addition to the prior decisions mentioned above, consideration should also be given to the following facts:

In 1919, after the termination of the first World War, the Attorney General, the Secretary of the Navy, and the Secretary of War organized the Interdepartmental Radio Board, a group of representatives of these three departments. The function of the Board was to consider the claims of owners of various patents for inventions in the radio field for compensation for the use of the inventions by the United States during the war period, and to recommend the amount of compensation, if any, to which the claimants were entitled. ("Other parts" R., pp. 1099 *et seq.*)

The Board included a patent attorney of long experience in litigation involving radio patents, and a Naval officer (Lieutenant Commander Loftin, Chairman of the Board) who subsequently acted as the chief technical expert for respondent in the present case. The Board undertook "a very careful consideration of the whole situation"; it familiarized itself not only with the many patents on which claims were based but with the great mass of applicable prior patents and publications, possible prior uses where known, prior litigation involving the patents, and the structure and operation of such of respondent's apparatus as was asserted to infringe. Informal hearings were held. The Board determined whether and to what extent, in its opinion, the patents were valid and infringed,—seeking to arrive at the conclusion that would be arrived at by the Courts of Claims. ("Other parts" R., pp. 1099 *et seq.*) The work of the Board extended over a period of nearly two years and a half ("Other parts" R., p. 1104).

In 1921, the Board recommended to the heads of the three Departments that petitioner be awarded compensation in the sum of over $1,250,000 for respondent's use of the Lodge patent, the Marconi patent No. 763,772, and the Fleming patent. This recommendation was accepted by the heads of the Departments, as well as by the petitioner.

The recommendations were thereafter presented to the Committee on Military Affairs of the House of Representatives. At the Committee hearings, the Board was represented primarily by Commander Loftin who urged that Congress accept the recommendations and appropriate the funds to pay the various claimants (Plaintiff's Exhibit 122, "Other parts" R., pp. 1934 *et seq.*; offered "Other parts" R., p. 1098). The Committee on Military Affairs reported the proposed bill favorably to the House of Representatives (Plaintiff's Exhibit 363, "Other parts" R., Vol. IV, pp. 2496 *et seq.*; offered "Other parts" R., p. 2103), but Congress failed to pass the necessary legislation.

Thus there are arrayed against the 1935 decision of the court below to the effect that the above-mentioned claims of Marconi patent No. 763,772 were invalid the following decisions:

1. The 1914 decision of Judge Veeder in the Eastern District of New York (and the decisions of the southern New York District Court and the Second Circuit Court of Appeals which followed Judge Veeder's decision);

2. The 1920 decision of the Circuit Court of Appeals for the Ninth Circuit affirming the 1916 decision of the District Court for the District of Washington;

3. Two decisions, rendered in 1911 and 1914, of the High Court of Justice, Chancery Division, in England;

4. The 1912 decision of the Civil Tribunal of the Seine, in France; and

5. The recommendation, in 1921, of respondent's Interdepartmental Radio Board.

Petitioner respectfully submits that, under the circumstances above set forth, this Court should grant petitioner's writ of certiorari and review the decision of the Court of Claims as to the validity of claims 1, 2, 3, 6, 8, 10 to 14, and 17 to 20 of Marconi patent No. 763,772.

On the issue of infringement of said claims of this second Marconi patent in suit, it is clear from the 1935 Special Findings of Fact of the Court of Claims, Nos. XLVI, XLVIII, XLIX, and L, and from the opinion of that Court that that court considered that, if the claims were valid, they were infringed by respondent's apparatus described in those Findings. Therefore, no review of such Findings is requested by petitioner; the only thing that is sought on this issue is the ultimate Finding that said claims of Marconi patent No. 763,772 were infringed by such apparatus.

Point II.

The Court of Claims, in holding that claims 1 and 37 of Fleming patent No. 803,684 were not infringed, and in failing to hold that these claims were valid, has rendered a decision in conflict with the decision, rendered on the same questions and on substantially the same evidence, of the Circuit Court of Appeals for the Second Circuit, in Marconi Wireless Telegraph Company of America v. De Forest Radio Telephone & Telegraph Co. (243 Fed. 560, affirming 236 Fed. 942), *and the two subsequent decisions of the United States District Court for the Southern District of New York in the same case (memorandum opinion of July 11, 1917, not reported,[25] and 261 Fed. 393).*

[25] This memorandum opinion appears at "Other parts" R., Vol. IV, pp. 2104-5.

The trial of the case against DeForest Radio Telephone & Telegraph Co. was a strenuously contested trial, substantially all of the evidence having been taken in open court. The questions involved were identical with those in the present case, namely, whether claims 1 and 37 of the Fleming patent were valid and whether they were infringed by the use of three element vacuum tubes (then usually referred to as "audions") in wireless or radio detection (the use described in the 1935 Special Findings of Fact of the Court of Claims herein, Nos. LXXV and LXXIX; 81 C. Cls. 735, 749). The District Court (the late Judge Mayer) held that the patent was valid and infringed; the decision was affirmed on appeal, Judge Hough writing the opinion.[26]

On a motion to extend the injunction in the *DeForest* case to cover the use of three-element tubes in amplifiers and in generators of oscillations ("oscillators" or "Oscillions"), the District Court held, in a memorandum opinion (~~Other pates~~ R., pp. 2104-5), that amplifiers, being part of a detector, were within the prior decree but that, as to oscillators, further evidence should be presented.

Accordingly, there was a further trial in open court after which the District Court held that the use of three-element tubes in generators of oscillations infringed claim 1 of the Fleming patent.[27]

The Fleming patent was also before the Interdepartmental Radio Board, which recommended that petitioner receive compensation for respondent's use of three-electrode tubes in detectors, amplifiers, and oscillators.

In direct conflict with these decisions, the Court of Claims held, on evidence taken before an Examiner, that none of

[26] This decision was followed, on a contested motion for preliminary injunction, by the District Court for the District of Delaware, in *Marconi Wireless Telegraph Co. of America* v. *Radio Audion Co.*, 278 Fed. 628.

[27] No appeals were taken by the defendant from the decisions that the patent was infringed by amplifiers and oscillators.

the apparatus used by respondent infringed either claim 1 or claim 37 of the Fleming patent.

As in the case of the Marconi patent, all of the prior art here relied upon by respondent with respect to the Fleming patent was admittedly involved in the prior (DeForest) litigation (Loftin, "Other parts" R., p. 1068).

As to the decisions of the courts in the *DeForest* case, the Court of Claims said, first, "that both sides represented to the Court and agreed that the inherent qualities of the two-electrode tube and the three-electrode tube are the same." (81 C. Cls. 781); and, second, that those decisions were "quite incorrect" (81 C. Cls. 784).

As to the former statement, the Court of Claims was, we submit, in error.[2]

Contrary to the inference that might be drawn from this statement in the opinion of the Court of Claims, the *DeForest* case was a bitterly contested one.

The plaintiff in that case (petitioner here) did, of course, take the position that the two-electrode tube or Fleming valve was inherently capable of performing the same functions as the three-electrode tube or audion—just as it has done in this case. But the defendant in the *DeForest* case,

[2] The statement in Judge Mayer's opinion (246 Fed. 963) that "both sides agree that the *DeForest* two-element and three-element bulbs operate on the same principle", and that of the Circuit Court of Appeals (243 Fed. 565) that "it is agreed that the 'two' and 'three' electrode *audions* operate on the same basic principle" apparently misled the Court of Claims. What was meant by these statements is clarified by the Court of Appeals at 244 Fed. 562, where it is pointed out that the defendant in that case "insisted that the [Fleming] valve and the Audion utilize and depend for efficacy upon wholly different operations of nature". It was only in connection with certain *DeForest* patents (subject matter of a counterclaim and held either invalid or not infringed) as to which defendant contended that the principle of operation was the same, it was the devices of these patents that the courts in the *DeForest* case referred to in speaking of "DeForest two element" bulbs and "two-electrode audions"—not the device of the Fleming patent.

(Emphasis in this brief, is ours unless otherwise stated.)

like the respondent here, took the definite position that the audion operated on entirely different principles from the Fleming valve. To support this statement of ours and to show that the court below misunderstood the position of the defendant in the *DeForest* case, we here quote from briefs of that defendant. In the main brief before the District Court, counsel for the DeForest Company said:

> "The attempt to make out infringement [of the Fleming patent] by saying that the Audion has the Fleming circuit 'split up' is too vague a generalization in view of *the different operation of the two devices resulting from the existence of two instead of one circuit.*"
>
> "* * * a patentee cannot expand his patent to cover changes which cause the device to *function in an entirely different manner.* * * *" (P. 339).
>
> "The attempt now being made to sweep within the monopoly of the Fleming patent the PN Audion with its *radically different mode of operation*, is similar", etc. (P. 341.)

In the main brief for the DeForest Company before the Circuit Court of Appeals appears (at page 62) a heading reading as follows:

> "The Audion and its Mode of Operation are *Vitally Different in all Essential Features* from the Fleming Device and Fleming's Mode of Operation."

It is then stated that

> "The audion is *radically different* from the device of the Fleming patent *in principle, in essentials of apparatus and circuit connections, in purpose, and in the uses to which it is put.*"

There follows a section of over twenty-five pages devoted to an effort to show so-called "*Contrasting Laws of Operation* of Fleming and of the Audion" (pp. 63-90). And the Circuit Court of Appeals said (243 Fed. 562) that defendant

(the DeForest Company) insisted "that the [Fleming] valve and the audion utilize and depend for efficacy upon *wholly different operations of nature.*"

In fact the DeForest Company, in its briefs in that case, made substantially every argument of non-infringement that the respondent has made herein.

We respectfully submit that the Court of Claims, in stating that the decision in the *DeForest* case "has no application to the instant case" (81 C. Cls. 781) was clearly in error.

The statement of the Court of Claims that the decision of the Court of Appeals in the prior case was "quite incorrect" merely emphasizes the conflict between the two decisions and shows that the present case falls directly within the category of cases in which this Court normally grants a writ of certiorari.

The Court of Claims made no finding herein as to the validity of the Fleming patent. In its opinion, however, it indicated (81 C. Cls. 774) that it considered the Fleming patent to be invalid because of unreasonable delay in making the disclaimer. In this respect, again, the Court of Claims was in conflict with the decisions in the *DeForest* case. The Court of Appeals held in that case (243 Fed. 565) that the disclaimer was proper and did not affect the validity of the patent.[29]

Petitioner respectfully submits that, in view of the direct conflict of decision between the Court of Claims and the Circuit Court of Appeals for the Second Circuit with respect to the Fleming patent, this Court should review the

[29] It cannot be said that this decision was reached without proper presentation of the question on behalf of the DeForest Company, for, in a Supplemental Memorandum, presented by the late Frederick P. Fish (probably the leading patent attorney of the Bar at that time), several pages were devoted to the argument that the "Fleming Patent is Void Because • • • there was Unreasonable Neglect and Delay in Filing the Disclaimer." (Pp. 1 to 11 of said supplemental Memorandum.)

judgment herein holding that petitioner is not entitled to compensation with respect to that patent.

Point III.

The Court of Claims, in limiting petitioner's compensation, for the use by respondent of upwards of $40,000,000 worth of radio apparatus during the accounting period, to less than $80,000 (plus additional compensation measured by interest), has rendered a decision which, in view of the prior recognized fundamental position of petitioner's patents in the radio art and in view of the proposed award to petitioner by the Interdepartmental Radio Board of upwards of $1,250,000, has resulted in a failure of justice as between the United States and one of its citizens.

We have set forth above the function of and procedure followed by the Interdepartmental Radio Board, the fact that it described petitioner's patents involved in this case as the fundamental patents in the radio art, and its recommendation that Congress appropriate over $1,250,000 as compensation to petitioner. Although the action of the Board was without prejudice and is therefore not binding on respondent, yet we submit that it should be considered here in view of the character and purpose of the Board. Its recommendation with respect to petitioner's claim shows what the Departments of Justice, Navy, and War considered, after over two years' study of the radio patent situation, that petitioner was entitled to receive from respondent.

We respectfully submit that the judgment of the Court of Claims, awarding to petitioner a sum only about 6½% of the sum recommended by the Interdepartmental Radio Board, should challenge the attention of this Court and that this Court should not permit the judgment to stand without a review of the findings upon which it was based.

Point IV.

The Marconi patent No. 763,772 was valid as to claims 1, 3, 5, 6, 8, 10 to 14, and 17 to 20 thereof, and the subject matter of said claims was used by respondent.

A. *Said claims of the patent were valid.*

The substance of the invention of Marconi patent No. 763,772 is very simply and briefly stated in the Petition (*supra*, pp. 3-4).

The general principles of wireless that are essential for an understanding of the invention of this patent and of what preceded it; the history of the art up to the time Marconi made the invention covered by this patent; and the nature of the invention, as well as what was accomplished thereby (both scientifically and practically), are set forth in considerable detail in the opinions of Judge Wooley and of Mr. Justice Parker, above referred to.

It does not appear to us to be necessary, at this stage of the case, to add to these statements nor to argue at length the merits of the case. Also, in petitioner's opinion, the discussion in the two above decisions and that of the French court of the prior art and of the question of presence of invention is a sufficient treatment thereof for present purposes. The only evidence bearing on the validity of the Marconi patent that can be found in the Special Findings of the court below which was not discussed in these prior decisions is the so-called "Stone defense".

Stone is alleged to have written two letters (of doubtful authenticity as to dates) to Baker prior to Marconi's application date (defendant's Exhibits F-3 and G-3; included in the exhibits that were incorporated in the court's 1935 Findings; offered "Other parts" R., p. 733); excerpts from the letters are quoted in the opinion of the District Court

in the *Kilbourne* v. *Clark* case (which held the Marconi patent to be valid)[30] and in the Findings of the court below. There was also in evidence a patent to Stone, No. 714,756 (defendant's Exhibit X-3; included in the exhibits incorporated in the court's 1935 Findings; offered "Other parts" R., p. 866) the application for which was filed prior to the Marconi application but which did not issue as a patent until after the Marconi application had been filed.

Petitioner submits that the Stone-Baker letters, even if authentic (which is doubtful) do not disclose the Marconi invention; that, even if they do, they do not, under existing law, invalidate the Marconi patent; and that the Stone patent application, as it existed at any time prior to Marconi's date, did not disclose the Marconi invention.[31]

The court below did not hold the Marconi patent invalid on the basis of the Stone-Baker letters, saying (81 C. Cls. 767 at 811) "it is not necessary that we should decide whether a private letter such as Stone wrote to his friend would constitute a disclosure which would affect the Marconi patent * * *."

Judging from the 1935 opinion of the Court of Claims, the Marconi patent was held invalid for want of invention

[30] The court below evidently overlooked this fact for it stated in its opinion (81 C. Cls. 767) that

> "It was unnecessary for him [Judge Neterer] to pass on the validity of the Marconi tuning patent and he did not do so. * * *. If any inference is to be drawn from his opinion it is that it was proper to take into consideration the Stone letters."

However, Judge Neterer signed a decree upholding the validity of the Marconi patent (see supra, p. 16).

[31] With this last point, the court below apparently was in agreement. After making certain quotations from the Stone *patent* which might be argued to describe the Marconi invention, the court said (in its 1935 Special Finding LIV, 81 C. Cls. 716):

> "The quotations from lines 16-20 of page 2 and lines 62-66 of page 6 of the Stone specification were inserted by the amendment of April 8, 1902, after the application was filed in the Patent Office."

The Marconi application was filed November 10, 1900.

and this holding was based on the same prior patents and publications that had been considered in the prior decisions. The holding was therefore not based on new evidence and was in direct conflict, not only as to result but also as to reasoning, with the prior decisions. Further discussion, on the merits, of the validity of the Marconi patent therefore does not appear necessary at this stage of the case.

B. *The above-mentioned claims of the Marconi patent were infringed.*

As to the merits of the question of infringement, it seems necessary only to quote from the opinion of the Court of Claims:

> "We think it clear that the plain open-gap apparatus would be an infringement if the patent was valid, and we are likewise of the opinion that this would be true as to the apparatus using the rotary gap * * *." (81 C. Cls. 768.)

As to quenched-gap apparatus, the opinion stated:

> "It also appears that when it was used it was necessary to follow the same method of tuning as before." (81 C. Cls. 769.)

It seems clear that the court below considered that, if the patent were valid, it was infringed.

Petitioner therefore submits that, with respect to Marconi patent No. 763,772, the merits of the case are such that, in view of the direct conflict of decision as to the validity of the patent, this Court should review the decision of the court below denying to petitioner compensation based on that patent.

Point V.

The Fleming patent No. 803,684 was valid as to claims 1 and 37 thereof and the subject matter of said claims was used by respondent.

A. The patent was infringed.

The Fleming patent constituted the first disclosure of a multiple-element vacuum tube for use at the high electrical frequencies employed in radio—frequencies normally above 15,000 cycles per second and running up into millions of cycles. The specific disclosure of the patent was the use of a two-element vacuum tube ("Fleming valve") as the rectifying element of a radio detector.

Rather than attempt to set forth here the technical details of the operation of vacuum tubes we refer this Court to its own decisions in *Radio Corporation of America* v. *Radio Engineering Laboratories*, 293 U. S. 1, 10-11 and in *DeForest Radio Co.* v. *General Electric Co.*, 283 U. S. 664, 670 *et seq.*, and, with particular reference to the Fleming patent, to the decisions of the District Court and the Circuit Court of Appeals in the *DeForest* suit on that patent (239 Fed. 942 and 243 Fed. 560).

The controlling fact on the question of infringement is that Fleming taught the art that the action of a vacuum tube containing an incandescent electrode (filament or cathode) and another, cold, electrode (plate or anode) was substantially without inertia, that such a tube would operate at or respond to the extremely high frequencies used in radio, and, specifically, that suitable electrical circuits and apparatus, utilizing such a vacuum tube, operated to detect the presence of radio signals.

Dr. Lee DeForest, who had been carrying on abortive experiments with various gaseous devices for use in radio, learned of Fleming's invention and, shortly afterwards,

added a third element inside of the vacuum tube which, in a later form, was located between the filament and the plate of the Fleming valve and became known as the "grid" or "control electrode".

This was an invention of great importance, as has been universally recognized, but it was a direct outgrowth of and was built on the Fleming invention. As this Court expressed it in *Radio Corporation* v. *Radio Engineering Laboratories*, 293 U. S. 1, at p. 11:

> "DeForest's 'audion' changed the Fleming tube by interposing a special wire known as the 'grid' between the filament and the plate, thereby increasing its capacity as a detector of waves of radio or inaudible frequency and serving better to transform them into waves of audible frequency."

That the DeForest tube was a direct out growth of and built on the Fleming invention was specifically held by both courts in the *DeForest* case (236 Fed. at page 955 and 243 Fed. at page 566). The Circuit Court of Appeals said:

> "He [DeForest] began with the heated gas theory; he ended with the three-electrode audion, employing the commercial vacuum, and before he produced that success he learned of Fleming's invention and the latter's address before the Royal Society."

The Court of Claims, in the present case, disregarded this fact and, we submit, considered the question of infringement on narrow, technical grounds.

For the purposes of the present petition, we submit that, without further argument, it is clear that a decision of non-infringement under the circumstances stated above and under Point II, especially in view of the prior contrary decision of the Circuit Court of Appeals for the Second Circuit, is one which calls for review by this Court.

It seems unnecessary to consider here the further findings

of the court below (also contrary to the decisions of the Southern New York District Court) that the Fleming patent was not infringed by respondent's use of amplifiers and generators of oscillations utilizing three-element tubes or audions, since the direct conflict with the decision of the Circuit Court of Appeals on the question of infringement by detectors should, in our opinion, be sufficient to induce this Court to review the case.

B. *The Fleming patent was valid.*

On the question of validity, the Court of Claims, in its opinion, stated that it considered the patent invalid because of unreasonable neglect and delay in filing the disclaimer, citing the decision of this Court in *Easton* v. *Simon Asher & Co.*, 282 U. S. 445, 452. This question, as we have shown above, was specifically before the New York courts in the *De Forest* case, but was overruled by both courts.

The disclaimer limited the subject matter of the patent to use of the Fleming valve with high or radio frequencies; it therefore did no more than limit the patent to the invention which was described therein specifically and in considerable detail. It in no wise affected claim 37 of the patent (one of the claims here in suit).

Even if the patent, as originally issued, may be said, in claim 1 or elsewhere, to have attempted to cover the use of the Fleming valve as a rectifier of low frequencies, it did not seek to cover "more than that of which he [the patentee] was the original or first inventor or discoverer" (the situation to which the disclaimer provisions of the statute apply). For, so far as appears from the record herein, Fleming was the original and first inventor or discoverer of the fact that the two-element vacuum tube would rectify low frequency, alternating currents (respondent's witness Miller, "Other parts" R., p. [illegible], 672).

Under such circumstances, the disclaimer provisions of the patent statutes and the decision of this Court in the *Enston* case have no application.[32] These provisions, embodied in Revised Statutes sections 4917 and 4922 (U. S. Code, Title 35, sections 65 and 71), are set forth in Appendix C (*infra*, pp. 38-39). By their terms they are applicable only when the patentee "has claimed *more* than that of which *he* was the original or first inventor or discoverer" or when he has "claimed to be the original and first inventor or discoverer of any material or substantial part of the thing patented, of which *he* was *not* the original and first inventor and discoverer".

Respondent has not shown that Fleming was not the first inventor or discoverer of low-frequency rectification—the disclaimed matter. Therefore, even if Fleming disclosed such low-frequency rectification a considerable time before he filed his application for the patent in suit, and even if the patent, as issued, purported to cover such use of the Fleming valve, nevertheless the patent did not claim more than that of which Fleming was the original and first inventor or discoverer. The disclaimer provisions of the statute, therefore, by their specific terms, do not apply to the Fleming patent.

We of course do not assert that, if Fleming published a description of the use of his tube as a rectifier of low frequency currents more than two years before his application was filed, he had the right validly to claim such use in the patent. What we do assert is that the Court of Claims was clearly in error in attempting to apply the disclaimer provisions and in asserting that the patent was void for unreasonable neglect and delay in filing a disclaimer.

[32] In the case of the Enston patent, the invalid claim was too broad and included "More than that of which he, the patentee, was the original or first inventor or discoverer." *Enston* v. *Rock-Sampliner Co.*, 13 Fed. (2d) 132, 133.

Even if the disclaimer sections of the statute were applicable to the circumstances above set forth, and even if, in so far as the patentee himself was concerned, it might be thought that there was unreasonable neglect and delay, we nevertheless submit that those sections do not invalidate the patent in so far as *petitioner* is concerned.

We note, first, that Revised Statutes section 4917 states that the patent "*shall be valid* for all that part which is truly and justly" the patentee's, and that the "patentee, his heirs *or assigns*, whether of the whole or any sectional interest therein, *may* * * * make disclaimer", etc. The statute also provides that the disclaimer is applicable only to the interest possessed by the one filing it (and those claiming under him).

In Revised Statutes section 4922, we find the provision that a suit at law or in equity may be maintained by the "patentee, his executors, administrators, and *assigns*" for infringement of any part of the patent "which was *bona fide* his own, * * * notwithstanding the specifications may embrace more than that of which the patentee was the first inventor or discoverer." The section then provides, as penalty for failure to file a disclaimer before commencement of suit, that "plaintiff" (i. e., the patentee, his executors, administrators, or assigns) shall not recover costs. The last sentence of the section reads:

> "But *no patentee* shall be entitled to the benefits of this section if he has unreasonably neglected or delayed to enter a disclaimer."

This is the only portion of the statute which requires that the disclaimer be filed promptly. In the absence of this sentence, failure to file a disclaimer would only affect the recovery of costs and, by the very terms of the statute, the patent would be valid as to all parts thereof of which the patentee was the first inventor or discoverer.

Throughout these two sections, Congress carefully distinguished between the patentee and those claiming under him (such as his assignees). The provision as to unreasonable neglect and delay applies, by its terms, only to the patentee and not to his assigns. Thus Congress saw fit to deprive a dilatory patentee (who had made oath to certain facts) of the benefits of this remedial statute but did not see fit to deprive his assignee of such benefits.[53] If it had been the intention of Congress, to make no distinction here between the patentee and his assignee, there would have been no difficulty in making this sentence read that no one maintaining such a suit at law or in equity should be entitled to the benefits of the section if there had been unreasonable neglect and delay in entering a disclaimer. Such, however, is not the way that the statute reads.

Petitioner therefore submits, as to the disclaimer, first, that Revised Statutes sections 4917 and 4922 do not apply where, as here, the patentee was himself the first inventor or discoverer of the disclaimed subject matter; and second, that the unreasonable neglect and delay provision of Revised Statutes section 4922 does not apply to the assignee of a patent.

We also submit that a proper construction of the patent, as originally issued and without the disclaimer, would construe claim 1, if necessary to sustain the validity thereof, as limited to the use of the apparatus thereof in connection with high-frequency currents, as described in the specification; that therefore, the disclaimer was unnecessary; and that the disclaimer, in any event, did no more than clarify the scope of the patent and should not be held to have invalidated it, or to have deprived petitioner of the right to recover from respondent for its unauthorized use of the subject matter thereof.

[53] Note that the far less drastic provision (that relating to costs) does, by the terms of the statute, apply both to patentee *and* assignee.

The Court of Claims, in its opinion, did not specifically pass on the other grounds of invalidity urged by respondent. The opinion, to us, indicates that the court below considered that, except for the disclaimer, the patent was valid. In view of the careful consideration of these other questions by the two New York courts, the lower of which had seen and heard the witnesses, we do not think that further discussion of the question of validity is necessary at this stage of the present case.

Petitioner therefore submits that, with respect to the Fleming patent, the merits of the case are such that, in view of the direct conflict between the decisions of the Court of Claims and of the Circuit Court of Appeals for the Second Circuit, this Court should review the decision of the Court below denying to petitioner compensation based on the Fleming patent.

Conclusion.

Wherefore, Petitioner respectfully prays that the petition for writ of certiorari be granted, the cause reviewed, and the judgment of the Court of Claims reversed in so far as error therein has been assigned by Petitioner.

Respectfully submitted,

Abel E. Blackmar, Jr.,
Richard A. Ford,
Counsel for Petitioner.

APPENDIX A.

Act of June 25, 1910, as amended July 1, 1918 (U. S. Code, Title 35, section 68): Whenever an invention described in and covered by a patent of the United States shall hereafter be used or manufactured by or for the United States without license of the owner thereof or lawful right to use or manufacture the same, such owner's remedy shall be by suit against the United States in the Court of Claims for the recovery of his reasonable and entire compensation for such use and manufacture: *Provided, however*, That said Court of Claims shall not entertain a suit or award compensation under the provisions of this act where the claim for compensation is based on the use or manufacture by or for the United States of any article heretofore owned, leased, used by, or in the possession of the United States: *Provided further*, That in any such suit the United States may avail itself of any and all defenses, general or special, that might be pleaded by a defendant in an action for infringement, as set forth in title sixty of the Revised Statutes, or otherwise: *And provided further*, That the benefits of this act shall not inure to any patentee who, when he makes such claim, is in the employment or service of the Government of the United States, or the assignee of any such patentee; nor shall this act apply to any device discovered or invented by such employee during the time of his employment or service.

APPENDIX B.

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Interior be, and he is hereby, authorized and directed to grant permission to The Marconi Memorial Foundation, Inc., for the erection on public grounds of the United States in the District of Columbia, other than those of the Capitol, the Library of Congress, and the White House, of a memorial of simple and artistic form to the late Guglielmo Marconi, inventor of an apparatus for wireless telegraphy, by the American people: *Provided*, That the site chosen and the design of the

memorial shall have the approval of the National Commission of Fine Arts and that the United States shall be put to no expense in or by the erection of the said memorial: *Provided further*, That unless funds, which in the estimation of the Secretary of the Interior are sufficient to insure the completion of the memorial, are certified available, and the erection of this memorial begun within five years from and after the passage of this legislation, the authorization her by granted is revoked.

APPENDIX C.

Revised Statutes section 4917 (U. S. Code, Title 35, section 65): Whenever, through inadvertence, accident, or mistake, and without any fraudulent or deceptive intention, a patentee has claimed more than that of which he was the original or first inventor or discoverer, his patent shall be valid for all that part which is truly and justly his own, provided the same is a material or substantial part of the thing patented; and any such patentee, his heirs or assigns, whether of the whole or any sectional interest therein, may, on payment of the fee required by law, make disclaimer of such parts of the thing patented as he shall not choose to claim or to hold by virtue of the patent or assignment, stating therein the extent of his interest in such patent. Such disclaimer shall be in writing, attested by one or more witnesses, and recorded in the Patent Office; and it shall thereafter be considered as part of the original specification to the extent of the interest possessed by the claimant and by those claiming under him after the record thereof. But no such disclaimer shall affect any action pending at the time of its being filed, except so far as may relate to the question of unreasonable neglect or delay in filing it.

Revised Statutes section 4922 (U. S. Code, Title 35, section 71): Whenever, through inadvertence, accident, or mistake, and without any willful default, or intent to defraud or mislead the public, a patentee has, in his specification, claimed to be the original and first inventor or discoverer of any material or substantial part of the thing patented, of which he was not the original and first inventor or discoverer, every such patentee, his executors, adminis-

trators, and assigns, whether of the whole or any sectional interest in the patent, may maintain a suit at law or in equity, for the infringement of any part thereof, which was bona fide his own, if it is a material and substantial part of the thing patented, and definitely distinguishable from the parts claimed without right, notwithstanding the specifications may embrace more than that of which the patentee was the first inventor or discoverer. But in every such case in which a judgment or decree shall be rendered for the plaintiff, no costs shall be recovered unless the proper disclaimer has been entered at the Patent Office before the commencement of the suit. But no patentee shall be entitled to the benefits of this section if he has unreasonably neglected or delayed to enter a disclaimer.

Here follows 2 Exhibits 21 and 22

IN THE

Supreme Court of the United States

OCTOBER TERM, 1942

No. 369

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA,

Petitioner,

vs.

THE UNITED STATES,

Respondent.

REPLY BRIEF FOR PETITIONER IN SUPPORT OF PETITION FOR WRIT OF CERTIORARI

ABEL E. BLACKMAR, JR.,
RICHARD A. POSTO,
Counsel for Petitioner.

December, 1942

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(1) There is adequate basis for review under the Act of February 13, 1925, as amended May 22, 1939 1

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IN THE

Supreme Court of the United States

OCTOBER TERM, 1942

No. 369

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA,

Petitioner,

vs.

THE UNITED STATES,

Respondent.

REPLY BRIEF FOR PETITIONER IN SUPPORT OF PETITION FOR WRIT OF CERTIORARI

Most of the arguments set forth in respondent's brief were anticipated in the petition and supporting brief and are there, we believe, fully answered. We will therefore here confine ourselves to two of the subjects discussed in respondent's brief.

(1) There is adequate basis for review under the Act of February 13, 1925, as amended May 22, 1939:

Section 3 of the Act of February 13, 1925 (U. S. Code, Title 28, section 288), *prior to the amendment of 1939*, provided that none of the evidence in a case before the Court of Claims should be included in the transcript of record on petition to this Court for a writ of certiorari. The record

We submit that the 1939 amendment made the decisions of this Court in cases like *Thomson Co.* v. *Ford Motor Co.*, 265 U. S. 445, 447, and *Sanitary Co.* v. *Winters*, 280 U. S. 30, 36, applicable to cases brought here from the Court of Claims. These cases pointed out, first, that the general rule, on review of decisions of circuit courts of appeals (as on review of decisions of the Court of Claims), is that concurrent findings of the lower courts on questions of fact will be accepted by this Court unless clear error is shown; it was then said, in the *Thomson* case (265 U. S., at p. 447):

> "We think, however, that this rule should not be strictly applied in cases brought here because of a conflict of decision in the different circuit courts of appeal, and have therefore given consideration to the question as to which of the decisions upon this question of fact, in the light of the prior art, is based upon the sounder reasoning."

Where two courts have reached diametrically opposed conclusions on substantially the same evidence, the question as to which conclusion is correct becomes, we submit, in effect a question of law.

(2) The decision of the Court of Claims herein that claims 1, 2, 3, 6, 8, 10-14, and 17-20 of Marconi patent No. 763,772 were invalid and that claims 1 and 37 of the Fleming patent had not been infringed was in direct conflict with prior decisions of other courts, including circuit courts of appeals:

(a) As to the decision in *Marconi Wireless Telegraph Company of America* v. *Kilbourne & Clark Mfg. Co.*, 239 Fed. 328, affirmed 265 Fed. 644 (Circuit Court of Appeals for the Ninth Circuit), respondent asserts (brief, p. 11) that the so-called "Stone defense" was presented solely to sustain the defense of "noninfringement of the invention as

limited by the prior art,' "—seeking thus to explain away the specific holding in the decree in that case that the Marconi patent No. 763,772 was valid. Respondent's assertion is not in accord with the facts.

The defendant in the *Kilbourne & Clark* case devoted over 90 pages of its brief before the district court to an attempt to show "prior invention" and "prior knowledge" of the subject matter of the Marconi patent by Stone; the conclusion stated in the brief was that "In all essentials Stone is an exact anticipation of Marconi." (Brief for Defendant, p. 212.)

Similarly, over 50 pages of defendant's appeal brief, in the *Kilbourne & Clark* case, was devoted to the alleged anticipatory character of the "Stone defense", defendant's conclusion reading—

> "The Stone anticipation ought to be conclusively adjudicated now by effectuating the favorable Stone dicta of the Court below and declaring the Marconi patent invalidated by Stone; because while defendants commercial apparatus is so clearly non infringing, yet the validity issue may become important in connection with apparatus made for the government on its specifications." (Brief for Kilbourne & Clark Mfg. Co., p. 435.)

The so called "Stone defense" was therefore litigated in the *Kilbourne & Clark* case on the issue of validity. As the Marconi patent was there held valid, the decision of the Court of Claims herein is in direct conflict therewith.

Likewise, the Tesla patent, No. 645,576, was considered at length in defendant's briefs in the *Kilbourne & Clark* case,—both before the district court and before the circuit court of appeals; and, of course, the Lodge patent, being in suit in that case, was also before both courts. As to the Tesla patent, the defendant in that case argued that—

"This is a complete anticipation of all the fundamentals of the four tuned circuit radio telegraph system of plaintiff's patent, wherein a 'closed' circuit is coupled by a transformer to a grounded antenna at each station." (Brief on appeal for Kilbourne & Clark Mfg. Co., p. 333.)

In view of the foregoing, respondent's argument that the adjudication of validity of the Marconi patent in the *Kilbourne & Clark* (and other) cases is not inconsistent with the result reached below, is clearly erroneous,—the same prior art having admittedly been before both courts.

Regardless of what respondent may say, the fact remains that the Marconi patent was held valid in all of the cases referred to in our petition herein (pp. 4-5) and was held invalid, as to claims 1, 2, 3, 6, 8, 10-14, and 17-20, by the court below.

(b) As to the Fleming patent, respondent is also in error in arguing that the prior *DeForest* case on that patent did not involve "the question of infringement here presented." As respondent admits (brief, p. 7), its alleged infringement consisted in the use of "the DeForest three-element vacuum tubes as detectors and amplifiers." Similarly, the alleged (and adjudicated) infringement in the case of *Marconi Wireless Telegraph Company of America* v. *DeForest Radio Tel. & Tel. Co.*, 236 Fed. 942, affirmed 243 Fed. 566 (Circuit Court of Appeals for the Second Circuit), was the use of DeForest three-element vacuum tubes as detectors.[1]

---

[1]Their use as amplifiers and as generators of oscillations was before the district court only, the adjudication of infringement in those subsequent decrees not having been appealed by defendant. (See p. 22 of our brief in support of our petition for certiorari.)

Again, the fact remains that the Second Circuit Court of Appeals held that claims 1 and 37 of the Fleming patent were infringed by the use of DeForest three-element vacuum tubes as detectors, whereas the court below held directly to the contrary.

(c) It is to be noted that respondent does not suggest that the *evidence* in the present case differs from that in the prior cases, but merely that the positions taken or arguments made by the parties have been different. Thus, respondent's argument is tantamount to saying that, in order to avoid the effect of a prior decision, it is only necessary to make a new argument on the same evidence.

As the issues in the prior cases were the same as in the present case and as the evidence was substantially the same, we submit that there is no sound basis for arguing, as respondent does, that the prior adjudications were not inconsistent with the results reached below.

CONCLUSION

We respectfully urge that plaintiff's petition for a writ of certiorari herein be granted.

Respectfully submitted,

ABEL E. BLACKMAR, JR.,
RICHARD A. FORD,
Counsel for Petitioner.

December, 1942.

CPY643

IN THE

Supreme Court of the United States

OCTOBER TERM, 1942.

Nos. 369 and 373.

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA,
Petitioner and Cross-Respondent,

vs.

THE UNITED STATES,
Respondent and Cross-Petitioner.

BRIEF FOR PETITIONER AND CROSS-RESPONDENT

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Of Counsel for Petitioner and Cross-Respondent.

March, 1943.

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IN THE

Supreme Court of the United States

OCTOBER TERM, 1942.

Nos. 369 and 373.

MARCONI WIRELESS TELEGRAPH COMPANY, OF AMERICA,
Petitioner and Cross-Respondent,

vs.

THE UNITED STATES,
Respondent and Cross-Petitioner.

BRIEF FOR PETITIONER AND CROSS RESPONDENT

This action was brought by the petitioner and cross-respondent, hereinafter referred to as plaintiff, under the Act of June 25, 1910, as amended by the Act of July 1, 1918, 35 U. S. Code, Sec. 68, claiming compensation because of use by the United States of certain inventions covered by United States Letters Patent.

A final judgment was entered on April 6, 1942 by the Court of Claims of the United States, each side petitioned for a writ of certiorari, and this Court granted the petitions on December 14, 1942.

This brief will discuss the issues on both petitions, because the only issues on the cross-petition relate to one claim of a Marconi patent, other claims of which are among the subjects of plaintiff's petition. Such discussion will avoid unnecessary repetition.

Opinions of the Court Below

The Court of Claims on November 4, 1935, filed its findings of fact and conclusions of law (1 R. 7; 81 Ct. Cl. 671) and its opinion (1 R. 75; 81 Ct. Cl. 741), on the issues of the validity and infringement of the patents; and on April 6, 1942, filed its findings of fact, including among them what previously had been expressed as conclusions of law (1 R. 117) and its opinion (1 R. 157) on the amount of compensation due plaintiff (not yet reported).

There are now only two patents before this Court. Originally, there were four patents in suit: Marconi reissue 11,913, Lodge 609,154, Marconi 763,772 and Fleming 803,684, all of which expired in 1922 or earlier.

The Marconi reissue patent was held not infringed (conclusion of law, 1 R. 75, and finding of fact, 1 R. 117). The Lodge patent was held valid and infringed (conclusion of law, 1 R. 75, and finding of fact, 1 R. 117), the Court finding as reasonable compensation $34,827.70 with interest "as a part of the entire or just compensation" (1 R. 135). Both parties have accepted these decisions, so only the last two patents are in issue here.

The Marconi patent 763,772 was decided to be invalid, except as to claim 16 which was held valid and infringed (conclusion of law, 1 R. 75, and finding of fact, 1 R. 117). This decision is in conflict with the decisions in *Marconi* v. *National Electric Sig. Co.*, 213 Fed. 815 (D. C., E. D. N. Y.); *Marconi* v. *Kilbourne & Clark Mfg. Co.*, 9 Cir., 265 Fed. 644, affirming 239 Fed. 328 (D. C. Wash.); *Marconi* v. *British Radio, etc. Co.* (1911), 27 T. L. R. 274, 28 R. P. C. 18 (4 R. 2525; offered, 1 R. 186) on the corresponding British patent; and *Societe*

Marconi v. *Societe Generale, etc.*, Civil Tribunal of the Seine, on the corresponding French patent (4 R. 2622; offered, 1 R. 202).

The Court of Claims allowed compensation for use of claim 16 of the Marconi patent amounting to $42,984.93 with interest "as part of the entire compensation" (1 R. 156), defendant assigning as error the findings that this claim was valid and infringed, but not the amount awarded if the claim was rightly held valid and infringed.

The Fleming patent was decided by the Court of Claims to be not infringed (conclusion of law, 1 R. 75, and finding of fact, 1 R. 117), and the Court also said in its opinion that the patent was invalid because of delay in filing a disclaimer (1 R. 106, 107), but did not so find. These views are in conflict with *Marconi* v. *De Forest*, 2 Cir., 243 Fed. 560, affirming 236 Fed. 942 (D. C., S. D. N. Y.).

Jurisdiction

The final judgment of the Court of Claims, now sought to be reviewed, was rendered April 6, 1942 (1. R. 117).

The judgment was rendered in an action to recover compensation for the use or manufacture by or for the respondent, the United States, of apparatus embodying the subject matter of four letters patent of the United States. The action was brought under the Act of June 25, 1910, as amended July 1, 1918 (U. S. Code, Title 35, Section 68).

The jurisdiction of this Court is invoked under Sections 3 and 8 of the Act of February 13, 1925, as amended by the Act of May 22, 1939 (U. S. Code, Title 28, Sections 288 and 350). The time to file petition for certiorari was enlarged by order of the Chief Justice of this Court (3 R. 2523).

Statement of the Case

This suit was brought in 1916 by the Marconi Wireless Telegraph Company of America, a New Jersey corporation (1 R. 1), which had then been engaged for several years in the wireless business in this country (Brennan, 1 R. 191, *et seq.*, 2 R. 1347, *et seq.*; Sarnoff, 2 R. 1256, 1273).

In 1919, the Marconi Company conveyed substantially all its assets, except some claims, including the present one, to Radio Corporation of America, which claims the Marconi Company reserved for prosecution, the Radio Corporation advancing the money for such prosecution (1 R. 9-11). The Marconi Company was dissolved in 1920, thereafter acting by trustees in dissolution (1 R. 9), and the claims in the present suit are and for many years have been its only asset.

The taking of testimony commenced in 1917 (1 R. 184-453), and was suspended at the request of the Government until after the war (4 R. 2842-2854), when, because of many claims for the use of radio patents by the Government, an Interdepartmental Radio Board was appointed, consisting of representatives of the Department of Justice, the War Department and the Navy Department, to examine the various patent claims, consider questions of validity, infringement and extent of use, and determine what would be reasonable compensation.

The Board made an exhaustive study of the numerous radio patents submitted to it and thoroughly investigated the entire radio art, examining about 2,500 United States patents, hundreds of foreign patents, and hundreds of United States and foreign publications, and "finally came down to a real serious consideration of 149 patents. This consideration involved searches of the art, writing of long reports, receipt of briefs from claimants, hearings, more

briefs, revised reports, and then an accounting on those patents considered good, which were 27 in number, with much discussion following as to the methods of accounting and the effect of decisions thereon" (hearings before House Committee, 4 R. 2831, 2847; off., 2 R. 1098). On some patents "we did question the validity and made no allowance on them" (chairman of board, hearings before House Committee, 4 R. 2852; off., 2 R. 1098).

The Marconi claim on the four patents in suit was $6,000,000 (1 R. 6), and the Board, after careful analysis of the patents and apparatus (4 R. 2858; off., 2 R. 1098), made a formal report, recommending $1,253,389.02 as compensation (4 R. 2877; off., 2 R. 1098), for $26,399,490.60 of infringing apparatus (4 R. 2823), which is about 4.7%. This report, however, is not in any way controlling in the present litigation, having been made without prejudice.

The report was presented to Congress by the Secretaries of War and the Navy, and the Attorney General, but as no legislation was enacted to carry out its recommendations, the taking of testimony in the present suit was resumed in 1922 (1 R. 453), and concluded in 1930. As customary in Court of Claims cases, a Commissioner was appointed to consider the evidence which had been taken, but another Commissioner succeeded him, who filed a report in June 1933 and the Court of Claims then considered the questions of validity and infringement, there being reserved by stipulation the taking of evidence on the issue of reasonable compensation for the patents found valid and infringed (1 R. 175), and in November 1935 filed its findings, conclusions and opinion (1 R. 7, *et seq.*). Then followed the taking of evidence as to how much apparatus

had been used by defendant which infringed the Lodge patent and claim 16 of the Marconi patent 763,772.

The claims urged in this suit were based upon apparatus purchased and used by the Army and Navy prior to 1920, principally during the last World War. Plaintiff did not know the extent of the infringement and could ascertain and prove the facts regarding it only by records which in the main were secret records of the Army and Navy departments. Before plaintiff could secure the production of such records, it had to identify them from such source records as it possessed or were made available to it by defendant and third parties. Government departments then produced, at plaintiff's request, hundreds of army and navy contracts, together with the files relating thereto, all of which had to be examined to determine the nature of the apparatus called for under the contracts, and whether it was delivered and paid for (1 R. 121). About 100 of these contracts are listed in the record (1 R. 122, 123, 145). This was a lengthy process because naturally the various Army and Navy officers who from time to time were in charge of records relating to the contracts were not primarily interested in the *Marconi* law suit.

The Court of Claims points out (1 R. 174) that defendant in 1940 stated

> "The highly technical character of the subject-matter, the difficulty of assembling competent witnesses, and the time required for preparation by both parties are believed to be such as to indicate reasonable speed by both parties".

Litigation against the Government is not always a speedy process. As appears from *U. S.* v. *Citizens Loan & Trust Co.*, 316 U. S. 209, it took about twenty-three

years to collect a $10,000 insurance policy. In cases such as the present one, where the evidence is taken out of Court, the issues are many and complicated, and defendant relies upon witnesses from the Army and Navy departments, more time is required than in ordinary suits. The submission of evidence on the accounting closed in March, 1940, the Commissioner twice reopened the case to take more evidence, and in 1941 filed his report, the Court of Claims deciding the case in April 1942.

Questions Presented by the Two Writs

1(a) Validity of all claims in suit, except claim 16, of Marconi patent 763,772 (plaintiff's writ). The Court of Claims found that they were invalid.

(b) Infringement of all claims in suit, except claim 16, of the Marconi patent (plaintiff's writ). The Court did not make any ultimate finding of fact on this issue, but intimated in its opinion and findings (1 R. 44, 45, 95, 96, 101) that the claims were infringed, if the claims were valid.

2. Validity and infringement of claim 16 of the Marconi patent (defendant's writ). The Court of Claims found that it was valid and infringed.

3(a) Validity of claims 1 and 37 of the Fleming patent, especially in view of a disclaimer (plaintiff's writ). The Court of Claims said the claims were invalid for delay in filing the disclaimer (1 R. 106, 107), but did not so find.

(b) Infringement of claims 1 and 37 of the Fleming patent (plaintiff's writ). The Court of Claims found that they were not infringed.

The specifications of error on the two petitions present the above points.

Specification of Errors on the Two Writs

Plaintiff in its brief on the petition for a writ urged the following errors by the Court of Claims:

(1) In holding that claims 1, 2, 3, 6, 8, 10 to 14, and 17 to 20 of Marconi patent No. 763,772 were invalid;

(2) In holding that the subject matter of said claims lacked invention;

(3) In holding that the subject matter of said claims, or certain of them, was anticipated in the prior art;

(4) In failing to hold that said claims of Marconi patent No. 763,772 involved invention, that they covered new and useful subject matter, and that Marconi was the first inventor of the subject matter thereof;

(5) In failing to hold that said claims were valid;

(6) In failing to make the ultimate finding of fact that said claims of Marconi patent No. 763,772 were infringed by the apparatus described in the Special Findings of Fact of the Court of Claims, Nos. XLVI, XLVIII, XLIX, and L, of November 4, 1935 (81 C. Cls. 705-710);

(7) In failing to enter a judgment awarding to petitioner compensation for the manufacture and use by and for the respondent of apparatus utilizing the subject matter of claims 1, 2, 3, 6, 8, 10 to 14, and 17 to 20 of Marconi patent No. 763,772;

(8) In failing to hold that claims 1 and 37 of Fleming patent No. 803,684 involved invention, that they covered

new and useful subject matter, and that Fleming was the first inventor of the subject matter thereof;

(9) In failing to hold that said claims of the Fleming patent were valid;

(10) In holding that said claims of Fleming patent No. 803,684 were not infringed by the apparatus described in the Special Findings of Fact of the Court of Claims, Nos. LXXV, LXXVI, LXXVIII, and LXXIX, of November 4, 1935 (81 C. Cls. 735-740);

(11) In failing to hold that said claims of the Fleming patent were infringed by the apparatus described in said findings Nos. LXXV, LXXVI, and LXXIX, and that claim 1 of said patent was infringed by the apparatus described in said finding No. LXXVIII;

(12) In failing to enter a judgment awarding to petitioner compensation for the manufacture and use by and for the respondent of apparatus utilizing the subject matter of claims 1 and 37 of Fleming patent No. 803,684.

Defendant in its petition for a writ urged the following errors by the Court of Claims (defendant's cross-petition for writ, p. 10):

(1) In finding as an ultimate fact that claim 16 of the Marconi patent was valid and was infringed, without first determining its scope in view of the prior art.

(2) In failing to make a finding of fact as to the particular advantage achieved by the shunt condenser in the open antenna circuit of the Marconi patent, and in making a finding of infringement in the absence of such finding.

(3) In failing to find as a fact that the disclosure of the Marconi patent upon which claim 16 is based did not possess the principal advantage of cross-petitioner's structure but possessed a different advantage not used by cross-petitioner.

(4) In basing compensation upon the principal advantage present in cross-petitioner's structures, when such advantage was not disclosed or attained in the patent in suit.

(5) In not revising its findings of fact to conform to the entire evidence in the case where evidence necessarily admitted in the accounting proceedings, to establish a basis for compensation, disclosed incompleteness and error in the findings of fact theretofore made in relation to the infringement of claim 16 of the Marconi patent (No. 763,772).

Summary of Argument

1. This Court can review questions of law, including whether there is a lack of substantial evidence to sustain a finding of fact, whether an ultimate finding or findings are not sustained by the findings of evidentiary or primary facts, and whether there was a failure to make any finding of fact on a material issue.

2. The broad claims of the Marconi patent, which the Court of Claims decided were invalid for want of invention, are valid. The contribution of the Marconi patent to the practical art was of great value, it was made in the obscure and mysterious pioneer days of wireless communi-

cation, no one had previously taught or employed the principle of the patent, and the opinion in 1935 of the Court of Claims that this principle should have been obvious in 1900 to those then skilled in the art was erroneous.

3. The broad claims of the Marconi patent were infringed, and the Court of Claims should have so found, sufficient basis for such finding being present in the opinion and findings of that Court.

4. Claim 16 of the Marconi patent was valid and was infringed, as the Court of Claims rightly found. This claim describes a specific connection of elements for using the broad invention of the other claims, which connection was new and highly useful.

5. The Fleming patent was the pioneer patent in the radio tube art and its principles have been widely employed. The Court of Claims should have found the claims in suit valid over the prior art, instead of failing to make any finding on this point.

6. The Fleming patent was infringed by detectors, amplifiers, and oscillators, using three-electrode tubes and the Court of Claims was wrong in finding that there was no such infringement.

7. The Fleming patent was not invalid because of unreasonable delay in filing a disclaimer, and the Court of Claims should have so found, instead of failing to make any finding on this point and saying in its opinion that the patent was invalid for such reason.

ARGUMENT

I. This Court can review questions of law, including whether there is a lack of substantial evidence to sustain a finding of fact, etc.

The Act of February 13, 1925, U. S. Code, Title 28, Section 288, was amended by the Act of May 22, 1939, to authorize this Court in cases before it by certiorari to the Court of Claims

> "to review, in addition to other questions of law, errors assigned to the effect that there is a lack of substantial evidence to sustain a finding of fact; that an ultimate finding or findings are not sustained by the findings of evidentiary or primary facts; or that there is a failure to make any finding of fact on a material issue" (Act of May 22, 1939).

Prior to this amendment this Court could not review such matters, as was held in *U. S.* v. *Esnault-Pelterie*, 303 U. S. 26 (January 31, 1938):

> "The argument that the Government is precluded from obtaining the sort of review which is permissible in this Court, when there is a conflict between circuit courts of appeals as to validity and infringement of patents, and the questions are submitted upon the evidence taken in the District Court, is unavailing, for the result is due to the procedure which has been established by the Congress for the determination of claims against the United States" (p. 32).

Thereafter the Act was amended, as above set forth, to permit such review.

In the present case, there was substantially the same evidence before the Court of Claims as there was before

the circuit courts of appeals with which it disagreed. The vital issues are whether the patents, written contracts between the patentee and the Government, should be sustained as enforceable, and whether their meanings are such that the complained of apparatus are infringements of the legal rights conveyed by the patents. The only questions presented by the two writs are questions as to the correctness of the decisions by the Court of Claims, on the record before it, and its failure to make findings of fact upon material issues.

II. The Marconi patent 763,772 was valid as to the broad claims.

The Court of Claims in 1935 decided that the Marconi patent was invalid, except as to a narrow claim 16 (1 R. 75), because the Court thought that in 1900, when Marconi made his invention, "one skilled in the art", having knowledge of the Tesla and Lodge patents and the Stone documents, would make the same invention (1 R. 99).

It may be helpful here to state briefly the nature of wireless communication.

A. The nature of wireless communication.

The nature of wireless communication is explained in the record (Waterman, 1 R. 309 *et seq.*) and may be briefly described as follows.

Wireless communication is by the so-called ether, which serves as the medium through which wireless waves travel from a transmitting station to a receiving station. The ether (wireless) waves, often termed Hertzian waves, because of the 1888 discoveries of Hertz, are of the same nature as light waves, heat waves, and X-rays, their different effects

being due to the fact that the lengths of the waves are different.

A wireless transmitter is like a lighthouse, emitting light of an invisible nature, which is intercepted by a receiving station, where is absorbed and used the minute portion of energy reaching the station. The transmitter produces waves in the ether, which waves radiate out from the transmitting antenna, and are intercepted by receiving antennas.

Each signal radiated from a transmitting, or sending, station is made up of either a series of groups or a train of waves, of high or radio frequencies (from about 15,000 up to several millions of cycles per second), which are interrupted or modified in accordance with some signal at an audio frequency (below 15,000 cycles per second)—telegraph dots and dashes, sound waves, etc. During the accounting period, the signals were almost exclusively telegraph signals. The radio waves may be either one of two kinds: spark waves (created by a series of electric sparks) or continuous waves.

In the case of spark waves, each spark creates a comparatively short train of radio waves, and each telegraph signal, whether dot or dash, comprises a group of sparks, a short group for a dot and a longer group for a dash. In the case of continuous waves, each signal is made up of a train of radio waves, the length of the train determining whether the signal is a dot or a dash. Spark waves can be heard (detected) at a receiver by providing apparatus which is responsive to each group of waves, since the group-frequency is always an "audio" frequency, that is, a frequency within the range of frequencies that are audible to the human ear. Continuous waves must be modified either at the transmitter or at the receiver, so that each train of waves is made to vary at an audio frequency.

Audio frequencies, from about 15 cycles to 15,000 cycles per second, are too low for effective communication through the ether; therefore, the signals must be "carried" by high or wireless frequency waves.

Currents of radio frequencies are impressed upon the transmitting antenna, the currents produce waves of corresponding frequency in the surrounding ether, and the waves spread out in all directions.

At the receiving station, a minute portion of the ether waves is intercepted by another antenna, thereby producing radio frequency currents in the circuits of the receiver, which currents have the same frequency characteristics as the waves (and as the currents at the transmitting station). In the case of spark waves, the radio currents are rectified or otherwise integrated into the group or audio frequency, and the resultant currents applied to some kind of device which is responsive to the audio frequency so that the original signals may be detected. In the case of continuous waves, the radio currents are modified or broken up at audio frequencies so that, while the waves are being received, an audible or other indication of that fact enables them to be detected.

As is apparent from the foregoing, the receiving process is essentially the reverse of the sending process. Simply, in sending, radio frequency currents are produced and are broken up into signal frequencies; these currents are applied to an antenna and the signal-carrying radio waves are radiated. In receiving, the ether waves are applied to an antenna to produce signal-carrying radio frequency currents; the signals are then separated from the radio currents to obtain signal currents, which are used to operate an indicator.

B. The state of the wireless telegraph art prior to the Marconi patent.

The history of the art prior to the Marconi patent is well stated in the opinion in *Marconi* v. *National El. Signalling*, 213 Fed. 815 (D. C. E. D. N. Y.), the latter opinion being referred to with approval in the *Kilbourne & Clark* decisions, 265 Fed. 665 and 239 Fed. 329.

Marconi in 1894 learned of the Hertz 1888 experiments and in 1896 filed an application in the United States, upon which was granted the patent which was reissued as 11,913. That patent, formerly in suit, described a sending station and a receiving station, without any tuned circuits.

This system would operate, but only at short distances, because there was too much waste of energy. The transmitting antenna would quickly, and not persistently, radiate the energy applied to it, with the result that the train of ether waves would be too short instead of being sustained. And at the receiving station, the antenna likewise would quickly absorb the received waves, instead of storing them up, and the antenna also would receive undesired waves from other transmitting antennas (Waterman, 1 R. 328 *et seq.*; *Marconi* v. *National*, 213 Fed. 847). The Lodge patent formerly in suit was an improvement, both the transmitting and the receiving antennas being tuned with inductance, so that each would vibrate longer and the receiver would be more selective (inductance in an electrical system is the same as inertia in a physical system). But even with the Lodge patent, signalling to only short distances, about eighty miles, was possible before the invention of the Marconi patent 763,772, which enabled communication in 1901 over a distance of more than 6,000 miles (Marconi, 1 R. 532; *Marconi* v. *National*, 213 Fed. 848).

Patents for Marconi's second invention were granted in England, France and this country, which were sustained by the courts in bitterly contested litigation. And the United States Patent Office did not casually grant the patent.

C. The Patent Office history of the Marconi patent.

The application for the Marconi patent received a very intensive and almost hostile examination by the Patent Office, and was granted only after unusually careful investigation. This was not a case where a patent application slipped through with only slight attention by the Patent Office.

The application was filed in November 1900, and was rejected in December on Lodge (British patent corresponding to Lodge 609,154, formerly in suit) and Marconi 586,193 (which became reissue 11,913). The application was amended in details unimportant here, and the Patent Office examiner then required explanation of the operation of the two transmitting circuits (action of August 12, 1901; 5 R. 3985; off., 2 R. 1226), because even he, although an expert in the wireless art through his study of many patents, did not understand how it could operate (the Court of Claims in 1935 considered the Marconi system simple and obvious). Some detail amendments were made and the operation of the system explained to the Patent Office examiner (*id.*, p. 3989).

In February, 1902, the application was rejected on Lodge and several Marconi, Braun and other patents (*id.*, p. 3992), an affidavit of Marconi being submitted in reply that Marconi had not made the invention when he invented his earlier patent, 627,650, etc. (*id.*, p. 3999),

as Marconi also testified (1 R. 562, 563). The claims were then rejected on the Tesla patent 649,621, a division of the Tesla patent 645,576 (*id.*, p. 4002).

This rejection was on June 3rd, 1902 and the one year period then allowed for reply elapsed without reply. On October 6, 1903, the Commissioner of Patents was petitioned to permit a reply because of absences of Marconi, etc., which was opposed by the Examiner, denied by the Commissioner, reconsideration asked, upon the basis of affidavits by Marconi and his attorneys, and granted in March 1904 (*id.*, pp. 4066, *et seq.*).

The Patent Office then rejected some claims on Stone 714,756, allowing other claims (*id.*, p. 4068), the applicant amended some claims and cancelled others (*id.*, p. 4070) and the patent was granted.

These Patent Office proceedings are referred to by the Court of Claims in its findings (1 R. 38, 55) and in its opinion (1 R. 94), pointing out that four claims in the application were cancelled because of the Stone patent, the present claims 4, 5 and 7 of the patent being substituted. But those claims are not in suit and the cancellation is not material to the question of whether the claims in suit are valid or are infringed. Marconi made broad claims to tuned circuit apparatus, which claims are in suit, and also narrower claims, and the examiner allowed the claims over the Stone and other references.

It is plain from this brief summary that the Patent Office gave very careful and thorough consideration to the Marconi application before finally granting it. And while it is recognized that the conclusions of the Patent Office that a patent should issue to Marconi for what he disclosed, different from the earlier Marconi, Lodge, Tesla,

MARCONI AND TESLA SYSTEMS

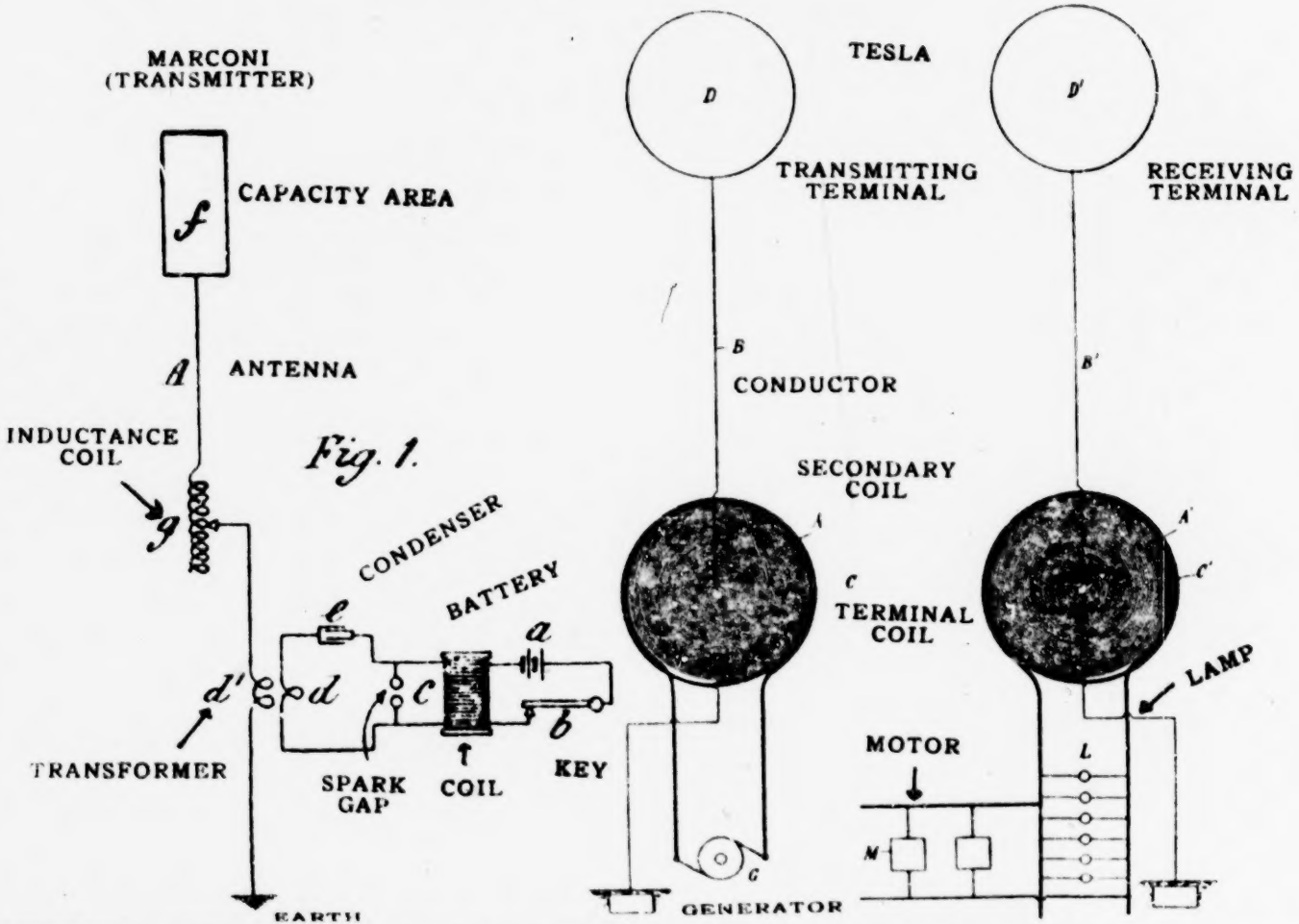


Fig. 1.

18-a

and other patents, is not controlling on the courts, surely the decisions of that administrative body of experts are entitled to some weight.

D. A description of the Marconi patent.

The Marconi patent (4 R. 2588; off., 1 R. 186) discloses transmitting and receiving circuits. For convenience, there are reproduced on the opposite page, diagrams of the Marconi transmitter and of Tesla patent 645,576, relied upon by the Court below.

Referring to Marconi's Fig. 1 (the transmitter), there are two circuits in which the radio frequency currents flow: the antenna circuit (elevated wire connected to ground, containing an inductance coil, g, and one coil, d', of a two-coil transformer) and the oscillation producing circuit (other coil, d, of the transformer, condenser, e, and spark gap). When the telegraph key, b, is pressed, current from the battery, a, flows through the primary of the induction coil, c, being broken up unto pulses by a vibrator (not shown in this patent but shown and described in the reissue patent 11,913; 4 R. 2567; off., 1 R. 190).

The pulsating current is transformed to a much greater voltage by the induction coil, c, and applied to the spark-gap circuit where, by the action of the elements therein, one group of radio frequency oscillations is produced by each pulse of battery current. The oscillations are then transferred to the antenna circuit and radiated therefrom as ether waves. Thus there are two separate radio circuits, the oscillation producing circuit and the antenna circuit. The antenna is a wire with widely separated ends; as the ends are not connected together, the antenna circuit is referred to as an open circuit. The oscil-

lation producing circuit is closed. The open and closed circuits are tuned to the same frequency.

The receiving system of Fig. 2 also has an open circuit and a closed circuit, tuned to the same frequency. The antenna circuit is open like the antenna circuit of Fig. 1, with the addition of a shunt condenser h (subject of Marconi claim 16) and some details unimportant here. There is a closed circuit, coupled to the antenna circuit by a two-coil transformer (pat. p. 2, l. 77 *et seq.*), to which are connected various things which enable the signals to be detected, such as "a telegraphing instrument or a printing device" (pat. p. 2, l. 113). Other detectors are also mentioned (p. 2, l. 56, *et seq.*)

The patent is plain in its description of the invention (Waterman, 1 R. 338 *et seq.*). As stated on page 1, ll. 37-55, the transmitter includes "a persistent oscillator, and a good radiator" (the oscillation producing circuit and the antenna circuit), and the receiver has "a good absorber of electrical oscillations, while a device responsive to electric waves, such as an imperfect contact or a device for operating the same, is included in a circuit" (the antenna circuit is the "absorber"). Marconi tunes the two circuits at the transmitter (and also at the receiver) "to be the same or octaves of each other" (pat., p. 2, l. 128; p. 3, l. 12 *et seq.*).

Again

> "The illustrated arrangement of parts at a transmitting-station enables much more energy to be imparted to the radiator f, the approximately closed circuit of the primary being a good conserver and the open circuit of the secondary being a good radiator of wave energy. My experiments have demonstrated that the best results are obtained at the transmitting station when I use a persistent oscilla-

> tor—an electrical circuit of such a character that if electromotive force is suddenly applied to it and the current then cut off electrical oscillations are set up in the circuit which persist or are maintained for a long time—in the primary circuit and use a good radiator—i.e., an electrical circuit which very quickly imparts the energy of electrical oscillations to the surrounding ether in the form of waves—in the secondary circuit" (pat. p. 2, ll. 6-25).

Transmitting systems prior to Marconi included the spark gap or other means for producing oscillations (high frequency currents) in the antenna circuit, which arrangements reduced the current in that circuit, because of the resistance of the spark gap. Marconi removed the spark gap from the antenna circuit and put it in an auxiliary circuit, which could be tuned to a high degree, thus greatly strengthening the oscillations produced. Thus two of the necessary functions of a transmitting system were greatly improved, namely, the production of oscillations and the radiation into space of ether waves caused by the oscillations. More energy can be produced in a closed circuit than in an antenna circuit, which has great resistance and little capacity, while the closed circuit is not so limited, and also, by reason of the resonant nature of the circuits, the energy can be efficiently transferred from the closed circuit to the open antenna circuit while the latter is radiating the ether waves into space (Waterman, 1 R. 347, 348).

In the similar two circuits of the Marconi receiving system, the tuning, which was essential in order to build up by resonance the extremely weak received signals, and also to discriminate against undesired electrical energy, caused by atmospheric conditions or undesired stations, was greatly improved.

The invention is well described in the British decision (4 R. 2525) and in the *National* opinion, 213 Fed. 847, 848. It immediately went into wide use, continued, with alterations only in the auxiliary apparatus, in almost exclusive use throughout the entire period covered by the record in this case, and has been appraised as one of high order by all courts which passed upon it in the early days of wireless; *National* case (213 Fed. 841), a "conspicuous advance in wireless telegraphy" (p. 858); *Kilbourne & Clark* case (239 Fed. 328), "a real accomplishment" and the ideas involved in the patent "have proven of great value to the world" (pp. 335, 342); High Court of Justice, Chancery Division, "an entirely new and useful result" (4 R. 2557); and the Civil Tribunal of the Seine, in France, "a new and very important industrial result" and "a wonderful conquest" (4 R. 2641) and "the Marconi patent stands out as an unassailable monument until new discoveries are made" (4 R. 2674).

E. The claims of the Marconi patent.

The Court of Claims correctly points out (1 R. 32) that the claims in suit may be divided into three classes, transmitter claims 1, 3, 6, 8, 11, and 12, receiver claims 2, 13, 14, 16, 17, 18 and 19, and combined transmitter and receiver claims 10 and 20. All these claims, except claim 16 for a specific type of receiving circuit, were held invalid by the Court of Claims, because of certain Tesla and Lodge patents and Stone documents (opinion, 1 R. 99).

In addition, the Court said that receiving claims 2, 13, 18 and 19 were also invalid, because they were not limited to the circuits being in tune with each other, and were anticipated by an earlier Marconi patent 627,650 (finding LIX, 1 R. 57). This was erroneous, because the descrip-

tion in the specification states that the circuits are so tuned, and claims are read in the light of the specifications, especially when they refer to them, as do the claims here, *Seymour* v. *Osborne*, 11 Wall. 516, 547; *Carnegie Steel* v. *Cambria*, 185 U. S. 403, 432. To the same effect is *Marconi* v. *Kilbourne & Clark*, 239 Fed. 328, 342 (D. C., Wash.), stating with respect to the Marconi patent:

> "The application not being for the principle of resonance or tuning, or such foundation as a scientific fact, reference to specification may be made for interpretation of claims made. *Tilghman* v. *Proctor*, 102 U. S. 707, 26 L. Ed. 279."

Upon such reference being made, it is plain that these specific claims describe the tuned circuits of the Marconi patent, and were valid, as indeed the Patent Office concluded in allowing them over the earlier Marconi patent, which was considered by the Patent Office (5 R. 3933; off., 2 R. 1226).

The real question is whether these and the other broad claims were invalid for lack of invention, as the Court of Claims concluded.

Claim 6 is a typical claim for transmitting circuits and claim 14 is a typical claim for receiving circuits. They are as follows:

> "6. At a transmitting-station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating-conductor at one end and capacity at the other end, and whose primary is connected to a condenser-circuit discharging through a means which automatically causes oscillations of the desired frequency, and means for adjusting the oscillation period of each of the two circuits connected

with the transformer to bring them into accord with each other, substantially as described."

"14. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a wave-responsive device electrically connected with the other winding of the oscillation transformer, and means for adjusting the two transformer circuits in electrical resonance with each other, substantially as described."

F. The Tesla, Lodge and Stone prior art.

In considering the patents urged against the Marconi patent, it is important to appreciate that they were disclosures and teachings as of their date, and not of today. There are now thousands of radio engineers, and probably great numbers of high school boys, who could take almost any early radio patent and, selecting a part, combine it with some parts from other radio patents, so as to produce a modern device. But that is because before they saw the patents they had been educated so that they knew the right thing to do. Problems once solved are not difficult, and there are many things which seem plain, natural and obvious after they have been done. It is easy to look back and see what should have been done—it is another matter to select the right course in an uncharted sea.

The Court of Claims based its views (finding, 1 R. 59; opinion, 1 R. 96 *et seq.*), that the broad claims of the Marconi patent were invalid, on the Tesla and Lodge patents and Stone documents, reproduced in the record here. It is not quite clear whether the Court thought that the Tesla

patents alone fully anticipated the Marconi claims, or whether a combination of Tesla, Lodge and Stone made the Marconi claims invalid because their subject matter was or should have been obvious to those in the radio art of that day. In either case, on a fair reading, these papers do not support the Court's conclusion.

1. *The Tesla patents.*

The Tesla patents 645,576 and 649,621 are based on a patent application filed September 2, 1897, which was divided, the first patent issuing on the original application and the second patent on the divisional application. The two patents describe the same method and apparatus, having the same illustrative drawings, method claims being in the original patent and apparatus claims in the divisional patent (5 R. 3602, 4089).

Although the proposed method is, in a broad sense, a "wireless" method, it is not one using radiated (Hertzian) ether waves, and the apparatus is not intended for or useful in such a system.

The Marconi and all other useful wireless systems operate by an antenna producing ether waves, which radiate out through the nonconducting and insulating air until they meet an antenna which converts them into currents. As distinguished from this, Tesla proposes to electrify the air, changing it from a non-conducting condition to a conducting state, so that currents at the sending station will run across the conducting air strata, as along a wire, to the receiving antenna. The electrification was to be accomplished by producing very high voltages, millions of volts, at the top of the transmitting antenna.

The Tesla apparatus was designed to carry out this method, and as we shall show, it was adapted to produce

large currents and high voltages, but not to perform in a Hertzian wave or radiation system.

Even a casual reading of the original patent 645,576 (5 R. 3002) discloses its Jules Verne nature.

The patent commences with some observations on the so-called Crookes tube, containing gas, which, when rarefied and electrified by a high voltage, became conducting so that it would carry a current. From this Tesla concludes that gases conduct better when electrified and that "the conductivity imparted to the air or gases increases very rapidly both with the augmentation of the applied electrical pressure and with the degree of rarefaction" (p. 1, ll. 65-69). For example, says Tesla (p. 2, l. 80) "it has long been known or surmised that atmospheric strata at great altitudes—say fifteen or more miles above sea-level, are, or should be, in a measure, conducting" (a something less than positive statement).

However, as Tesla could not reach this extremely rarefied and high strata, he proposed to electrify lower strata, and thus make them conducting, even better than "a copper wire of a practicable size" (pat. p. 3, l. 101), by using a high antenna with millions of volts at its top. For example, the patent says that using antennas of about thirty to thirty-five thousand feet high and electrical pressures of fifteen or twenty million volts, "the energy of many thousands of horse-power may be transmitted over vast distances, measured by many hundreds and even thousands of miles" (p. 4, l. 132, *et seq.*).

The Tesla patents are plain that they describe a current-conducting method and not radiation of ether waves. The original patent distinguishes its method "from other known methods of transmission . . . based, in so far as the

atmosphere is concerned, upon those qualities which it possesses by virtue of its being an excellent insulator" (p. 2, l. 65, *et seq.*), namely, a non-conductor, as it is in radio communication. The same statement is expressed in the divisional patent in different words (p. 2, l. 73, *et seq.*) as follows:

> "It is to be noted that the phenomenon here involved in the transmission of electrical energy is *one of true conduction* and *is not to be confounded with the phenomena of electrical radiation* which have heretofore been observed and which from the very nature and mode of propagation would render practically impossible the transmission of any appreciable amount of energy to such distances as are of practical importance."*

Turning now to the apparatus by which Tesla produces the very large currents to carry the energy and also the millions of volts to make the air strata conducting:

This apparatus is shown in the single drawing of both Tesla patents. No tuning is shown in the drawing. Referring first to the original patent, which contains the fullest description, its explanation of the drawing does not contain a word about tuning (p. 2, l. 122 to p. 3, l. 85). There is a primary circuit, containing a source of alternating currents, G, and a coil C, which is the primary coil of a transformer. There is also a secondary circuit, which is an open circuit, containing a vertical conductor B with an upper terminal D and a coil A, which is the secondary of the transformer. Energy in the primary circuit may be transferred across the transformer to the open circuit. By this apparatus, large currents of fairly high voltage are pro-

*Italics in quotations are ours throughout unless otherwise stated.

duced in the primary circuit, and are transformed into currents of much higher voltages in the wire, whose terminal D electrifies the air strata, along which the currents run to a similar receiving system.

If Tesla had considered that tuning was essential, or even important, to producing his currents or voltages, he would have said so in describing this apparatus.

However, the patent also describes "a model plant which has been long in use and which was constructed for the purpose of obtaining further data to be used in the carrying out of my invention on a large scale" (p. 3, l. 108, *et seq.*), and this very peculiar experimental device did have a kind of tuning. This apparatus comprised a fifty foot tube of rarefied air, with a transmitting terminal in the tube at one end and a receiving terminal at the other end of the tube. The voltage in the primary circuit was 50,000 volts, the primary coil had one turn, the secondary coil had fifty turns and the secondary voltage was 2,500,000 volts (fifty times 50,000), the voltages at the terminals being "from two to four million volts" (p. 4, l. 30). In connection with this fifty foot, several million volt, apparatus, tuning is referred to. Tesla proposed tuning the circuits, to produce high voltage to electrify the air, but not to increase the currents nor for any other purpose.

> "The primary and secondary circuits in the transmitting apparatus being carefully synchronized, an electromotive force from two to four million volts and more was obtainable *at the terminals*" (Tesla pat., p. 4, l. 27, *et seq.*).
>
> "The results were particularly satisfactory when the primary coil or system A', with its secondary C', was carefully adjusted, so as to vibrate in synchronism with the transmitting coil or system AC" (p. 4, l. 40, *et seq.*).

> "The high electromotive force obtained *at the terminals* of coil or conductor A was, as will be seen, in the preceding instance, not so much due to a large ratio of transformation as to the joint effect of the capacities and inductances in the synchronized circuits" (p. 4, l. 60, *et seq.*).
>
> "a transmitting and receiving coil, or conductor, both connected to the ground and to an elevated terminal and adjusted so as to vibrate in synchronism" (p. 5, l. 49, *et seq.*).

The plain purpose of this synchronization (tuning) was to produce the millions of volts which Tesla thought would make conductive the high air strata. There was no tuning of the wire circuit to produce more powerful ether waves or a more selective ether wave (Tesla repudiates ether waves). Indeed, the great length of the wires proposed by Tesla, "thirty to thirty-five thousand feet above the level of the sea", which was "a comparatively-small elevation" (Tesla pat., p. 5, il. 2-4), would prevent tuning (Weagant, 2 R. 1641; Hogan, 3 R. 1862; *National* opinion, 213 Fed. 847).

The Tesla divisional patent has a shorter description of what was in the original patent, and contains claims to the apparatus described in the original patent. There is nothing in this patent concerning tuning one antenna circuit to another circuit in the same system, but only to tuning the transmitting circuit as a whole to the receiving circuit (p. 1, l. 98, *et seq.*).

The Court of Claims says (finding, 1 R. 39) that the Tesla original patent

> "instructs those skilled in the art that the open and closed circuits of the transmitting system and the open and closed circuits of the receiving system of

the Tesla patent, should be in resonance with each other, or, in other words, that all four circuits should be in resonance.

"Such teaching is further implied in Tesla patent #649,621, based on a divisional application of the above-named Tesla patent in which it is stated, beginning with line 97, page 1, that 'it will be readily understood that when the above-prescribed relations exist the best conditions for resonance between the transmitting and receiving circuits are attained, and, owing to the fact that the points of highest potential in the coils or conductors AA' are coincident with the elevated terminals the maximum flow of current will take place in the two coils, and this, further, necessarily implies that the capacity and inductance in each of the circuits have such values as to secure the most perfect condition of synchronism with the impressed oscillations.'"

The vital error in the Court of Claims' reasoning was that it did not understand that Tesla synchronizes only for the purpose of obtaining his tremendously high voltages, at the terminals, so that the air could be made conducting. For example, in the divisional patent, the system and apparatus is described without a word concerning tuning (resonance) except the portion above quoted in the court's finding, and there Tesla is referring to his specific example, composed of "the above-prescribed relations" in which there is not a word regarding tuning. The "relations" include "a secondary of fifty miles in length", and adjusting the length of wire so that "the points of highest potential are made to coincide with the elevated terminals DD'" (p. 1, l. 88, *et seq.*). There is not a word about the two things which determine tuning, namely, capacity (condensers)

and inductance (coils), but only the frequency of the currents, the potential and the length.

The Court of Claims also says (opinion, 1 R. 97):

> "Just what method he [Tesla] proposed to use for synchronizing the circuits is not stated, but Lodge had shown how it could be done by the system of adjustable inductance and as we have specially found (see Finding LXII), anyone skilled in the art was capable of applying the Lodge method of tuning to the Tesla system."

The Court of Claims said after the Tesla and Lodge patents "were issued it was only necessary to put them together to have the Marconi system" (opinion; 1 R. 98). But the Patent Office and the other courts were right in concluding otherwise, especially as the Tesla ideas would not have appealed to an intelligent reader, who would doubt the extraordinary statements made by Tesla that it was possible by his system to transfer electrical energy "in quantities suitable for industrial uses on a large scale up to practically any amount and, according to all the experimental evidence I have obtained, to any terrestial distance" (pat., p. 2, l. 60, *et seq.*), this being based on experiments with a fifty-foot tube (*id.*, p. 4, l. 14).

In the French litigation, the decision considered the Tesla French patent corresponding to the United States Tesla patents here (4 R. 2661 *et seq.*) and also the Tesla patent 645,576 (p. 2688), with respect to which the court says (p. 2672)

> "whereas doubtless vague references are made therein to the transmission of intelligible messages, but the language being, so to speak, with evident intention couched in vague terms, cannot be considered as imparting to the patent the character of a wireless telegraphy invention; moreover it is diffi-

> cult to see how a device capable of conveying currents at a high voltage, and intended for continuous lighting or motive action, could be made suitable to the special requirements of transmitter and receiver, providing the intermittent but repeated action requisite for the working of wireless telegraphy with manipulators;"

In the *National* decision, 213 Fed. 815, Tesla is discussed and it is pointed out that his antenna could not be resonant, although the transformer might, and that "Tesla's conception seems to be entirely remote from the subject-matter of the patent in issue" (p. 857).

In the *Kilbourne & Clark* opinion in the district court, 239 Fed. 328, Tesla's book and his patent 649,621 are referred to (pp. 334, 337), but the court sustained the claims of the Marconi patent, saying (p. 335): "To reconcile persistency of oscillations and amplitude of vibration in the radiator was a real accomplishment." The appellate court's opinion refers to the Patent Office consideration of the Tesla patents (265 Fed. 659) and says (661): "we find that the claims of the [Marconi] patent may be sustained for the combination of elements such as are found typical in claims Nos. 6, 14, 10 and 20 for both transmitting and receiving apparatus."

The Tesla patents did not describe the invention of the Marconi patent, they did not teach it to anyone, they did not lead to anything practical, and they did not anticipate or invalidate the Marconi patent.

2. *Lodge.*

The Lodge patent 609,154 (4 R. 2579; off., 1 R. 190) was applied for and issued in 1898, and describes a wireless communication system, operating by Hertzian waves.

The invention consisted in tuning the antenna, by means of an inductance coil, so that the transmitting antenna would transmit longer trains of waves and also the length of the waves would be increased. Thus interference between messages can be greatly reduced (Waterman, 1 R. 330, *et seq.*).

The Lodge patent describes in Fig. 1 a single-circuit transmitting antenna and a single-circuit receiving antenna, each being tuned. Fig. 4 is a tuned transmitting antenna circuit with a closed coupled circuit, *not tuned*, and Fig. 13 is a tuned receiving antenna, with a coupled closed circuit, *not tuned* (Hogan, 1 R. 1864; Weagant, 2 R. 1629; Waterman, 3 R. 1929; *National* opinion, 213 Fed. 857).

Sir Oliver Lodge was a great scientist, who knew as much as, if not more than, any other worker in the radio field. He was thoroughly familiar with Hertz's work, believed that Hertzian waves could be satisfactorily utilized, made many experiments on radio waves, and delivered lectures in 1894 on this subject, including discussions of transmitting and receiving antennas, tuned circuits, etc., (deft's ex. E-4, 5 R. 3872; off., 2 R. 867).

But Lodge did not make the Marconi invention, and the sensible view of Lodge's work is that it establishes, not negatives, invention in what Marconi did.

The British court referring to the Lodge patent, said (4 R. 2546)

> "This, in my opinion, is exceedingly strong evidence that Marconi's 1900 invention was not so obvious as to deprive it of subject matter Here was Lodge, an electrical engineer of first rate ability, actually devising means to get over the difficulty he had himself explained in his first lecture (1894), the

> difficulty that a good radiating or absorbing circuit is a bad oscillating circuit and a bad conserver of energy. To get over this difficulty, he is making a compromise at both ends by partially sacrificing the radiating or absorbing qualities of his aerial. He introduces two circuits at the receiving end, and yet he does not see that if only he utilized the principle of resonance, as between those two circuits the problem would be solved, at any rate at the receiving end, and really the problem at the transmitting end is the same problem from the reverse point of view. The common knowledge of the art was so far as material for the present purpose, the same when Lodge prepared his 1897 specification as when Marconi prepared his 1900 specification. How then can I treat as obvious at the latter date what so able a man as Lodge entirely failed to see at the former date".

The fact that Lodge did not see the desirability of tuning his closed circuit is very convincing that it was not as obvious in 1900 as the Court of Claims in 1935 thought it should have been.

3. *Stone.*

The Stone patents 714,756 and 714,831 (5 R. 3648, 3667; off., 2 R. 865) were considered by the Patent Office before granting the Marconi patent (1 R. 38), and they, with perhaps some letters from Stone to a friend, are relied upon by the Court of Claims (1 R. 99, 100).

Stone believed that an antenna necessarily radiated a complex wave, that is, a wave containing simultaneously a considerable number of different frequencies. He proposed to cure this defect by producing a simple wave in a tuned closed circuit and forcing this simple wave on an untuned antenna, so that the waves emitted by the antenna would be

controlled, as to form, solely by the characteristics of the closed circuit, regardless of the characteristics of the antenna. On the other hand, Marconi, while using a closed tuned circuit in which the currents are produced, also tunes the antenna circuit so that the currents are built up in it and greatly amplified by resonance.

Similarly, at the receiving station, Stone has an untuned antenna and Marconi a tuned antenna, and each has an associated closed circuit tuned to the frequency of the oscillation producing circuit at the transmitter.

(1) *The Stone antenna circuit was not tuned.*

In 1899 Stone wrote some letters (5 R. 3630, 3634; off., 1 R. 733), which described some ideas he had regarding wireless telegraphy, and some months later prepared and filed a patent application, on February 8, 1900 (5 R. 3685; off., 2 R. 865), which resulted in Stone patent 714,756. Stone had worked for several years with the American Telephone & Telegraph Company, and was thoroughly familiar with tuned circuits and resonance phenomena (Stone, 1 R. 755, *et seq.*).

The letters described in rough fashion the system and ideas which later were written and illustrated in the elaborate, carefully worded and lengthy description of his application. There is nothing important in the letters, which is not in the later filed application for a patent.

Briefly, the letters refer to tuned circuits, that is, circuits tuned to the same frequency, but these are closed circuits and not tuned antenna circuits. One of the tuned circuits is at the transmitting station, associated with an untuned antenna wire, and the other tuned circuit is at the receiving station, similarly associated with an untuned

receiving antenna wire. The letters clearly state that the two closed circuits should be tuned and that the antenna should not be tuned (Weagant, 2 R. 1649). For example, the Stone letter of July 18, 1889 (5 R. 3637-8) states:

> "In my arrangement the vibratory current developed in the vertical wire is not due to the oscillatory discharge of the wire, but is due to a simple harmonic electro-motive force impressed upon it which electromotive force produces *forced current vibrations* in the wire which forced vibrations as is well known depend for their period and form only upon the period and form of the impressed force *and not upon the electro-magnetic constants of the circuit in which they are developed as is the case with free or natural vibrations of a system*".

The vertical wire is the antenna, and Stone here says that its currents are forced, and do not depend upon "the electro-magnetic constants" of the antenna. If the antenna were tuned, its currents would not be forced, but would depend upon its "electro-magnetic constants". In other words, Stone does not vary the period or tuning of his antenna, but relies upon his closed circuit to provide the tuning.

After writing these letters, Stone then prepared a patent application, which he filed in February 1900, the Court of Claims pointing out that "The Stone application *as filed* impressed these oscillations upon the open circuit, and therefore used 'forced' oscillations in the open circuit of the transmitter" (finding, 1 R. 51). Marconi thereafter filed his application and the Marconi British patent, corresponding to the one here in suit, became public on May 4, 1901 (1 R. 52). Then Stone in April 1902 amended his application to describe tuning the antenna (5 R. 3723), the

amended parts appearing in the Stone patent (p. 2, ll. 16-29 and p. 6, ll. 62-66, 5 R. 3649, 3653; Court of Claims finding, 1 R. 49).

The Stone patent is substantially the same as the application as originally filed, except for the 1902 statements that the antenna might be tuned. Omitting those statements and referring to the patent, it is plain that Stone taught that the antenna should be untuned, *i.e.*, contain forced oscillations, as the Court of Claims said. The patent first says that "present systems of signalling by means of electromagnetic waves" (p. 3, l. 65), have complex waves, while in his "invention the vertical conductor of the transmitting-station is made the source of electromagnetic waves of but a single periodicity" (p. 3, l. 107), and that when the

> "elevated conductor is aperiodic, it is adapted to receive or transmit all frequencies, and accordingly a single aperiodic elevated conductor may be associated with a plurality of local circuits, each attuned to a different frequency after the manner now well known in the art of multiple telegraphy by wire conductors" (p. 3, l. 117, *et seq.*).

The word "aperiodic" means without a natural period, *i.e.*, untuned, so that it will "receive or transmit all frequencies", Stone producing "what are substantially forced electric vibrations in the vertical conductor in lieu of producing natural vibrations in the conductor, as has heretofore been practiced" (p. 4, l. 48, *et seq.*).

The Stone closed circuit which produces the oscillations to be forced upon the antenna is tuned. The receiving station has a similar arrangement, the antenna being untuned and there being an associated tuned closed circuit (p. 5, l. 12).

Nowhere in the application as filed is an antenna circuit referred to as tuned.

The Stone claims refer to an elevated conductor and to "a resonant circuit associated with said conductor", and there is no statement that the elevated conductor is resonant or tuned.

The Stone patent and letters were before the district court in the *Kilbourne & Clark* case, 239 Fed. 338, 339, which sustained the Marconi claims, but are not mentioned in the opinion of the ninth circuit court of appeals, which however states that it has carefully examined the proceedings in the Patent Office, the opinion of the district court, and others, and "In the prior art, as thus disclosed, we find that the claims of the patent may be sustained for the combination of elements such as are found typical in claims Nos. 6, 14, 10 and 20 for both transmitting and receiving apparatus" (265 Fed. 661).

Summary

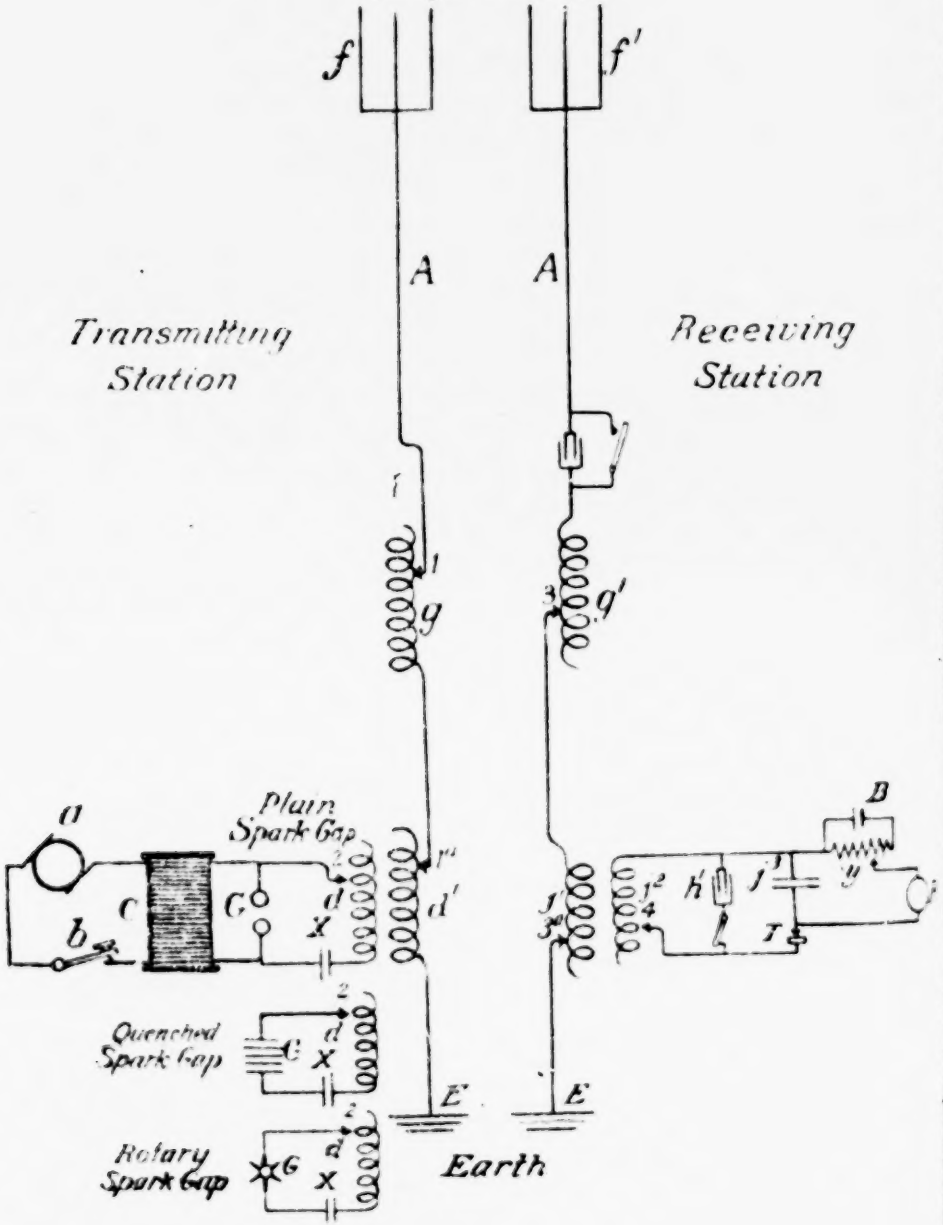
When Marconi in 1900 made his invention, wireless telegraphy was still an unknown land in which the greatest scientists of the times were often at a loss because of their ignorance concerning the fundamental principles, as well as how they could be usefully applied. Edison, Fessenden, Pupin, Lodge, Tesla, and many another were attempting in some way to solve the problem of satisfactory communication without wires.

The record is undisputed that the Marconi invention did solve this problem, changing radio communication from a haphazard, unreliable system covering perhaps 80 miles, to a practical commercial business, operating over many thousands of miles, and the invention going into practically universal, if not universal, use.

PLAINTIFF'S EXHIBIT No. 105

National Electric Signalling System

(Enjoined)



Tesla, Lodge, Stone, and many others came near to Marconi's solution, and it is possible to take parts of some of the things they described and, with some changes, construct from them the Marconi system. But this is not the test of validity, because otherwise no valid patent ever could be obtained for a new and useful combination of old things, regardless of how valuable or unexpected the result would be. And that is not the law, *Keystone Mfg. Co.* v. *Adams*, 151 U. S. 139, 144; *Williams Co.* v. *Shoe Mach. Corp.*, 316 U. S. 364; *Walker, Patents, Deller's Ed.*, 1 Vol. 215, citing cases.

III. The broad claims of the Marconi patent were infringed.

The Court of Claims did not make any ultimate finding of fact as to whether the broad claims of the Marconi patent were infringed, because it considered that they were invalid (1 R. 75). But the opinion and findings show that the Court would have found that these claims were infringed, if the claims were valid, and such finding should have been made.

In the transmitting apparatus charged to infringe, three different kinds of spark gaps were used in the closed circuit coupled to the transmitting antenna, referred to by the Court of Claims as "(a) the plain open-gap apparatus; (b) that having a rotary gap; (c) the larger group using a quenched gap" (opinion, 1 R. 101). These spark gaps are illustrated in plaintiff's exhibit 105 (off., 1 R. 435), reproduced on the opposite page (Waterman, 1 R. 433).

In the closed circuit the high frequency oscillations are created, a spark being produced and extinguished across the

terminals of a gap in the closed circuit, at the frequency of the oscillations, which usually is many hundreds of thousands of cycles a second.

The plain gap had two ball terminals; the rotary had one terminal consisting of rotating studs; and the quenched employed circular plates for the electrodes. Each type of gap had the "property of rapidly cooling and extinguishing the spark," differing in degree (Weagant, 2 R. 1593). The three kinds of gaps operate on the same principle, but the rotary and the quenched would quench the spark quicker than the plain gap, thus enabling the gap to return more quickly to the condition that existed before the spark was created (Weagant, 2 R. 1591).

Many types of spark-gap have been devised before and after Marconi, but they all operated on the same principle with respect to the production of a series of oscillations, each series or group of oscillations lasting while there was a spark discharge across the gap. Whatever type of spark-gap was used, it was essential for high efficiency to get the oscillations in the closed circuit across to the antenna circuit, to be radiated with as little loss of energy as possible. Probably the most important single feature of the Marconi invention was the resonant transfer from the closed to the open circuit, which was both necessary and highly useful, whether the spark gap be of the open, rotary or quenched type (Hogan, 3 R. 1851, 1852).

The type of spark-gap used is immaterial to the question of infringement of the Marconi patent, because its invention relates to tuning transmitter and receiver circuits, and not to spark gaps. The Court correctly found the Marconi patent is not limited "to any specific type of spark producer or oscillation producer" and that the claims in

suit are not limited "to any specific spark producer or to a closed circuit possessing elements which would cause it to function as a persistent oscillator when coupled to the open circuit" (findings, 1 R. 43). It was the opinion of the Court that "All of the wireless sets of defendant made use of apparatus constructed in accordance with the principle which formed the basis of the patent" (opinion, 1 R. 95, 96).

Specifically, with respect to the three types of spark-gap apparatus, the Court of Claims opinion and findings state:

> "We think it clear that the plain open-gap apparatus would be an infringement if the patent was valid, and we are likewise of the opinion that this would be true as to the apparatus using the rotary gap which, as we think, was merely a variation of the plain open gap and apparently used for the purpose of cooling the terminals used in making the gap across which the spark passed" (opinion, 1 R. 101).

The rotary gap was found to have

> "the dual effect of cooling the spark electrode and effecting a lengthening of the spark and its quenching as the moving electrodes recede from the fixed electrode.
>
> "Such operation causes the primary circuit oscillations to tend to cease and the operation, therefore, approximates that of the quenched gap. The circuits and apparatus utilized by the rotary gap apparatus in the Government installation, with the exception of the spark producer or gap, are identical with those used with the plain gap, and the same condition of resonance between the open and closed circuits exists" (findings, 1 R. 44, 45).

With respect to the quenched gap transmitters, the Court of Claims found that they "are substantially similar

in form and function to those utilized in connection with a plain open gap apparatus with the exception that a closer coupling can be achieved between the open and closed circuits" (findings, 1 R. 43), and also said that the quenched gap was

> "only another device for a spark producer and that Marconi in an earlier patent had shown a somewhat similar contrivance. It also appears that when it was used it was necessary to follow the same method of tuning as before. On the other hand, this device apparently was more efficient than the plain open gap for in a comparatively short time it largely displaced the latter system" (opinion, 1 R. 101).

Other courts have also decided that the type of spark gap was immaterial with respect to infringement, all three types of spark gaps having been found to infringe.

In the *National* decision, all three types were held to infringe (Waterman, 1 R. 433; Hogan, 2 R. 1895), and there was "testimony at length regarding the transmitter with the quenched-gap specifically" (Waterman, 3 R. 1975).

The transmitting apparatus held to infringe in *Marconi Co. v. Atlantic Communication and De Forest Co.*, a contested motion for preliminary injunction, was of the quenched gap type (stipulation, 3 R. 2103, *et seq.*; decree off. 3 R. 2094).

In *Marconi v. De Forest Co.*, 225 Fed. 65 (D.C. S.D. N.Y.), aff'd. 2 Cir., 225 Fed. 373, a contested motion for preliminary injunction, quenched gap transmitters were held to infringe (stipulation, 3 R. 2104, 2107; off. 3 R. 2095).

In the *Kilbourne & Clark* case, there were three types of quenched gap transmitters. One type was that manufactured and sold by defendants to the United States

Government and, therefore, the question of its being an infringement was not passed upon by the court (239 F. 355; 265 Fed. 645). The two other types of quenched gap transmitters, the Simpson mercury valve and the Thomson, were held not to infringe, because they did not depend upon tuning, *Kilbourne & Clark* decision, 265 F. 663, 667, as do depend the transmitters in the present case (Court of Claims finding, 1 R. 43). This difference was pointed out in the Interdepartmental Radio Board's preliminary report, in which it was said (4 R. 2818):

> "In the case of *Marconi* v. *Kilbourne & Clark*, a case in which it was argued that there was no effective transfer of energy from the one circuit to the other, the two being substantially energized simultaneously, and in which at any rate *there was no effective transfer from one to the other due to syntony*, was held not to infringe. This, however, is not decisive of the present issue, as to the use of quenched gaps by the Government in which there is a close coupling and a slight or negligible detuning, and *in which, undoubtedly, advantage is taken of syntony to secure an effective transfer of energy*."

The Court of Claims also found that the Government apparatus relied on resonance (syntony, tuning), saying with respect to quenched gap apparatus (finding, 1 R. 43):

> "Defendant instructed its personnel in manuals distributed both by the United States Navy and the Signal Corps of the United States Army, that the closed transmitting circuit should be tuned in resonance with the open circuit in transmitting apparatus using the quenched gap. A Signal Corps pamphlet of 1916, plaintiff's exhibit 92, page 110, states that, '*Tuning of the closed and open circuits to resonance*

and the determination of the correct coupling between them are the two most important adjustments in a quenched spark transmitter."

The Marconi patent was for a broad invention in the then infant art of wireless communication, and there is no reason to limit it to any particular kind of spark gap, when there is no such limitation in the claims and there are not any prior patents or publications which warrant such action.

The Court of Claims declared that defendant's apparatus infringed the claims if valid, and this should have been expressed in a finding.

IV. Claim 16 of the Marconi patent was valid and infringed.

The Court of Claims found that claim 16 of the Marconi patent was valid and infringed (1 R. 117), and that reasonable compensation for the infringing use was $42,984.93, with interest "as part of the entire compensation" (1 R. 156).

Defendant assigns as error the conclusions as to validity and infringement, but does not question the amount of compensation if claim 16 be valid and infringed (specifications of error, *supra*, p. 8).

A. Claim 16 was valid.

In the opinions of other courts on the Marconi patent, there was no discussion of the specific feature of claim 16, which was natural, because the other claims were broader, and they being held valid, there was no reason for consideration of the narrower claim.

Claim 16 is:

> "At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, an adjustable condenser in a shunt connected with the open circuit and around said transformer-coil, a wave-responsive device electrically connected with the other coil of the oscillation-transformer, and means for adjusting the two transformer-circuits in electrical resonance with each other, substantially as described."

The Court of Claims states that the gist of this claim is "an adjustable condenser in a shunt connected with the open circuit" in a receiver, and that prior to Marconi

> "no such apparatus had ever been used or devised. Being new, if it was useful, it was patentable. Its usefulness, we think, is shown by the fact that the receiving apparatus of the Kilbourne & Clark Company and that made by the Telefunken Company used by the Government embodied this device" (opinion, 1 R. 102).

Stone, a witness hostile to plaintiff, testified (1 R. 819) with respect to the British Marconi patent corresponding to the Marconi patent under consideration here, as follows:

> "The British patent No. 7777 of 1900 discloses the really important advances made in the art at that date. Marconi therein discloses a variable inductance coil in series in the antenna, or aerial structure, conductor, and the tuning condenser in shunt with the primary of the transformer in a tuned secondary of which is connected the detector and tuning condensers and inductance coils. Both

> the condenser in the primary and secondary and tuning inductance coils in the secondary, are made variable for the purpose of tuning the circuits with which they are associated."
>
> * * * * * * * *
>
> "The first very clear and complete exhibition of the use of a continuously variable tuning condenser in shunt to the primary of a transformer in a wireless telegraph receiver, so far as I am aware, is contained in the specifications and drawings of the English patent to Marconi, No. 7777, of 1900."

This condenser in shunt (parallel, as distinguished from in series) is in the receiving system (Waterman, 1 R. 358) shown in Fig. 2 of the drawings of the Marconi patent, the patent stating (p. 2, l. 83) "In a shunt around the primary j' I usually place a condenser h," which is said to be similar to condenser e, described as adjustable (p. 1, l. 92). It is a means "of tuning the circuit (Waterman, 1 R. 356). The Court of Claims points out in its finding LX (1 R. 57):

> "The tables on page 4 of the specification thereof [of the Marconi patent] indicate that the purpose of the condenser connected in shunt with the primary winding of the transformer of the receiver, is to enable the electrical periodicity or tuning of the open circuit of the receiver to be altered."

There is nothing in the prior art disclosing this very useful arrangement, and claim 16 is valid.

In this connection, some testimony taken by defendant during the accounting proceedings should be referred to, as apparently defendant is basing a defense of invalidity upon such evidence.

B. The testimony on the accounting was not material to the issues of validity or infringement.

The Court of Claims first heard, considered and adjudicated the issues of validity and infringement of all the claims in suit, including claim 16, it being stipulated that the issues concerning amount of compensation should be deferred until after determination of validity and infringement (1 R. 74, 75). This is common practice in the Court of Claims whose rule 39 specifically authorizes the practice.

The Court decided that claim 16 was valid and infringed by certain Kilbourne & Clark and Telefunken receivers (opinion, 1 R. 102), illustrated in the drawings, exhibits 95 and 79 (finding LXIII, 1 R. 60). This was upon the basis of extensive testimony concerning the receivers (Waterman, 1 R. 369-435; Clark, 2 R. 1488-1511; Weagant, 2 R. 1591-1620; Waterman, 3 R. 1936-1978; Hogan, 3 R. 1878-1912) and in the accounting proceedings, the only receivers that were held liable to account under claim 16 were Kilbourne & Clark, Telefunken and similar receivers.

At no time did defendant move for a rehearing or for leave to offer new evidence concerning claim 16.

During the accounting proceedings, defendant offered in evidence a Pupin patent 640,516 (which had been in the prior record on the issues of validity and infringement, as defendant's exhibit U-2), not as attacking the validity of claim 16, but merely "to show the function of the condenser h in the Marconi patent, and the difference between that function and mode of operation and the function and mode of operation of corresponding condensers in the prior art and in the defendant's device" (defendant's counsel, 3 R. 2376). The Commissioner received it, on the understanding that "it does not in any way attack the validity of claim 16 of the Marconi patent in suit" (3 R. 2377).

On the same basis, defendant also offered a Fessenden patent 706,735 (which also had been in the prior record as a part of plff's. ex. 171), defendant's counsel stating (3 R. 2381): "But here I offer it, not to show invalidity but as showing justification for the defendant's use." There was then some testimony by defendant's witnesses concerning the Pupin and Fessenden patents.

Defendant cannot attack by this testimony the prior decision of the Court of Claims that claim 16 was valid and was infringed by the Kilbourne & Clark and Telefunken receivers. That could only be done by application to the Court to reopen and reconsider its former decision, which was not done. The Court of Claims correctly said:

> "Evidence of the prior art can find no initial entrance into the case through the accounting. The place of prior art in patent law is to invalidate or limit the scope of the patent. The suggestion that it can be introduced for the first time in the accounting for the purpose either of modifying or of interpreting the infringement adjudication is not sound" (opinion, 1 R. 177).

The only possible effect of this testimony might have been to limit the accounting to only the adjudicated types of receivers, but as only those and similar receivers were held liable to account, the testimony was worthless. The Court of Claims in its decision on the accounting proceedings said (1 R. 177, 178):

> "It is clear from the record that the construction and mode of operation of the additional receivers were similar to the Kilbourne & Clark receiver and the Telefunken receiver when the antenna tuning condenser was connected in the parallel position.

> None of the defendant's witnesses has asserted to the contrary, and we have so found in Finding 24."

Claim 16 was decided by the Court of Claims, on a record including the Pupin and Fessenden patents, to be valid and infringed by certain apparatus. Defendant did not attempt to reopen that decision. The accounting was solely to determine how many of the adjudicated types of apparatus had been used, and what was a fair compensation for them. The evidence on the accounting was rightly held by the Court of Claims incompetent as to validity or infringement.

C. The Kilbourne & Clark, Telefunken and similar receivers infringed claim 16.

Findings 23 and 24 (1 R. 139) and the illustrative drawings of the Kilbourne & Clark and Telefunken receivers (1 R. 140) show that the receivers in question employed the shunt condenser and the other features of claim 16, and that the Court rightly found that the claim was infringed by these receivers.

V. The Fleming patent, 803,684, was valid.

The Fleming patent 803,684, application filed April 19, 1905, was granted November 7, 1905. Claims 1 and 37 are in suit. On November 17, 1915, a disclaimer was filed as to low frequency currents, leaving the patent limited to high frequency currents (4 R. 2600).

The Court of Claims decided (1 R. 117) that the claims were not infringed, and said in its opinion that they were invalid because there was unreasonable delay in filing the disclaimer (1 R. 106, 107). The second

circuit court of appeals had previously decided that the claims were valid, that the disclaimer was proper, and that the claims were infringed, *Marconi Co.* v. *De Forest Co.*, 2 Cir., 2 Fed. 560, affirming 236 Fed. 942 (D. C. S. D. N. Y.).

Fleming was the first to discover that a rectifying hot-cathode vacuum tube was useful in wireless communication; that discovery was the genesis of the modern radio art. Practically all modern radio tubes, which are the very heart of radio communication, utilize that discovery.

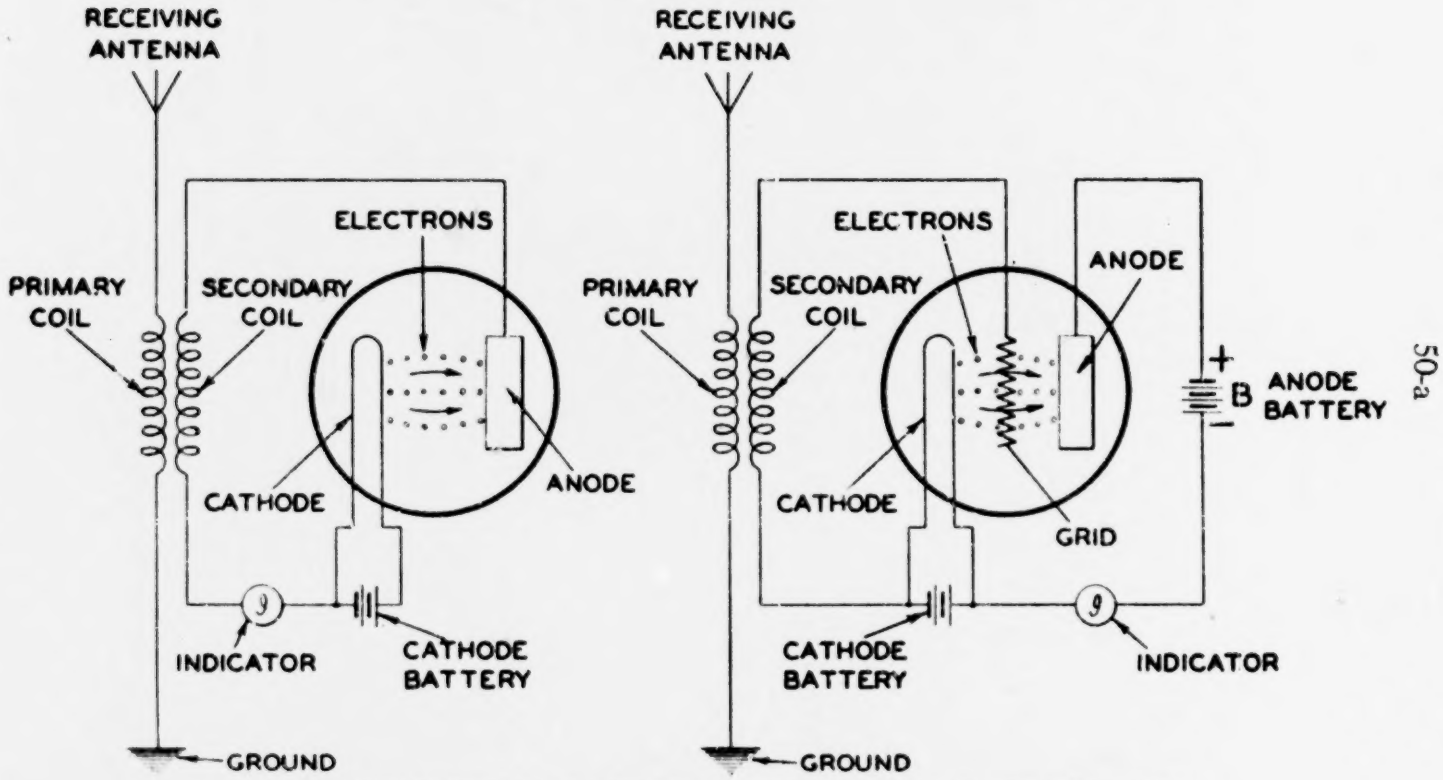
A. Radio tube principles.

This Court has considered radio tubes and their operation in *De Forest Co.* v. *General Electric*, 283 U. S. 664, *Radio Corp.* v. *Radio Laboratories*, 293 U. S. 1, and *Detrola Corp.* v. *Hazeltine Corp.*, 313 U. S. 259. In them some of the basic principles of radio tube operation are stated.

The *De Forest* case involved the amount of vacuum in radio and other tubes, the Langmuir patent in suit there claiming a "high vacuum", and being held to be anticipated by the Fleming patent (283 U. S. 681) and other prior art. The *Radio Laboratories* opinion considered whether Armstrong or De Forest was the first to invent the feed-back or regeneration circuit, used with a three-electrode tube, mentioning that De Forest had added a grid to the Fleming tube, "thereby increasing its capacity as a detector of waves of radio or inaudible frequency and serving better to transform them into waves of audible frequency" (293 U. S. 11).

In the *Detrola* case, this Court discussed the relative merits of a diode and of a triode used as a detector in

DIODE AND TRIODE CHART



SIGNAL VARIATIONS IN RADIO FREQUENCY CURRENTS IN ANTENNA ARE REPRODUCED IN ANODE CIRCUIT, DUE TO A ONE-WAY ELECTRON STREAM IN A VACUUM, FROM THE HEATED CATHODE TO THE ANODE. THE GRID AND ANODE BATTERY AID AMPLIFICATION

modern radio broadcast receiving sets. Diode is another name for the two-electrode tube shown in the Fleming patent, and triode is another name for that tube with the addition of a third electrode, usually called grid, and also sometimes referred to as a De Forest audion, because De Forest contributed the grid. No distinction was made in the *Detrola* opinion between the detecting actions of the diode and the triode, it being pointed out that the diode had the advantage of dispensing with a battery with the corresponding disadvantage of furnishing no amplification, the triode amplifying, but with an additional battery (313 U. S. 263, 264).

There is no difference between the experts as to the essential principles of operation of diodes and triodes (Waterman, 1 R. 436 *et seq.*; Miller, 1 R. 595). Simply stated, their operation is as follows, a chart illustrating them being reproduced on the opposite page.

A diode and a triode each has an evacuated glass bulb, a cathode heated by a current passing through it, an anode, and a circuit outside the tube, connecting the cathode and the anode, called the cathode-anode circuit (sometimes the "plate circuit", because the anode is sometimes called a plate). The triode also has a third electrode inside the tube (called a grid), a cathode-grid circuit and a battery in the cathode-anode circuit.

Both diode and triode depend for operation upon an uni-directional current through the tube, consisting of a stream of electrons emitted by the cathode and proceeding to a cold electrode, which current carries variations derived from the incoming current. The cathode-anode circuit includes a wire outside the tube and also an evacuated space in the tube between the cathode and the anode.

The electrons emitted by the cathode complete the cathode-anode circuit when flowing to the anode, both in

the diode and in the triode. The electrons can flow only in one direction, from the cathode to the anode, and they cannot flow in the opposite direction. Thus the current (electron stream) in the tube is uni-directional (unilateral, one-way), as must be also the entire cathode-anode current, because a part of its circuit, the space inside the tube, is uni-directional.

1. *The process of detection.*

When alternating currents, flowing first in one direction and then in the other, are applied to either a diode or a triode detector, they are rectified, *i.e.* cut in half, because they can flow only one way through the uni-directional circuit. Thus, if a current alternates between one volt plus and one volt minus, when rectified it would vary between either one volt plus and zero, or between one volt minus and zero. This is sometimes called half-wave rectification, because only half the wave of current remains.

The rectified half wave will be repeated in the direct current in the form of variations in its strength (amplitude), in accordance with the form of the impressed currents. These variations are often referred to as pulsations, and also as currents because they are equivalent to alternating currents of the same frequency and amplitude as the pulsations. Technically, they are pulsations, but the art usually refers to them as alternating currents.

When a tube is used in a detector system, the radio frequency currents carrying the signals are rectified, so that the signals appear as audio frequency pulsations in the direct current from cathode to anode, where they can be "detected", by actuating an indicator, such as a galvanometer needle, as in the Fleming patent, or the diaphragm of a loud speaker, as in modern radio broadcast receivers.

The Court of Claims completely misunderstood the nature of detection, and, indeed, the fundamental principles of operation of diodes and triodes, which undoubtedly resulted in its erroneous conclusions concerning infringement. It disregarded all the expert evidence in the case, not only that in behalf of plaintiff, but also that in behalf of defendant, as we shall point out.

The Court of Claims thought that in a diode detector, the diode rectified, and its indicator was operated by *radio* frequency variations, whereas a triode detector did not rectify and its indicator was operated by *audio* frequency variations, there being no *radio* frequency variations in its indicator circuit. The fact is that in both cases there is rectification, both diode and triode have *radio* frequency and *audio* frequency variations in their input and output (indicator) circuits, and their indicators are operated by *audio* frequency impulses.

The Court of Claims said that Fleming's detector made "feeble high-frequency impulses measurable with an ordinary direct-current mirror galvanometer" (finding, 1 R. 63). The "high-frequency" is radio frequency and the "galvanometer" is the indicator. Contrasting the triode and its indicator, a telephone receiver, with the diode, the Court declared:

> "The telephone receiver would not indicate the presence of unidirectional current of constant strength pulsating at *radio* frequencies as would the galvanometer in the Fleming patent" (opinion, 1 R. 71).

The Court also said that Fleming detected

> "by rectification of the full *radio or high*-frequency oscillations impressed upon an indicator adapted to

> register the strength of the rectified one-way pulsating current, while the three-electrode tube in the diagram set out in finding LXXV and marked 'Exhibit 83' detects by substantially suppressing the high-frequency oscillations and amplifying principally the low or audio frequency oscillations" (opinion, 1 R. 111).

But that is not so (Waterman, plaintiff's expert, 1 R. 628; 3 R. 1987; Miller, defendant's expert, 1 R. 606, 607), and it is impossible. The indicator, whether it be a needle, mirror, or the diaphragm of a modern loud speaker, responds only to audio frequency impulses, because these are the signals which are to be reproduced, either by the motions of a needle, seen by the eye, or by air waves, detected by the ear. The radio frequencies, of the order of tens of thousands or millions of cycles per second, are much too rapid for indicators to follow, and even if the indicator could operate at such rates, neither the eye nor ear could observe them. In both the Fleming diode and the De Forest triode, the indicator responds only to audio frequency variations.

And the way that each obtains the audio frequencies is by rectification of the radio frequency currents carrying the audio frequency signals, to produce audio frequency variations, using a one-way directional current which includes the stream of electrons from the cathode.

Defendant's expert witness, Miller, testified with respect to the operation of the Fleming diode detector and the PN (De Forest) triode detector (1 R. 660):

> "In the PN circuit we have two distinct circuits both carrying high frequency currents and low frequency or direct currents. The circuits are distinct and separate because they terminate respectively

> at the grid and plate terminals which are points having different potentials both steady and varying. Radio-frequency voltage variations are applied to the grid, and, as I have explained before, these variations produce through the action of the grid condenser and leak, low or audio-frequency variations of the grid voltage also. Through the controlling action of the grid, amplified variations of both radio and audio-frequency are produced in the plate current of the tube. *The amplified audio-variations affect the indicator I* which is a telephone receiver, the radio variations go to waste in this circuit."

Again, on the same page, he said with respect to "the circuit of Figure 4", which was a triode detector circuit,

> "the incoming oscillations produce, it is true, ***some feeble rectified current pulses***, but only so as to vary the electrostatic potential of the grid electrode. This takes no appreciable power from the received oscillations. There is no indicator for the received oscillations to actuate. The variations in grid potential produce corresponding variations in the plate current which flowing through the indicator produce the response".

With respect to the Fleming diode detector, on the same page, Miller testified:

> "the incoming oscillations are rectified and themselves supply the power to actuate the indicator".

On the basis of the foregoing, Miller says (same page):

> "Thus the detecting action is different in the two devices and the PN circuit, in addition, entails amplification which is a functioning not possessed by the Fleming valve".

Miller is plainly right in saying that the grid enters into the detecting action of the triode. But the point is that the triode, like the diode, uses, and cannot operate without the rectified current through the tube of the applied radio frequency variations, because otherwise the grid circuit would have no audio variations to affect the electron stream and thereby produce audio variations in the current to actuate the indicator.

2. *Amplification, regenerative amplification and oscillation.*

A simple diode cannot amplify, because it merely changes the form of the received currents. A triode can amplify, because of a grid-electron stream amplifying process, with a local battery to provide energy for the cathode-anode circuit. This local battery is additional to the battery for heating the cathode. It may be observed that local batteries were used with the Fleming tube prior to the invention of the triode (Fleming 1905 paper, 4 R. 3140; off., 3 R. 1752) and also with other types of detectors (plff's. ex. 298, 4 R. 3185; off., 3 R. 1800), showing local batteries in Lodge 609,154, Marconi 627,650, etc.). However, these local batteries were not used to amplify.

A very small change of voltage on the grid can produce a larger voltage change in the direct current in the cathode-anode circuit. This is because the grid, through an electrostatic field, acts upon infinitesimally small parts of the current, namely, electrons whose mass is about 1/1700 of hydrogen, the smallest atom. It is as if a river could be diminished at one place to a small rivulet, in which, waves being produced, the whole river would have the same waves.

The grid repeats in the electron stream whatever frequencies are applied to the grid, radio frequencies, audio

frequencies or both (Miller, 1 R. 660). And these same frequencies appear as variations, having the same frequencies, in the direct current which includes the electron stream.

Some tube circuits are used to amplify the radio frequency pulsations (or currents) and others to amplify audio frequency pulsations (or currents). The operation of the tube itself is precisely the same in either case.

From the foregoing, it is plain that when a triode amplifies, it uses the one-way current, including a hot cathode stream of electrons, described in the Fleming patent. The amount of amplification was only about one and one-half times (finding, 1 R. 73), but was increased by the later feedback invention to twenty or thirty times (1 R. 73).

Feed-back, or regeneration, was considered by this Court in *Radio Corp. v. Radio Laboratories*, 293 U. S. 1. Simply, it is amplification repeated many times in the same tube. The incoming currents are amplified by the grid action, appear in amplified form in the output circuit, a part of them is fed back to the input circuit, from where they again go through the tube and are amplified, and so on in a cyclic process, until further amplification ceases due to the resistances in the system (Waterman, 1 R. 446, 497; Miller, 1 R. 646 *et seq.*)

The regenerative amplification above described may be so great that the tube circuits commence to produce their own alternating currents, the tube then being often spoken of as an oscillator tube, because the currents produced are often termed oscillations.

When the tube circuits are oscillating, *i.e.*, producing oscillations, the one-way current through the tube is being employed, as in detection, amplification, and regenerative amplification. . .

3. *A diode can amplify and oscillate without a grid.*

The third electrode inside the tube, usually called a grid, is not necessary for either amplification or for oscillation. Defendant in the present case, as well as the defendant in *Marconi* v. *De Forest*, insisted that a grid was necessary for amplification and for oscillation. Plaintiff in both cases showed that this was not true and that these effects could be produced by gas inside the tube or by an electrical field outside the tube (Weagant, 2 R. 1530 *et seq.*; Waterman, 3 R. 2008-2016, 2019). As plaintiff has never claimed that the Fleming patent describes amplification, oscillations or either such use of gas or external field, or that Fleming knew these things, the joint is not of great materiality. However, it has some importance in showing that the Fleming invention had many potentialities other than its use in a grid tube.

It is plain from the foregoing that the triode, like the diode, depends for its operation upon a hot cathode and a cold anode inside an evacuated vessel, producing a one-way stream of electrons as an integral part of a unidirectional current.

4. *The two-electrode tube, Fleming valve, has been practically used.*

Defendant in the present case, as well as defendant in *Marconi* v. *De Forest*, has contended that a two-electrode tube (diode) has no practical utility. That is not so.

The Court of Claims found that "The Fleming two-electrode valve went into use in a limited way; less than seven hundred Fleming valves having been shipped to various ship and shore stations by plaintiff between 1910

and 1915. These Fleming valves were more sensitive than some types of crystal detectors and less sensitive than other types" (finding, 1 R. 63) and "While in some respects an improvement on the crystal detectors, it did not entirely displace them" (opinion, 1 R. 108).

But the indisputed evidence showed that from 1907 to 1915, which is when the triode with regenerative amplification came in, the Fleming valve was preferred by many wireless operators who had the choice of using other types of detectors, including the crystal, principally because the tube was the most reliable and it was essential to be able to receive continuously weather reports, distress signals, etc. The crystal had the serious disadvantage of having to be readjusted after each message was received and sometimes during reception (Hartley, 2 R. 1403; Reinhard, 2 R. 1424), and the tube was more reliable, although it was more fragile, being made of glass and having a delicate filament. The relative sensitivity of the two was about the same or the tube was somewhat better (wireless operators, 2 R. 1372, 1384, 1387, 1411, 1424).

The Fleming valve detector was employed in many stations, and the names of many American line, British line, German line and privately owned ships, relying on Fleming valves, are listed in the record (2 R. 1360, 1371). A Fleming valve receiver was in continuous communication for about 72 hours with the ships rescuing survivors of the S.S. Titanic disaster in 1912 (Sarnoff, 2 R. 1388).

At least 1,500 valves were manufactured for plaintiff from 1907 to 1915, which was a large number for that early date, and the records which could be found did not show all that had been manufactured (Brennan, 2 R. 1371). The Stanley "Textbook on Wireless Telegraphy" stated that Fleming patented a valve detector in 1904 and "At that

time it was considered so reliable and robust compared to crystal detectors that it was largely adopted on wireless installations by the Marconi Company" (Weagant, 3 R. 1762). About 1915, it was planned to replace all the crystal detectors used by the Marconi Company with the Fleming diode, but this was not done because of "the rapid development of the three-electrode device" (Weagant, 3 R. 1759).

The Fleming diode has been used in modern radio broadcast receivers (Mauborgne, 2 R. 1151), and was considered by this Court in such use, *Detrola Corp.* v. *Hazeltine Corp.*, 313 U. S. 259. The essential rectifier principle of Fleming is still used today, in its original diode form.

Unquestionably, the addition of a modern high vacuum (*De Forest Co.* v. *General Electric*, 283 U. S. 664), a grid, feed-back (*Radio Corp.* v. *Radio Laboratories*, 293 U. S. 1) and many other inventions, have increased greatly the usefulness of the hot cathode type of tube. But all these inventions and improvements have utilized and been based upon the fundamental operation taught and disclosed by Fleming. As this Court said in *Radio Corp.* v. *Radio Laboratories*, 293 U. S. 1, 14, on the point of whether the De Forest feed-back patent was entitled to cover the use of an oscillator as a generator of radio frequencies, despite the possible ignorance of De Forest as to such use:

> "If De Forest's explanations and excuses were to be disregarded altogether, the result at most would be that the apparatus of the coupled circuits had potencies and values more important than the uses that were immediately apparent, potencies and values at least dimly apprehended, and never discarded or forgotten down to the time of their complete fruition

> The benefit of all alike belonged to the inventor. *Corona Cord Tire Co.* v. *Dovan Chemical Corp.*, 276 U. S. 358, 369; *Roberts* v. *Ryer*, 91 U. S. 150, 157; *Stone* v. *Chicago*, 104 U. S. 547, 550; *cf. Lowell Manufacturing Co.* v. *Cary*, 147 U. S. 623, 634; *The Telephone Cases*, 126 U. S. 1, 536; *Robinson, Patents*, Vol. 1, § 81, p. 124."

B. The Fleming patent, and its claims 1 and 37.

The Fleming patent was a pioneer in the radio art, and upon its invention has been founded the marvelous radio industry of today. There was nothing in the wireless art prior to him which taught the invention, set forth in his patent and claims 1 and 37 in suit.

The Fleming patent states (p. 1, l. 11, *et seq.*):

> "This invention relates to certain new and useful devices for converting alternating electric currents, *and especially high-frequency alternating electric currents or electric oscillations*, into continuous electric currents for the purpose of making them detectable by and measurable with ordinary direct current instruments, such as a 'mirror-galvanometer' of the usual type or any ordinary direct-current ammeter".

And (p. 2, l. 102, *et seq.*):

> "It will be understood that when an alternating current is impressed upon a circuit including one of my improved rectifiers, as in Fig. 1, the alternating impulses in one direction will be suppressed and the alternating pulsations in the other direction will pass through the circuit in the form of a pulsating unidirectional current. This pulsating unidirec-

> tional current actuates the galvanometer or other continuous-current-indicating instrument I".

It is this "pulsating unidirectional current", produced by the hot cathode and anode in the tube, whose pulsations actuate the indicator in the output circuit, of either a diode or a triode.

Claim 1 of the Fleming patent, as originally filed, was:

> "The combination of a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for heating one of the conductors, and a circuit outside the vessel connecting the two conductors."

On November 17, 1915, this claim was limited to use "in connection with high frequency alternating electric currents or electric oscillations of the order employed in Hertzian wave transmission".

Claim 37 is as follows:

> "At a receiving-station in a system of wireless telegraphy employing electrical oscillations of high frequency a detector comprising a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for heating one of the conductors, a circuit outside of the vessel connecting the two conductors, means for detecting a continuous current in the circuit, and means for impressing upon the circuit the received oscillations."

C. The claims were valid.

Radio commenced in 1884 with the discoveries of Hertz and from that time on many eminent scientists worked on devising apparatus which would enable wireless communication, including Marconi, Lodge, Fleming, Fessenden,

Pupin, Edison and many others. But no one proposed the use of a rectifying hot cathode tube until Fleming, who filed a British patent application on November 16, 1904 (finding, 1 R. 63), his United States application for the patent in suit having been filed April 19, 1905.

The closest references are an 1884 Edison patent 307,031 and a 1903 French patent to Vaibrieze 327,687.

Edison patent 307,031.

The Edison patent (4 R. 3295; off., 1 R. 690) describes "a system of incandescent electric lighting" in which there is "a standard lamp" (pat., p. 1, ll. 44, 45), through whose filament passed the ordinary direct current for heating the filament to incandescent. Edison put a plate inside the lamp, which received current, and was connected to a galvanometer needle which would indicate changes in the current, or could "close circuit to electrically-operated devices for accomplishing the automatic regulation of the generator supplying current to the system, or for any other purpose" (pat., p. 1, l. 60 *et seq.*). This idea of thus regulating the voltage of the current supplied to the filament amounted to nothing (Waterman, 3 R. 2027), and taught nothing. Edison was interested in wireless communication, as evidenced by his 1891 patent 465,971 for such a system (1 R. 21), but there is no contention that he ever thought that his lamp had any relevancy to wireless.

In the present case, the Court of Claims refers to the 307,031 Edison patent (finding, 1 R. 64, 65) and declares that "Edison's tube is referred to as the two-electrode tube"; although there is nothing in the record to suggest that it was ever referred to as anything more than the lamp it is, at least until long after Fleming.

Defendant's expert witness testified (Miller, 1 R. 679):

> "At this time [1883] the mechanism underlying Edison's discovery was completely unknown, and the phenomenon was mystifying. It was called the 'Edison effect'. In 1884 Edison obtained a patent on his device, utilizing it as a means of controlling the voltage supply for incandescent lamps."

As has already been pointed out, this "Edison effect" meant nothing to Edison in connection with wireless. And it was as unobvious to others, including many who published papers on it (Waterman, 3 R. 2026). Professor Houston in 1884 gave a paper before the American Institute of Electrical Engineers (5 R. 3459; off., 1 R. 692); Fleming himself, in 1890 had a paper in the Proceedings of the Royal Society, in which for the first time was pointed out the possibility of rectifying alternating current (4 R. 3131; off., 3 R. 1572); in 1897 there was a paper by Howell before the American Institute of Electrical Engineers (5 R. 3459; off., 1 R. 692); a 1904 article was published by Dr. Wehnelt, a great scientist, in the Physikalishe Zeitschrift (4 R. 3515; off., 1 R. 692); and there were many other articles and discussions, but no one knew or suspected that there was any practical usefulness in the "Edison effect", notwithstanding the intensive studies and hundreds of experiments conducted on this phenomenon.

The courts in the *Marconi* v. *De Forest* case were right in their views concerning this Edison defense. The district court said (236 F. 946):

> "Stripped of technical phraseology, what Fleming did was to take the well-known Edison hot and cold electrode incandescent electric lamp and use it

> for a detector of radio signals. No one had disclosed, nor even intimated, the possibility of this use of a device then long known in another art. Cohering filings, magnets, electrolytes, and sensitive crystals *at that time*, failed to give any hint of the utility in this art of the Edison lamp. What led Fleming to his result was his adherence to the theory of the 'rectified' alternating currents."

And the court of appeals (243 Fed. 504):

> "Edison's patent stated a fact and suggested a tantalizing mystery, because even he did not pretend to state or assert that he knew why his 'effect' took place. His disclosure remained (so far as we can discover from this record) a laboratory problem until Fleming applied it (whether with a wrong theory or a right one is immaterial) to a new and very practical field of usefulness."

Valbreuze French patent 328,687.

The Court of Claims correctly found that this 1903 patent (5 R. 3540; off., 1 R. 693) was proposed for use as a rectifier of radio currents and that it had two electrodes in a vacuum tube, neither of which was heated (finding, 1 R. 65). As it lacked the essence of the Fleming invention, which requires a heated cathode to emit electrons, and is a useless device (Weagant, 3 R. 1765; Waterman, 3 R. 2027), the Valbreuze patent argues strongly that the Fleming invention was not obvious.

What Fleming did was invention, as held by the courts in the *Marconi* v. *De Forest* case, relying upon the following and other decisions of this Court.

In *Du Bois* v. *Kirk*, 158 U. S. 58, a Kirk patent for movable dams was upheld, although the structure used was not in itself new, this Court stating (p. 63):

> "It was in fact the application of an old device to meet a novel exigency and to subserve a new purpose."

In *Hobbs* v. *Beach*, 180 U. S. 383, 392, a patent for a machine for attaching strips to the corners of boxes was sustained, though a similar structure had been used previously in addressing machines.

> "Beach did not have before him a machine for attaching strips to the corners of paper boxes, but a machine for attaching addresses to newspapers, and while there is an analogy, there can scarcely be said to be a similarity in these functions."

D. The claims were infringed.

Claims 1 and 37 are infringed by defendant's use of the triodes, both as a matter of substance and as a matter of claim terminology.

Claim 1, as modified by the disclaimer, calls for a vacuous vessel (evacuated glass bulb), heated conductor (cathode), cold conductor (either grid or anode), and a circuit outside the tube, used in connection with high frequency alternating currents. This in terms describes defendant's triodes, whether used in detector, amplifier or oscillator circuits, and, as a matter of substance, they use the gist of the invention, as stated *supra*, pages 52-57.

All of defendant's triode circuits employed, in connection with either the transmission or the reception of high frequency alternating currents, a unidirectional current in a vacuum tube circuit, having a heated cathode to emit electrons which proceed to a cold conductor. It was essential to their operation.

In receiving, the tubes were used in detectors, causing an indicator to respond to the signal variations which are carried by the high frequency alternations, and in amplifiers, causing the received electrical variations to be amplified, in each case utilizing the uni-directional current in the tube circuits.

In transmitting, the tube circuits were used as oscillators, employing regeneration, which also depends upon the uni-directional current in the tube circuits.

The audio frequency amplifiers, using tubes, claimed by plaintiff to infringe the patent, were used as a part of a detector system, in which either a crystal or a tube detector produced audio frequency variations, which were then amplified so that they could be detected by the ear. If the received signal was too faint to be readable, one or two tubes were included in to the detector system, so that the ear could observe the signals (Waterman, 1 R. 448).

Claim 37 is more limited than claim 1, claim 37 calling for, among other things, "a detector comprising a vacuous vessel", etc., and "means for detecting a continuous current in the circuit". So defendant's tubes when used in oscillators, or in amplifiers apart from a detector tube, did not infringe this claim, but did infringe when used in detectors.

1. *The Marconi* v. *De Forest and Radio Audion decisions on detectors, amplifiers and oscillators.*

In the original *Marconi* v. *De Forest* case, one of the principal issues was whether a detector, using a De Forest triode, infringed the Fleming patent, both the district court and the circuit court of appeals so deciding. Subsequently, a motion was made upon affidavits to extend the

injunction to amplifiers and "oscillions" which was the De Forest trade name for oscillators. The motion was granted as to amplifiers, but a trial was ordered as to oscillators and, after the taking of evidence regarding oscillators, it was held that the oscillators infringed claim 1 (4 R. 3246, 3247; off., 2 R. 1340). The Court of Claims disagrees with these decisions, apparently because it thought that there was no substantial issue as to infringement of the Fleming patent in the main *Marconi* v. *De Forest* case, the Court of Claims saying (1 R. 112)

> "both sides represented to the court and agreed that the inherent qualities of the two-electrode tube and the three-electrode tube are the same. This being admitted by counsel, the decision, of course, was based upon that conclusion."

But this agreement was with respect to some De Forest patents, and not the Fleming patent, whose infringement was bitterly contested by defendant, as is very plain from the opinions of the district court, 236 Fed. 951-955, and of the court of appeals, 243 Fed. 564, *et seq.* The Court of Claims was misled by an observation of the court of appeals in the *Marconi* case in considering the question of infringement of certain counterclaim De Forest patents, not in suit here, where it was said (243 F. 565):

> "While not accepting such view of the law, we shall first ascertain what visible objects plaintiff has made, sold, or used *which are said to infringe the counterclaim patents*. The detectors called by defendant 'Marconi's earlier infringement' or the 'two-electrode audion' are especially complained of, though, *since it is agreed that the 'two' and 'three'*

> *electrode audions operate on the same basic principle*, no reason appears why defendant must not contend that the same things which admittedly infringe the confessed patents also infringe the counterclaim patents".

But this had nothing to do with the question of whether the diode and the triode operated on the principle of the Fleming patent, but instead, whether the ideas of certain De Forest patents, the subject of a counterclaim by the De Forest Company, were used in the Marconi tubes. These counterclaim patents were based on the idea of using conductive gas in the tubes, while it was agreed that the so-called audions of plaintiff, whether two-electrode or three-electrode, operated in a vacuum, by a hot cathode stream of electrons, independently of gas, which was the "basic principle" referred to. As for the Fleming patent, the De Forest Company never agreed that its triodes operated on the same principle as the patented Fleming tube.

In *Radio Corp.* v. *Radio Audion Co.*, 278 Fed. 628 (D. C., Dela.), a motion was made for preliminary injunction upon affidavits, the district court deciding that claim 1 of the Fleming patent was valid and infringed by defendant's tube detectors, saying "I am not satisfied by the present record, consisting largely of *ex parte* affidavits, that the defendant's device, when used as an amplifier, or as a generator of high-frequency electrical oscillations, falls within the scope of either of those claims", and also not deciding whether claim 37 was "invalid for want of a supplemental oath". The opinion is very brief, does not state the reasons for the conclusions, and therefore is of little aid on the issues here. There was no appeal, the decision being in January, 1922, the patent

expiring in November, 1922, defendant having practically ceased business, and any possible recovery of damages not being worth the trouble and expense of further litigation (stipulation, 3 R. 2093).

E. The disclaimer was not filed unreasonably late.

The Court of Claims in its opinion said that there was "unreasonable delay in making the disclaimer * * * and that the Fleming patent must be held invalid for that reason" (opinion, 1 R. 106), but did not so find (1 R. 75, 117). There was no unreasonable delay.

The patent issued on November 7, 1905, and the disclaimer was filed November 17, 1915, shortly before the commencement of the trial in *Marconi* v. *De Forest*.

The controlling principles are stated in *Ensten et al.* v. *Simon, Ascher & Co., Inc.*, 282 U. S. 445, 452:

> "'The same principle which forbids a patentee to assert a right to more than he has actually invented compels him to disavow the right as soon as he discovers that it has been unjustly claimed. Unreasonable delay in disclaiming is thus tantamount to an original fraudulent claim, and through it the patentee loses the privilege of making the amendment by which alone his patent could be saved. The question of unreasonable delay is a question for the court, upon the facts as found either by its own investigation or the verdict of a jury. *Delay begins whenever the patentee becomes aware that he has claimed more than he has invented or described.* In cases where the excess is not apparent at once upon the inspection of the patent by the patentee, the allowance of his claim by the patent office raises such a presumption in its favor that he may rely on its

validity until a court of competent jurisdiction decides that it is broader than his real invention.' *Robinson on Patents* (1890), Vol. II, p. 284."

In the present case, the Patent Office allowed claim 1 and there had been no decision with respect to it before the disclaimer was made. The Court of Claims thought there was unreasonable delay because Fleming in 1890, and others subsequently, had observed the so-called Edison effect. The Court of Claims says (opinion, 1 R. 106):

"Fleming stated further in his patent:

'I have discovered that if two conductors are enclosed in a vessel in which a good vacuum is made, one being heated to a high temperature, the space between the hot and cold conductors possesses a unilateral electric conductivity, and negative electricity can pass from the hot conductor to the cold conductor but not in the reverse direction.'

But this was not a new invention. As stated above, Fleming himself some fifteen years before (1890), in a lecture, showed that the current flowed only in one direction when *an alternating current was used* in connection with the lamp of an Edison apparatus, and discussed the flow of current from the hot negative terminal of the lamp to the cold electrode of the plate, observing that negative electricity flowed from the plate into an additional circuit connected with the lamp. In 1897 similar statements made by Howell and Kennelly were published. In stating this feature in his patent specifications as new and patentable, Fleming *must have known* that he was making a claim that could not be sustained. There could have been no inadvertence in making this statement, and this matter alone would seem to be sufficient to render the Fleming patent invalid."

But there is nothing in the record to show that the Fleming patent was not correct in stating that Fleming discovered what is set forth in the above quotation, and which is also in his 1890 paper (deft's ex. K-1, 4 R. 3445; *off.*, 1 R. 692). Fleming was the first to discover this, and there is no basis in the record for a contrary finding or conclusion. The Court is also mistaken in thinking that this claimed discovery was disclaimed, because it was not, as clearly appears from the disclaimer at the end of the patent. The disclaimer only limited the patent to the use of the diode device in connection with radio frequency currents.

As this Court stated in the *Ensten* opinion, "Delay begins whenever the patentee becomes aware that he has claimed more than he has invented or described". Disclaimers filed after suit has been commenced are not necessarily too late, *Smith* v. *Nichols*, 88 U. S. 112, 117; *Sessions* v. *Romadka*, 145 U. S. 29, 41; *Carnegie Steel* v. *Cambria Iron*, 185 U. S. 403, 435; *France Mfg. Co.* v. *Jefferson Electric Co.*, 6 Cir., 106 F. 2d 605, certiorari and rehearing denied, 309 U. S. 657, 696.

In the present case, the gist of the invention was Fleming's discovery that the phenomenon observable in an incandescent lamp with an interior plate added to it could be utilized in radio communication, by constructing a tube with proper circuits and applying to it radio frequency currents carrying signal variations. The only system described in the patent and the only use of the device disclosed in the contemporaneous 1905 Fleming paper (plff's. ex. 269, 4 R. 3140) was with such currents. Fleming was the first to teach that the Edison effect could be employed as a useful rectifier of either high (radio) frequency or low fre-

quency currents; before his 1904 discovery, this Edison effect was merely a laboratory curiosity. Although claim 1, without a disclaimer, probably would have been held valid and infringed in the *Marconi* v. *De Forest* suit, there was no reason for litigating this question, because the only devices complained of were used with radio frequency currents. It was plain common sense to confine plaintiff's claim to the only things in controversy, by the disclaimer, and thereby avoid unnecessary argument.

The second circuit court of appeals in *Marconi* v. *De Forest*, 243 Fed. 560, 565, said:

> "The contention that Fleming's patent, whatever its original merit or lack thereof, was voided by an unlawful disclaimer, is without substance. The mistake (if there was one) was in claiming something not needed, and the disclaimer abandoned what was not wanted, without broadening or enlarging any claim; it also left the claims fully supported by the original specification. No injury to defendant, or any one else, is shown. The procedure is within *Carnegie Steel Co.* v. *Cambria Iron Co.*, 185 U. S. 403, 22 Sup. Ct. 698, 46 L. Ed. 968, and our former decisions in *Simplex, etc. Co.* v. *Pressed Steel Co.*, 189 Fed. 70, 110 C. C. A. 634, and *Strause, etc. Co.* v. *Crane Co.*, 235 Fed. at page 129, 148 C. C. A. 620."

There was no unreasonable delay in entering the disclaimer.

In any event, the plaintiff, which is suing as assignee of the patentee, is entitled to the benefits of the disclaimer statute without being penalized for delay in filing a disclaimer. The disclaimer provisions are contained in Revised Statutes 4917 and 4922 (35 USC, Secs. 65 and 71). Section 4922 provides that a suit may be brought on a

patent, even if it claims more than it should, by a "patentee, his executors, administrators, or assigns"; that "plaintiff" may not recover costs "unless the proper disclaimer has been entered"; and also "But no *patentee* shall be entitled to the benefits of this section if he has unreasonably neglected or delayed to enter a disclaimer." Thus Congress distinguished between penalizing a patentee, whose knowledge might be such as to make unreasonable the delay in filing a disclaimer, and an assignee or purchaser of the patent, which might not have such knowledge, and which, therefore, is nevertheless entitled to the benefits of the section.

Conclusion

The decision of the Court of Claims should be reversed with respect to claims 1, 2, 3, 6, 8, 10-14 and 17-20 of the Marconi patent 763,772, because they are valid over the prior art and those claims should be declared infringed, as in effect found by the Court of Claims if the claims are valid; the decision below that claim 16 of the Marconi patent is valid and infringed should be affirmed; and the decision below that claims 1 and 37 of Fleming patent 803,684 were not infringed should be reversed, and those claims should be declared valid and infringed.

Respectfully submitted,

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March, 1943.

IN THE

Supreme Court of the United States

OCTOBER TERM, 1942

Nos. 369 and 373

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA,

Petitioner and Cross-Respondent,

vs.

THE UNITED STATES,

Respondent and Cross-Petitioner.

REPLY BRIEF FOR PETITIONER AND CROSS-RESPONDENT

STEPHEN H. PHILBIN
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RICHARD A. FORD
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April, 1943.

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IN THE

Supreme Court of the United States

OCTOBER TERM, 1942.

Nos. 369 and 373.

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA,
Petitioner and Cross-Respondent,

vs.

THE UNITED STATES,
Respondent and Cross-Petitioner.

REPLY BRIEF FOR PETITIONER AND CROSS-RESPONDENT

This reply brief will deal with the issues in both cases, Nos. 369 and 373, namely, the broad claims of the Marconi patent and the Fleming patent, No. 369, and claim 16 of the Marconi patent, No. 373.

I. Marconi 763,772, broad claims.

A. The claims were valid.

The broad claims in suit of Marconi patent 763,772 were held invalid by the Court of Claims.

There is no dispute concerning the teaching of the Marconi patent, which discloses and claims a tuned transmitting antenna circuit, an associated tuned circuit (to

produce radio frequency currents), a tuned receiving antenna circuit, and an associated tuned circuit (to detect radio frequency currents).

Nor is there much serious dispute concerning what the prior art discloses, although here it will be necessary, as will be pointed out, sometimes to distinguish between that disclosure and defendant's inferences therefrom.

Clerk Maxwell in 1865 published a mathematical theory of electro-magnetic waves, usually referred to as the electro-magnetic theory of light, but he did not disclose "the theory of wireless telegraphy", as defendant's brief asserts (p. 30) nor even mention that art.

Hertz, in the period of 1879 to 1890 (5 R. 3872) discovered that it was possible to produce electro-magnetic waves of substantial strength, and defendant's brief (p. 33 *et seq.*) says he understood something about tuning. However, whether he did or not is unimportant because Lodge, earlier than Marconi, clearly understood the then familiar principles of tuning and knew that tuned circuits were sometimes desirable in wireless telegraphy, as defendant states (brief, p. 35), and plaintiff agrees.

The prior Marconi patent 586,193, formerly in this suit, as reissue 11,913 (4 R. 2507), is referred to in defendant's brief (p. 39), but it did not have any tuned circuits, nor does defendant so claim.

The prior art against the Marconi patent relied upon by defendant are Tesla 645,576, Lodge 609,154, Marconi 627,650, and the Stone patent 714,756 and letters. None of these is new here, each having been before one or more courts which sustained the Marconi patent. Before considering this prior art, it may not be amiss to state briefly the test to be applied to it.

Anticipating disclosures must be substantially the same in structure, mode of operation and effect.

This well established principle is recognized in defendant's brief (p. 42), stating

> "the propriety of the conclusion below that the prior art invalidated Marconi's patent depends upon whether the anticipating disclosures and Marconi's device were substantially the same in structure, mode of operation and effect."

To the same effect are decisions of this Court, including *Clough* v. *Barker*, 106 U. S. 166, 176:

> "The structure was not designed for the same purpose as Clough's, no person looking at it or using it would understand that it was to be used in the way Clough's is used, and it is not shown to have been really used and operated in that way."

Topliff v. *Topliff*, 145 U. S. 156, 161:

> "It is not sufficient to constitute an anticipation that the device relied upon might, by modification, be made to accomplish the function performed by the patent in question, if it were not designed by its maker, nor adapted, nor actually used, for the performance of such functions."

We shall turn now to the prior art relied upon by defendant.

1. TESLA PATENT 645,576.

The Tesla patent 645,576 (5 R. 3602) has no relation to the Clerk Maxwell, Hertz, Lodge or Marconi electromagnetic work, nor to ether (Hertzian) waves, which Tesla

considered "practically impossible" for his purpose (Tesla pat., plff's. main brief, pp. 26, 27). Tesla proposed instead to produce a current, and to conduct it over wires and a conducting strata of air, like "a copper wire" (Tesla pat., p. 3, l. 101; 5 R. 3005), to the place where it was to operate motors or lamps. He did not contemplate "the transmission of waves", as defendant's brief asserts (p. 44), but merely currents over conductors.

Tesla did not tune his transmitting wire or his receiving wire, because the wires were part of a power line, as in the ordinary power line system of today. That is the reason why he neither shows a variable inductance coil or other variable element in the wires nor says that they are tunable (they could not be tuned). He did want maximum voltage in his circuits, which he obtained by synchronized circuits (plff's. main brief, p. 29 *et seq.*).

The conclusions of the Patent Office and of the courts in the French, National and Kilbourne & Clark suits (plff's. main brief, pp. 31, 32) that Tesla did not invalidate the Marconi patent were right.

(2) LODGE PATENT 609,154.

Lodge patent 609,154 (4 R. 2579) discloses a tuned antenna, for either a transmitter or a receiver, the tuning being by a variable inductance coil. Lodge also had closed circuits (the antenna is an open circuit) associated with his antennas, but the closed circuits were not tuned (plff's. main brief, p. 33), nor does defendant's brief so assert (p. 46 *et seq.*).

As defendant's brief states (pp. 35, 36), Lodge fully understood the principles of tuning or resonance, which, of course, had long been familiar knowledge among physicists.

but what Lodge did not know was what electrical circuits should be tuned, to accomplish the great advance in the art obtained by the Marconi invention. Electrical systems are like other physical systems, and some parts should be tuned to certain frequencies, other parts to other frequencies and some not to any frequency. The knowledge that tuning is possible is not enough—there is also required the knowledge of whether or not to tune and how much. The fact that Lodge, a brilliant worker in the wireless and other fields, did not understand the importance of tuning the associated circuits argues strongly for invention. "How then can I treat as obvious at the latter date what so able a man as Lodge entirely failed to see at the former date," Justice Parker, *Marconi v. British, etc. Co.*, 4 R. 2546.

3. MARCONI PATENT 627,650.

Marconi patent 627,650 (5 R. 4085) has a receiving system, in which the open (antenna) circuit is tuned, but an associated closed (detector) circuit which is not tuned, as found by the Court of Claims, saying "It was not known to Marconi at the time this patent was filed that it was desirable to have the closed oscillating circuit in tune with the open oscillating circuit" (finding LII, 1 R. 47).

Defendant's brief (p. 55) contends that the closed circuit was tuned, because its witness Loftin said it was, defendant asserting that plaintiff's witness was wrong in saying that it was not. But the Court of Claims found, as above stated, that this circuit was not tuned, agreeing in effect with the Patent Office which considered this Marconi patent before granting the Marconi claims in suit (Marconi application history, 5 R. 3993).

4. STONE PATENT AND LETTERS.

Stone patent 714,756 (5 R. 3648), as originally filed, did not describe tuning the antenna, but only the associated closed circuit. The application was filed on February 8, 1900, the Marconi British patent corresponding to the Marconi patent in suit here was published on May 4, 1901 (1 R. 52), and on and after April 8, 1902 Stone amended his application to describe tuning the antenna (Court of Claims finding, 1 R. 4; Stone application history, 5 R. 3723 *et seq.*).

Defendant's brief says that Stone disclosed a system of four circuit tuning "which the court below held anticipated Marconi", and in which Stone "preferably adjusted the antenna circuit to be resonant to the same frequency" as the closed circuit, defendant's brief (p. 59) quoting three portions from the specification of the Stone patent. But the first two quotations, which describe a preferable antenna tuning (pat., p. 2, ll. 16-20; 5 R. 3649, and p. 6, ll. 62-66, 5 R. 3653) were added in April 1902 or later (Court of Claims finding, 1 R. 51), and the third quotation (pat., p. 4, ll. 17-36; 5 R. 3651) does not mention the antenna, but merely says that the "apparatus" can be tuned to a desired frequency, which was done by the tuning of the closed circuit. "Stone's application as filed was primarily concerned with having the *closed** circuits in tune at both stations", (Court of Claims finding, 1 R. 52, pltf's. main brief, p. 37).

Defendant's brief (p. 63) says that claims 1, 3 and 4 of the Stone application as originally filed claimed "pro-

*Italics ours throughout

ducing the same wave length or frequency in both circuits", *i.e.*, the open antenna circuit and the closed circuit. But that is not so, as apparent upon reading the claims (not quoted in defendant's brief), claim 1, for example, being "The method of developing simple harmonic electromagnetic waves of a definite periodicity, which consists in producing *forced* simple harmonic electric vibrations of the same periodicity in an elevated conductor" (Stone application history, 5 R. 3708), which means producing by force —not by tuning (resonance)—in an antenna the desired currents. Stone knew perfectly the difference between tuned and untuned circuits, and how to describe them. He did not say anywhere in his original application, including the claims, that his antenna was tuned.

Defendant argues that the Stone amendments in 1902 to the effect that the antenna might be tuned must have had a foundation in the original application, because otherwise the Patent Office examiner would have refused them and there is "the presumption that public officers have properly performed their duties" (deft's. brief, p. 64). But the Patent Office has frequently erred in allowing amendments to applications, *Schriber Co. v. Cleveland Trust*, 305 U. S. 47, 56, 57 and cases cited; and defendant relies too strongly upon the presumption that the patent office examiners "properly performed their duties", in view of defendant's attacks upon the grant of the Marconi patent over the prior art urged now by defendant (deft's. brief, pp. 73, 76).

The amendment of the Stone application to add the new feature of antenna tuning was much like the amendment of a Fessenden application "to include the tuning of the closed circuit". *National El. Co. v. Telefunken Wire-*

less, 209 Fed. (D. C., S. D., N. Y.) 856, 864, per Judge Learned Hand, who, incidentally points out (p. 864):

> "in patent causes we are chary of too ready an assumption of the obvious. Everyone concedes that Stone is a very expert person and one of the best men in the art, yet it was not so obvious but that he put an untuned condenser across a coherer in a local circuit".

This was the same Stone, and the entire opinion, filed in 1913, shows how little was known even then concerning the mysteries of wireless.

Turning back to the present case, the Stone letters in evidence (5 R. 3030, 3034), which were written before he applied for a patent on his system, do not contain anything material which he did not put in his patent application, as might be reasonably expected. Stone wanted a single frequency, and he proposed to accomplish this by tuning a single circuit and impressing its currents upon an untuned antenna (plff's. main brief, pp. 35, 36).

Defendant's brief (pp. 71, 72) states that the Stone Telegraph & Telephone Company, organized in December 1901, built and operated some wireless stations and apparatus having tuned open and closed circuits. But all these were in 1902 or later (Stone, 1 R. 762, 772) and, of course, all after Marconi filed his patent application in November 1900, and after the Marconi British patent had been published in May 1901.

Defendant asserts (brief, p. 73 *et seq.*) that "Marconi's 'variable inductance' in the antenna circuit cannot save his patent" which infers, erroneously, that plaintiff so contends. But the Marconi invention was not the use of a variable inductance, nor indeed any other specific way of

tuning an antenna—before Marconi it was known that electrical circuits could be tuned or not tuned, by inductance coils or condensers. His broad invention was the combination of a tuned antenna circuit and a tuned closed circuit. Some of the claims in suit are limited to a variable inductance but others are not.

Claims 1, 2, 3, 8, 12, 13, 18 and 19 specify "a variable inductance"; claim 11 "an inductance"; claims 6, 14, 16, 17 and 20 call for "means" for tuning; and claim 10 for resonant circuits. It is very plain that Marconi, and the Patent Office, did not think that the Marconi invention consisted in only tuning by a variable inductance.

Defendant's brief (p. 78 *et seq.*) comments upon the prior decisions sustaining the Marconi patent: *Marconi* v. *British Radio etc. Co.*, 27 T. L. R. 274, 28 R. P. C. 18, 4 R. 2525; *Marconi* v. *National*, 213 Fed. 815; and *Marconi* v. *Kilbourne & Clark*, 239 Fed. 328, affirmed 265 Fed. 644; but omits mention of the French decision, 4 R. 2622. We think these carefully considered decisions in bitterly contested litigations, in the early days of wireless, when contributions to the practical art perhaps could be more readily appraised at their just value than after the art has fully developed, and paths once discovered seem obvious, speak for themselves.

Marconi made a real invention, he changed wireless operations from experimental signalling for a few miles to regular commercial operation over more than 6,000 miles (Marconi, 1 R. 532; *Marconi* v. *National*, 213 Fed. 848); it was recognized by all the courts considering it as a great practical contribution (plff's. main brief, p. 22); it was used almost exclusively during the period covered by the accounting; and his patent was valid.

B. The Marconi claims were infringed.

Defendant's brief (p. 84 *et seq.*) considers the question of infringement by its transmitters and receivers.

1. DEFENDANT'S TRANSMITTERS.

Defendant's transmitters were of the plain gap type, rotary gap type and quenched gap type, as stated in plaintiff's main brief (pp. 39-44), where it is pointed out that the Court of Claims considered that they all infringed the Marconi claims and would have so found if it had upheld the claims, and the reasons for this conclusion are stated, including defendant's admissions to such effect. Defendant's answering brief does not question any of these statements.

Defendant says that the prior decisions show that its transmitters do not infringe (brief, pp. 79, 80, 87), which it is impossible for us to understand, because the British decision found that a plain gap transmitter infringed (4 R. 2525); in the *National* case the plain gap, the rotary gap and the quenched gap were all found to infringe (plff's. main brief, pp. 28-a, 42), notwithstanding which defendant's brief (p. 79) asserts that in this suit "The apparatus alleged to infringe consisted of a plain gap"; and, in the *Kilbourne & Clark* case, defendant's transmitters were not adjudicated, being expressly excluded from the case, and later found by the Interdepartmental Radio Board to be different from the adjudicated infringements in the *Kilbourne & Clark* case, the Board saying that in defendant's quenched gap transmitters "undoubtedly, advantage is taken of syntony [tuning] to secure an effective transfer of energy" (plff's. main brief, p. 43).

Infringement depends upon whether the circuits are tuned—not upon the kind of gap used. The invention, as expressed in the claims, relates to tuned circuits and not to spark gaps. The Court of Claims correctly found that the claims "in no way limit the patent monopoly expressed in them to any specific spark producer" (1 R. 43).

Defendant's brief asserts that its spark gap circuits were not in "tune with the antenna circuit" (p. 90), there was "non-resonance" (p. 91), "detuning" (pp. 94, 95), "intentionally detuned" (p. 97). But the Court of Claims found as a fact that defendant's plain gap circuits were "in tune or electrical resonance with each other" (1 R. 42); in the quenched gap transmitter there was "tuning of the closed and open circuits to resonance (1 R. 43); and in the rotary gap transmitters "the same condition of resonance between the open and closed circuits exists", as in the plain gap (1 R. 45), the opinion being to the same effect (1 R. 101). These findings were supported by the evidence, as stated in plaintiff's main brief (pp. 40-44).

2. Defendant's receivers.

Defendant's receivers also infringe the claims if they are valid. The Court of Claims in its findings (1 R. 41-45) refers to typical receivers having tuned antennas and tuned closed circuits associated with a detector ("wave responsive device"), and defendant's brief (p. 101 *et seq.*) does not seriously question infringement if the claims were valid over the prior patents to Marconi 627,650 and "Tesla, Stone and others" (deft's brief, p. 102, footnote).

The broad claims in suit of the Marconi patent, 763,772, claims 1, 2, 3, 6, 8, 10 through 14, 17 through 20, were

valid and the Court of Claims erred in deciding otherwise, and the claims were infringed by defendant's apparatus as stated by that court.

II. Claim 16 of the Marconi patent.

The Court of Claims sustained claim 16 of the Marconi patent as valid and infringed, defendant successfully petitioned this Court for a writ of certiorari and the matter is before this Court in case No. 373.

Defendant's brief (pp. 6-8) in this case contends that the Court of Claims erred in deciding that claim 16 of Marconi patent No. 763,772 was valid and infringed, and in deciding that the value of the invention to the defendant should be based on its usefulness in defendant's apparatus.

There were two trials before the Court of Claims. The first, by stipulation of the parties (1 R. 74-75) under a Rule of that Court, was for the purpose of *determining* the issues of validity and infringement of the various patents in suit. The second was for the purpose of ascertaining reasonable compensation for infringement. This is common practice in patent and other cases involving accountings.

On the first trial, the parties thoroughly litigated the issues of validity and infringement of the various claims in suit of the four patents upon which the action was brought. The evidence was submitted to a Commissioner who made his report, and the case was argued before the Court of Claims, which decided that some claims only were valid and infringed, and ordered an accounting as to them. The decision was not satisfactory to plaintiff with respect to broad claims of the Marconi patent and the Fleming patent, nor to defendant as to claim 16 of the Marconi

patent. But neither party moved for rehearing, reargument, nor, at any time, to reopen the decision on validity and infringement.

A. The Court of Claims correctly found that claim 16 was valid and infringed.

Defendant had full notice on the trial of the issues of validity and infringement that plaintiff was relying on claim 16, and both plaintiff and defendant offered evidence regarding its validity and infringement. Defendant had its day (*i.e.*, years) in court.

In plaintiff's opening case, the operation of claim 16 was explained, the claim being quoted (Waterman, 1 R. 356-7, 361, 365), and it was also testified that various receivers of defendant used the condenser of the claim, for tuning the antenna circuit (Waterman, 1 R. 389, 390, 447). Thereafter, defendant put in its case, Loftin, its expert witness, testifying at length concerning the claims in suit, including claim 16, of the Marconi patent with respect to their meaning, validity, and infringement (2 R. 873-1060; infringement of the claims, 985-1060), but without contradicting any of the aforesaid cited testimony on behalf of the plaintiff.

The report of the Commissioner was that claim 16 was valid and infringed, to which defendant excepted, and defendant argued those two issues, and others, before the Court of Claims. Defendant does not contend that these issues were not argued by it before that court (they were, deft's. brief there, validity, pp. 4126 *et seq.*, infringement, pp. 4135 *et seq.*).

The Pupin and Fessenden patents, upon which defendant now argues invalidity and noninfringement (deft's.

brief, pp. 20-31), were before the court on the first trial. Defendant apparently did not then consider them to be so important as it does now, because it did not urge that they showed either noninfringement or invalidity of claim 16 (or any other claim).

The court found (1 R. 57) that claim 16 was "directed to a combination of elements which is new and useful" and that some tables in the Marconi patent "indicate that the purpose of the condenser connected in shunt with the primary winding of the transformer of the receiver, is to enable the electrical periodicity or tuning of the open circuit of the receiver to be altered", and that certain specified receivers of defendant "each has apparatus coming within the terminology of claim 16" (1 R. 60); and as a conclusion of law, that claim 16 was valid and infringed by the specified receivers "and any other apparatus used by defendant coming within its terminology" (1 R. 75).

This decision that claim 16 was valid and infringed, including the finding that in the Marconi patent the shunt condenser tuned the antenna circuit, was based upon undisputed evidence to such effect. Defendant points to no evidence on the first trial to the contrary.

B. In view of the stipulation, as well as under orderly trial procedure, the Court of Claims rightly decided that defendant was precluded from relying on evidence, taken after the interlocutory decision, to show invalidity or noninfringement.

In view of the stipulation, as well as under usual procedure, the issues of validity and infringement of claim 16 were determined by the interlocutory decision of the

court below. Defendant made no motion for new trial (*i.e.*, "to question the correctness or sufficiency of the court's conclusions on its findings of fact or to amend the same", Court of Claims Rule 91) nor otherwise sought to reopen the case on those issues. It accepted the interlocutory decision as final, subject only to review by this Court on the evidence that was then before the Court of Claims.

On proceedings under the interlocutory decision, evidence was taken before a Commissioner to determine the amount of compensation due plaintiff. No evidence was offered by defendant for the purpose of showing that the prior decision on validity or infringement was erroneous (undoubtedly the Commissioner would have rejected any such). Certain testimony regarding the Pupin and Fessenden patents was offered and received, on the expressed understanding that it did not relate to validity (3 R. 2376, 2377, 2381). On the accounting, there was and could be no issue as to validity, and no issue as to infringement by what had been adjudicated to infringe claim 16.

However, on the hearing before the Court of Claims on the question of the amount of damages defendant attempted to raise and reargue the issue of infringement, the Court declined to reconsider the issue (1 R. 175). The question is not whether the Court of Claims had the power to change its former decision (as defendant's brief, pp. 38-39, seems to argue). Of course, a court clearly has the power on a subsequent proceeding to reopen its prior decision, and then decide differently. *Messinger* v. *Anderson*, 225 U. S. 436, 444; *Simmons Co.* v. *Grier Co.*, 258 U. S. 82. But that is not the situation here, because not only did the Court not exercise such power but defendant did

not even so request, as the Court of Claims pointed out (1 R. 175, 177).

C. Even if the accounting evidence be considered, it does not establish non-infringement or invalidity.

Defendant now contends, based on some evidence taken on the accounting, that the shunt condenser of Marconi claim 16 does not tune the antenna circuit, being used merely to loosen the coupling between the antenna circuit and the closed circuit (brief, pp. 17-21). Upon this assumption, defendant argues that the claim is not infringed, because defendant's receivers do use the condenser to tune the antenna circuit (as plaintiff established, Waterman, 1 R. 389 *et seq.*), defendant also saying that the damages awarded by the court were wrong because they were based on the tuning utility of the condenser in defendant's apparatus, and not on the coupling advantage alleged to be shown in the Marconi patent.

Thus, the underlying question is whether in Fig. 2 of the Marconi patent the condenser h tunes the antenna circuit. Defendant now asserts that it does not, relying upon some accounting evidence. Plaintiff asserts that it does, relying upon the undisputed evidence on the trial of the issues of validity and infringement, and also pointing out that the accounting evidence, if competent, does not contradict, but on the contrary, supports this conclusion.

At the first trial, in plaintiff's opening case, it was testified that the condenser tuned the antenna circuit (Waterman, 1 R. 357). In defendant's lengthy answering testimony on the Marconi patent, including claim 16 and other claims, their validity and infringement by defend-

ant's apparatus (Loftin, 2 R. 837-1060), not only was there no contradiction of this, but defendant's expert witness Loftin expressly stated that the Marconi receiving antenna was tunable by the shunt condenser h, not only by inductance (2 R. 876), saying in connection with claim 16 that its shunt condenser "is merely one of numerous ways for obtaining an adjustment of the product of capacity and inductance of a circuit, *in this case the adjustment being obtainable through varying the capacity*" (1 R. 920); and that the condenser was "an arrangement rarely used in tuning the antenna or open circuit through varying the effect of the coil of the winding which it shunts" (2 R. 977). Neither Loftin nor any other witness for defendant questioned the prior evidence in the record that this condenser was used in defendant's apparatus as had been previously shown in plaintiff's prima facie case.

Upon this evidence, the Court of Claims found that claim 16 was valid and infringed, and also that the condenser tuned the antenna (open) circuit, saying that the condenser was "to enable the electrical periodicity or tuning of the open circuit of the receiver to be altered" (*supra*, p. 14).

Turning now to the evidence on the accounting, where defendant's witnesses sought to minimize, but did not deny, the tuning effect of the condenser.

Referring to the condenser in the Marconi patent, defendant's witness Dow testified on the accounting:

> "XQ.557. What is it in the antenna circuit that is *tuned* to the received wavelength?
>
> "A. The antenna f, the coil g', the *condenser h*, and the earth capacity e" (3 R. 2400).

"XQ. 506. Now, if the *condenser h*, in figure 2 of the patent, is variable, then is it not correct to say that a variation of the capacity of that condenser enables the electrical periodicity of tuning of the open circuit of the receiver to be altered?

"A. That is correct" (3 R. 2402).

"A. That the antenna has some effect on the resonance frequency; but that it is principally determined by the value of the *condenser h* and the coil j'" (3 R. 2404).

Wheeler, another witness for defendant, said that the condenser h could be used to bring the receiver into tune with the transmitter (3 R. 2460, 2461, XQs. 212-4, 219), and, "The value of adjustment for condenser h is to adjust it to the exact value of the received wave-length, which may not be exactly .0040" (3 R. 2463, XQ. 239).

Pickard, a witness for plaintiff, also testified in the accounting proceedings to the same effect, pointing out the various tuning advantages of the condenser in the Marconi patent (3 R. 2330-2337).

And it is plain that a variable condenser, such as h, must vary the capacity of the circuit in which it is connected, because that capacity includes the capacity of the condenser.

With respect to the validity of claim 16, defendant contends (p. 24 *et seq.*) that if its receivers infringe, the claim is invalid because of prior art. But this was an issue pertaining to validity and infringement which was litigated in the trial to determine validity and infringement (and was then raised by defendant, "All of the claims read quite as easily upon the prior art receivers * * * as they do upon the defendant's receivers", deft.'s Court of Claims brief, p. 4135). However, the argument then was based upon prior

art patents other than Pupin 640,516 and Fessenden 706,735.

Defendant seeks at several places (by references to testimony on the first trial, by stating that the basic evidence was introduced at the first hearing, brief p. 32, etc.) to make it appear that the accounting evidence is not necessary to its present position. But none of the evidence on the first trial supports or was even intended to support defendant's present argument. Likewise, defendant misrepresents the stipulation, saying (brief, pp. 33-34) that "The parties had stipulated that the first hearing be limited to the issues of validity and infringement", whereas the stipulation was expressly that the issue of reasonable compensation be postponed until the *determination* of the issues of validity and infringement (1 R. 74-75).

If defendant had moved to reopen the case with respect to validity and infringement, to offer additional evidence concerning the Pupin and Fessenden patents, and the motion had been granted, with leave to plaintiff also to offer evidence on these issues, plaintiff would have pointed out, among other things, that claim 16 of Marconi is for a wireless receiving system containing an antenna circuit tuned by a variable shunt condenser, and a tuned transformer-coupled closed circuit with a detector; that the Pupin patent describes a wire telegraph system having no antenna or open circuit or equivalent, and no elevated wire or antenna-earth capacity, and has condensers which are not varied in operation to receive different wave lengths, as in Marconi; that the application for the Fessenden patent (only the application was prior to Marconi) discloses a wireless receiving antenna circuit containing a shunt condenser not used for tuning, and no coupled circuit; and other matters per-

tinent to the issues of validity and infringement. However, as these issues were not open on the accounting proceeding, plaintiff properly made no real effort to meet the evidence upon which defendant now relies to show invalidity and noninfringement.

The Pupin and Fessenden patents were much relied upon as defenses in the *National* case, the opinion there discussing them, particularly Fessenden, 213 Fed. 850 *et seq.*, 860, and holding claim 16 and other claims valid and infringed. Moreover, Fessenden, like Stone, had no thought of tuning until after he had become acquainted with Marconi's invention, after which he amended his application to describe tuning (*United Wireless Co.* v. *National Elec. Sig. Co.*, 198 Fed. 386; *National Elec. Sig. Co.* v. *Telefunken*, 209 Fed. 856; aff'd 221 Fed. 629). In the present case, claim 16 was correctly held valid and infringed, as pointed out in plaintiff's main brief (p. 47).

To conclude, defendant had its day in court and a fair trial on the issues of validity and infringement, the decision of the Court of Claims on claim 16 was supported by the uncontradicted evidence, that decision became the law of the case and binding upon defendant so far as that court was concerned in the absence of a motion to set it aside, and the court rightly refused to consider accounting evidence on the issues of validity and infringement. And, as the Marconi patent had the tuning advantages of the shunt condenser, admittedly in defendant's receivers, the court rightly took such advantages into consideration in ascertaining the damages.

The decision below as to claim 16 of the Marconi patent should be affirmed. In any event, it should not be re-

versed without giving plaintiff an opportunity to meet the evidence which defendant took on the accounting, ostensibly on questions of amount of damages, if such evidence is to be used on the issues of validity and infringement.

III. Fleming patent 803,684.

The Fleming patent is in Case No. 369, upon plaintiff's petition. The Court of Claims found that the claims in suit of the Fleming patent 803,684, claims 1 and 37, were not infringed (findings, 1 R. 72, 117), and said that the claims were invalid because of delay in filing a disclaimer (opinion, 1 R. 106, 107). Defendant's position is that the court below was right on these points, and also that the Fleming patent was invalid because of the prior art and because the subject matter of the disclaimer was improper (deft's. brief, p. 102 *et seq.*).

A. The claims were valid.

Defendant relies for its defense of invalidity upon Edison patent 307,031, some laboratory experiments of Fleming, followed by others, with incandescent lamps, some Wehnelt experiments with oxide coated cathodes in tubes, and a Valbreuze French patent.

1. Edison patent 307,031.

Edison patent 307,031 (4 R. 3295) issued October 21, 1884. It discloses an ordinary incandescent lamp, having a filament heated to glowing incandescence by a direct current, with the addition of a plate inside the lamp. Edison observed that there was a direct current in the external circuit connecting the filament to the plate, and

that the amount of the current was in proportion to the degree of incandescence of the filament. He proposed to use the filament-plate current to indicate or regulate variations in the lighting current in the system, by means of a galvanometer.

Defendant's brief repeatedly refers to this lamp as "the Edison tube" (brief, pp. 7, 113, 116, 117, 118, etc., etc.) presumably to make it seem like a radio tube, but it was nothing but an incandescent lamp with an external circuit to indicate variations in the lighting current, which was never used (Waterman, 1 R. 21), and never meant anything to anyone in connection with wireless, including Edison, who was a worker in many electrical fields, including wireless (Edison 1891 wireless patent, 465,971, 1 R. 21).

Defendant also refers to this lamp as "Edison's two-electrode rectifier" (brief, p. 103), although it was merely a variety of lamp with a circuit for indicating variations in the lighting current, his patent containing nothing with respect to rectification (the change of alternating currents to a direct current), and not even mentioning alternating currents.

The Edison patent does not explain why there was a current in the external circuit, there is no evidence that Edison himself knew why there was, and defendant's expert (Miller, 1 R. 679) admitted that at the time of the Edison patent "the mechanism underlying Edison's discovery was completely unknown and the phenomenon was mystifying".

About twenty years elapsed before Fleming discovered that a hot cathode-cold anode tube had any usefulness in wireless or in connection with electro-magnetic waves, notwithstanding the many eminent scientists who studied and

wrote papers on the mysterious "Edison effect" (deft's. exhibits I-1, J-1, K-1; 4 R. 3413-3448 and L-1, M-1, N-1; 5 R. 3449-3514, including discussions by many scientists).

Defendant's brief (p. 112) asserts that "Structurally, the Fleming tube and its circuit as defined in the claims in suit are identical with those disclosed by Edison", that "Fleming's claim 1 is patterned after the cited Edison claim 5", and that "plaintiff does not seriously dispute that features of the Fleming patent cannot be treated as his discovery". Plaintiff does so dispute seriously, and the obvious differences between the Edison lamp patent and the Fleming patent are apparent from Edison claim 5 and Fleming claims 1 and 37, especially when read in the light of the specifications, as claims should be read. The same rules of interpretation apply to patents, written contracts between the patentee and the government, as apply to other contracts, which are to be read as a whole.

Claims are read in the light of the patent description.

"The claims of a patent are always to be read or interpreted in the light of its specification", *Schriber Co.* v. *Cleveland Trust Co.*, 311 U. S. 211, 217; *Carnegie Steel* v. *Cambria Iron*, 185 U. S. 403, 432; *Fruit Growers* v. *Brogdex*, 283 U. S. 1, 6; *Tilghman* v. *Proctor*, 102 U. S. 707, 730. In *Consolidated Roller Mill* v. *Walker*, 138 U. S. 124, 132, the following statement was approved, viz.: "To understand the nature of the invention intended to be covered by the first claim, resort must be had to the specification".

Turning now to the claims, Edison claim 5 is:

> "5. The combination, with *an incandescent electric lamp* of a circuit having one terminal in the vacuous space within the globe of said *lamp*, and the

other connected with one side of the *lamp-circuit*, and electrically controlled or operated apparatus in said circuit, *substantially as set forth*".

What this means is "set forth" in the specification of the patent, from which it appears that Edison had the ordinary "incandescent lamp", whose filament was heated by a direct current, and a circuit between the filament and a plate inside the lamp, to indicate variations of current in the lamp circuit.

The Fleming claim 1 as originally filed and claim 37 are:

> "1. The combination of a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for heating one of the conductors, *and a circuit outside the vessel connecting the two conductors.*"

> "37. At a receiving-station in a system of *wireless telegraphy* employing electrical oscillations of high frequency a *detector* comprising a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for heating one of the conductors, *a circuit outside of the vessel connecting the two conductors*, means for detecting a continuous current in the circuit, and means for impressing upon the circuit the received oscillations."

It is plain that the Edison and Fleming claims are substantially different, that the Fleming claims are based upon the disclosure of his patent, including the use of "conductors", explained in the patent as employed for conducting a unidirectional current between them, obtained from alternating currents impressed upon an external circuit containing them, and that they do not cover the Edison lamp.

2. FLEMING'S EXPERIMENTS WITH INCANDESCENT LAMPS.

Fleming experimented with the Edison lamp and observed that if the filament was heated to incandescence by an alternating current, instead of the direct current used by Edison, there would be current in the external circuit in only one direction, *i.e.*, from the heated filament (Fleming 1890 paper, 5 R. 3416, 3511); and later others verified Fleming's discovery (Howell 1897 paper, 5 R. 3459, and see plff's. main brief, p. 64).

In none of these experiments was there any application to the tube of alternating currents from a circuit other than a tube circuit, and, of course, no application of signal carrying currents to be detected.

3. THE WEHNELT EXPERIMENTS.

In October 1904, the Physikalische Zeitschrift, a German scientific paper, was published, containing an article by Wehnelt (translation, 5 R. 3515), on some experiments on certain special types of tubes which contained cathodes having oxid coatings.

In the experiment of Fig. 1 (deft's. brief, p. 119), a direct current battery B is connected between the cathode and the anode, first in one direction and then in another, Wehnelt observing that "The experiment shows consequently that only negative ions are emitted from the incandescing oxid" (5 R. 3516).

In the experiment of Fig. 4 (deft's. brief, p. 120), an anode is pushed "close to the glowing metallic oxid" cathode, the "discharge potential" is about 20 volts when the cathode and anode are connected one way, and in the other way "some thousands of volts, since under deep pressures the cathode drop on metals takes on exceedingly high

values". Discharge potential does not mean current, because current is potential (voltage, electrical pressure) divided by resistance, and Wehnelt does not give the resistance. Wehnelt concludes that "If, therefore, we connect the electrodes A and K with an alternating source of current, *the potential of which lies below the value which the cathode drop on the metallic cathode A has*", the tube "can consequently serve for the purpose of transforming alternating current into pulsating direct currents" (5 R. 3517).

At most, the Wehnelt laboratory experiments showed that, under certain special conditions, an oxide coated cathode might be used in a tube to rectify alternating currents applied to the tube. There was no suggestion that these observations could be applied to and developed into anything useful in wireless telegraphy.

4. VALBREUZE FRENCH PATENT *328,687*.

The Valbreuze French patent *328,687* (translated, 5 R. 3547) is much relied upon by defendant (brief, p. 123 *et seq.*), which repeatedly refers to the tube of the patent as "a two-electrode tube" (brief, pp. 123 *et seq.*), thus confusing it with what the radio art commonly refers to as such a tube, namely, the hot cathode-cold anode type of the Fleming patent.

The Valbreuze patent proposes to use as a detector of high frequency currents a tube which does *not* have a heated electrode, but instead is to rectify by "a point and ball very close together" (Valbreuze patent translation, 5 R. 3550), what defendant's expert called "the well-known sphere and point rectifier" (Miller, 1 R. 682).

Defendant contends that Valbreuze has an electrode heated to emit electrons, like the Fleming patent (brief, p.

126, 128, 165, etc.), declaring that the point would be heated, by ionic bombardment, etc., so that it would emit enough electrons to operate. The record does not warrant such theorizing. The patent does not say that an electrode is heated. Defendant's expert witness who testified concerning the Valbreuze patent did not claim that it had a heated electrode (Miller, 1 R. 682); plaintiff's witnesses testified that it did not have a heated electrode, and also that the Valbreuze idea was a useless thing (Weagant, 3 R. 1765; Waterman, 3 R. 2027); this was not contradicted by defendant's witnesses although Miller again testified concerning the Valbreuze patent (3 R. 2149); and the Court of Claims found that the patent "did not have a vacuum tube with heated filament but did propose a vacuum tube with two cold electrodes for use with radio frequencies as a rectifier" (findings, 1 R. 65).

Incidentally, defendant's footnote to page 131 of its brief that "Fleming himself, in his patent, acknowledged that when strong Hertzian waves are received, their alternating current will itself be sufficient to heat the filament to incandescence" is erroneous. It is true that the patent says that the filament may be incandesced by sufficiently strong "high frequency or low frequency alternating currents of electrical oscillations" (pat., p. 2, l. 99), but it does not say that the ordinary ether (Hertzian) waves are sufficiently strong for such operation (and they would not be).

The Valbreuze patent was applied for and issued in 1903, by a scientist who was familiar with vacuum tubes and wireless, as appears from his patent, and who undoubtedly knew of the "Edison effect" and perhaps many of the learned papers and discussions on it after the Edison patent was published in 1884. The fact that Valbreuze proposed

to employ the highly inefficient and practically useless point and ball type of rectifier, instead of the hot cathode-cold anode Fleming type, is strongly convincing that the "Edison effect" did not teach the Fleming invention.

5. THE FLEMING PATENT WAS VALID OVER THE PRIOR ART.

What Fleming did was patentable invention, whether tested by the "flash of creative genius" standard, *Cuno Engineering* v. *Automatic Devices*, 314 U. S. 84, 91, or the standard applied in *Williams Mfg. Co.* v. *United Shoe Mach. Co.*, 316 U. S. 364. He discovered that a vacuum tube containing a heated cathode and a cold anode, to the external circuit of which incoming alternating high frequency currents were applied, would rectify those currents and would "detect" the signals carried by those currents. This was new, useful, a discovery of great merit, the foundation of modern radio tubes, and worthy of the patents which were granted him here and in Great Britain.

The Fleming diode, two-electrode hot cathode tube, was widely used as a detector from 1907 to 1915, and relied upon for vitally important communication between ship and shore, being superseded about 1915 by the triode which differed only by the addition of a grid and associated battery, for amplification (plff's. brief, pp. 59-60). But Fleming's diode detector is in wide use today in radio broadcast receivers, in the form considered by this Court in *Detroit* v. *Hazeltine*, 318 U. S. 259, in which suit the Sixth Circuit Court of Appeals stated that "The patented device is used today in all well-known radio receivers manufactured in the United States", 117 F. 2d. 239, 240. Fleming made a real contribution to the practical radio art.

IV. The disclaimer was filed in time and its subject matter was proper.

A. The disclaimer was filed in time.

The Court of Claims said in its opinion that the patent was invalid because the disclaimer was filed too late (1 R. 106, 107) but did not make any finding on this point. The court referred (1 R. 106) to an 1890 observation of Fleming "that the current flowed only in one direction when an alternating current was used in connection with the lamp of an Edison apparatus" and "1897 similar statements made by Howell and Kennelly", and also to Fleming's statement in his patent that "I have discovered that if two conductors are inclosed in a vessel * * * the space between the hot and cold conductors possesses a unilateral electric conductivity, and negative electricity can pass from the hot conductor to the cold conductor, but not in the reverse direction" (pat., p. 1, l. 53 *et seq.*). The court erroneously thought that Fleming was "stating this feature in his patent specifications as new and patentable" (opinion, 1 R. 106), and that it was this discovery by Fleming which was disclaimed. Not at all; the disclaimer was with respect to frequencies other than high frequencies.

Claim 1 as issued was:

> "The combination of a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for heating one of the conductors, *and a circuit outside the vessel connecting the two conductors.*"

This circuit was the one to which were applied alternating currents from an external source, which currents the

specification of the patent said might be either of low frequency or high frequency. The disclaimer limited the claim to "high frequency alternating electric currents or electric oscillations of the order employed in Hertzian wave transmission".

The 1890 Fleming paper did not invalidate claim 1 as originally filed, because Fleming did not apply external alternating currents to "a circuit connecting the two conductors", but merely heated his filament by an alternating current instead of a direct current (Fleming paper, 4 R. 3415). The 1892 Howell paper (5 R. 3459) containing some remarks by Kennelly (5 R. 3464) discussed the Fleming experiments.

Defendant's brief (p. 137-8) says that the disclaimer is invalid, because "Fleming had full knowledge of Edison's work before he filed his patent application" and the Fleming "claim 1 was patterned closely upon Edison's claim 5, covering Edison's device without change". This is essentially the same contention as above discussed (*supra*, p. 23), where the differences between Edison and Fleming are pointed out.

We think that claim 1 without the disclaimer was valid, because there was nothing in the prior art teaching the use of a hot cathode-cold anode vacuum tube, producing a one-way electron stream inside the tube from alternating currents applied to an external circuit including the cathode. However, the test is not whether the claim would or would not have been sustained, but whether there was unreasonable delay after the patentee became "aware that he has claimed more than he has invented or described" and until then "the allowance of his claim by the Patent Office raises such a presumption in its favor that he may rely on its

validity until a court of competent jurisdiction decides that it is broader than his real invention", *Ensten* v. *Simon Ascher*, 282 U. S. 445, 453. In the present case, it is plain that Fleming did not consider that the "Edison effect" or his 1890 experiments on it were more than observations from which his discovery and invention resulted, as appears from his 1905 paper where he states that he had recently returned to his 1890 observations and "it seemed quite possible that such a device would provide us with a means of rectifying electric oscillations and making them measurable on an ordinary galvanometer" (5 R. 3141). There is nothing in the record to justify the Court of Claim's view that Fleming must have known, when taking out his patent, that his 1890 experiments invalidated claim 1 (opinion, 1 R. 106). It is at least as probable that the Wehnelt German article, cited against the Fleming patent in the *Marconi* v. *De Forest* litigation, caused the disclaimer, it being plain common sense to avoid unnecessary argument, by limiting the claim to the particular subject matter of the *Marconi* v. *De Forest* suit, namely, the radio tubes used by defendant, which were used in connection with high frequency current (plff's. main brief, p. 73).

B. The subject matter of the disclaimer was proper.

Defendant's brief (p. 138 *et seq.*), asserts that the form of the disclaimer is improper and, therefore, that the disclaimer is invalid. This contention is unsound, and the Court of Claims did not so find or state.

This Court has often considered the form of disclaimers, sustaining some and invalidating others. The controlling principle of the decisions has been that a disclaimer narrowing the disclosed invention, as by limiting a claim to a

specific type of its general class or by deletion of unnecessary parts, is valid, but that a disclaimer which broadens the patent, or which changes the claimed combination, as by adding a new element, is invalid.

Disclaimers were sustained in *Silsby, et al.* v. *Foote*, 61 U. S. 378, the disclaimer limiting a broad claim for automatic stove opening mechanism to heat regulation; *Dunbar* v. *Myers*, 94 U. S. 187, disclaiming a single plate apparatus and claiming only a two plate apparatus (p. 192-194); *Hurlbut* v. *Schillinger*, 130 U. S. 456, limiting a process of forming blocks to the use of tar paper or its equivalent (p. 465); *Carnegie Steel* v. *Cambria*, 185 U. S. 403, 405, etc. Many other similar decisions are discussed in *Electrical Accumulator* v. *Julien Electric Co.*, 38 Fed. (C. C. S. D., N. Y.) 117, 134, *et seq.*

Altoona Publix v. *American Tri-Ergon*, 294 U. S. 477, considered the question of the form of disclaimers, incidentally referring to the disclaimer now before this Court. In the *Altoona* case, the disclaimer was held invalid, because it added a new element to the claim, namely, a fly wheel (pp. 490, 491). But this Court did not hold or intimate that a limiting disclaimer was improper, observing in the footnote to page 490 that disclaimers had been upheld

> "where the elimination from the patent of the matter not relied upon did not operate to enlarge the monopoly of the patent, but narrowed it . . . by limitation of a claim or specification by deletion of unnecessary parts, *Carnegie Steel Co.* v. *Cambria Iron Co.*, 185 U. S. 403, 435, 436; *Marconi Wireless Telegraph Co.* v. *DeForest Radio Telephone & Telegraph Co.*, 243 Fed. 560, 565 (C. C. A. 2nd), or by limiting the claim to a specific type of the general class to which it was applied, *Minerals Separation, Ltd.* v.

Butte & Superior Mining Co., 250 U. S. 336, 354; *United Chromium Inc.* v. *International Silver Co.*, 60 F. (2d) 913, 914 (C. C. A. 2d); *Seiberling* v. *Thropp's Sons Co.*, 284 Fed. 746, 756, 757 (C. C. A. 3rd)".

The *Marconi* v. *De Forest* case above cited sustained at the page referred to (565) the disclaimer here under consideration.

In *Milcor* v. *Fuller*, 316 U. S. 143, the courts below invalidated certain claims because disclaimers added new elements to the claims, and this Court affirmed. One disclaimer added a particular kind of flange to one claim, and the other disclaimer added a particular kind of a strip to another claim, this Court saying (p. 146) "the revised patent includes new elements which were not present in the original".

The disclaimers were there held improper because they did "more than delete a 'distinct and separable matter . . . without mutilating or changing what is left standing' ". The Fleming disclaimer, on the other hand, merely deletes a separable matter (use with low frequencies), without changing what is left (use with high frequencies).

Thus the disclaimer in the present case is like those referred to in the above quotation from the *Altoona* opinion (and, indeed, is one of them), and in the *Silsby*, *Dunbar* and *Hurlbut* decisions. It specifically limited broad claims for certain electrical apparatus to use "in connection with high frequency alternating currents or electrical oscillations of the order employed in Hertzian wave transmission" (disclaimer). These claims originally might have been argued to have to read upon some earlier work, and therefore been held invalid. The invention that Fleming made was to transform a laboratory experiment of scientific curiosity

and speculation into a practical device of the highest possible utility in the radio art, no one before Fleming knowing that a thing which produced unidirectional currents would rectify oscillations of the order used in radio communication, or that a thing which would rectify would detect, *i.e.*, act upon radio frequency currents carrying signal components so as to make the latter perceptible, *Marconi v. De Forest*, 2 Cir., 243 F. 560, 563, 564.

The Fleming patent plainly discloses that the invention is to be used in radio communication. The only apparatus shown in the drawings is radio apparatus, and the specification (pat. p. 1, l. 11, *et seq.*) states that the invention "relates to certain new and useful devices for converting alternating electric currents, and *especially* high-frequency alternating electric currents or electric oscillations" (pat. p. 1, l. 11, *et seq.*), "feeble electric oscillations, such as are employed in Hertzian-wave telegraphy" (*id.*, p. 1, l. 17), etc. Under such circumstances, it was proper to narrow the monopoly of the patent "by limitation of a claim or specification by deletion of unnecessary parts" or "by limiting the claim to a specific type of the general class to which it relates", *Altoona* opinion, *supra*.

Fleming made a real invention, which was clearly described in his specification. Limitation of specification and claims to that invention was proper, because "the disclaimer statute is remedial, and intended for the protection of both the patentee and the public", *Triplett v. Lowell*, 297 U. S. 638, 645; "The power to disclaim is a beneficial one, and ought not to be denied, except where it is resorted to for a fraudulent and deceptive purpose", *Sessions v. Romadka*, 145 U. S. 29, 40.

The form of the disclaimer was not improper.

V. The Fleming claims were infringed.

Defendant's argument on the issue of infringement of the Fleming claims 1 and 37 in suit (deft's. brief, p. 141, *et seq.*) is not that the claims do not read upon defendant's tubes (except as to tubes used as audio frequency amplifiers, brief, p. 158*), but it is, in essence that the De Forest improvement of a grid and a local battery avoids infringement. However, the real question is not whether defendant's tubes are better than the diode shown in the Fleming patent, but whether the Fleming invention is the foundation and basis of these tubes.

Cochrane v. *Deener*, 94 U. S. 730, 787:

> "The defendants admit that the process has produced a revolution in the manufacture of flour; but they attribute that revolution to their improvements. It may be, as they say, that it is greatly due to these. But, it can not be seriously denied that Cochrane's invention lies at the bottom of these improvements, is involved in them, and was itself capable of beneficial use, and was put to such use. It had all the elements and circumstances necessary for sustaining the patent, and cannot be appropriated by the defendants, even though supplemented by and enveloped in the very important and material improvements of their own."

*Defendant's point here is that claims 1 and 37 are limited to use in connection with radio frequencies, claim 37 being also limited to "a detector", and defendant's tubes merely amplify audio frequencies after detection by an associated tube. But both claims are infringed, because the tubes are used in connection with radio frequencies, as they amplify the audio frequencies carried by the radio frequencies, and the tubes are part of a detector, which would not "detect" without them (plff's main brief, p. 67).

The Fleming invention consists of an evacuated tube, a hot electrode (cathode), a cold electrode (anode), and an electrical circuit so arranged that when high frequency alternating currents carrying signals are applied to the tube circuits there is produced a unidirectional current between the hot electrode and cold electrode, containing the signal in the form of pulsations. This is found in defendant's tubes, whether used to detect or to amplify (the latter including regenerative feed back and oscillations, plff's. main brief, p. 56), and defendant's tubes would not operate if their cathodes were not hot and the alternating currents applied to the tube were not rectified to produce a unidirectional current through the tube. This should decide the issue of infringement in favor of plaintiff.

Defendant's discussion of the functions and operations of the grid in its tubes (brief, p. [illegible], *et seq.*) are irrelevant, because there is no question but that the grid was an improvement, plaintiff in the *Marconi* v. *De Forest* case agreeing that "De Forest in his three-electrode Audion has undoubtedly made a contribution of great value to the art", 236 Fed. 955 (Sept. 20, 1916).

The grid, whether the tube is used for detecting or amplifying, acts upon and utilizes *the Fleming uni-directional flow of electrons from heated cathode to anode inside the tube*. Such action is necessary in the operation.

When a triode tube is detecting, the grid, because of rectification of the radio frequency currents by the tube, accumulates on it the audio frequency variations, which are the signals, and are carried by the radio frequency currents. The Court of Claims so found (finding LXXV, 1 R. 69), and although it correctly says that after the rectification has charged the grid "rectification of the full

high radio-frequency waves ceases", it is obvious that rectification is necessary. The court appears to have been so impressed with the importance of the grid that it overlooked the fact that there must be a uni-directional rectifying current in order for the tube to operate. Defendant's brief (footnote, p. 161) says with respect to its tube that "one of its most important characteristics is that it is uni-directional only", but it is more than that, it is essential. The grid impresses its audio frequency variations upon *the uni-directional electron stream from heated cathode to anode*, which is a part of the cathode-anode circuit, and the variations operate an indicator. In Fleming, the audio frequency variations of the incoming radio freqency currents themselves operate, in the cathode-anode circuit, an indicator, Fleming of course using both rectification and the same uni-directional stream.

When a triode tube is amplifying, the grid varies with all the variations of the incoming currents, and impresses all these variations upon *the uni-directional electron stream from heated cathode to anode*, the resulting variations in the cathode-anode circuit then operating any desired device, including a following tube. Fleming does not disclose any amplification.

If the Fleming invention was the contribution to the radio art of an invaluable tool, namely, a hot cathode-cold anode tube with uni-directional electron stream carrying radio frequency variations, as was held in *Marconi* v. *De Forest*, and we think rightly, defendant's tubes infringe, because they use that invention, which is necessary to any function performed by the grid.

In connection with the *Marconi* v. *De Forest* case, defendant's brief (p. 169, *et seq.*) repeats the error of the

Court of Claims that there was no issue of infringement in that case (1 R. 112), although that error was pointed out in plaintiff's main brief (pp. 68, 69). As this error undoubtedly influenced the court below, it is desirable to make perfectly clear that the question of whether the De Forest triode tubes infringed the Fleming patent was contested.

In the district court, 230 Fed. 942, the defendants argued vigorously that the De Forest triodes did not infringe the Fleming patent, the district court stating (p. 951):

> "We now come to what I think is the only substantial question in the case—the infringement claimed against defendants."

Defendants alleged there, as defendant does here, that the addition of the grid and a local battery to the Fleming tube avoided infringement, and the operation of these things was much discussed (p. 952, *et seq.*).

In the circuit court of appeals, 243 Fed. 500, infringement again was contested, the court saying (p. 504), "it is upon the question of infringement that this record has been filled with theories", and again the action of the grid and local battery are considered, including their legal effect on the issue of infringement.

Defendant's brief (p. 171) quotes from the district court's opinion, 230 Fed. 953, "In reading this literature it must be remembered that both sides agree that the De Forest two-element and three-element bulbs operate *on the same principle*". By "same principle" was meant the principle of "unilateral conductivity or, in other words, a rectifier permitting current to flow in one direction only, *viz.*, from plate to filament and from grid to filament", as appears from the same page of the opinion. In the present case there is no

dispute that both the Fleming and De Forest tubes have this "unilateral conductivity". But the question there, as is the question here, was whether the addition of the grid and local battery avoided infringement.

Defendant's brief (p. 171) also quotes a similar statement from the opinion of the circuit court of appeals, 243 Fed. 405, in considering the issue of infringement of some De Forest counterclaim patents (not the Fleming patent) by Marconi diodes and triodes, where it was said "it is agreed that the 'two' and 'three electrode audions' operate on the same basic principle", 243 Fed. 405. Here again the "principle" was unilateral conductivity, and there was no agreement that the De Forest triodes infringed the Fleming patent. And, as above pointed out, infringement was contested in the court of appeals as well as in the district court.

The Fleming patent was infringed, if it contains patentable subject matter over the prior art, which it does.

CONCLUSION

This case is not like *Detrola* v. *Hazeltine*, 313 U. S. 259, where a 1927 diode circuit in the radio art was held unpatentable, nor *Cuno Engineering* v. *Automatic Devices*, 314 U. S. 84, where a 1929 cigar lighter patent was held invalid. The Marconi and Fleming inventions were made in the pioneer days of wireless, when little was known, and most of that was wrong.

Minerals Separation, Ltd. v. *Butte & Superior Mining Co.*, 250 U. S. 336, 345:

> "It is always difficult to recover the realities of a situation long past, such as we have here, but it is especially difficult when the importance of the

> discovery has led, as in this case, to extensive improvements in mechanical appliances for utilizing the invention and to large additions to the knowledge of the adaptability to the process of various oils, singly and in combination."

Kintner v. *Atlantic Communication Co.*, 249 Fed. (D. C., S. D., N. Y.), 73, 77-8, was a suit on a radio patent and the court in 1917 said:

> "In approaching the subject, it is extremely important to think, if possible, as of 1901. In this case, that is a troublesome task, because of the extraordinary progress in this art since then, and the consequent difficulty of discarding from consideration many items of after acquired knowledge. It is also necessary in this case not to accord undue importance to isolated suggestions in scientific papers and discussions. Such suggestions are not infrequently controlling in a well developed and well understood art where skilled men can readily appreciate the disclosure. In the infancy of a new, and, at the time, little understood, art, however, the alleged prior art, necessary to negative invention must be clear and doubts as to its meaning and disclosures should ordinarily be resolved in favor of the inventor."

The Marconi invention was a great advance in the practical art—it meant something useful to the public, and indeed was practically the only system employed for many years. At the risk of repetition, attention is again called to the unanimous verdict of the courts which considered it in the early days of the art, when the then realities of the situation could be more accurately appraised than today, those courts saying (plff's. main brief, p. 22), *National*

case (213 Fed. 841), a "conspicuous advance in wireless telegraphy" (p. 858); *Kilbourne & Clark* case (239 Fed. 328), "a real accomplishment" and the ideas involved in the patent "have proven of great value to the world" (pp. 335, 342); High Court of Justice, Chancery Division, "an entirely new and useful result" (4 R. 2557); and the Civil Tribunal of the Seine, in France, "a new and very important industrial result" and "a wonderful conquest" (4 R. 2641) and "the Marconi patent stands out as an unassailable monument until new discoveries are made" (4 R. 2674).

The Fleming invention was of even greater importance, because it contributed the hot cathode-cold anode tube to the radio art. The invention is widely used today in its original diode form, and also in the triode form, which, because of the De Forest grid and local battery, enables the tube to accomplish also the highly desirable result of amplification of electrical currents.

There was nothing in the prior art, which consists of merely laboratory experiments and unfruitful patented ideas, to anticipate the Marconi and Fleming patents. The multitude of prior papers and patents collected by defendant and contained in volumes 4 and 5 of the record are full of mistaken proposals and suggestions which led nowhere except to failures. It would have required ability of the highest order at that early time to have selected correctly the right principle to follow, even if it had been among the many advanced, which, however, was not the case.

If Marconi and Fleming made real inventions, as we believe, there is no substantial question but that their patents were infringed. The Court of Claims so declared with

respect to the Marconi patent, and it should have so found with respect to the Fleming patent, as indeed we have no doubt it would have, if the court had thought that Fleming was entitled to patent the high frequency rectifying operation described and claimed in his patent and upon which defendant's tubes depend for operation.

In Case 369, claims 1, 2, 3, 6, 8, 10 through 14, and 17 through 20 of the Marconi patent 763,772 should be held valid and infringed by the apparatus declared by the Court of Claims to infringe if the claims were valid; and claims 1 and 37 of the Fleming patent 803,684 should be held valid and infringed by defendant's triodes used as detectors or parts thereof, and as oscillators.

In Case 373, the judgment of the Court of Claims, that claim 16 of the Marconi patent was valid and infringed, and fixing compensation therefor, should be affirmed.

Respectfully submitted.

STEPHEN H. PHILBIN
ABEL E. BLACKMAR, JR.
RICHARD A. FORD
Counsel for Petitioner and Cross-Respondent.

April, 1943.

IN THE

Supreme Court of the United States

OCTOBER TERM, 1942

No. 369

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA,

Petitioner,

vs.

THE UNITED STATES,

Respondent.

Motion and Notice of Motion

SIR:

PLEASE TAKE NOTICE that, upon the annexed affidavit of Abel E. Blackmar, Jr., verified the 25th day of November, 1942, the petitioner herein, Marconi Wireless Telegraph Company of America, by the undersigned, its counsel, hereby moves this Honorable Court for an order requiring respondent to reimburse petitioner for the cost of printing, and the fees of the Clerk of this Court for supervising the printing of, the required forty (40) copies of that portion of the printed transcript of the record herein which was included in the transcript and printed solely for use in connection with respondent's cross petition for a writ of certiorari (Case No. 373 of the October, 1942, Term of this Court) with respect to certain portions of the judgment

herein as to which petitioner has assigned no error, said portion of the printed transcript of the record comprising pages 2313 to 2522, inclusive, thereof, and for such other and further relief as may be proper in the premises.

Dated, November 25, 1942.

ABEL E. BLACKMAR, JR.,
RICHARD A. FORD,
Counsel for Petitioner.

To

THE HONORABLE THE SOLICITOR GENERAL
OF THE UNITED STATES,
Counsel for Respondent,
Washington, D. C.

IN THE

SUPREME COURT OF THE UNITED STATES

OCTOBER TERM, 1942

No. 369

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA,

Petitioner,

v.

THE UNITED STATES,

Respondent.

Affidavit

STATE OF NEW YORK)
COUNTY OF WESTCHESTER) ss.:

ABEL E. BLACKMAR, JR., being duly sworn, deposes and says:

That he is a member of the bar of this Court and of counsel for petitioner herein, and that he has been of counsel for petitioner throughout the proceedings in this cause in the court below since prior to the interlocutory judgment entered November 4, 1935, herein.

That this cause was instituted by petitioner in the Court of Claims of the United States, under the provisions of the Act of Congress of June 25, 1910 (amended July 1, 1918), U. S. Code, Title 35, Section 68, to recover compensation for the use, by respondent, of the subject matter of four

United States Letters Patent for invention, as more fully set forth in petitioner's Petition for Writ of Certiorari herein.

That the interlocutory judgment herein, among other things, held that claim 16 of Marconi patent No. 763,772 was valid and had been infringed by respondent. That thereafter, this cause was referred to a Commissioner of the Court of Claims to take the evidence on a proceeding to ascertain the amount of compensation to which petitioner was entitled by reason of respondent's infringement of said claim 16 and of certain claims of the Lodge patent No. 609,154, and to report thereon. That such report was made and the parties filed their exceptions thereto, which were duly heard by the Court of Claims. That said court thereupon rendered its final judgment herein, awarding compensation to petitioner for respondent's infringement of said claim 16 of the said Marconi patent and of the Lodge patent.

That, during the course of the accounting proceeding before the Commissioner, respondent introduced evidence directed to the issue of infringement of said claim 16 and argued, both before the Commissioner and before the Court of Claims, on final hearing, chiefly on the basis of such evidence, that the original decision of the Court of Claims on such issue was erroneous. That the Court of Claims, however, held that its interlocutory decision on this issue was the law of the case.

That, after the final judgment of the court below, deponent informed counsel for respondent that petitioner proposed to apply to this Court for a writ of certiorari with respect to the decision of the Court of Claims that the claims, *other than claim 16*, of the said Marconi patent were invalid and that the Fleming patent No. 803,684 had not been infringed. That deponent thereafter submitted to counsel for respondent a proposed transcript of the por-

tions of the record herein that deponent considered material to the errors which he intended to assign on behalf of petitioner; that this was done in the hope that the parties could agree on the record and thus avoid the difficulty, time, and great expense that would be involved both in the preparation of eight complete copies of the proposed record (both testimony and exhibits) for filing in the Court of Claims and for counsel, and in the submission of the record to the Court of Claims for settlement. That this portion of the record, including additional portions designated by counsel for respondent, was referred to, in correspondence between counsel, as "plaintiff's record".

That thereafter, counsel for respondent, in addition to designating such additional portions of plaintiff's record, also submitted, for inclusion in the proposed transcript, "extracts from the accounting testimony which the defendant desires to accompany its proposed cross-petition for certiorari, if the plaintiff's petition is allowed." (Letter of April 29, 1942, from Mr. C. V. Edwards, counsel for respondent, to deponent. The cross-petition is case No. 373 of the October, 1942, Term of this Court.) That this portion of the record, taken solely from the accounting proceeding and including additional parts designated by deponent, is material only to the issue of infringement of claim 16 of the said Marconi patent,—the subject matter of respondent's cross-petition,—and is not material to any of the issues assigned by petitioner, all of which were decided by the Court of Claims prior to the accounting proceeding. That, in correspondence between counsel, this portion of the record was referred to as "defendant's record".

That thereafter, counsel agreed upon the entire transcript of record—both those portions material to errors to be assigned by petitioner and those portions material to

errors to be assigned by respondent. That, prior to submission of the proposed transcript to the Court of Claims for certification, deponent was advised that the Court of Claims would not certify two records, one as plaintiff's record and the other as defendant's record. That the entire record was therefore submitted as a single record and has been printed as such for use both on petitioner's application for a writ of certiorari (No. 369) and on respondent's cross-petition (No. 373).

That petitioner moved, before the Court of Claims, for an order relieving it of the cost of certification of that portion of the record that was material solely to respondent's proposed cross-petition, but that the motion was denied without opinion. That, under Rule 101 of the Court of Claims, the Clerk's fee for preparing and certifying a transcript of the record for the purpose of a writ of certiorari is chargeable only when such transcript is "sought by plaintiff".

That the portion of the printed transcript of the record herein that is material solely to respondent's cross-petition is contained in pages 2313 to 2522, inclusive, thereof. That the said record was printed, in accordance with Rule 41 of this Court, under the supervision of the Clerk of this Court, and that the cost of printing, and of supervising the printing of, the entire record has been paid by petitioner.

That deponent is informed and believes that the cost of printing the required forty (40) copies of said pages 2313 to 2522, inclusive, of the transcript of the record amounted to Four Hundred and Eight and 85/100 Dollars ($408.85); and that the fee of the Clerk of this Court for supervising the printing thereof was approximately Eighty-one and 70/100 Dollars ($81.70).

WHEREFORE, deponent respectfully prays that this Court enter an order requiring respondent to pay to petitioner the sum of Four Hundred and Ninety and 55 100 Dollars ($490.55) to reimburse it for the cost of printing, and of supervising the printing of, said portion of the record.

ABEL E. BLACKMAR, JR.

Subscribed and sworn to before me
this 25th day of November, 1942.

JOSEPHINE M. CESTONE
Notary Public, Westchester County, New York.
My Commission expires March 30, 1944.

[NOTARIAL SEAL]

No. 369

In the Supreme Court of the United States

OCTOBER TERM, 1942

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA, PETITIONER

v.

THE UNITED STATES

ON PETITION FOR A WRIT OF CERTIORARI TO THE COURT OF CLAIMS

BRIEF FOR THE UNITED STATES IN OPPOSITION

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In the Supreme Court of the United States

OCTOBER TERM, 1942

No. 369

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA, PETITIONER

v.

THE UNITED STATES

ON PETITION FOR A WRIT OF CERTIORARI TO THE COURT OF CLAIMS

BRIEF FOR THE UNITED STATES IN OPPOSITION

OPINIONS BELOW

The opinion of the Court of Claims on the issues of validity and infringement of the patents in suit (R. 7–116) is reported in 81 C. Cls. 671. The opinion of the Court of Claims on the accounting proceedings (R. 117–182) is not yet officially reported.

JURISDICTION

The interlocutory judgment of the Court of Claims concerning validity and infringement, in

pursuance of which an accounting was held, was rendered November 4, 1935 (R. 75); the final judgment after accounting proceedings was rendered April 6, 1942 (R. 182). The petition for a writ of certiorari was filed September 2, 1942 (R. 2524), pursuant to an extension of time granted by the Chief Justice (R. 2523). The jurisdiction of this Court is invoked under Section 3(b) of the Act of February 13, 1925, as amended.

QUESTIONS PRESENTED

(1) Whether the Court of Claims erred in holding the Marconi patent, No. 763,772, invalid as to all the claims in suit other than Claim 16 (*viz.* as to Claims 1, 2, 3, 6, 8, 10–14 and 17–20).

(2) Whether the Court of Claims erred in holding that Claims 1 and 37 of the Fleming patent, No. 803,684, had not been infringed by the United States.

STATUTE INVOLVED

The Act of June 25, 1910, c. 423, 36 Stat. 851, as amended by the Act of July 1, 1918, c. 114, 40 Stat. 704, 705 (35 U. S. C. § 68), to the extent pertinent reads as follows:

> That whenever an invention described in and covered by a patent of the United States shall hereafter be used or manufactured by or for the United States without license of the owner thereof or lawful right to use or manufacture the same, such owner's remedy shall be by suit against the United States in the Court of Claims for the recovery of

his reasonable and entire compensation for such use and manufacture: * * * *Provided further*, That in any such suit the United States may avail itself of any and all defenses, general or special, that might be pleaded by a defendant in an action for infringement, as set forth in Title Sixty of the Revised Statutes, or otherwise. * * *

STATEMENT

On July 29, 1916, petitioner brought this suit in the Court of Claims under the Act of June 25, 1910, to recover compensation for the alleged unauthorized use by the United States of inventions alleged to have been covered by four patents, two issued to Guglielmo Marconi, one to Sir Oliver Lodge, and one to Sir John Ambrose Fleming. One Marconi patent (reissue No. 11,913) was held not to have been infringed, and as to this no review is sought by petitioner. The Lodge patent (No. 609,154) was held to be valid and infringed, and is not here involved. The remaining two patents are Patent No. 763,772 to Guglielmo Marconi, granted June 28, 1904 (Claims 1, 2, 3, 6, 8, 10, 11, 12, 13, 14, 16, 17, 18, 19, and 20 involved in suit), and Patent No. 803,684 to John Ambrose Fleming, granted November 7, 1905 (Claims 1 and 37 involved in suit).

The court below, in its interlocutory judgment of November 4, 1935, held that all the claims in suit of Marconi Patent No. 763,772, except Claim

16[1] were invalid, and that Fleming Patent No. 803,684 had not been infringed by the defendant (81 C. Cls. 671; R. 75). These holdings were embodied by the court in the ultimate findings of fact (R. 117) made in connection with its final decision of April 6, 1942. The final judgment (R. 182) entered on that date awarded compensation to plaintiff in the amount of $42,984.93, plus interest, for infringement of Claim 16 of the Marconi patent, and in the additional amount of $34,827.79, plus interest, for infringement of the Lodge patent (not here involved).

The evidentiary findings of fact of the court below, supporting the ultimate findings of fact referred to above, may be briefly summarized as follows:

(a) *Marconi Patent No. 763,772 (all claims involved in suit other than Claim 16)* is directed to the tuning of wireless telegraph transmitters and receivers.

The pre-existing transmitter alleged to have been improved consisted of an antenna-circuit (also known as the radiating-circuit) and a charging-circuit. The antenna-circuit had an antenna at one end and a connection to earth at the other; the charging-circuit was coupled to the antenna-circuit through a transformer. The charging-

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[1] The defendant has filed a petition (No. 373) praying that in the event this Court grants the petition here involved (No. 369), but only in that event, a cross-writ of certiorari be issued to review that portion of the final judgment which awards damages against the United States for infringement of Claim 16 of the Marconi patent.

circuit contained a spark-coil, a charging condenser, and a spark gap—all three being known means for producing high frequency electrical oscillations (Finding XLIII, R. 38).

The pre-existing receiver alleged to have been improved likewise consisted of two circuits: the antenna-circuit which received the oscillations had an antenna at one end and a connection to earth at the other; and the detector-circuit which was coupled to the antenna-circuit through a transformer. Detecting and translating means, as a coherer and telegraph sounder, were connected in the detector-circuit (Fig. 13, Lodge patent, Ex. 20 R. 26), Finding XXVII, R. 24).

The alleged improvement of the Marconi patent (as embodied in all claims involved in suit except Claim 16) consisted in adjusting the inductance and capacity of either the two circuits at the transmitter or the two circuits [1] the receiver, or all four of these circuits to bring them into resonance to the same frequency or wave-length (Findings XXXVIII–XLIII, R. 31–38).

The court below found as facts that the alleged improvement of these claims was anticipated by the prior art (Findings LVII, LVIII, LIX, LXI, LXII, R. 56–60) as follows:

CLAIMS OF MARCONI PATENT INVOLVED IN SUIT	ANTICIPATING PRIOR ART
All claims for four-circuit tuning (except Claim 16)[1]	Stone Patent No. 614,756; and Tesla Patent No. 645,576 in conjunction with Lodge Patent No. 609,154

[1] Claim 16 was sustained for another feature. See cross petition for certiorari in No. 373 this Term, 1942.

[In addition, as anticipating prior art with respect to certain of these claims the Court found]

Claims 2, 12, 18, 39	Marconi Patent No. 627,650
Claims 1, 3	Lodge Patent No. 609,154, Fig. 4
Claim 2	Lodge Patent No. 609,154, Figs. 12, 13
Effecting four-circuit tuning by means of a variable inductance	Lodge Patent No. 609,154

(b) *Fleming Patent No. 803,684 (Claims 1 and 37)* disclosed a radio receiving circuit using as a rectifying detector the two-electrode tube of Edison patent No. 307,031 (Findings LXIV, LXX, LXXI, R. 60, R. 64–67). Fifteen years before the filing of this patent application in 1905 Fleming described in publications the unilateral conductivity of the Edison tube and its ability to rectify alternating currents when connected in a circuit as defined in Claim 1 of the Fleming patent. In 1915, ten years after his patent issued—long after the three-electrode tube had been invented and employed in radio apparatus as detector, amplifier and oscillator, and after the United States had used substantial quantities of three-electrode tubes as detectors and amplifiers—Fleming's assignee filed a disclaimer limiting "the combinations of elements" in certain claims, including Claim 1, and making other modifications in the specification (Findings LXV, LXXI, R. 62, 74).

The opinion of the court below indicated that the Fleming patent may be invalid because the new use it made of the "Edison effect" lacked invention (R. 104–105), and because of insufficiency and unreasonable delay in filing the disclaimer (R. 105–107). However, these matters are not included in

As modified by the disclaimer, the Fleming patent does not include all uses for the electron emissions from the heated electrode of the tube of the Edison patent, nor all uses for such emissions in connection with radio frequencies, but relates only to a *rectifying* use of such emissions of the Edison tube in connection with *alternating* currents of radio frequencies (Finding LXXII, R. 67).

All the alleged infringements comprise use of the three-electrode vacuum tubes of De Forest and purchase of such tubes and apparatus for use (Finding LXXV, R. 69). The defendant's structures used the De Forest three-element vacuum tubes as detectors and amplifiers. In these arrangements (both detector and amplifier), the hot filament and plate of the Edison tube were connected with a *direct current* battery circuit polarized so that current would flow, and the translating device, i. e., headphone, was placed in this battery circuit. In the detector arrangement, the incoming alternating current signal was connected through a grid condenser to a grid placed in the space between the hot filament and the plate so that the audio-components of the received oscillations would alternatingly stop and permit flow of a larger local battery current (Finding LXXV, R.

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the findings of fact on which the judgment is based (R. 60–74), since those findings are restricted to the pivotal issue of infringement (R. 75).

69); in the amplifier arrangement, the alternating current of audio frequency was also applied to the grid to control increase or decrease of a larger current in the local battery circuit (Finding LXXVI, R. 72).

The court below found that insofar as defendant's structures and the invention disclosed in the Fleming patent had anything in common, the common matter had been disclosed in the earlier Edison patent (Finding LXXII, R. 67); that the Fleming patent was limited to his manner of applying the so-called "Edison effect" (Finding LXXII, R. 67); that the defendant's manner of using the "Edison effect" differed in means, mode of operation and result from that of Fleming (Findings LXV–LXXX, R. 62–74); and that, therefore, defendant's structures did not infringe the Fleming patent (R. 116; Finding I, R. 117).

ARGUMENT

In making the evidentiary findings in support of its ultimate findings as to invalidity of the Marconi patent (except Claim 16) and noninfringement of the Fleming patent, the court below analyzed in detail the prior art relied upon by defendant and pointed out wherein it anticipated or limited the subject matter and claims of these patents. Petitioner has not challenged these analyses, nor has it charged, or made any showing, that there is a lack of substantial evidence to sustain the findings, or that any ultimate finding is not sustained by the

evidentiary findings. Likewise no contention has been made, nor could it have been made, that the court below failed to make any finding of fact on a material issue. There is thus no basis for review under the 1939 amendments to the Act of February 13, 1925, providing for review by certiorari of decisions of the Court of Claims.[4]

As the sole reasons for allowing the writ petitioner urges (1) an alleged conflict between the conclusions reached below and several decisions of the lower federal courts, and (2) recommendations of an administrative board in 1921 that Congress enact legislation awarding petitioner a greater sum

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[4] Section 3 (b) of the Act of February 13, 1925, c. 229, 43 Stat. 936, as amended by the Act of May 22, 1939, c. 140, 53 Stat., part 2, 752, provides that in cases of certiorari to the Court of Claims, "the Supreme Court shall have authority to review, in addition to other questions of law, errors assigned to the effect that there is a lack of substantial evidence to sustain a finding of fact; that an ultimate finding or findings are not sustained by the findings of evidentiary or primary facts; or that there is a failure to make any finding of fact on a material issue."

Indeed, the only questions involved—the issue of invalidity with respect to the Marconi patent, and the issues of scope of claims and of infringement with respect to the Fleming patent, are purely factual. *United States* v. *Esnault-Pelterie*, 299 U. S. 201; 303 U. S. 26, 29. And even before the Act of May 22, 1939, decisions of the Court of Claims upon such matters were not subject to review by this Court except where the ultimate findings were not sustained by the evidentiary findings. *United States* v. *Esnault-Pelterie*, 303 U. S. 26. The decision of such issues in the federal courts will not ordinarily be reviewed except to resolve a conflict of decision between circuit courts of appeals. *Keller*

than it has recovered below. Neither of these grounds justifies the issuance of the writ.

1. *The decision below does not conflict with decisions of other federal courts on either of the two questions in this case.*

The Marconi patent here involved was considered by the federal courts in three reported cases, but, as the Court of Claims pointed out in its decision of this case (R. 95–102), none of these adjudications is inconsistent with the result reached below. In *Marconi Wireless Telegraph Co. of America* v. *National Electric Signaling Co.*, 213 Fed. 815 (E. D. N. Y.), the District Judge held the Marconi patent valid and infringed, but the defense of the prior art Stone patent (which the Court of Claims relied upon in this case to hold the patent invalid) was neither presented nor referred to. *Marconi Wireless Telegraph Co. of America* v. *De Forest Radio Telephone & Telegraph Co.*, 225 Fed. 65 (S. D. N. Y.), affirmed 225 Fed. 373 (C. C. A. 2), involved a motion for preliminary injunction under the Marconi patent. The court, merely issuing preliminary relief against infringement, did not pass upon the question of validity. In *Marconi Wireless Telegraph Co.* v. *Kilbourne & Clark Mfg. Co.*, 239 Fed. 328 (W. D. Wash.), affirmed 265

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v. *Adams-Campbell Company*, 264 U. S. 314, 319; *Layne & Bowler Corporation* v. *Western Well Works, Inc.*, 261 U. S. 387; *cf. General Talking Pictures Corp.* v. *Western Electric Company*, 304 U. S. 175. There is no such conflict here.

Fed. 644 (C. C. A. 9), the district court, again not passing upon validity, merely held the Marconi patent not to have been infringed. While the "Stone" defense was before the court, it was presented solely to sustain the defense of "noninfringement of the invention as limited by the prior art," and the circuit court of appeals in affirming the decision as to noninfringement expressly recognized defendant's position in this respect (265 Fed. 646). The significance of the court's language as to validity is thus considerably diminished. Of greater significance is the fact, as the court below recognized (R. 97–99), that anticipation by Lodge Patent No. 609,154 taken with Tesla Patent No. 645,576—the other basis for the Court of Claims' conclusion of invalidity—was not considered in that decision.

The Fleming patent was considered by the federal courts in two cases, neither of which involved the question of infringement here presented. In *Marconi Wireless Telegraph Co.* v. *De Forest Radio Telephone & Telegraph Co.*, 236 Fed. 942 (S. D. N. Y.), the plaintiff sued for infringement of the Fleming patent by the use of the three-electrode tube, alleging that it was the same in principle as the Fleming two-electrode tube. The defendant agreed they were the same in principle, but urged that the hot-gas tube patents of defendant, which were earlier than the Fleming patents, were also the same in principle. The court held the hot-gas

tube patents to be different in principle, and the Fleming patent to be valid and infringed. The Circuit Court of Appeals for the Second Circuit affirmed (243 Fed. 560), noting that both parties agreed the two-element and three-element tubes were the same in principle. In 261 Fed. 393, the district court extended the decree to oscillators, on the theory that the Fleming valve was inherently capable of oscillating. Since there was no conflict between the parties in that litigation as to the point most important to the issue of infringement here involved—*viz.*, whether the two-electrode and three-electrode tubes are different in principle—the decision cannot be deemed a holding in conflict with the result reached below.[1] Nor did *Radio Corporation of America* v. *Radio Audion Co.*, 278 Fed. 628 (Del.), pass on the point here involved.[2]

The decisions of the British and French courts to which petitioner refers plainly have no application, being rendered under different patents and different statutory standards.

2. Petitioner makes reference to the recom-

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[1] In this connection it should be noted that the findings and opinion of the Court of Claims in the present case as to the operation of the three-electrode tube are in accord with the analysis thereof made by this Court in *De Forest Radio Co.* v *General Electric Co.*, 283 U. S. 664.

[2] In that case, the district court, without explanation, but apparently following the *De Forest* case (Pet. 22, note 26) granted a preliminary injunction under the Fleming patent as to detectors, but refused to grant restraint as to amplifiers and oscillators.

mendation of an Interdepartmental Board in 1921 that legislation be enacted granting petitioner $1,250,000 for respondent's use of the Marconi, Fleming, and Lodge patents (Pet. Br. p. 20). Not only is this factor irrelevant, but whatever significance is sought to be attached to it is virtually nullified by petitioner's admission that the recommendation, which was based upon an *ex parte* presentation by petitioner, was without prejudice and not binding upon the Government, and was rejected by Congress (Pet. Br. pp. 20, 26).

Since the patents in suit have long since expired (Pet. Br. 12), no question of importance with respect to the patents is here involved. And no novel question of law is presented by this case.

CONCLUSION

The decision of the court below is correct. There is no conflict and no question of importance is involved. It is therefore respectfully submitted that the petition for a writ of certiorari should be denied.

CHARLES FAHY,
Solicitor General.
FRANCIS M. SHEA,
Assistant Attorney General.
C. V. EDWARDS,
Special Assistant to the Attorney General.
D. L. KREEGER,
J. Y. HOUGHTON,
Attorneys.

NOVEMBER 1942.

FILE COPY

No. 369

In the Supreme Court of the United States

OCTOBER TERM, 1942

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA, PETITIONER

v.

THE UNITED STATES

ON WRIT OF CERTIORARI TO THE COURT OF CLAIMS

BRIEF FOR THE UNITED STATES

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In the Supreme Court of the United States

OCTOBER TERM, 1942

No. 369

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA, PETITIONER

v.

THE UNITED STATES

ON WRIT OF CERTIORARI TO THE COURT OF CLAIMS

BRIEF FOR THE UNITED STATES

OPINIONS BELOW

The opinion of the Court of Claims on the issues of validity and infringement of the patents in suit (I R. 7–116[1]) is reported at 81 C. Cls. 671; its opinion on the accounting proceedings (I R. 117–182) is not yet officially reported.

JURISDICTION

The interlocutory judgment of the Court of Claims concerning validity and infringement, pur-

[1] The record citations refer to the volume and page.

suant to which an accounting was held, was rendered November 4, 1935 (I R. 75); the final judgment after the accounting proceedings was rendered April 6, 1942 (I R. 182). The petition for a writ of certiorari was filed on September 2, 1942 (III R. 2524), pursuant to an extension of time granted by the Chief Justice (III R. 2523), and was granted on December 14, 1942. The jurisdiction of this Court is invoked under Section 3 (b) of the Act of February 13, 1925, as amended.

QUESTIONS PRESENTED

I. Whether the Court of Claims erred in holding the Marconi patent No. 763,772 invalid as to all the claims in suit other than claim 16.

II. If the answer to the first question is in the affirmative, whether the Marconi patent was infringed by defendant's apparatus.

III. Whether the Court of Claims erred in holding that claims 1 and 37 of the Fleming patent No. 803,684 were not infringed by the United States.

IV. If the answer to the third question is in the affirmative, whether the Fleming patent was invalid for—

(1) anticipation by the prior art;

(2) unreasonable delay in disclaiming a part of the patent lacking invention; or

(3) impropriety of the subject matter of the disclaimer.

STATUTES INVOLVED

The Appendix, pp. 175–178, *infra*, contains the pertinent provisions of the statutes involved.

STATEMENT

On July 29, 1916, petitioner Marconi Wireless Telegraph Company of America (herein called "plaintiff") brought this suit in the Court of Claims under the Act of June 25, 1910, to recover compensation for the allegedly unauthorized use by the United States (herein sometimes called "defendant") of inventions alleged to have been covered by four United States patents, two issued to Guglielmo Marconi, one to Sir Oliver Lodge, and one to Sir John Ambrose Fleming.

The court below held that one Marconi patent, reissue No. 11,913, was not infringed (I R. 117), and that the Lodge patent No. 609,154 was valid and infringed (I R. 117). As to these, no review has been sought by either party.[1] The court below further held that claim 16 of Marconi patent No. 763,772 was valid and infringed (I R. 117), and after accounting proceedings rendered final judgment on April 6, 1942, awarding plaintiff compensation in the amount of $42,984.93 plus interest (I R. 182). The decision concerning claim 16 is now before this Court in *The United States* v.

[1] The final judgment rendered after the accounting proceedings awarded plaintiff $34,827.70 plus interest for infringement of the Lodge patent (I R. 182).

Marconi Wireless Telegraph Company of America, No. 373, this Term.

The remaining claims in suit of Marconi patent No. 763,772[1] were held invalid (I R. 117), and the Fleming patent No. 803,684 was held not infringed (I R. 117). This decision is the subject of the present proceeding.

The findings of fact of the court below, briefly summarized, were:

Marconi Patent No. 763,772 granted on June 28, 1904, was directed to the tuning of wireless telegraph transmitters and receivers, and claimed an improvement therein. The preexisting transmitter alleged to have been improved by Marconi consisted of a charging circuit and an antenna circuit. The charging circuit of the preexisting transmitter, which generated the oscillations, contained means for producing high frequency electrical oscillations, namely, a spark coil, a charging condenser and a spark gap. The antenna circuit, which transmitted the oscillations, had an antenna at one end and a connection to earth at the other. The charging circuit and the antenna circuit were coupled together by a transformer. (Finding XLIII; I R. 38.)

The preexisting receiver alleged to have been improved by Marconi likewise consisted of two circuits: an antenna circuit and a detector circuit. The antenna circuit, which received the

[1] Claims 1, 2, 3, 6, 8, 10, 11, 12, 13, 14, 17, 18, 19, and 20.

oscillations, had an antenna at one end and a connection to earth at the other. The detector circuit contained a means for detecting the transmitted oscillations (such as a coherer) and a means for translating them (such as a telegraph sounder). The detector circuit and the antenna circuit were coupled together by a transformer (Finding XXVII; I R. 24).

The alleged improvement of the Marconi patent (as embodied in all claims involved in suit except claim 16) consisted in adjusting the inductance and capacity of either the two circuits at the transmitter or the two circuits at the receiver, or all four of these circuits, in order to tune or bring them into resonance to the same frequency or wave length (Findings XXXVIII–XLIII; I R. 31–38).

The court below found that this alleged improvement was anticipated and consequently invalidated by the prior art (Findings LVII–LIX, LXI, LXII; I R. 56–60). It made findings as to the subject matter of the prior art and of the claims in suit, showing, by direct comparison, the lack of novelty in the latter (Findings XXVII, XL–XLIII, LI–LIX, LXI–LXII; I R. 23, 32–40, 45–57, 57–59). More specifically, it found or held that all claims for four-circuit tuning (except claim 16, which was sustained on account of a feature not relevant here) were anticipated by Stone patent No. 714,756 (Finding

LVIII; 1 R. 57), and by Tesla patent No. 645,576 read in conjunction with Lodge patent No. 609,154 (1 R. 98).*

Fleming Patent No. 803,684 granted on November 7, 1905 (claims 1 and 37 in suit), disclosed a radio receiving circuit using as a rectifying detector the two-electrode tube of Edison patent No. 307,031 (Findings LXIV, LXX, LXXI; 1 R. 60, 64–67). The unilateral conductivity of the Edison tube and its ability to rectify (by changing to direct current) alternating currents when connected in a detector circuit as defined in claim 1 of the Fleming patent had been described in publications as early as 1890, fifteen years before Fleming filed his patent application; and it was such rectification, with the same detector circuit, that claim 1 of the Fleming patent described (Finding LXXI; 1 R. 67). In 1915, ten years after the patent issued, plaintiff as Fleming's assignee filed a disclaimer purport-

* The Marconi claims for effecting four-circuit tuning by means of a variable inductance were also found to have been anticipated by the Lodge patent, and six Marconi claims were found to be additionally anticipated in other prior art, as follows (Findings LIX and LXI; 1 R. 57):

Marconi Patent No. 763,772	*Anticipating Prior Art*
Claims 2, 13, 18, 19.	Marconi Patent No. 627,650.
Claims 1, 3.	Lodge Patent No. 609,154, Fig. 4.
Claim 2.	Lodge Patent No. 609,154, Figs. 12, 13.

ing to limit the field of use of certain claims (including claim 1) to the use of the two-electrode rectifier, without change, to rectify alternating currents of high (or Hertzian wave) frequencies (Finding LXXII; 1 R. 67). The Edison two-electrode rectifier used by Fleming consisted of two elements within a vacuous enclosure: a filament heated to cause it to emit electrons, and a colder plate in proximity to but not touching the filament. The two elements were connected by a circuit outside the tube, and, because the electrons flowed through the tube only from the hotter to the colder element, alternating current introduced into the circuit from an external source would pass in only this one direction through the vacuous space between the elements, thus resulting in rectification.

The alleged infringements by the defendant consist of the use of the three-electrode vacuum tubes of DeForest, and the purchase of such tubes and apparatus for use in receivers and transmitters (Finding LXXV; 1 R. 69). The defendant's receivers used the DeForest three-electrode vacuum tubes as detectors and amplifiers. In these arrangements, the vacuum tube contained not only the two electrodes of the Edison tube, but also contained a third element—a grid of spaced wires—placed in the vacuous space in the tube between the hot filament and the plate. The heated filament and plate of the tube were

here connected with a *direct current* battery circuit, having its negative end permanently connected to the filament and its positive end permanently connected to the plate, and thus tending to produce a flow of current through the tube at all times. The operation of the device depended on the discovery that by changing the potential of the grid, the flow of electrons from the always negatively charged filament (cathode) to the always positively charged plate (anode) could be controlled. In the detector arrangement, the translating device (the headphone) was placed in the local battery circuit, and the incoming alternating current signal was connected through a grid condenser to the grid in the tube, so that the audio-components of the received oscillations would so polarize the grid relative to the filament as alternately to retard and accelerate the flow of the larger battery current between filament and plate (Finding LXXV; 1 R. 69). In the amplifier arrangement, an alternating current of audio-frequency was applied to the grid to control the increase or decrease of a larger current in the battery circuit (Finding LXXVI; 1 R. 72).

The court below found that insofar as defendant's structures and the invention disclosed in the Fleming patent had anything in common, the common matter had been disclosed in the earlier Edison patent and was well known to the art

before the earliest date to be accorded the Fleming patent; that the art was familiar with the ability of the Edison tube to rectify alternating currents; that the Fleming patent, to one skilled in the art, included only the use of the well-known "Edison effect" to rectify alternating currents of radio frequencies; that the defendant's manner of using the "Edison effect" differed in means for applying it, mode of operation, and result, from that of Fleming (Findings LXV–LXXX; I R. 62–74); and that defendant's structures therefore did not infringe the Fleming patent (Finding 1; I R. 116–117).[3]

Although the ultimate findings of fact on which the judgment relating to the Fleming patent is based (I R. 60–74) were restricted to the issue of infringement (I R. 75), and did not include matters relating to validity, the court made evidentiary findings relating to the prior art and to the disclaimer; and in its opinion the court below held that the Fleming patent was invalid because of unreasonable delay in filing the disclaimer (I R. 105–107).[4] The court further indicated, without

[3] Findings identified by arabic numerals refer to those made by the court below after the accounting proceedings, in connection with the final judgment of April 6, 1942; roman numerals refer to findings made before such proceedings, in connection with the interlocutory judgment of November 4, 1935.

[4] The court found that the disclaimer was filed long after the three-electrode tube had been invented and employed in radio apparatus as a detector, amplifier and oscillator, and

deciding, that the patent may also be invalid because the alleged new use Fleming made of the "Edison effect" lacked invention (I R. 104–105).

SUMMARY OF ARGUMENT

I

The court below properly held that the Marconi patent No. 763,772, as to all claims in suit except claim 16, was invalid because anticipated in the prior art. The alleged improvement in the field of wireless communication, which the patent purported to disclose as of November 10, 1900, consisted in adjusting the inductance and capacity of either the two circuits at the transmitter or the two circuits at the receiver, or all four of these circuits, in order to tune them to the same frequency or wave length. All these features had already been shown in the art, as the court below properly found. Hertz between 1879 and 1890 had established the basic principles of tuning the transmitting and receiving circuits of a wireless system to the same frequency in order to sustain the maximum response. Lodge in 1894 fully explained Hertz' teachings in terms of a wireless communication system, and Marconi in an 1897 patent showed receiving apparatus which could be electrically tuned to oscillations from a transmitter.

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after the United States had used substantial quantities of three electrode tubes as detectors and amplifiers (Findings LXV, LXXI; I R. 62, 74).

Then Tesla in 1897 showed (as Marconi's patent in suit showed in 1900) a wireless transmitter system containing a charging circuit for causing oscillations of a desired frequency, an antenna circuit for transmitting these oscillations, coupled to the charging circuit through a transformer, and the synchronizing or tuning of these two circuits by adjusting the inductance of the circuits. Tesla, moreover, disclosed the same arrangement in the receiver, and thus anticipated the four circuit tuning combination of Marconi.

The only feature in Marconi's arrangement which was absent from Tesla's was the use of a more readily variable inductance in the antenna circuit as the tuning medium of the transmitter, but this very feature, used for the same purpose, was found in Lodge's disclosure of 1898, almost three years prior to Marconi. Hence, the court below properly held that Tesla, read in conjunction with Lodge, anticipated all of Marconi's claims for four-circuit tuning. It might properly have found that Lodge alone anticipated all the receiver claims. Similarly, the 1899 patent of Marconi, antedating the one in suit, brought out the principle of tuning the circuits of transmitter and receiver by variable inductance coils, in accordance with the varying wave lengths. Finally, before Marconi's date of November 10, 1900, Stone disclosed on February 8, 1900 (and even earlier in his letters to Baker) the

tuning of all four of the open and closed circuits of transmitter and receiver to the same frequency. While Stone did not prescribe the particular means for adjusting the frequency of the aerials, he did prescribe tuning them to the desired fundamental frequency; and the art was familiar at that time with the use of a variable inductance for such purpose.

Prior litigation upholding the Marconi patent is of no authority on the question of validity since in two of the cases the Stone defense was not before the court and in the third the patent was held not infringed, rendering unnecessary any opinion as to invalidity. Moreover, none of the prior cases considered specifically whether there was any invention in using the Lodge tuning coil to effect the tuning of Tesla's apparatus.

II

An additional ground for affirmance of the judgment for defendant, urged but not passed on below, is that the evidentiary findings made by the court and the record upon which they are based establish that defendant's apparatus did not infringe the Marconi patent. No criteria of infringement are available under the decision below since all claims of the Marconi patent (except claim 16, not here involved) were held invalid. But the conclusion must be against infringement even if, as the criteria, there be taken

features judicially upheld in two decisions of lower federal courts (*Marconi Wireless Telegraph Co.* v. *National Electric Signaling Co.*, 213 Fed. 815 (E. D. N. Y.) and *Same* v. *Kilbourne & Clark Mfg. Co.*, 239 Fed. 328 (W. D. Wash.) affirmed 265 Fed. 644 (C. C. A. 9)), and in a decision of an English court concerning the corresponding British patent (*Marconi* v. *British Radio Telegraph & Telephone Co.*, 27 T. L. R. 274). The feature held novel in these cases was the use in the transmitter of a persistently oscillating charging circuit employing a low resistance plain spark gap, with loose coupling between that circuit and an antenna circuit in exact tune therewith. With this arrangement the charging circuit fed only a small part of its energy to the antenna circuit on each oscillation, so that the radiation of the antenna circuit would be continually replenished on each oscillation and thus be prolonged. The courts in question distinguished this arrangement from the prior art transmitter of the Lodge patent, which used tight coupling and a more highly resistant, and less persistent oscillator circuit, whereby the latter would deliver its energy to the antenna in a rush and then cease operating, to leave the antenna circuit free to oscillate at its own natural period and rate of damping.

The defendant's quenched gap transmitters, constituting most of the transmitter apparatus

alleged to infringe, do not employ the distinctive structure, mode of operation, and result held to differentiate Marconi's system from Lodge, but instead follow Lodge's principles, using a high-resistance quenched gap in a charging circuit tightly coupled to a somewhat detuned antenna circuit—features which prevent the charging circuit from being a persistent oscillator, and give both the charging and antenna circuit a mode of operation like that of Lodge and different from that of Marconi's arrangement. The commercial displacement of the plain gap transmitters by the quenched gap type soon after their development further attest to their substantial dissimilarity. On principle and authority and in view of the prior art, these transmitters did not infringe Marconi's alleged invention.

Defendant's rotary gap transmitters were similar to the quenched gap type, also quenching the spark quickly and preventing the charging circuit from being a persistent oscillator; these transmitters did not infringe for the reasons stated with respect to the quenched gap transmitters. And the few plain gap transmitters used by the defendant did not trespass upon Marconi's patent because defendant's apparatus had direct instead of transformer coupling between the charging and antenna circuits, and there is no evidence that they were loosely coupled or that they attained Marconi's slow feeding operation and result.

Defendant's receivers also do not infringe the Marconi patent. The features of Marconi's system upheld by the three courts referred to above were attributable solely to Marconi's transmitter, and not to his receivers, *per se;* and to the extent that any matters disclosed by Marconi are to be found in defendant's receivers, they are equally to be found in the prior art.

III

The court below properly found that the Fleming patent No. 803,684 was not infringed, and did not pass upon the defense of invalidity urged by defendant. However, the court's evidentiary findings as to the prior art, and as to the structure, operation, and effect of Fleming's device—which were required in order to enunciate the proper criteria for gauging the alleged infringement—necessarily lead to a conclusion of invalidity.[49] The Fleming patent disclosed a two-electrode vacuum tube, one electrode of which was heated, with a circuit connecting the two electrodes outside the tube. A direct current indicator in this circuit responded when an alternating current was impressed on the circuit and rectified by the one-way conductivity of the tube. The incoming alternating current signal was received in an antenna circuit and was impressed on the single external circuit of the tube by a transformer.

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[49] As to the order of argument, see n. 49, p. 105, *infra.*

Every element of this arrangement, and this combination, was to be found in the prior art. Edison in 1884 received a patent on the very two-element tube shown by Fleming as of November 16, 1904, containing a heated filament and a colder plate, connected together outside the tube. The rectifying operation of the Edison tube upon alternating currents, due to the unidirectional flow of current between filament and plate, was recognized and published by Fleming in 1890, more than ten years before his patent application; it was also described and illustrated by others in 1897. In 1903, the deValbreuze patent employed a similar two-electrode tube in an identical circuit to rectify alternating currents of high or Hertzian wave frequency, and Wehnelt in October 1904—a month before Fleming's earliest date—also disclosed the specific arrangement described in Fleming's patent to rectify alternating currents. The art prior to Fleming, in discussing the rectifying operation of the Edison tube, properly had drawn no distinction between rectifying high frequency and low frequency alternating currents; and to those skilled in the art it was implicit in the known operation of the device, that it would rectify low or high (Hertzian) frequencies of alternating current with equal facility. The specific disclosure of the prior art de Valbreuze patent applying a like two-electrode tube as a rectifying

detector of wireless waves, in the same circuit proposed by Fleming, disposes of any contrary contention. The Fleming patent was thus invalid for anticipation and lack of invention.

Additional reasons exist for invalidity of the Fleming patent. Plaintiff disclaimed from the scope of that patent all use of the device to rectify low-frequency currents, but did so more than ten years after it had been held out to the public as dominating rectification of high and low frequencies. Indeed, whatever the frequencies, the arrangement operated without change in but one manner, to produce but one result, rectification. The patent when issued, on its face squarely covered subject matter which Fleming knew had entered the public domain years before. The disclaimer thus was unreasonably delayed. Moreover, the subject matter of the disclaimer was improper, for it either did not disclaim any properly separable part of the patent, or it attempted to add a new element to the invalid claims—the requirement that the current rectified be of radio frequency.

IV

The finding of the court below that the Fleming patent No. 803,684 was not infringed by the De-Forest three-electrode tube employed by defendant, is sustained by evidentiary findings which are in turn supported by substantial evidence. The Fleming patent employed the Edison two-electrode

tube as a rectifier of alternating current introduced into its single external circuit to enable that very current, when rectified, to operate an indicator in that circuit. DeForest's three-electrode tube, on the contrary, employed only the large direct current of a local battery in its plate circuit to operate the indicator. This current needed no rectification. DeForest added a new discovery to the Edison tube, nowhere suggested by Fleming, namely, that by placing a third element, a grid, in the evacuated space between the filament and plate, it would be possible to impart to the tube a new mode of operation, relay action, enabling one to produce large changes in the local battery current of the plate circuit by impressing small potential changes on the grid.

As the incoming energy acted in the grid circuit to control a local current in the entirely separate plate circuit, the device was a relay. As it produced the proportionately large changes in the current of the plate circuit, compared to the changes of potential on the grid, the device was an amplifier. Thus its structure, mode of operation and result were different from those of the Fleming device.

Further, the three-electrode tube served to reproduce, as variations in the local plate current, changes of potential, however derived, applied to the grid. In defendant's amplifiers, the changes of potential were derived from an alternating

current of low or audio-frequency (excluded from the Fleming patent by disclaimer). In one form of defendant's detector, the grid was given a basic negative charge by a small battery in the grid circuit so that it would permit only a small current to flow in the plate circuit. Alternating current applied to the grid then rendered it alternately more positive and negative than its basic charge, reproducing by relay action the modulation of the incoming alternating current by allowing large increases and causing only small decreases in the plate current. These plate current variations, when averaged up by an indicator, caused the indicator to respond to the reproduced modulation. In the other form of detector, a grid condenser bridged by a high resistance leak was employed in lieu of the grid-biasing battery. This arrangement caused the grid to assume a negative charge proportional to the modulation (amplitude) of the incoming signal and thus, by relay action, to reproduce, in variation of the local direct current in the plate circuit, a replica of the intelligence transmitting characteristic of the signal, suitable to operate the indicator.

The ability of the three-electrode tube to amplify enables it to be used as an oscillator or self-sustained generator of oscillations for use in a transmitter; and plaintiff now concedes that the two-electrode valve, as disclosed by Fleming, cannot either amplify or oscillate. Oscillation in

the triode is effected by using a little of the current variation in the plate circuit to effect changes in potential of the grid which in turn produce larger variations in the plate current, until a maximum variation of plate current results; and this continues as a steady oscillation continuously replenished by amplification through the tube. That portion of the steady oscillation not being "feedback" to maintain the tube in oscillation may then be delivered to a transmitting antenna circuit coupled directly, or through a transformer, to the plate circuit of the oscillating tube circuit, for radiation thereby. The regenerative receivers employed the same "feed-back" principle, but feed-back only enough energy to reenforce an incoming signal applied to the grid, and not enough to sustain the tube in oscillation.

Thus the Fleming patent used the two element tube theretofore shown by Edison, in an already known alternating current rectifying circuit containing a direct current indicator, to *rectify* the received alternating currents of Hertzian frequencies, so that the rectified energy of those received currents could operate the direct-current indicator in the alternating-current circuit. Defendant's three-electrode tubes employed a different structure (a three-element tube) operating in a different way (by relay action) to produce a different result (an amplified reproduction in a large local direct current of a replica of voltage variations impressed on the grid).

The substantial dissimilarity between defendant's and Fleming's devices is further shown by the rapidity with which the triode replaced the older form of tube, and the signal contributions which the triode made to the art. The only case which held the Fleming patent valid and infringed by DeForest's triode is *Marconi Wireless Telegraph Co. of America* v. *DeForest Radio Telephone & Telegraph Co.*, 236 Fed. 942 (E. D. N. Y.), affirmed 243 Fed. 551 (C. C. A. 2). That decision is entitled to little weight on either of these issues, for both parties had there agreed, for collateral reasons, that the two-electrode and three-electrode vacuum tubes were essentially alike, thus eliminating any controversy on the matter crucial to the decision here.

ARGUMENT

The judgment entered below holding Marconi patent No. 763,772 invalid and Fleming patent No. 803,684 not infringed can be challenged only by showing that the findings of fact lack substantial evidence to support them or that the ultimate findings of fact are not sustained by the evidentiary findings of fact. We believe that plaintiff has not and cannot make any such showing. But even if the court below were in error in holding the Marconi patent invalid and the Fleming patent not infringed, we submit that the judgment should be affirmed because it is adequately sustained by additional grounds, which were urged

but not passed on by the court below. More particularly, we submit that the Marconi patent, even if valid, was not infringed by the defendant's transmitters because these differed substantially from Marconi's arrangement in structure, mode of operation and result. Likewise, the Fleming patent, whether or not infringed, was in our view invalid because anticipated, at least as to the features alleged to have been infringed, by prior disclosures. In any event, Fleming's patent was invalid because the 1915 disclaimer of the device as applied to low frequency currents was made after unreasonable delay and was not in its substance within the disclaimer statutes. The evidentiary findings made below will sustain the judgment in defendant's favor upon these alternative grounds; and such alternative grounds, having been urged below, may be considered by this Court. *Stelos Co.* v. *Hosiery Motor-Mend Corp.*, 295 U. S. 237.

PART ONE: MARCONI PATENT NO. 763,772

POINT I

THE COURT BELOW PROPERLY HELD MARCONI PATENT NO. 763,772 INVALID BECAUSE ANTICIPATED IN THE PRIOR ART

The court below found that Marconi patent No. 763,772, as to all claims in suit except claim 16, was anticipated by the prior disclosures of Tesla, Lodge and Stone, and by an earlier patent to Mar-

coni himself. This conclusion is supported by adequate evidentiary findings of fact, which are in turn grounded upon substantial evidence.

1. *The Disclosures of Marconi Patent No. 763,772*

Marconi patent No. 763,772 was granted on June 28, 1904. Its stated object was "to increase the efficiency" of wireless telegraph transmitting and receiving systems, and

> to provide new and simple means whereby oscillations or electric waves from a transmitting station may be localized when desired at any one selected receiving station or stations out of a group of several receiving stations (Ex. 21, p. 1, lines 13–19; IV R. 2588).

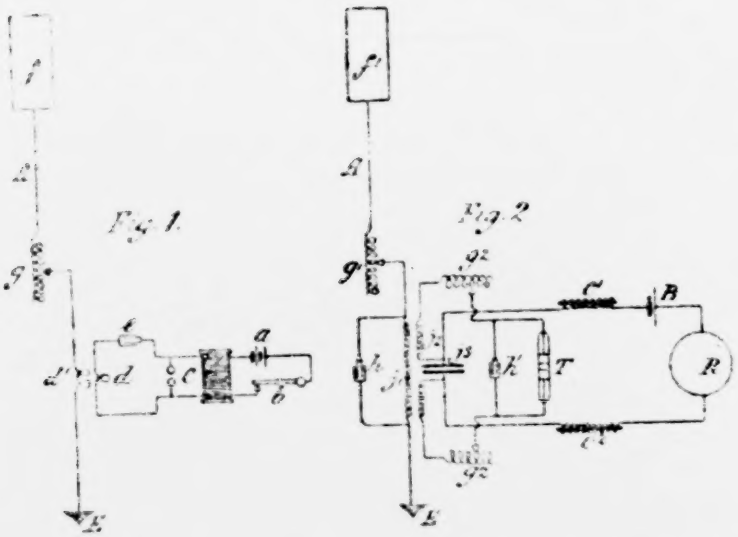
The means employed by Marconi to carry out his invention are illustrated as follows in Figures 1 and 2 of his patent:

(a) The Transmitter: Claims 1, 3, 6, 8, 11, and 12

At the transmitting station (Fig. 1), the patent specification (IV R. 2591) calls for

(i) an oscillation transformer *d d'* "of a kind suitable for the transformation of very rapidly alternating currents" (lines 36–38),

(ii) "one coil of said transformer" *d'* "being connected between the aerial wire or plate" *f* "and the connection thereof to earth" *E*,



(iii) "while the other coil of the transformer" *d* "is connected in circuit with a condenser" *e* (lines 39–43), and forms part of

(iv) a persistent oscillator, which further comprises "a producer of Hertzian oscillations or electric waves shown in the form of a spark producer" (i. e., the low-resistance plain spark gap, adjacent to the letter *c*) "and an induction coil (*c*) controlled by a signaling instrument" *b* (lines 43–46), and

(v) a good radiator (i. e., the open antenna circuit, *f A E*).

The specification explains that the battery *a*, through the induction coil *c*, charges the condenser *e* until the voltage thereof is sufficiently high to break down the resistance of the spark gap (adjacent to the letter *c*), whereupon the current leaps the gap and completes the primary

circuit, *e d* and gap, creating high frequency oscillations therein. This circuit, sometimes referred to as the charging circuit, constitutes the "persistent oscillator" of the patent.[1] The spark gap is shown as a "plain gap", i. e., one of relatively low resistance which allows the oscillations to persist in the charging circuit, *e d* and gap, for some time before being damped out by the resistance of the circuit. The circuit is tuned to the desired frequency of transmission by the inductance (the coil *d*) and capacity (the condenser *e*) in the circuit; hence, the oscillations in the charging circuit will persist for a maximum period of time commensurate with their transfer to the antenna circuit before the spark gap ceases to be conductive. As long as the oscillations persist in the charging circuit they will induce correspondingly prolonged oscillations in the antenna *A* to which the charging circuit is coupled by the oscillation transformer *d d'*. The persistency of the oscillations is aided, and their

[1] The patent specification states (IV R. 2392, lines 12–24):

"My experiments have demonstrated that the best results are obtained at the transmitting station when I use a persistent oscillator—an electrical circuit of such a character that if electromotive force is suddenly applied to it and the current then cut off electrical oscillations are set up in the circuit which persist or are maintained for a long time—in the primary circuit, and use a good radiator—i. e., an electrical circuit which very quickly imparts the energy of electrical oscillations to the surrounding ether in the form of waves—in the secondary circuit."

gradual transfer from the charging circuit to the antenna or radiating circuit is effectuated, by "loosely" coupling the circuits so that only a small portion of the energy of each oscillation in the charging circuit is transferred to the antenna circuit on each alternation of the current. This "loose-coupling" is effectuated by the presence in the antenna circuit of the relatively large inductance *g*, which, not being coupled to the charging circuit, acts to delay (i. e., "swamp" or "bog down") the influx of energy from the charging circuit into the antenna circuit, thus permitting the remainder of the energy to persist as oscillations in the charging circuit.*

The principal features of Marconi's transmitter are thus

> i. means for adjusting the charging and antenna circuits to the same frequency by a variable capacity (*c*) in the charging circuit and a variable inductance (*g*) in the antenna circuit, and

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* When the circuits of an oscillation transformer (such as *d d'* in Marconi's Fig. 1) are coupled tightly, as by the coils being close together or wholly overlapping each other without other provisions for loosening the coupling between the circuits, the reaction of the currents in the circuits produces resonance to waves of two frequencies (known to the art as a "double hump") in the resonance characteristic of the antenna at the transmitter or of the detector circuit at the receiver. This reduces the power applied in generating the desired frequency, and reduces the persistency of oscillation (II R 900-905; Ex. M-2, Loftin Sketch F; V R. 3590).

> ii. means for making the oscillations in the charging circuit persistent, that is, the low resistance plain spark gap and the loose coupling between the circuits produced by the "swamping" action of the inductance *g*.

Of the claims in suit, claims 1, 3, 6, 8, 11, and 12 relate to the transmitting station. They cover both the charging circuit and the antenna circuit, and provide either for a "variable inductance included in the open circuit" (claims 1, 3, 8, and 12) or "an inductance" (claim 11) or a "means for adjusting the oscillation period of each of the two circuits" (claim 6).

(b) The Receiver: Claims 2, 13, 14, 17, 18, and 19

At the receiving station (Figure 2), the patent specification calls for an oscillation transformer *j' j''*

> one coil whereof is included between the aerial receiving-wire and earth, constituting a good absorber of electrical oscillations, while a device responsive to electric waves, such as an imperfect contact or a device for operating the same, is included in a circuit with the other coil of said transformer (p. 1, lines 49–56).

The receiver consists of a receiving circuit *f' A g' h j' E*, and a detector circuit $j'' g'' h'$—*T* j^3 containing a wave responsive device *T*, with variable inductances *g'* and g'' for adjusting the two circuits to the same frequency. Of the claims in

suit, claims 2, 13, 14, 17, 18, and 19 deal with the receiving station.[9] They cover both the antenna circuit and the detector circuit, and provide for a wave-responsive device in the detector circuit together with "means for adjusting the two transformer circuits" (claims 14 and 17), or for a variable inductance in the antenna circuit (claims 2, 13, 17, 18, and 19).

(c) Tuning: Claims 10 and 20

An essential element of Marconi's system is the tuning of the two circuits at the transmitter and of the two circuits at the receiver to the same frequencies, so that all four circuits will be in electrical resonance with each other. The specification first prescribes tuning the two circuits at each station (p. 1, lines 56–62), and particularly states (this having been added by amendment, IV R. 3955–3967, 3968):

> The system also requires as essential elements thereof the inclusion in the lines (at both stations) from the aerial conductor to the earth of variable inductances and the use at both stations of means for varying or adjusting the inductances of the two circuits at each station to accord with each other.

[9] Claim 16, which also relates to the receiving station, is dealt with in the *United States* v. *Marconi Wireless Telegraph Company of America*, this Term, No. 373.

It then provides for tuning all four circuits (p. 2, lines 118–129):

> The capacity and self-induction of the four circuits—i. e., the primary and secondary circuits at the transmitting-station and the primary and secondary circuits at any one of the receiving-stations in a communicating system—are each and all to be so independently adjusted as to make the product of the self-induction multiplied by the capacity the same in each case or multiples of each other—that is to say, the electrical time periods of the four circuits are to be the same or octaves of each other.

The variable elements e g g' g^2 constitute the means whereby all four circuits can be adjusted to the same frequency. Claim 10 specifies that the two circuits at each station shall be in electrical resonance with each other, and claim 20 recites that there shall be "means" for bringing the four transformer circuits, two at each station, into electrical resonance with each other.

2. *Wireless Development Prior to the Marconi Patent*

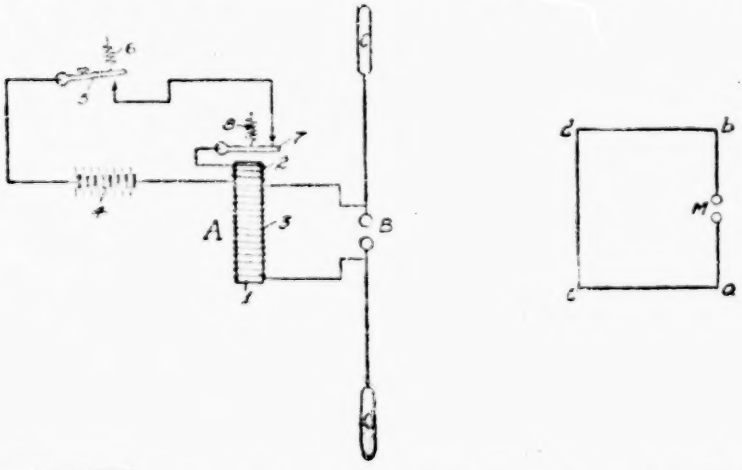
A brief summary of the early development of wireless telegraphy will facilitate a comparison between Marconi's alleged invention in suit and the prior art which the court below found anticipated Marconi.

(a) Hertz' Teachings

Clerk Maxwell at an early date disclosed the theory of wireless telegraphy, and his statements of fundamental laws still serve as the foundation of wireless communication (II R. 858). Maxwell, however, did not reveal any apparatus for utilizing his theory; it was Heinrich Hertz, between 1879 and 1890, who first evolved and demonstrated apparatus for carrying the Maxwellian theory into effect (II R. 869, 872, 873). One form of apparatus used by Hertz and described in a publication of September 21, 1888, was as follows (transmitter on the left, receiver on the right):[10]

(i) *Hertz' Transmitter*

Referring to the transmitter (left), A represented an induction coil (or Ruhmkorff coil),



[10] Hertz' work was described by De Tunzelmann in 1888 in a series of articles published in the *London Electrician* (Ex. F-2, bound in reversed order at V R. 3566–3589).

which was already a well-known device. It consisted of an iron core *1*, upon which were wound a primary coil *2*, consisting of relatively few turns of heavy wire, and a secondary coil *3*, consisting of a large number of turns of fine wire, so that an alternating or pulsating current in the primary coil would induce a current of much higher voltage in the secondary coil. The primary circuit of the induction coil consisted of the primary coil *2*, a battery *4*, a circuit breaker *5*, normally held in open position by a spring *6*, and another circuit breaker or "trembler" *7*, normally held closed by a spring *8*, but adapted to be opened by the attraction of core *1* when energized by current in the closed primary circuit. The secondary circuit of the induction coil (the charging circuit for the antenna) comprised the secondary coil *3*, the spark gap or discharger *B*, and the plates or capacity areas *C C*. These capacity areas *C C*, being connected to the spark gap *B*, imparted capacity to this charging circuit and also, with the spark gap *B*, formed the antenna or radiating circuit.

The operation of this transmitter was as follows: Upon closing switch *5*, battery *4* would energize coil *2*, magnetizing core *1* and causing it to attract switch *7*; such attraction would then open the primary circuit and thus demagnetize the core *1*, permitting switch *7* again to close (through its spring *8*) and start the energization

of coil 2, to resume the entire process. As long as switch 5 was held closed, switch 7 was thus caused to "tremble", i. e., to make and break its circuit. The constant making and breaking of the primary circuit induced in the core a rising and falling magnetism which in turn induced an alternating current in the secondary coil 3. The voltage of the current in the latter coil, however, was higher than that in the primary coil 2, in the same proportion that the number of turns of wire in the secondary coil bore to the number of turns of wire in the primary coil.

By connecting the secondary coil to the spark gap or discharger *B*, the voltage built up in the knobs or terminals of the gap would ionize the air between them until the insulating effect broke down, causing a spark to leap across the gap from knob to knob. So long as the switch 5 was closed, a succession of sparks was caused to pass across the gap of the discharger, and during the continuation of each spark, a high-frequency oscillation of current occurred in the circuit *C B C*, consisting of several "swings" or impulses steadily decreasing in amplitude. As long as the primary circuit was closed there would occur a succession of these group oscillations.

By connecting the spark gap to the plates *C C* in the antenna circuit, which had a large area, capacity areas were provided for receiving a large charge of current from the induction coil,

thus increasing the power of the transmitting system. The frequency or wave length to which a circuit resonates or vibrates (the "fundamental" of the circuit), and thus the wave length of the oscillations it can generate, is determined by the circuit's inductance (length and disposition of the straight or coiled-up wire in the circuit) and capacity (area of and distance separating charged metal surfaces in the circuit, as the plates *C C*). Consequently, the additional capacity areas *C C*, as Hertz recognized (see n. 12, p. 34, *infra*), changed one of the two components determining the frequency of the oscillations in the circuit and thus constituted a means modifying or adjusting the frequency of its oscillations. This was one of the first principles in tuning.

(ii) *Hertz' Receiver*

Hertz' receiver comprised a loop or ring of wire, shown in the form of a rectangle half a meter in length, the ends being connected to the knobs of a spark gap or micrometer *M*. In the apparatus illustrated above (p. 30), the terminal conductors of the transmitter, *C* and *C*, "were three meters apart" while the receiver or "micrometer circuit" consisted of a "rectangle 80 centimeters broad by 120 centimeters long" (Ex. F–2; V R. 3585).

These measurements are significant in demonstrating Hertz' awareness of the principles of

tuning or synchronization, for the dimensions of Hertz' receiving circuit (the inductance) were so chosen, and the spacing of his micrometer knobs *M* (determining the capacity between them) was intentionally so adjusted as to render the circuit resonant to the wave length of his transmitter.[11]

There is thus no doubt that the principles of resonance, so universally employed in all wireless apparatus, were understood and applied by Hertz in determining the constants for his receiver (i. e., the length of wire and the micrometer dimensions) and that he selected those constants which would cause his receiver to resonate to the transmitted wave length.[12]

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[11] This is revealed in Hertz' own detailed description of his apparatus (Ex. J 4; V R. 3891) and was recognized by Lodge (see p. 36, *infra*).

[12] De Tunzelmann recognized this in 1888. He wrote that in order to determine whether "the oscillations were of the nature of a regular vibration," Hertz "availed himself of the principle of resonance," according to which "an oscillatory current of definite period would, other conditions being the same, exert a much greater inductive effect upon one [i. e., a receiving circuit] of equal period than upon one differing even slightly from it.

"If, then, two circuits are taken having as nearly as possible equal vibration periods, the effect of one upon the other will be diminished by altering either the capacity or the coefficient of self-induction of one of them, as a change in either of them would alter the period of vibration of the circuit." (V R. 3585.)

Prof. Ebert also recognized in 1894 that the Hertz receiver was "electrically tuned" to resonance, and that he used "tuned circles of wire." (V R. 3888.)

(iii) *Lodge's Observations on Hertz' Teachings*

After about six years, during which the work of Hertz attracted wide attention, Sir Oliver Lodge in 1894 published a series of articles in the *London Electrician*[13] describing and explaining Hertz' teachings by diagrams corresponding to those now in common use. In an article of June 8, 1894, he explained the elementary principles in precisely the way they are explained today:

> Conversely, if the source is a persistent vibrator, correct tuning is essential, or it will destroy at one moment motion which it originated the previous moment. Whereas, if it is a dead-beat or strongly damped exciter, almost anything will respond equally well or equally ill to it. * * *
>
> Furthermore, any conductor electrically charged or discharged with sufficient suddenness must emit electrical waves into the ether, because the charge given to it will not settle down instantly, but will surge to and fro several times first, and these surgings or electric oscillations must, according to Maxwell, start waves in the ether, because at the end of each half swing they cause electrostatic, and at the middle of each half swing they cause electromagnetic effects, and the rapid al-

[13] This series of articles, June 8 to July 20, 1894, is in evidence as Exhibit E–4. (V R. 3872.)

ternating from one of these modes of energy to the other constitutes etherial waves.

Maxwell and his followers well knew that there would be such waves; they knew the rate at which they would go, they knew that they would go slower in glass and water than in air, they knew that they would curl around sharp edges, that they would be partly absorbed but mainly reflected by conductors, that if turned back upon themselves they would produce the phenomena of stationary waves, or interference, or nodes or loops; it was known how to calculate the length of such waves, and even how to produce them of any required or predetermined wave length from 1,000 miles to a foot. * * *

Electric syntony.—That was his [Hertz'] discovery, but he did not stop there. He at once proceeded to apply his discovery to the verification of what had already been predicted about the waves, and by laborious and difficult interference experiments he ascertained that the previously calculated length of the waves was thoroughly borne out by fact. These interference experiments in free space are his greatest achievement. (V R. 3873–3874.)

The range of wave lengths given by Lodge—from one foot to 1,000 miles—includes the entire range of what are sometimes called radio frequen-

cies and a very large part of the range of the so-called audio-frequencies.[9]

The Lodge papers also pointed out that several different types of detecting device could be employed in the receiving circuit to detect or ascertain the existence of the transmitted wave: spark gaps, telephones, vacuum tubes, galvanometers and even a pair of frog's legs used by Hertz and Ritter. (V R. 3876–7.)

(iv) *Summary of Hertz' Disclosures*

Thus from the work of Hertz the art was informed that by applying to a spark gap current of a voltage sufficiently high to break down the gap and to send the current across it, an oscillating electrical discharge of high frequency (now known as "Hertzian waves") would be caused in

[9] Wave lengths are expressed today in terms of meters, or more commonly in terms of cycles or frequency. A wave length of 1,000 miles is the same as one of 1,584,000 meters, or 186 cycles per second—an extremely long wave length. A wave length of one foot is the same as a wave length of three-tenths of a meter or 982,080,000 cycles per second—an extremely short wave length.

The ordinary human ear can hear sound wave frequencies ranging from 16 cycles up to about 10,000 cycles per second; some extremely sensitive ears may hear such frequencies as high as 30,000 cycles. The range of radio frequencies may be said to be from 30,000 cycles per second up to 1,500,000 cycles per second (I R. 311). There is no fixed dividing line between radio frequencies and audio-frequencies (i. e., those corresponding to the frequencies of audible soud waves) but as a sound frequency rises above 6,000 cycles per second it begins to become inaudible to human ears.

the spark gap or charging circuit and would be communicated to the antenna circuit; that these high frequency waves would propagate ether waves of the same frequency, which could be intercepted by a receiving circuit at a distance; that either mechanical detectors or vacuum tubes could be employed as detector devices in the receiving circuit; that by tuning the antenna and the receiving circuits to the same frequency the maximum response would be obtained; and that the plain gap circuit was a "persistent vibrator."

Hertz did not discover the principles of resonance; they were already well known. He did, however, appreciate from the beginning that in view of the minute values of the energy utilized in the receiving apparatus, tuning to resonance would be essential to almost all practical apparatus, in order that the transmitted waves might be effectively received.

The basic soundness of the Hertz disclosures, and their faithful embodiment in most wireless systems, were judicially recognized in 1905. *Marconi Wireless Telegraph Co. of America* v. *DeForest Radio Telephone & Telegraph Co.*, 138 Fed. 657 (C. C. S. D. N. Y.).[15]

[15] The court there said: "The means for the later development of wireless telegraphy were furnished in the proof by actual experiment of the correctness of certain theories promulgated by Prof. Maxwell, of Cambridge, in 1865, that electricity, like light, traversed space through the medium of ether, and that, if a spark be created by a disruptive dis-

(b) Marconi Prior Patent No. 586,193

Marconi in a patent antedating by seven years the one here involved also recognized the principles of resonance, and tuned the antenna circuit of his receiver to accord with the antenna circuit of the transmitter. This prior patent No. 586,193, covering Marconi's earliest invention, was granted July 13, 1897, upon an application filed December 7, 1896, and was reissued as Reissue patent No. 11,913 on June 4, 1901 (Ex. 19, IV R. 2567). It disclosed the following transmitter (Fig. 10) and receiver (Fig. 11), both substantially like Hertz' apparatus:

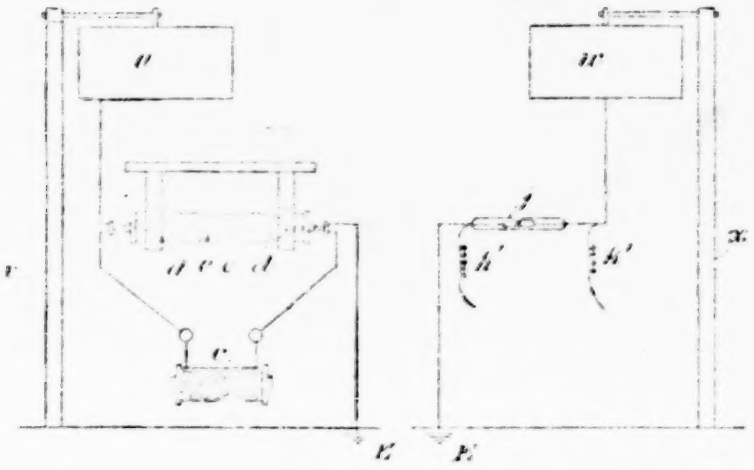
At the transmitting station (Fig. 10), the 1897 Marconi patent showed a Ruhmkorff coil c^{10} which

charge, it will spread out in waves or undulations. These waves are known as 'Hertz waves' or 'Hertz oscillations,' from the name of their discoverer, Heinrich Hertz. He produced these waves by the use of an apparatus consisting of a radiator and a receiver equipped with rods having small metallic knobs on the ends, and separated a short distance from each other. This separation is the spark-gap, by means of which the Hertzian waves or oscillations are produced. When the transmitter or radiator is connected with a Ruhmkorff coil, or any source of high electric tension, such as an induction coil, with mechanical vibrator, or a producer of electric current, such as a dynamo, a charge of electricity is sent through the circuit which includes the spark-gap, and a spark passes across the spark-gap and creates the electrical vibration or wave called the 'Hertz wave'" (p. 658).

[10] This coil, as shown in Fig. 1 of the patent (IV R. 2569) was the usual Ruhmkorff coil shown in the illustration on p. 30, *supra*, and had the customary key in its primary or battery circuit.

delivers a high tension, high frequency current to the spark gap, *d c c d* in the secondary circuit of the coil. One side of the spark gap is grounded at *E* and the other side connected to an elevated wire and plate *a* insulated from the earth on the pole *v*.

Fig. 10. Fig. 11.



At the receiving station (Fig. 11), a coherer *j* is inserted in the antenna circuit *w E* as the detector device. The coherer, a tube containing a rather coarse metallic powder, normally prevents flow of current in the local battery circuit (connected to choke coils *h' h'* but not shown in Fig. 11), but as soon as an impulse is received by the antenna circuit the metallic particles are caused to cohere,

so as to provide a conductive path closing the battery circuit, thereby causing a signal. Choke coils *k' k'* are provided to keep high frequency waves out of the local battery circuit. A relay in the battery circuit operates a stronger battery circuit containing a sounder and a trembler for tapping the coherer so that its circuit will be broken after the incoming waves have ceased (Ex. 19; Findings IX and X, I R. 12, 13). Metal plates are used for tuning, "preferably of such a length as to be electrically tuned with the electric oscillations transmitted" (Ex. 19, p. 3, lines 28–30; IV R. 2574).

In this Marconi patent the apparatus is substantially the same as that disclosed by Hertz, with the following exceptions: (i) Hertz, unlike Marconi, did not employ the earth as one of the capacity areas of his transmitter or use similar capacity areas at the receiver, and (ii) Marconi, unlike Hertz, used a coherer as the detector device in his receiver.

3. *Prior Art Anticipating Marconi's Patent No. 763,772*

Following the development in the art discussed above, came disclosures which the court below found anticipated Marconi's patent here involved.

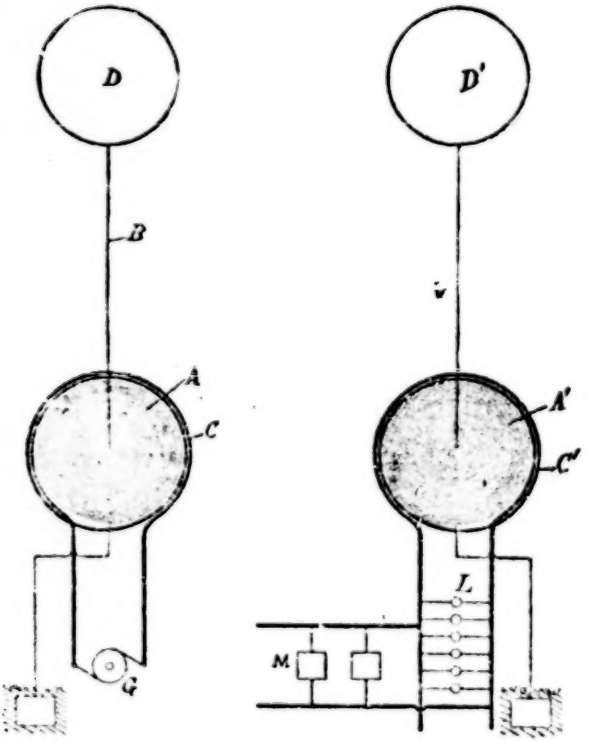
The art thus held to invalidate the Marconi patent consisted of prior inventions by Tesla, Lodge, Stone and Marconi himself. These disclosures antedated the earliest date which Marconi is entitled to claim for his alleged invention in patent No. 763,772—viz., November 10, 1900, the filing date of his application (Finding XLI, I R. 37). Consequently, the propriety of the conclusion below that the prior art invalidated Marconi's patent depends upon whether the anticipating disclosures and Marconi's device were substantially the same in structure, mode of operation and effect. We submit that such substantial similarity was properly found to exist.

(a) Tesla Patent No. 645,576

Tesla patent No. 645,576, granted March 20, 1900 upon an application filed September 2, 1897, disclosed two circuits (one open and one closed) at both the transmitter and the receiver, and provided for synchronizing or tuning these circuits together. The following apparatus was shown in the Tesla patent (Ex. X–2, V R. 3602):

In the transmitter (left-hand figure), high frequency oscillations are delivered from the source *G* to the primary coil *C* of an oscillation transformer.[1] The secondary coil *A* of the oscillation

[1] The source *G*, "one of the elements of the transmitter," is described in the Tesla patent as "a condenser of a capacity of about four one-hundredths of a microfarad * * * charged from a generator of alternating currents of fifty



transformer, which has many more turns than the primary coil *C*, is connected at one end to earth and at the other end to an aerial *B D*. Thus the primary or charging circuit automatically causes oscillations of the desired frequency and delivers them to the open or antenna circuit, from whence they are radiated into space.

In the receiver (right-hand figure), a similar transformer is employed, except that it is the

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thousand volts' pressure and discharged by means of a mechanically-operated break five thousand times per second through the primary *C*'" (Ex. X–2, p. 3, lines 117–125, V R. 3605.)

primary coil *A'* which is of thin wire and which has more turns than the other, the secondary coil *C'*. Tesla contemplated primarily the transmission of waves sufficiently powerful to operate motors and the like, for in the secondary circuit he included lamps *L*, motors *M* "or other devices for utilizing the current" (Ex. X–2, p. 3, lines 24–26; V R. 3605). However, he also recognized that this method of energy transmission, without change of apparatus, could be used for wireless communication (p. 5, lines 28–35; V R. 3607):

> The apparatus which I have shown will obviously have many other valuable uses—as, for instance, when it is desired to transmit intelligible messages to great distances * * *.

Since the transmission of intelligible messages to great distances involved no change of apparatus disclosed, and was merely dependent upon the use of the usual key to interrupt the power supplied through the source *G* at the transmitter, Tesla clearly disclosed to those skilled in the wireless telegraphy art an open aerial circuit coupled to a closed charging circuit at the transmitter, and an open aerial circuit coupled to a closed detector or receiving circuit at the receiver.

Moreover, as the court below properly found (Finding LXXII, I R. 58), Tesla instructed those skilled in the art that the open and closed circuits of the transmitting system and the open and

closed circuits of the receiving system should be in resonance with each other; in other words, that all four circuits should be in resonance. The Tesla patent states that the "primary and secondary circuits in the transmitting apparatus" are "carefully synchronized", this synchronism being attained—

> When the primary coil or system A', with its secondary C'', was carefully adjusted, so as to vibrate in synchronism with the transmitting coil or system AC. (Ex. X–2, p. 4, lines 27–29; V R. 3696).[*]

Thus, Tesla concentrated most of his inductance in the form of coils in his antenna circuits, and adjusted this inductance by adjusting those coils, so tuning his circuits. Indeed, in 1899 Stone recognized "four-circuit" tuning as Tesla's contribution (see p. 69 and note 28, *infra*).

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[*] Tesla's teaching in this respect is further set forth in his prior art patent No. 649,621 granted May 15, 1900, upon a division of the application for patent No. 645,576, wherein he says (Ex. L–6, p. 1, line 97 to p. 2, line 10; V R. 4090, 4091):

"It will be readily understood that when the above-described relations exist the best conditions for resonance between the transmitting and receiving circuits are attained, and owing to the fact that the points of highest potential in the coils or conductors A A' are coincident with the elevated terminals the maximum flow of current will take place in the two coils, and this, further, necessarily implies that the capacity and inductance in each of the circuits have such values as to secure the most perfect condition of synchronism with the impressed oscillations."

It is thus clear that Tesla disclosed and anticipated the following features of the Marconi patent: (i) a charging circuit in the transmitter for causing oscillations of a desired frequency, (ii) an aerial or antenna circuit in the transmitter coupled through a transformer to the charging circuit for transmitting these oscillations, and (iii) the synchronizing of these two circuits by adjusting the inductance in the antenna circuit. Moreover, by disclosing the same arrangement in the receiver, Tesla anticipated the four-circuit tuning combination of Marconi.

The only feature in Marconi's arrangement which was absent from Tesla's—the use of a "variable inductance" in the antenna circuit of the transmitter and receiver as the tuning medium—was found in the Lodge disclosure prior to Marconi, as we shall show.

(b) Lodge Patent No. 609,154

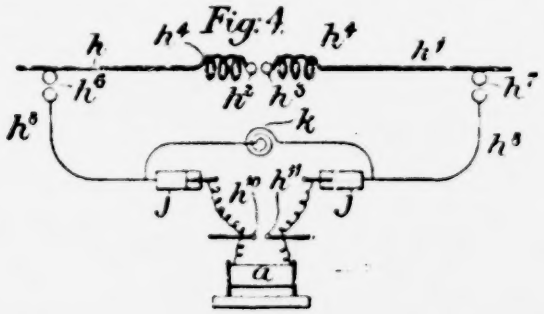
In patent No. 609,154, granted August 16, 1898, upon application filed February 1, 1898 (Ex. 20, IV R. 2581), Sir Oliver Lodge disclosed, prior to Marconi, a variable inductance coil in a wireless transmitter or receiver to enable them to be tuned together. The finding of the court below to this effect (Finding XXIX, I R. 26) is clearly sustained by substantial evidence.

Lodge's patent provided for a self-inductance coil *h* ' between a pair of capacity areas *h* and *h'*

(which, he disclosed, may be antenna and earth respectively) in an oscillating circuit of either a sending or receiving set (or both) for Hertzian wave telegraphy. The patent disclosed that such coil should be made adjustable at will to vary the value of its self-inductance. Lodge explained that the adjustment, that is, "the desired frequency of vibration or syntony with a particular distant station," may be attained by a coil itself capable of adjustment, or

> by replacing one coil by another, for the frequency can be adjusted either by varying the capacity of the condenser or jar or other conductor employed or the charged body on the one hand or by varying the number and position of coils or other portion of the discharge-circuit on the other (Ex. 20; IV R. 2585, lines 39–48).

The transmitter was illustrated as follows in Figure 4 of the patent:



As decribed in the specification, the transmitter contained three or four spark gaps (h^{10}–h^{13}, h^{a}, h^{c}, and optionally h^{d}–h^{f}), instead of the usual single

spark gap. The effect of this was to cut off quickly the arc of energy in the charging circuit, and, with the aid of tight coupling between the open and closed circuits, to transfer the energy quickly from the closed to the open circuit," i. e., in "an impulsive rush." (Ex. 20; IV R. 2584, lines 72-75).

The Marconi patent, claims 1 and 3, describe the open circuit of the transmitter simply as "electrically connected with" the charging circuit, and as containing a variable inductance. These Marconi claims do not require an oscillation transformer in the transmitter, nor the tuning of the open and closed circuits; consequently, as the court below properly found (Findings LXI; I R. 57), they read directly upon the auto-transformer arrangement in Figure 4 of the Lodge patent and are anticipated.[*]

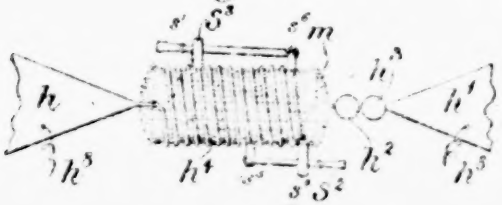
As the court below found, the Lodge patent also described and claimed a variably acting self-inductance coil in a transmitter or receiver, to enable the transmitter and the receiver to be tuned together (Finding XXIX; I R. 26). The adjustable inductance of the Lodge patent is set

[*] All of the inductance h^1 h^4 is common to the charging circuit and the antenna circuit, hence the coupling between the two oscillatory circuits is tight. When two circuits are each connected to include a common coil, the coil is called an "auto-transformer."

[*] The similarity between the two devices is plainly to be seen from a comparison of Figure 1 of the Marconi patent (*supra*, p. 24) with Loftin's simplified sketch of Lodge's Figure 4 (*infra*, p. 50).

forth in Figure 9 of his specification (following), in which the switches s' s^2 are so related to the inductance coil h' as to short-circuit any desired number of turns of the coil to adjust its effective inductance and thus tune the circuit.

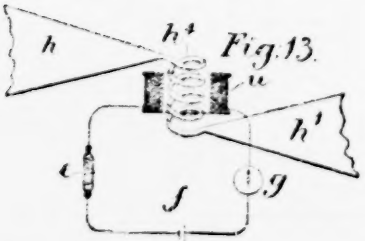
Fig. 9.



The two forms of receiver in the Lodge patent are shown in Figures 12 and 13:

Fig. 12.

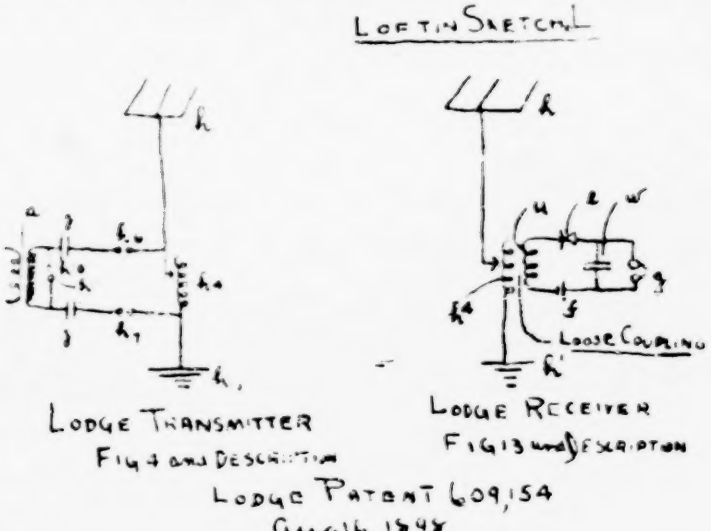
Fig. 13.



In Figure 12, the detector circuit e f g is directly coupled to the terminals of the inductance coil h' in the antenna circuit; in Figure 13, the two circuits are inductively coupled through a

transformer having the primary coil h^4 in the antenna circuit and the secondary coil u in the detector circuit. The element w in Figure 12 is either a resistance or a capacity (IV R. 2586, line 65), which may be used across the instrument g, i. e. in circuit with coherer c in Figure 13 (IV R. 2586, line 62).

The following simplified sketch submitted by defendant's witness Loftin presents, in the conventional diagrammatic form, the Lodge transmitter of Figure 4 and the Lodge receiver of Figure 13, with antenna and earth as the capacity areas, as previously taught by Marconi in patent No. 586,193 (pp. 39–40, *supra*),[a] and as contemplated by Lodge (Ex. 20, IV R. 2584, line 37 and lines 103–107; and Figs. 6 and 7, IV R. 2581):



[a] Ex. V-2, IV R. 3600. Loftin fully explained this sketch and the operation of Lodge Fig. 4 at II R. 946–952.

The only feature in Marconi which was not shown in Tesla's system was the use of a variable inductance in the antenna circuit of the transmitter as the tuning medium to vary its periodicity, instead of accomplishing the same result by selection of a proper fixed inductance. But, as shown above, this more convenient mode of effecting the tuning specified by Tesla was shown by Lodge before the earliest date attributable to Marconi. Since Lodge's variable inductance was the only feature which Marconi combined with Tesla's system of tuning the two transmitter circuits to the same frequency, the court below correctly held (I R. 98) that Tesla, read in conjunction with Lodge, anticipated all of Marconi's claims for four-circuit tuning.[22]

Indeed, the court might properly have found that Lodge alone fully anticipated the receiver

[22] The court below made evidentiary findings of fact explaining the structure and mode of operation of Tesla's disclosure of four-circuit tuning (Finding LXII, I R. 58-59) and of Lodge's showing of a variable inductance coil as an instrumentality for effecting tuning (Finding XXIII, I R. 23). It also made evidentiary findings as to the structure and operation of Marconi's four-circuit tuning (Findings XXXVIII, XLIII, XLVII; I R. 31-40, 42). While it made no "findings" labeled as such, that Tesla and Lodge anticipated particular claims of Marconi, such "findings" are mere conclusions readily to be drawn from a simple comparison of the appropriate evidentiary findings, and are in any event implicit in the ultimate finding made by the court as to invalidity of the Marconi patent, as its opinion in fact reveals (I R. 97-99).

claims of Marconi's patent here involved. These claims (2, 13, 14, 17, 18, and 19) were directed to the combination of an oscillation receiving conductor (the antenna circuit), a wave responsive device electrically connected with the conductor (the detector circuit), and a variable inductance in the antenna circuit (claims 2, 13, and 18), or "means for adjusting the two transformer circuits in electrical resonance with each other" (claims 14 and 17). As the court below found (Findings LIX and LXI, I R. 57), none of these claims actually require that the two circuits shall be in resonance with each other; they require only that there shall be means for making the adjustment, the means shown being an adjustable inductance in the antenna circuit. Lodge's patent alone, as shown above, fully disclosed the use of the variable inductance coil for tuning the antenna circuit; consequently, no invention was involved in Marconi's employing the Lodge variable inductance for adjusting the circuits in lieu of making the adjustment by varying the length of the wire or the size of fixed coils, especially since no new function was imparted thereby either to the circuits or to the variable inductance.[*] Merely making known elements ad-

[*] The court below also found (Finding LXI, I R. 57) that claim 2 of Marconi's receiver group was the same in structure and operation as Figure 13 of the Lodge patent, and

justable, when no new or unexpected result is attained thereby, is not invention, particularly when the prior art shows such adjustability to be known in the same or analogous uses, *Peters* v. *Hanson*, 129 U. S. 541, 550–551.

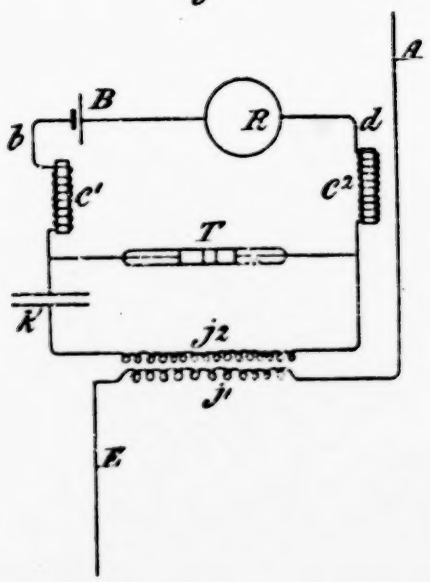
(c) Prior Art Marconi Patent No. 627,650

As the court below found (Finding LII, I R. 46), the principle of tuning the respective circuits of the receiver (and transmitter) by varying inductance coils to accord with the varying wave lengths, was also brought out in the prior art Marconi patent No. 627,650, granted June 27, 1899, upon an application filed January 5, 1899 (Ex. P–5, same as Ex. B–6, V R. 4085–8). The receiver described in this patent was illustrated in Figure 1 as follows:

---

hence anticipated by it. This is fully sustained by the evidence. Marconi's claim 2 is not limited to the tuning of the open and closed circuits, nor to a variable inductance used in addition to the transformer primary coil. Lodge's Figure 13, with condenser *w* of Lodge's Figure 12 connected in circuit with coherer *e* as described by Lodge (p. 50, *supra*), satisfied every requirement of Marconi's claim 2. Indeed, that claim does not even require an oscillation transformer, and is thus directly applicable to Figure 12 of Lodge as well.

Fig. 1.



In it, Marconi employed a coupling transformer j' j^2 which he referred to as an "induction coil," the antenna or aerial conductor A being connected to the primary winding j' of the "induction coil" and thence grounded to earth E. The secondary winding j^2 of the coil was in the detector circuit, and a coherer T (described as an "imperfect contact") was connected to the ends of the secondary winding of the coil, through a variable condenser k' (id., V R. 4087, lines 14–20). The specification recited that:

> It is desirable that the induction-coil should be in tune or syntony with the electrical oscillation transmitted, the most appropriate number of turns and most appro-

> priate thickness of wire varying with the length of wave of the oscillation transmitted.
>
> The capacity of the condenser on the connection between the imperfect contact and the secondary of the coil should be varied (in order to obtain best effects) if the length of wave is varied. (id., lines 31–42).

As was pointed out by defendant's expert witness Loftin (II R. 951), these are clear directions to tune the respective circuits, by means of the variable inductance in the antenna circuit and the variable condenser in the detector circuit. The apparently contrary statement of plaintiff's expert witness Weagant that varying the condenser *k'* would be "totally incapable of tuning the receiving circuit" (II R. 1627) is the result of a confusion between the effect of resistance and the effect of inductance and capacity. *Resistance*, it is true, does not affect the tune or frequency of the circuit, and merely affects the amplitude of the wave, whatever its frequency. But it is clear that changing the *capacity* does affect the tune. This was brought out by Marconi himself, who in effect contradicted Weagant's testimony as follows (I R. 539):

> How do you tune a coherer circuit?
>
> A. We tune it by proportioning the inductance and the capacity of the circuit

> in which it is, so that that circuit will be in tune with the oscillations which you want to receive.

The tuning of the two receiver circuits by using a variable inductance in the antenna circuit was the subject matter of claims 2, 13, 18, and 19 of Marconi's patent in suit (see pp. 27–28, *supra*). Since Marconi's earlier patent in 1899 disclosed such tuning by the use of an "induction coil" containing "the most appropriate number of turns" and by the use of a variable condenser in the secondary winding of that coil, the finding of the court below that Marconi's earlier patent anticipated claims 2, 13, 18, and 19 in suit is fully sustained by substantial evidence.

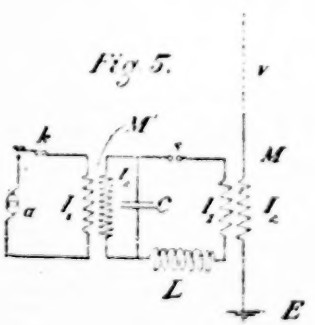
(d) Stone Patent No. 714,756

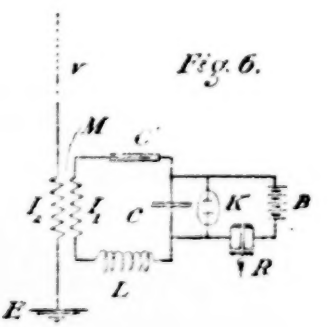
(i) *Stone's Disclosures*

Also before the earliest date for Marconi's alleged invention (November 10, 1900) John Stone Stone clearly disclosed the tuning of the aerial circuits of wireless apparatus by inductance, and the tuning of the open and closed circuits of the transmitter and receiver, all four to the same frequency. This disclosure was made by Stone in a patent application filed February 8, 1900, upon which patent No. 714,756 was granted on December 2, 1902 (Ex. P–3, V R. 3648.) While Stone did not describe the partic-

ular means for adjusting the frequency of the aerial, he did prescribe adjusting the value of the inductance to the desired frequency, and to one skilled in the art this meant the use of a variable inductance, such as had previously been disclosed by Lodge patent No. 609,154, for example (Finding LVII, I R. 56).

Stone's patent explained in great detail the effect of one circuit upon another, and showed that in a *single* tuned circuit there is a "single degree of freedom," i. e., one natural period in which the current oscillates with freedom, whereas if *two* such circuits are coupled together, there will result a system of "two degrees of freedom," i. e., the super-position of two frequencies. Stone then described the following transmitter (Figure 5) and receiver (Figure 6):





The transmitter (Fig. 5) had a telegraph key *k* in the primary winding I'_1 of an induction coil *M'*. In the secondary winding I'_2 of this induction coil there was a spark gap *s* which generated high-frequency oscillations through the closed cir-

cuit s C L I_1. This circuit was electrically connected, through an oscillation transformer M, with an open or antenna oscillating circuit r I_2 E.

The receiver (Fig. 6) comprised an open oscillating circuit r I_2 E, inductively coupled through the transformer M with a closed oscillating circuit I_1 C' C L. A coherer or wave-responsive device K was connected across the condenser C.

In his specification, Stone disclosed two systems of four-circuit tuning, one of which the court below held anticipated Marconi. In that system Stone disclosed tuning the open and closed circuits at the transmitter and receiver, all to the same frequency or wave length.[5] For this purpose, at the transmitter he adjusted the charging circuit (C s I_1 L) to the desired frequency, and preferably adjusted the antenna circuit to be resonant to the same frequency, thus tuning the two transmitter circuits to the desired wave length: at the receiver he tuned the antenna circuit to the incoming frequency, and tuned the detector circuit to the antenna circuit. This is to be seen

[5] For the other system, a multiplex arrangement, Stone proposed employing two tuned circuits at the transmitter and two at the receiver, all tuned to the same wave length, those at the transmitter forcing the selected wave length on an aperiodic antenna circuit, and those at the receiver receiving the selected wave length from an aperiodic antenna circuit. The aperiodic antennas used in this form of Stone's system were ones capable of radiating or absorbing any one of a number of wave lengths in the range of wave lengths to be employed. Figures 13, 14, 16 and 17 of the Stone patent relate to this system.

from the following statements in his specification referring to the transmitter:

> Thus the frequency impressed upon the elevated conductor may or may not be the same as the natural period or fundamental of such conductor (Ex. P–3; V R. 3648, lines 16–20).
>
> The vertical wire may with advantage be so constructed as to be highly resonant to a particular frequency, and the harmonic vibrations impressed thereon may with advantage be of that frequency (Ex. P–3; V R. 3653, lines 62–66).

And with respect to the receivers:

> When the apparatus at a particular station is attuned to the same periodicity as that of the electromagnetic waves emanating from a particular transmitting-station, then this receiving-station will respond to and be capable of selectively receiving messages from that particular transmitting-station to the exclusion of messages simultaneously or otherwise sent from other transmitting-stations in the neighborhood which generate electromagnetic waves of different periodicities. Moreover, by my invention the operator at the transmitting or receiving station may at will adjust the apparatus at his command in such a way as to place himself in communication with any one of a number of stations in the neighborhood by bringing his apparatus into resonance with the periodicity em-

ployed by the station with which intercommunication is desired (Ex. P–3; V R. 3651, lines 17–36).

Indeed, further to insure that only the one desired fundamental frequency would be transferred at the transmitter from the charging circuit to the antenna circuit, and at the receiver from the antenna circuit to the detector circuit, Stone proposed that another closed circuit be interposed between the closed (charging or detecting) circuit and the open (antenna) circuit of transmitter and receiver, as shown in Figures 7 and 8, respectively, of his patent:

Fig. 7

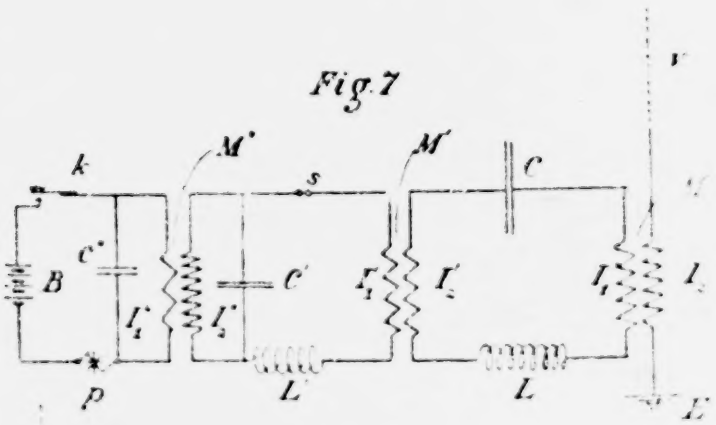
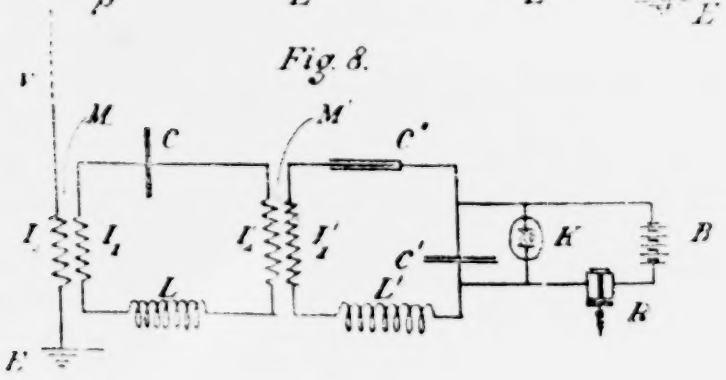


Fig. 8.



In respect of the transmitter (Figure 7), the specification states:

> In the transmitter arrangements illustrated in Figure 7 the circuit $C I'_2 L I_3$ is attuned to the same period as the circuit $C'' L' I'_3 s$ and merely tends to weed out and thereby screen the vertical wire from any harmonics which may exist in the current developed in the circuit $C'' L' I'_3 s$ (Ex. P–3; V R. 3653, lines 89–94).

And in respect of the receiver (Figure 8), the specification states:

> In the organization illustrated in Figure 8 the electric resonator $C I'_2 L I_3$, interposed between the vertical conductor and the circuit containing the coherer is attuned to the same period as the circuit $L' C'' C''' I'_1$ and acts to screen the coherer-circuit from the effect of all currents developed in the vertical conductor, save that of the current of the particular period to which the receiving-station is intended to respond (*id.*, lines 122–131).

The Stone disclosures thus fully support the finding below that Stone tuned the closed circuit of his receiver and transmitter "to the frequency of the transmitted signal," and that from his suggestion to tune the open transmitter circuit "it was obvious to one skilled in the art that the receiver open circuit should also be tuned." Indeed, as the court further found, Lodge among others had earlier disclosed the desirability of

such tuning and the manner of accomplishing it (see pp. 47–48, *supra*), and the disclosure and first claim of Stone's application as filed had suggested it.[25] In short, "to one skilled in the art, Stone's patent contemplated having all four oscillating circuits in tune or accord with each other" (Findings LIII and LVII; I R. 47, 50, 56–57).

The court recognized that the Stone patent drawing made no attempt to show adjusting of the condensers or inductances in any of the oscillating circuits, but found that "one skilled in the art at the time knew how to adjust any or all of them to obtain the desired resonance in the open and closed circuits." (Finding LIII, I R. 47, 50). This finding is equally supported by the evidence. Lodge, among others, had informed the art how to adjust the inductances (see p. 49, *supra*) and easily adjustable condensers were also well known at this time, having been shown by Marconi himself in a prior patent (pp. 54–55, *supra*) and by Tesla in 1894 (Ex. B-4; V R. 3839, 3840–3841). Consequently, the Stone patent was correctly found to anticipate Marconi with respect to adjustable four-circuit tuning.

Plaintiff attacks the Stone defense, asserting that the description of tuning the open antenna

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[25] The specification as filed also shows clearly Stone's understanding that any coupled circuits would be tuned to resonance in obtaining the single frequency by his loose coupling arrangement. (V R. 3653, lines 98–102; see also footnote 26, p. 64, *infra*.)

circuits was inserted in the Stone application by amendment in April 1902, after Marconi's application was filed on November 10, 1900. This contention is in effect that the 1902 amendment of Stone's application departed from the original disclosure and for the first time introduced the matter of tuning the antenna circuits. But the record completely disproves this.

In claims 1, 3, and 4 of his application as originally filed, Stone claimed producing the same wave length or frequency in both circuits (Ex. R-3; V R. 3685, 3708). His original specification explained that the antenna or vertical conductor "is made the source of electromagnetic waves of but a single periodicity" (V R. 3697), and directed that the closed circuit should be tuned to the desired frequency, that the closed and antenna circuits should be "loosely" coupled, and that the coupling between these circuits should be adjusted to impart the desired single frequency to the antenna circuit (V R. 3697–9). These directions necessarily amounted to a disclosure that the antenna currents of both transmitter and receiver would be of the same frequency.[27] Moreover, Stone's original specification had made clear that if but one frequency was to be transmitted, the apparatus would correspond to a tuning fork (V R. 3698), whereas when the elevated conductor was aperiodic several fre-

[27] I R. 770, last two paragraphs, and particularly last three lines. (See also footnote 26, p. 64, *infra*.)

quencies would be transmitted. This in effect was a statement that the elevated conductor was *not* aperiodic when only one frequency was to be transmitted.[29] The subject of the 1902 amendment, which merely explained these matters in more detail, was thus plainly found in the original disclosure. Indeed, if plaintiff's contention had any foundation, it would have been the duty of the Patent Office examiner to have refused the 1902 amendment, as containing matter not shown, described or suggested in the original specification.[30] The absence of any indication in the record that the examiner had the slightest difficulty in allowing the amendment, coupled with the presumption that public officers have properly performed their duties,[31] require the conclusion that the tuning of the antenna circuits had been sufficiently disclosed in the original application to be apparent to the examiner as one skilled in the art at the time.[32]

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[29] I R. 769-770; see also footnote 24, p. 62, *supra*.

[30] *Western Elec. Co.* v. *Sperry Elec. Co.*, 58 Fed. 186, 196 (C. C. A. 7); *Individual Drinking Cup Co.* v. *Errett*, 200 Fed. 955, 959 (S. D. N. Y.); *Diamond Power Specialty Co.* v. *Bagley Co.*, 13 F. (2d) 337 (C. C. A. 8).

[31] *United States* v. *Crussell*, 14 Wall. 1, 4; *United States* v. *Chemical Foundation, Inc.*, 272 U. S. 1, 15; *In re State Chemical Co.*, 126 F. (2) 296, 299 (C. C. A. 6); *Atchison, T. & S. F. Ry.* v. *Elephant Butte Irr. Dist.*, 110 F. (2) 767, 771 (C. C. A. 10).

[32] When a "single frequency" is to be attained by loosely coupled circuits, the circuits *must* be attuned to the same natural period (I R. 770).

But even if the disclosure of tuning the open circuits had not been complete in the original application and had been supplemented by the 1902 amendment, it would not deprive Stone of priority. For the record shows that long before Marconi's date Stone had conceived four-circuit tuning (including tuning of the antenna circuits as previously taught by Lodge); that Stone had recorded this conception and disclosed it to others as early as June and July 1899; and that during the intervening period Stone was diligent in reducing the invention to practice and in obtaining capital to exploit his invention.

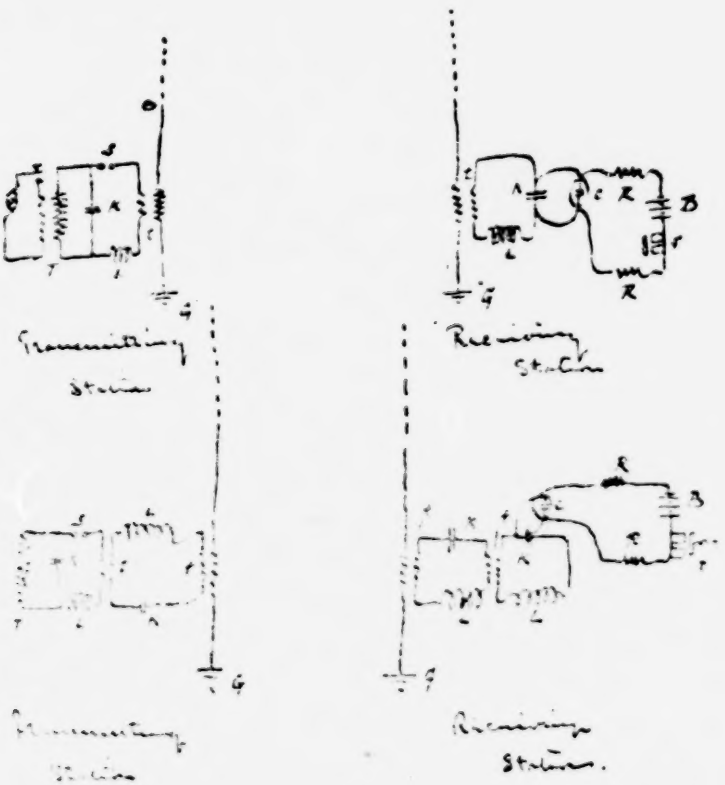
(a) *Stone's Disclosures Prior to His Patent Application*

In the summer of 1899, Stone disclosed his four-circuit tuning system to his friend, Mr. J. B. Baker, who was also skilled in the art, and who corroborated the disclosure (I R. 735, 738, 739). Stone's letter of June 30, 1899, to Baker, reads in part as follows:

> Instead of utilizing the vertical wire itself at the transmitting station as the oscillator, I propose to impress upon this vertical wire, oscillations from an oscillator, which oscillations shall be of a frequency corresponding to the fundamental of the wire. Similarly, at the receiving station, I shall draw from the vertical wire, only that component of the complex wave which is of lowest frequency.
>
> If now the fundamental of the wire at the receiving station be the same as that

of the wire at the transmitting station, then the receiving station may receive signals from the transmitting station, but if it be different from that of the transmitting it may not receive those signals.

* * * * *



In these sketches, G is ground, K is condenser, C is coherer, L is inductance coil without iron, T is step-up transformer, t is transformer without iron, R is retardation coil, B is battery, r is relay.

The tuning of these circuits one to another and all to the same frequency will probably be best accomplished empirically.

though the best general proportions may be determined mathematically (Ex. F–3, V R. 3631–3633).

In the first paragraph quoted above, Stone clearly showed that at the transmitter he would not put the spark gap in the vertical wire of the antenna circuit, as had Marconi's 1897 patent (see pp. 39–40, *supra*), but instead would put it in a separate oscillator or charging circuit adjusted to generate oscillations of the same frequency or wave length as that of the antenna circuit, and then transfer these oscillations to the antenna circuit. In his sketches he showed this transfer to be accomplished by a coupling transformer *t*.

Plaintiff attempts to construe the arrangement disclosed in the above letter as limited to "forced" oscillations, because of the phrase "I propose to impress," etc. Plaintiff argues that this letter consequently makes no disclosure of the transfer of oscillations through inductive coupling of resonant circuits, the method used by Marconi and the defendant (Pl. Brief, pp. 35–36). This argument, based upon a mere play on words, is untenable.[*] Any limitation of Stone's disclosure to

[*] If Stone had used the words "I propose to induce in the vertical wire," he might have limited his concept to transformer coupling, which was the specific mode of transfer shown by Tesla (see pp. 42–46, *supra*), and in Stone's diagrams, reproduced above. The use of the broader term "impress upon," to distinguish his method from the prior manner of generating the oscillations directly in the antenna circuit, indicates an intention to embrace generically the idea

"forced" oscillations is impossible in view of the context of the letter and more particularly the statements (1) that the oscillator circuit frequency would be made to correspond to the fundamental of the antenna circuit, (2) that the fundamental of the vertical aerial wire at the receiver should be the same as that of the aerial wire at the transmitter, and (3) that the several circuits would be tuned "one to another and all to the same frequency" (Ex. F–3; V R. 3631, 3633).

Since in the letter of June 30, 1899, Stone clearly disclosed, prior to Marconi, a transmitter having a charging or spark gap circuit and an antenna circuit coupled together by a transformer, a receiver having an antenna circuit and a detector circuit coupled together by a transformer, the two circuits at each station being tuned to one another, and all four circuits being tuned to the same frequency, this letter alone would be sufficient evidence to support the finding below (Finding LIV, LVIII; I R. 51, 57) that Stone anticipated this concept of Marconi's patent. But there is further supporting evidence.

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of transfer. That other than transformer coupling could be used is borne out by the fact that at the time of the letter Hertz's direct coupling was well known (p. 30, *supra*, and Lodge had already filed his application for patent showing such transfer accomplished by autotransformer coupling (see Lodge figs. 4 and 12, pp. 47 and 49, *supra*). See also I R. 762. Stone's careful choice of broad language was to be expected, for the letters to Baker were written for the purpose of making a record (I R. 739).

On July 18, 1899, Stone again wrote to Baker (Ex. G-3; V R. 3634), explaining and mathematically demonstrating how to achieve the "single" frequency. He pointed out that if the fundamental of the vertical wire (antenna) is of the same period (or frequency) as the oscillator circuit in the transmitter, the "*current*" in the vertical wire will be greater. Significantly, Stone himself observed in this letter that the tuning of the four circuits to the same frequency, which he had disclosed to Baker in the letter of June 30, "is practically the same as that employed by Tesla" (see pp. 42–46, *supra*), except that by the use of the large inductance coil *L* Stone "swamped" the reactions from the coil of the oscillating transformer. The "swamping inductance" *L* reduced the coupling between the open and closed circuits of the transmitter,[28] and

[28] The letter of July 18, 1899, from Stone to Baker is in part as follows:

"The current in the vertical wire in my system may therefore be represented by a simple harmonic

$$A_2 \sin 2 pt$$

and if the period of the impressed force be the same as that of the fundamental of the vertical wire then it may be represented by

$$A_1 \sin pt$$

"*The radiations will also be simple harmonic and of the same periodicity p* and will develop in the vertical wire at the receiving station a corresponding simple harmonic electromotive force *of periodicity p.*

"I space the coherer at the receiving station in a resonant circuit tuned to the periodicity p.

* * * * * *

(Continued at bottom of p. 70.)

slowed down the transfer of energy from the plain gap charging circuit to the antenna circuit, thus permitting the former to oscillate more persistently.

These letters were acknowledged by Baker in a letter of July 22, 1899, to Stone, reading in part (Ex E–3; V R. 3629):

> The "selective" methods of space telegraphy therein described I believe I understand sufficiently to set up and operate them.
>
> Allow me to add that this speculation of the work which Marconi's experiments to date leave in rather primitive condition is

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"The first transmitting circuit shown in my letter to you of June 30 is practically the same as that employed by Tesla for the production of high frequency currents, except that I place an inductance coil *L* in the circuit to give additional means of tuning and to swamp by its greater inductance the reactions from the induction coil *t*, which would tend to make the oscillations multi-periodical instead of simple harmonic. The induction of this coil should be made large compared with the inductance of the primary of *t*.

* * * * *

"At the receiving station the coil *L* and condenser *k* form a resonant circuit which is attuned to the frequency of the current developed at the transmitting station.

"Again the inductance of the coil *L* should be made larger compared to the inductance of the secondary of the induction coil *I* at the receiving station in order to obtain well defined resonance to a single frequency."

The mode of operation of this "swamping inductance" to reduce the coupling between the circuits is explained in detail by defendant's expert Loftin at II R. 977, in connection with Ex. M-2, Loftin Sketch F; V R. 3590. See Brief for the United States in No. 373, this Term, pp. 20, 21, notes 19 and 20.

very important and should be prosecuted without delay by way of further development and protection by letters-patent.

Besides being the prior inventor in this respect, Stone showed diligence in adapting and perfecting his invention. He disclosed his invention to several persons in addition to Baker, and in January 1900 described the invention to his class at the Massachusetts Institute of Technology (I R. 760, 765, 1120, 1123). Further, during this and the succeeding period he was diligent in obtaining capital to form the Stone Wireless Syndicate (I R. 760) and in reducing the invention to actual practice (I R. 762), and he filed his application for patent on February 8, 1900, still prior to Marconi's earliest date (I R. 37). Thereafter, the Stone Telegraph & Telephone Company was organized in December 1901 (I R. 821), and it built wireless stations and sold apparatus, equipped a Navy collier and some battleships, and applied for a large number of patents (I R. 762–763, 822).

The character of apparatus used in the stations is described by Stone (I R. 766–767) as comprising, at both the transmitter and the receiver, resonant open and closed circuits loosely coupled inductively with each other, and all tuned to the same wave length in accordance with the Stone system as set forth in the Baker letters, the Stone patent No. 714,756, and the Stone M. I. T. lectures (I R. 765–766). All of these were prior to the earliest date established for the Marconi

invention, and although some of the stations built by the Stone Company continued up to 1909 or 1910 (I R. 822), the Company was never notified by plaintiff or Marconi that it infringed upon the Marconi patent in suit (I R. 774). What is of even greater significance, when the Stone patent was cited against Marconi's application in the Patent Office, Marconi acquiesced in Stone's priority, and purportedly limited his claims expressly or by inference to the use of the "variable inductances" in the *antenna* circuits, stated in his specification to be "essential elements" in his invention (see p. 28, *supra*).

(iii) *Summary*

Thus, in sum, the court below properly held that Stone anticipated Marconi's transmitter claims 1, 3, 6, 8, 11, and 12, because Stone, like Tesla, disclosed a charging circuit in the transmitter for causing oscillations of a desired frequency, and an antenna circuit coupled to the charging circuit through a transformer, and Stone disclosed the tuning of the two transmitter circuits to the same frequency.[39]

The court was equally corrected in holding that Stone anticipated Marconi's receiver claims here involved (claims 2, 13, 14, 17, 18, and 19) for

[39] Indeed, as pointed out above (pp. 69–70), Stone further disclosed loose coupling of the two circuits in conjunction with the plain gap persistently oscillating circuit which had been known to the art as such since 1894 (p. 35, *supra*, and footnote 32, p. 75, *infra*).

Stone disclosed loosely inductively coupled antenna and detector circuits in the receiver, both tuned to the frequency being received.

Similarly, the court was correct in holding that Stone anticipated the combined transmitter and receiver claims (claims 10 and 20). Claim 10 is the only claim requiring that the four circuits shall actually be in resonance with each other; it does not require tuning by a variable inductance and hence in any aspect is readable directly upon the Stone disclosure. Indeed, this claim was apparently inadvertently allowed in the Patent Office, as we shall show (n. 34, p. 76, *infra*). Claim 20, which also covered the transmitter and receiver, was likewise properly held anticipated by Stone, since if the four circuits are in electrical resonance with each other, then there must be means for bringing them into resonance. Stone disclosed such syntony for all four circuits, and justifiably left it to those skilled in the art to utilize any of the well-known means to achieve such synchronization.

The court's findings of fact as to anticipation by Stone thus sustain the ultimate findings of invalidity of Marconi's patent, and are adequately supported by the evidence.

(c) Marconi's "variable inductance" in the antenna circuit cannot save his patent

The only difference between Stone's disclosure and the claims of Marconi's transmitter group

was the use by Marconi of a "variable inductance" in the open antenna circuit to tune that circuit, in lieu of tuning it otherwise, as by adjusting the length of the antenna wire. This was the feature upon which the Marconi patent was allowed. We submit that this involved no novelty since it had already been disclosed in the earlier Lodge patent, and in any event was not a patentable invention.

The original Marconi application, filed November 10, 1900, was repeatedly rejected by the Patent Office examiners because of the prior art.[30] For example, a letter of rejection on June 3, 1902, held that the claims specifying a variable inductance were not patentable in view of Tesla and Lodge, and that an adjustable or variable condenser was not patentable over Tesla.[31] The ap-

[30] For example, the Braun British patent No. 1862 of 1899 (Ex. Z-2, V R. 3620); Lodge patent No. 609,154 (p. 46, *supra*); Marconi patent No. 627,650 (p. 53, *supra*); and Tesla patent No. 645,576 (Ex. X-2, V R. 3662); cited by the Examiner V R. 3982, 3983, 4002. The Braun British patent and the corresponding Braun U. S. patent No. 797,344, granted August 15, 1905, upon original application filed February 6, 1899 (Ex. X-6, V R. 4006), disclosed a transmitter consisting of a separate charging circuit with spark gap and condensers, coupled to the antenna circuit by an oscillation transformer consisting of two inductance coils. These patents did not refer directly to tuning the circuits, but at that date the art was fully conversant with the fact that they should be, since Hertz, Lodge, Tesla, and Marconi (in No. 627,650) had fully appreciated and discussed its desirability.

[31] The examiner's letter of rejection, dated June 3, 1902, was as follows (Ex. X-5; V R. 4002):

"Claims 4, 13, 14, and 16, which specify a variable inductance and means for adjusting the inductance, are not pat-

plication was then abandoned and no action taken until October 6, 1903, when a petition to revive was filed, with an amendment containing all the claims here involved except claim 19 (V R. 4003). The examiner recommended that it be denied on account of the prior art,[*] and the Commissioner denied it on December 2, 1903 (V R. 4040). Some months later, another petition for revival was presented (*id.* 4043) and was granted by the Commissioner on March 28, 1904 (*id.* 4066). The case was immediately referred to a new examiner, who on March 31, 1904—only three days later—allowed all but four of the rejected claims (*id.* 4068).

The sole basis for the allowance was that although the earlier Stone patent No. 714,756, like the Marconi application, showed a system in

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entable over Tesla because Lodge, of record, has shown that it is old to adjust the period of the circuit by a variable inductance; and claims 3 and 5, which specify an adjustable condenser, are not patentable over Tesla because applicant has shown in his prior patent 627,650, that this adjustment may be produced by a variable condenser. Since it is impossible to exactly calculate the values of the electro magnetic constants of two circuits for the purpose of making their time periods agree, it is fair to assume that the electrical oscillator of Tesla must necessarily be made with an adjustable inductance or condenser, or both."

[*] Particularly Tesla patents No. 645,576 and 649,621, Fessenden patents Nos. 706,735 and 706,736, Stone patents Nos. 714,756 and 714,831, and a paper presented by Pupin in December 1899 (V R. 4022). The examiner stated that Stone had disclosed "tuning a closed persistently oscillating circuit with the vertical transmitting wire as well as the advantages resulting therefrom," with the closed and open circuits "inductively connected" (V R. 4023).

which the circuits were in resonance with each other. Stone attained resonance (in the view of the new examiner) by adjusting the length of his aerial conductors, whereas Marconi attained the same result by including a variable inductance in the aerial circuit. The examiner accordingly allowed all claims which included that element (*id.* 4069). And the four remaining claims (claims 4, 5, 6, and 7) were held by the examiner to be allowable if amended by inserting a reference to a "variable inductance" in each claim (*id.* 4070).

The narrow ground upon which Marconi's application was allowed by the new examiner—that it included an inductance coil for tuning the aerial already shown by Stone[1]—was clear error. For, as the former examiner had held, Lodge had already disclosed such an inductance coil, and had taught its use in precisely the same manner for tuning the same kind of aerial used by Stone.

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[1] Marconi's amended specification, and his patent as issued, represented the use of the variable inductance a and a' to be one of the "essential elements" required by his invention (Ex. X-5; V R. 3908; Ex. 21, IV R. 2791, lines 50-70).

[2] Because of the examiner's reliance upon the variable inductance coil in the antenna circuit, his allowance of claim 10, the only claim in Marconi's patent which does not require tuning by a variable inductance, was apparently inadvertent, and doubtless attributable to the misleading statement in Marconi's amendment (Ex. X-5; V R. 4073) that the "claims now presented, all include an elevated conductor, or a circuit which is a good radiator of electrical waves, and means for adjusting the time of such elevated conductor or radiating circuit."

This was the view of the court below in holding the Marconi patent anticipated, and its decision is fully sustained by the evidence.

Lodge in his patent No. 609,154 of August 16, 1898, had included a variable inductance in the antenna circuits at the transmitter and receiver for the purpose of tuning them (see pp. 46–53, *supra*). Marconi merely applied the function and mode of operation of Lodge's variable inductance without change to tune Stone's antenna circuit. Moreover, the use of Lodge's variable inductance in the antenna circuit, in lieu of tuning by adjusting the length of wire, had no practical effect upon the operation of the apparatus. The Stone system functioned in precisely the same way under either method, and no new result was accomplished. The combining of Lodge's feature with Stone's circuit was nothing more than the "skill of the calling," for to those skilled in the art, the variable inductance was plainly susceptible of, and indeed intended for, such use. Certainly, this exercise of ingenuity fell far below the level of invention.[8]

The court below therefore properly held that Stone in conjunction with Lodge anticipated the only feature of Marconi's transmitter which the

[8] *Cf. Electric Cable Joint Co.* v. *Brooklyn-Edison Co., Inc.*, 292 U. S. 69; *Paramount Corp.* v. *Tri Ergon Corp.*, 294 U. S. 464, 473; *Altoona Public Theaters, Inc.* v. *Tri Ergon Corp.*, 294 U. S. 477, 486; *Toledo Pressed Steel Co.* v. *Standard Parts, Inc.*, 307 U. S. 350, 356.

Patent Office regarded as novel, and which was not anticipated by Stone alone.

4. *Prior litigation upholding Marconi patent No. 763,772 is distinguishable*

Plaintiff cites a prior decision of a British court holding the corresponding British patent valid, and two decisions in the lower federal courts favorable to the Marconi patent in suit. These constitute little authority on the question of validity in the case at hand, since in two of the decisions the Stone defense was not raised; and in the third Marconi's patent was held not infringed.

(a) Corresponding British Patent

Marconi v. *British Radio Telegraph & Telephone Co.*, 27 T. L. R. 274, 28 R. P. C. 18 (Ex. 7; IV R. 2525), involved the Marconi British Patent No. 7777 of 1900 (Ex. 34; IV R. 2606). This patent, which claimed four-circuit tuning (IV R. 2614), was upheld as against the prior art by Mr. Justice Parker in the High Court of Justice (the case was not appealed). His decision, rendered on a record which contained no reference to the work of Stone, attributed all of Marconi's improvement to the radiation of prolonged oscillations from the transmitter by slowly feeding to the radiating or antenna circuit the energy of a closed, persistently oscillating charging circuit, by means of loose coupling between those circuits. But these features, as the court

below held, were previously disclosed in the United States by Stone; and since the work of Stone was not before Judge Parker in the English case, that decision is of no authority respecting the Stone defense. Indeed, far from aiding the plaintiff here, the English decision, as will be shown herein (pp. 81 *et seq.*), supports defendant's contention that its apparatus did not infringe Marconi's patent in suit.

(b) *Marconi Wireless Telegraph Co. of America v. National Electric Signaling Co.*, 213 Fed. 815

In the above captioned case, Judge Veeder in the Eastern District of New York held Marconi's United States patent here involved to be valid and infringed. The apparatus alleged to infringe consisted of a plain gap, persistently oscillating charging circuit, loosely coupled to the antenna circuit, as in the English case. Although the court recognized that "the broad claim of invention resides * * * in the independent adjustment of the capacity and self-induction of the four circuits, two at the transmitting station and two at the receiving station," the work of Stone was not referred to. Moreover, Judge Veeder virtually followed the reasoning in the British case (213 Fed. 848–849), and in his opinion the supposed novelty was found to inhere in features other than the tuning. For example, Judge Veeder stated:

> Marconi's improvement in his second patent, upon his own prior apparatus, and his solution of the difficulty involved in Lodge's compromise, consists in the substitution for a single circuit in both transmitter and receiver of a pair of circuits, one of which is so constructed as to radiate or absorb readily and the other to oscillate persistently and be a good conserver of energy * * * (p. 846).

For these two reasons, this case (which did not go to the circuit court of appeals) adds nothing persuasive to the British case, but like the British case, supports defendant's contention of noninfringement.

(c) *Marconi Wireless Telegraph Co. of America* v. *Kilbourne & Clark Mfg. Co.*, 239 Fed. 328, affirmed 265 Fed. 644

Judge Netterer in the Western District of Washington held the Marconi patent in question not infringed, mainly because it was construed in the light of the prior Stone invention to exclude quenched gap transmitters—the principal devices here charged to infringe. Although the district court entered a formal finding as to validity, that conclusion, in view of the decision as to noninfringement, is little more than *dictum* and would not be entered under more recent practice in like circumstances.* For while the Stone

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* *Electrical Fittings Co.* v. *The Thomas & Betts Co.*, 307 U. S. 241.

defense was before the court, it was relied on solely to sustain the defense of "noninfringement of the invention as limited by the prior art," and the circuit court of appeals in affirming the decision as to noninfringement expressly recognized Kilbourne & Clark's position in this respect (265 Fed. 646). The court's references to validity must therefore be treated as having been made *obiter*. Of even greater significance in depriving that case of any weight on the issue of validity is the fact recognized by the court below (I R. 97–99), that Judge Netterer did not consider the earlier Lodge patent No. 609,154 read together with the earlier Tesla patent No. 645,576, which was the alternative basis for the conclusion of invalidity below. Indeed, as regards the feature here involved, the *Kilbourne & Clark* case favors defendant's contentions, since Judge Netterer there specifically stated that tuned circuits and even four-circuit tuning were known prior to Marconi (265 Fed. 655, 661).

In the *Kilbourne & Clark* case, the apparatus alleged to infringe employed a quenched gap and tight coupling, and had no persistently oscillating charging circuit.[*] The district court described it as one which transfers the energy by a single

[*] These features were found to characterize defendant's transmitters in the present case, which are the principal apparatus alleged to infringe (Findings LXVIII, LXIX; I R. 4344).

impulse, as distinguished from other means (239 Fed. at 345):

> Such conversion is known to the art as impulse excitation. Impulse excitation of the oscillating currents is one in which the energy is set in motion within the oscillating, radiating circuit by a single impulse, as distinguished from a transfer of energy by other means.

This feature was held to distinguish the quenched gap transmitter of Kilbourne & Clark from Marconi's patented transmitter. After pointing out that the antenna circuit of Kilbourne & Clark's "impulse transmitter" was tuned to the desired frequency, and that the charging circuit (called "a disturbing circuit") had fixed elements of capacity and inductance, the court stated (p. 348):

> The difference in the operation of the defendant's impulse transmitter and the plaintiff's type of transmitter is in the fact that there is an entire absence of resonant tuning in the impulse transmitter, whereas in the tuned, coupling circuit transmitter, for any change in wave length there must be a change of tune of the two associated circuits, so as to keep them in resonance. The defendant's impulse transmitter is electrically the same as Lodge's and carries out his thought with relation to the transmission of energy.

The court's conclusion as to non-infringement because of differences in mode of operation was thus rested on the facts that Kilbourne & Clark used a high resistance spark gap which would rapidly cut off the charging circuit, damping further oscillations in that circuit but leaving the antenna circuit free to oscillate at its own natural frequency, and that the two circuits in the transmitter were neither loosely coupled nor required to be attuned to exact resonance with each other; whereas the essence of the Marconi system was the low resistance plain gap with its persistently oscillating circuit (i. e., reservoir circuit) loosely coupled to the antenna circuit and tied electrically to the antenna circuit for the entire period of persistent oscillation during which the energy is gradually transferred. This clear distinction in apparatus, producing a different mode of operation, lead inevitably to the court's conclusion of non-infringement. Because of this conclusion, the court held it unnecessary to enter into any detailed discussion of the validity of Marconi's patent.

It did, however, hold Kilbourne & Clark's apparatus to be identical with Lodge's transmitter [35] and, as to the feature of synchronization,

[35] Judge Netterer stated: "The operation of Lodge patent, Fig. 2, is identical with defendant's in using impulse charging and variable inductance coil in the antenna. No reservoir circuit is used, and, when the radiating circuit is charged, it is entirely separated from the source of supply circuit which necessarily has some natural period" (239 Fed. 350).

it held that Marconi was not the first to invent tuned circuits nor even four circuits tuned to the same frequency (239 Fed. 328, 338–342).

Although the decree of non-infringement entered by the district court recited the validity of the Marconi patent, the Circuit Court of Appeals for the Ninth Circuit, affirming the decision below, noted that defendant's counsel "did not find it necessary to depend upon the validity of the Marconi patent for a defense" (265 Fed. 644, 646). This observation, coupled with the absence of any statements or reasoning in the district court's opinion as to validity, renders the recital of validity purely formal and in effect entered upon consent. Such a decree would scarcely be entered today, and is entitled to little weight. *Electrical Fittings Corp.* v. *The Thomas & Betts Co.*, 307 U. S. 241.

Hence, nothing in the *Kilbourne & Clark* case can serve as authority against the propriety of the decision below, in accepting the Stone (and Lodge) defense as a prior disclosure in anticipation of the Marconi patent. Indeed, upon the question of infringement the *Kilbourne & Clark* case is in accord with defendant's contention that its quenched gap, tightly coupled, transmitter apparatus did not infringe Marconi's patent, as will hereinafter appear.

Point II

MARCONI PATENT NO. 763,772, EVEN IF VALID, WAS NOT INFRINGED BY DEFENDANT'S APPARATUS

In the court below, the defendant urged at the close of the hearing that Marconi patent No. 763,772 had been proved not only invalid for anticipation, but also not infringed by defendant's apparatus.[20] The court below made evidentiary findings of fact which, we believe, would adequately support a conclusion of non-infringement, but held in its opinion that it was unnecessary to pass upon that defense because of the conclusion as to invalidity of the patent (1 R. 94, 101). Since we consider that the defense of non-infringement is a sufficient ground to sustain the judgment in the Government's favor even if that court erred in its holding of invalidity, we reassert that defense before this Court. *Stelos Co.* v. *Hosiery Motor-Mend Corp.*, 295 U. S. 237.[21]

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[20] Record, C. Cls. No. 33,642; pp. 3883, 4133 *et seq.*

[21] Nothing in *Esnault-Pelterie* v. *United States*, 299 U. S. 201, precludes such a finding by this Court. It was there held that a judgment of the Court of Claims in a patent case could not be sustained in the absence of ultimate findings concerning either validity or infringement, and the case was remanded for such findings. Besides being distinguishable from the instant case—in which an ultimate finding of invalidity was made—the *Esnault-Pelterie* decision was rendered on certiorari to the Court of Claims under Section 3 (b) of the Act of February 13, 1925, which, before the amendment of May 22, 1939, permitted only "the findings of fact, the conclusions of law, and the judgment or decree" of the Court of Claims to be brought up. The amendment of

1. *Criteria available to test infringement*

In surveying the prior art to determine possible elements of novelty in Marconi's disclosure, the court below stated that Marconi in this case was attempting to claim the tuning of all four circuits as his improvement and as the feature infringed (I R. 31–38; p. 5, *supra*). The court then found that four-circuit tuning had been known and disclosed in the prior art by Stone, as well as by Tesla's patent taken with that of Lodge (Findings LVIII and LXII; I R. 57, 58). Hence, under the approach adopted below, there remained no feature of Marconi's asserted invention which could be used as a criterion to test the allegations of infringement. To obtain such a criterion we may look to the only decisions which have recognized and upheld any element of novelty in Marconi's patent—the decision of Judge Veeder in *Marconi Wireless Telegraph Co. of America* v. *National Electric Signaling Co.*, 213 Fed. 815 (E. D. N. Y.), and the decision of Judge Netterer in *Same* v. *Kilbourne & Clark Mfg. Co.*, 239 Fed. 328 (W. D. Wash.).

May 22, 1939 (c. 140, 53 Stat. 752), now permits the entire record in the Court of Claims to be reviewed in the Supreme Court on certiorari, as is true on certiorari to a circuit court of appeals under Section 240(a) of the Judicial Code. The scope of review in patent matters coming from a circuit court—as did *Stelos Co.* v. *Hosiery Motor-Mend Corp.*, 295 U. S. 237—would therefore appear to apply to review of patent decisions of the Court of Claims under the 1939 amendment, when the evidence is brought up, as here.

affirmed 265 Fed. 644 (C. C. A. 9). We may also look to the decision of Justice Parker in respect to the corresponding British patent, *Marconi* v. *British Radio Telegraph & Telephone Co.*, 27 T. L. R. 274, 28 R. P. C. 18 (IV R. 2525). Even if these decisions be accepted as properly establishing invention in Marconi's patent over the prior art, the conclusion is inescapable that defendant's devices do not infringe.

Marconi's transmitter, to the extent held novel by these prior adjudications, involved the use of a persistently oscillating charging circuit, loosely coupled to the antenna circuit, and feeding only a small part of its energy thereto on each oscillation, so that the radiation in the antenna circuit for each discharge in the charging circuit would be prolonged, i. e., spread over a longer train of oscillations. Thus, Justice Parker in considering the Marconi British patent, found that from his transmitter Marconi desired to radiate a long train of waves of single frequency, as Lodge had wished to do; that instead of attempting suddenly to charge the antenna circuit by impulsive rush and then leave it to oscillate freely, as Lodge had done, Marconi proposed to feed it the energy to be radiated, a little at a time; that for this purpose Marconi proposed to use a charging circuit which was a persistent oscillator (i. e., a circuit of low resistance, shown as having a low-resistance plain spark gap, so that its oscil-

lations would not soon damp out) and to loosely couple this charging circuit to the antenna circuit so that only a small part of the energy of the charging circuit would be delivered to the antenna circuit on each oscillation, thus spreading the energy being radiated over a longer number of oscillations (i. e., lengthening the wave train) and at the same time avoiding the generation of a double frequency in the antenna circuit. The decision indicated that the entire improvement of Marconi's system flowed from the prolonging of the transmitted wave, which, when picked up by the antenna circuit of the receiver, thereby induced and then built up the amplitude of the oscillations in the coherer circuit (itself already a persistently oscillating circuit) and thus effectively actuated the receiver. Justice Parker attributed no novelty to the receiver,[1] and only incidentally adverted to the necessity of tuning the respective circuits to resonance, a requirement well understood by the prior art.

Judge Veeder in the *National Electric* case and Judge Netterer in the *Kilbourne & Clark* case made substantially the same analysis of the Marconi patent in suit. Tested by the features regarded as novel in these cases, the conclusion inevitably follows that defendant's apparatus did not infringe the Marconi patent in suit.

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[1] No claim of the British patent covered the receiver apart from the transmitter (IV R. 2613, 2614).

2. *Defendant's transmitters*

The transmitters here charged to infringe were of three types. By far the greater number were quenched gap transmitters (Finding XLVI; I R. 40). A few used the rotary gap (Finding XLIX; I R. 41), and only a very few early transmitters were of the plain gap type (Finding XLVI; I R. 41).

(a) Quenched Gap Transmitters

The quenched gap transmitters, comprising practically all of the defendant's transmitter types,* employed in their charging circuit a high-resistance "quenched gap" (instead of a low resistance plain gap) and relied on relatively tight coupling quickly to transfer the energy of the charging circuit to the antenna circuit in the relatively few oscillations permitted by the high resistance gap.† Because the charging circuit in-

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* The Telefunken type (Ex. 79); Kilbourne & Clark type (Ex. 95); the type manufactured by the Navy (Ex. 93); Wireless Improvement type (Ex. 88); Simon type (Ex. 89); Lowenstein transmitter (Ex. 101); National Electric Supply type (Ex. 90); and Wireless Specialty type (Ex. 87).

† The "quenched gap" consists of a series of gaps or open spaces separated by cooling plates. The gaps are of high resistance, and the plates separating them offer large cooling surfaces, thereby tending to cool and extinguish the arc of current quickly. In the plain gap, on the contrary, there is only one gap or open space, and the terminals offer a minimum of cooling surface; hence the gap has low resistance, facilitating persistence of the spark. The conventional symbol for the quenched gap is a series of parallel lines of equal length, as G in Ex. 89.

cluded a high resistance gap tending to damp-out the oscillation quickly, and because the tight coupling enabled the charging circuit to part with its energy rapidly, it was not a persistent oscillator. The high resistance gap "quenched" the spark quickly, after but a few oscillations; the charging circuit then ceased to oscillate, after transferring the energy rapidly to the antenna circuit; and the antenna circuit then continued to oscillate at its own natural frequency. (Finding XLVIII; I R. 43.)

Further to aid in quickly suppressing the oscillation of the charging circuit, the frequency of that circuit was in practice preferably adjusted so that it would *not* be in tune with the antenna circuit." With such detuning, after a few cycles

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"This detuning is explained by defendant's expert Loftin (II R. 991, 1031) and illustrated by him in Exhibit D-3. The *Electrician* article of November 10, 1911 (Ex. C-5, V R. 39 g 3993) pointed out:

"To give the best result it is necessary that the reaction of the secondary circuit should assist the quenching in the primary, and for that reason the two circuits are slightly mistuned, namely, to the extent of about 2 percent. The closer the coupling the greater must be the mistuning."

Close coupling itself effects detuning and produces the "double hump" phenomena tending to prevent persistent oscillation of the charging circuit (see p. 26, n. 8, *supra*). Consequently, the instructions given by the Army Signal Corps to its personnel "that tuning of the closed and open circuits to resonance and the determination of the correct coupling between them are the two most important adjustments in a quenched gap transmitter," which plaintiff cites to distinguish defendant's quenched gap transmitters from those held not to infringe in the *Kilbourne & Clark* case (Pl. Brief,

of oscillation, the voltages of the two transformer coils (one in the charging and one in the antenna circuit) are in opposition with each other and hence stop the current flow in the charging circuit. Because the two circuits are thus coupled for only a brief instant, and because the quenched gap prevents persistence of oscillation in the charging circuit, the energy must be transferred rapidly from the charging circuit to the antenna circuit, which requires that the circuits be coupled tightly. It is true that during the extremely short time in which the current oscillation in the charging circuit continues, there is the generation of a double wave and diminution of efficiency which results from tight coupling and nonresonance, but these phenomena are only transitory. The close coupling is permissible and useful notwithstanding this minor fault because, when the charging circuit is cut off, its interference ceases, the antenna has received a much higher charge of energy than it would with the slow-feeding system of Marconi, the antenna is then free to oscillate at its own natural period, and it radiates a single frequency of greater initial amplitude (Ex. D–3, V R. 3628, II R. 991–998, 1031).

As was held in the *Kilbourne & Clark* case, *supra*, this principle was originally disclosed by

p. 43) are immaterial, for the "correct coupling" of defendant's apparatus, being tight, necessarily results in a detuning. Moreover, the apparatus does not employ the "persistent oscillator."

Lodge in 1898. In his patent No. 609,154, he employed a plurality of spark gaps, and his specification (p. 2, lines 57–85) described the manner of charging the aerial by "aerial disruption or impulsive rush," whereby the "charges so communicated are left to oscillate free from any disturbance due to maintained connection with the source of electricity" (see Fig. 4 of Lodge patent, p. 47, and n. 19, p. 48, *supra*). In 1906, Professor Wien in Germany redesigned Lodge's invention, devised a suitable spark gap apparatus having even more gaps than Lodge's system (since known as "quenched gap" apparatus) and arranged that the charging circuit and the antenna circuit should be out of tune during the charging process in order to aid quick extinguishment of the current flow in the gaps, thus cutting off the charging circuit from the antenna circuit as soon as possible."

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[*] Professor J. A. Fleming, an expert associated with the Marconi Company (I R 554), in an article in *The Electrician* on June 11, 1909, explained and diagrammed the difference between the plain gap and the Telefunken quenched gap systems as follows (Ex. B 5; V R 3897):

"The Telefunken discharger is based on the known fact that the damping of very short sparks is extremely large, and that if we can 'quench' or stop the primary oscillations after one or two swings the secondary circuit then continues to oscillate freely within a single period, as shown in Fig. 1. * * *

"Finally, as the whole of the energy transferred to the secondary circuit expends itself in the production of radia-

The substantial difference between Marconi's and the defendant's transmitters in arrangement, mode of operation, and result are thus apparent. Marconi's structure involves a *low-resistance plain spark gap* in the charging circuit, *loose-coupling* between antenna and charging circuits, and *exact tuning* of these circuits. This *decreases* the resistance of the charging circuit and renders it a *persistent oscillator*, a reservoir-like conserver of energy. Because the coupling is loose, it feeds to the antenna circuit, on each oscillation, only a little of its energy, thereby prolonging the trans-

tion of one single wave length it must be more economical than methods which generate waves of two wave-lengths, but capture at the receiver radiation conveyed by only one of these wave-lengths."

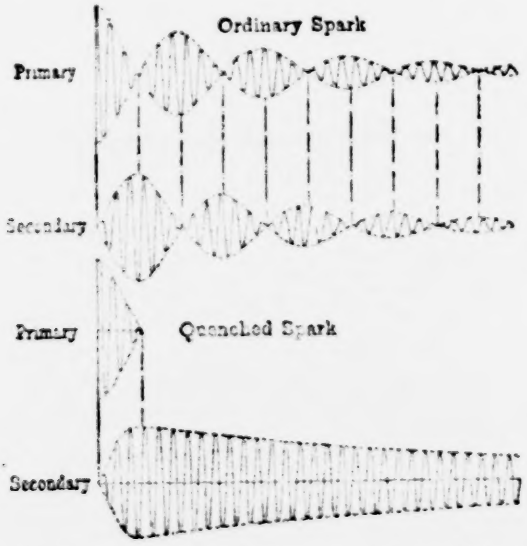

FIG. 1.—OSCILLATIONS IN INDUCTIVELY-COUPLED CIRCUITS.

mitted wave, but reducing its initial power. Marconi's charging circuit is thus electrically tied to the antenna circuit, as a driver, throughout its prolonged period of persistent oscillation, and does not leave the antenna circuit free to oscillate entirely by itself. The useful signal is transmitted *while* the persistent oscillation continues. (Ex. R–2, Loftin sketch J; V R. 3594, II R. 923–929.) *

The defendant's structures, on the contrary, involve a *high resistance quenched gap* in the charging circuit, *tight coupling* between the two transmitter circuits, and *detuning* of those circuits, thereby *increasing* the resistance of the charging circuit, preventing it from being a persistent oscillator, and providing for delivery of its energy to the antenna circuit "in a rush," after which it ceases to oscillate, leaving the antenna circuit free to oscillate at its own natural frequency. The useful signal is radiated *after* the charging circuit has delivered its energy to the antenna circuit and has ceased to oscillate. (Ex. D–3, Loftin sketch O; V R. 3628, II R. 991–998.)

The differences between Marconi's and the defendant's devices are tabulated, for convenient reference, in Table I, following:

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* *Marconi* v. *British Radio Co.*, 27 T. L. R. 274, characterized Marconi's charging circuit as a reservoir feeding energy to the antenna in a manner similar to clock escapement mechanism.

TABLE 1

STRUCTURE

Marconi's transmitter	Defendant's quenched gap transmitter
(1) *Low resistance*, plain spark gap in the charging circuit.	(1) *High resistance*, quenched gap in the charging circuit.
(2) *Loose* coupling between the charging and antenna circuits.	(2) *Tight* coupling between the charging and antenna circuits.
(3) *Exact tuning* of the two transmitter circuits.	(3) *Detuning* of the two transmitter circuits.

OPERATION

(1) The low resistant gap *decreases the* resistance of the charging circuit, making it a persistent oscillator.	(1) The high resistant gap *increases* the resistance of the charging circuit, preventing it from being a persistent oscillator.
(2) The loose coupling feeds to the antenna circuit on each oscillation only a little of the energy, prolonging the transmitted wave but reducing its initial power.	(2) The tight coupling delivers to the antenna circuit on each oscillation a large part of the energy in a rush.
(3) No useful signal is transmitted from the antenna circuit while the persistent oscillation continues in the charging circuit.	(3) The useful signal is transmitted from the antenna circuit after the charging circuit has ceased to operate.

RESULT

The transmitter transmits a prolonged series of oscillations not initially of very great strength but continually replenished by energy being withdrawn from the charging circuit so long as it persists in oscillation.	The transmitter transmits a series of oscillations of such greater initial strength and which die out at the natural rate of damping of the antenna circuit.

Contrary to Marconi's theory, the "impulsive rush" operation of defendant's transmitter results in a great increase in the efficiency of the quenched gap over the plain gap apparatus of the Marconi patent (11 R. 1139), for there is no resonant retransfer of energy from the antenna circuit to the charging circuit after the antenna has been charged and commences to radiate at its natural frequency; and the transmitter's useful radiation has an initial amplitude or power much

greater than that obtained by slow feeding (*cf.* Ex. O-2, P-2, R-2, D-3; III R. 2120, 2291–2292).

Defendant's quenched gap apparatus is like that involved in *Marconi Wireless Telegraph Co. of America* v. *Kilbourne & Clark Mfg. Co.* (*supra*, pp. 80–84). This the Circuit Court of Appeals for the Ninth Circuit held did not infringe Marconi's patent because the quenched gap transmitters did not use the persistently oscillating charging circuit slowly feeding the energy to the antenna circuit, but instead followed Lodge's principle of charging the antenna quickly and then leaving it free to oscillate at its own natural frequency.

In summary: (1) The Lodge patent pointed the art along one path when it suggested that the antenna circuit be charged by "impulsive rush" to obtain in it an *initially strong oscillation*, and when it used a high resistance series of three or four spark gaps in the charging circuit to cause it quickly to stop oscillating and driving the antenna circuit, so that it would leave the antenna circuit free to oscillate at its own natural frequency and rate of damping. (2) Marconi pointed the art away from this principle, and in his system charged the antenna circuit only a little at a time, to obtain a *weaker but more prolonged series of oscillations* in the antenna circuit, using a single low resistance plain gap in the charging circuit to cause it to continue or

persist in oscillating and driving the antenna circuit during practically the entire period of radiation. (3) The Wien quenched gap systems employed by defendant returned to the path pointed out by Lodge, and travelled that path to a point still further removed from Marconi's principle than that at which Lodge had stopped, for Wien increased the number of gaps (to nine in the arrangement photographed at V R. 3906A for example), thus increasing their cumulative resistance, and also provided them with cooling flanges, all to extinguish the spark even more quickly. This produced still quicker cut-off of the charging circuit and still quicker stopping of any driving of the antenna circuit so as to leave the latter free to oscillate alone.

This difference in basic principle required differences in arrangements of apparatus. Marconi, in order to practice his slow feeding of energy during a large number of oscillations, required loose coupling and very exact tuning of the charging and antenna circuits to obtain a sufficient oscillation of the desired frequency in his antenna circuit. The quenched gap system, on the other hand, because it fed its energy in a rush and then allowed the antenna circuit to oscillate by itself, needed no such loose coupling or exact resonance, but preferred the opposite. In its preferred form, the two circuits were not only tightly coupled but intentionally de-tuned to further aid in

quickly stopping any prolonged driving of the antenna circuit by the charging circuit.

Since the prior art Lodge patent is the basis of the quenched gap system, Marconi's patent cannot embrace the latter without including and being invalidated by the Lodge disclosure.

That the quenched gap transmitter differs markedly from the plain gap type is further evidenced by the commercial displacement of the latter by the former, notwithstanding that the quenched gap transmitter went back to a principle antedating Marconi's patent. Soon after its introduction in this country in 1909, the quenched gap system displaced the plain gap "persistently oscillating" charging circuit of the patent in suit because its different mode of operation resulted in such greatly increased efficiency (II R. 1178). The Navy adopted the quenched gap and abandoned the plain gap apparatus in or about 1911 (II R. 1044). After 1911 the plaintiff's own United Wireless Company manufactured *quenched* gap transmitters exclusively, and because of the inability of the loose-coupled persistent oscillator to transmit beyond a short range (II R. 1044; III R. 2201) it abandoned the tuned circuit type (II R. 1181, 1210–1213) except at some existing stations (II R. 1269, 1270) and except for emergency use in war time.

Thus, upon the interpretation of the Marconi patent adopted by the courts in the few cases

which have considered and upheld it, upon principle, and in light of the prior art, defendant's quenched gap transmitters do not infringe. The differences in mode of operation and result requiring this conclusion are set forth in the evidentiary findings made below, which are supported by substantial evidence; and these evidentiary findings afford a sufficient foundation to uphold the judgment for defendant as to quenched gap transmitter systems on the ground of non-infringement.

(b) Rotary Gap Transmitters

A few of the transmitters alleged to infringe were of the rotary gap type, which consists of two widely spaced stationary electrodes and a rotating disc between them, having a number of spaced studs. The spark jumps from the stationary electrodes to the studs of the rotating disc when they are brought into alignment, and further rotation of the disc moves the studs away from the electrodes, lengthening the gap quickly and extinguishing the spark. As the court below held (Finding LXIX, I R. 44), this gap is similar to the quenched gap in that it effects a quenching of the spark as the moving electrodes recede from the stationary electrodes. Thus the rotary gap is simply another means for quickly quenching the spark and preventing the charging circuit from being a persistent oscillator. The finding of the quenching action of the rotary gap is not chal-

lenged by plaintiff; consequently the rotary gap transmitters must stand or fall with those containing the quenched gap, for they also employed the principles set forth by Lodge and avoided Marconi's system, as was urged below. The reasons urged above, to support the conclusion that quenched gap transmitters did not infringe, are equally applicable here.

(c) Plain Gap—Direct Coupled Transmitters

The few plain gap transmitters employed by defendant had the antenna circuit directly coupled across an inductance in the charging circuit, without any separate swamping inductances to loosen the coupling, as shown in the drawing in Finding XLVI, I R. 41. These transmitters thus did not embody the "essential" features of the Marconi patent, in which both loose coupling and persistent oscillation were required to attain Marconi's mode of operation and result. While in these plain gap transmitters the charging circuit had fewer gaps than that of Lodge, and hence would not cut off as quickly and efficiently, Lodge's mode of coupling the antenna and charging circuits to a common inductance (see illustration on p. 50, *supra*) was nevertheless common to these transmitters, and there is no evidence that they attained Marconi's slow feeding operation and result. For these reasons, as urged below, no infringement has been established in respect of the plain gap transmitters.

3. *Receivers*

We have shown above that the receivers charged to infringe the Marconi patent are so thoroughly grounded in the art prior to Marconi that if they infringe Marconi's receiver claims, those claims must necessarily be invalid for anticipation. The court below held these claims invalid, as it found no element in them not disclosed in the prior art. But if we turn to the other prior litigation on the patent, and on its British counterpart, we find that there is little basis even in them for any test of infringement of the receivers apart from the specific transmitters of Marconi.

In the prior litigation, no charge of infringement under the Marconi patent was brought or maintained against receivers except as parts of a system alleged to embody four-circuit tuning *and* the wave-prolonging loose coupled persistent oscillator at the transmitter. In the British case, Mr. Justice Parker indicated that the entire alleged improvement of Marconi's patent flowed from the supposed improvement of the transmitted wave (p. 78, *supra*), and Judges Veeder and Netterer followed substantially the same reasoning (pp. 79–84, *supra*). But, as we have already shown, these features are no part of the defendant's systems and, in any event, have no relevancy to the Marconi claims for receivers, *per se*. Hence even under the interpretation given Mar-

coni's patent by the courts which considered and upheld it, defendant's receivers are excluded from the valid scope of the patent. In any event, if any claim of the Marconi patent reads upon defendant's receivers, the identity of the prior art with such receivers is alone sufficient in our opinion to preclude any conclusion of infringement.[47]

PART TWO: FLEMING PATENT NO. 803,684

The court below found that Fleming patent No. 803,684, covering a use of a two-electrode vacuum tube, was not infringed, as charged, by defendants use of the three-electrode vacuum tubes in its receivers and transmitters, because the apparatus alleged to infringe was substantially different in structure, mode of operation and result from the device disclosed by Fleming. This decision is grounded upon adequate evidentiary findings of fact and upon substantial evidence. Moreover, apart from the question of infringement, the record and the findings of fact below would fully support the conclusion that the Fleming patent was invalid.

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[47] As pointed out (pp. 54-55, *supra*), Marconi's own prior patent No. 627,650 disclosed inductive coupling of two tuned circuits at the receiver, with the detector circuit tuned by a variable condenser, and the antenna circuit tuned in ways also known to the prior art and clearly tunable by a variable inductance as taught by Lodge. We have also shown (*supra*, pp. 42, 50, 56 *et seq.*) that Tesla, Stone, and others had taught that the two receiver circuits should be tuned and preferably loosely coupled.

The Fleming patent employed a two-element vacuum tube, and claimed its use as a rectifier to render capable of indication the high frequency alternating currents of wireless oscillations. The court below found as facts that the earliest date available to Fleming for his alleged invention was November 16, 1904; that prior to this date, the two-element device described by Fleming had been disclosed by Edison and was known to be a rectifier or detector of low-frequency alternating currents;* that use of a similar two-element vacuum tube rectifier as a detector of high-frequency waves was also known prior to Fleming's date; that the Fleming patent, if valid, was restricted to this particular use of the known Edison device to rectify the received alternating currents of radio signals in order to operate a direct current indicator in the received energy circuit, and that on principle, and in view of the prior art, Fleming's particular manner of using Edison's two-electrode rectifier was not embraced in the defendant's differently arranged and differently operating three-electrode vacuum tubes (Findings LXV, LXVI, LXX, LXXI, LXXII, LXXIII, LXXV–LXXX; I R. 62–74). The court below then found as an ultimate fact (I R. 117) that Fleming's claims in suit—claims 1 and 37—were not

* The court committed inconsequential error in impliedly limiting the prior art to use of the two-element rectifier with low frequencies. The prior art was not so limited, as we shall show (*infra*, p. 121 *et seq.*).

infringed by defendant's devices and entered judgment accordingly (I R. 75, 182).

The court below made no ultimate finding on the issue of validity, because as is not unusual it decided to rest its decision on the ground of non-infringement. However, for either ground, the prior art is an essential frame of reference. On the issue of infringement, it is used to determine distinguishing features of the plaintiff's patent in order to establish the criteria by which to gauge the alleged infringing use; on the issue of invalidity, the prior art is itself the test of whether the alleged invention was a patentable invention. In either case, therefore, evidentiary findings regarding the prior art and a comparison between it and plaintiff's alleged improvement are necessary; and such findings were made by the court below, together with findings as to the structure and operation of the devices. From these findings, the court below concluded there was no infringement, and we submit that this conclusion was clearly correct. But we further urge that, even were that holding improper, the same evidentiary findings would require an ultimate finding of invalidity, in that the device disclosed by Fleming, and its uses, were fully known to the art before Fleming's earliest date. Moreover, we shall show that apart from want of invention, Fleming's patent was void because of unreasonable delay in disclaiming, as the court below held

in its opinion, and for the additional reason that the subject matter of the disclaimer was improper. All these grounds were urged below by defendant, and although the judgment for defendant in respect of the Fleming patent was placed primarily upon absence of infringement, we reassert them as alternative and additional grounds for sustaining the judgment below.[*] *Stelos Co.* v. *Hosiery Motor-Mend Corp.*, 295 U. S. 237.

Point III

The Fleming patent is invalid

1. *Disclosure of the Fleming Patent; Claims 1 and 37*

Patent No. 803,684, entitled "Instrument for Converting Alternating Electric Currents into Continuous Currents", was applied for on April 15, 1905 and granted on November 7, 1905 to plaintiff as assignee of Professor J. A. Fleming (Finding IV; I R. 8). Its specifications stated:

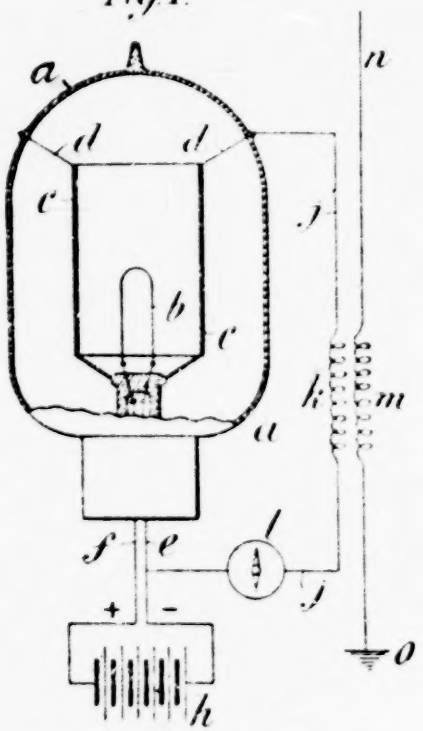
> This invention relates to certain new and useful devices for converting alternating electric currents, and especially high frequency alternating electric cur-

[*] Review of the art prior to Fleming is a necessary preliminary to a discussion of either infringement or validity. The latter issue, however, requires only a comparison between the prior art and Fleming's disclosures, while the issue of noninfringement calls for treatment of the alleged infringing structures as well. For convenience, we shall present our argument on invalidity after a review of the prior art, and follow with the discussion of noninfringement.

rents or electric oscillations, into continuous electric currents for the purpose of making them detectable by and measurable with ordinary direct-current instruments, such as a "mirror-galvanometer" of the usual type or any ordinary direct-current ammeter (Ex. 22; IV R. 2600, lines 11 *et seq.*).

Figure 1 of the patent illustrated the following apparatus to carry out the alleged invention (IV R. 2599):

Fig. 1.



Alternating current impulses are received through an antenna circuit *n o*. A transformer

m k couples the antenna circuit to a secondary circuit *c d j k j l c b*. In the latter circuit the element *b* is a carbon filament like that of an incandescent lamp (IV R. 2600, lines 85–86) and *c* is "a cylinder of aluminum open at the top and bottom, which surrounds but does not touch the filament" (*id.*, lines 87–90). The cylinder and the filament are enclosed in an evacuated vessel such as an ordinary lamp bulb *a*. The secondary coil *k* of the coupling transformer conducts the received alternating current to the cylinder *c* and the filament *b*. The indicating instrument or galvanometer *l* responds to the flow of current in this circuit.

The specification explained the operation of this device (IV R. 2601):

> The arrangement described above operates as an electric valve and permits negative electricity to flow from the hot carbon *b* to the metal cylinder *c*, but not in the reverse direction, so that the alternations induced in the coil *k* by the Hertzian waves received by the aerial wire *n* are rectified or transformed into a more or less continuous current capable of actuating the galvanometer *l* by which the signals can be read * * * (lines 18–27).
>
> * * * the aerial wire *n* may be replaced by any circuit in which there is an alternating electromotive force, whether of low frequency or of high frequency * * * (lines 30–34).

> Hence the device may be used for rectifying either high-frequency or low-frequency alternating currents of electrical oscillations * * * (lines 97–101).[20]

Only claims 1 and 37 of the patent are in suit, and read as follows (italicized letters refer to Figure 1):

> 1. The combination of a vacuous vessel (*a*), two conductors adjacent to but not touching each other in the vessel, (*b* and *c*), means for heating one of the conductors (*e*, *g*, battery *h*), and a circuit (*j*) outside the vessel connecting the two conductors. (IV R. 2601, line 125.)
>
> 37. At a receiving-station in a system of wireless telegraphy employing electrical oscillations of high frequency a detector comprising a vacuous vessel (*a*), two conductors adjacent to but not touching each other in the vessel (*b* and *c*), means for heating one of the conductors (*e*, *g*, battery *h*), a circuit (*j*) outside of the vessel connecting the two conductors, means for detecting a continuous current in the circuit (indicator *l*), and means for impressing upon the circuit the received oscillations (*e*, *g*, transformer coil *k*). (IV R. 2604, line 125).

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[20] In Figure 2 of his patent, Fleming showed two of the vacuum tube rectifiers in reversed position so that current will flow through either one or the other of the valves during each half cycle of the alternation of current to provide two usable pul-sating direct currents. This arrangement is not involved in the present suit, nor is the arrangement of three tubes in parallel, shown in Figure 3 of Fleming.

Both claims were thus identical in their structural elements: a vacuum tube containing two adjacent but noncontiguous elements or electrodes, connected by a circuit outside the tube, one element being heated. The claims differed only in that claim 37 included "means for detecting" the continuous or direct current in the circuit between the two elements (the indicator *l*) and "means for impressing upon the circuit the received oscillations" (transfo mer coil *k*). In the patent as originally issued, another difference had existed: claim 37 had specified that the tube was to be used "in a system of wireless telegraphy employing oscillations of high frequency" whereas claim 1 was applicable to any use of the claimed device, including use with low frequency. This distinction was, however, eliminated by disclaimer filed November 17, 1915, restricting the combination of the elements of claim 1 to use "in connection with high frequency alternating electric currents or electric oscillations of the order employed in Hertzian wave transmission" (Ex. 22; IV R. 2505).[5] The result of the disclaimer was to limit both claims to use of the device for rectifying high frequency alternating waves or currents.

2. *The Art Prior to Fleming*

November 16, 1904, is conceded by plaintiff to be Fleming's earliest invention date for the patent

[5] The specification was correspondingly amended by disclaiming all references to low frequency alternating currents (IV R. 2605).

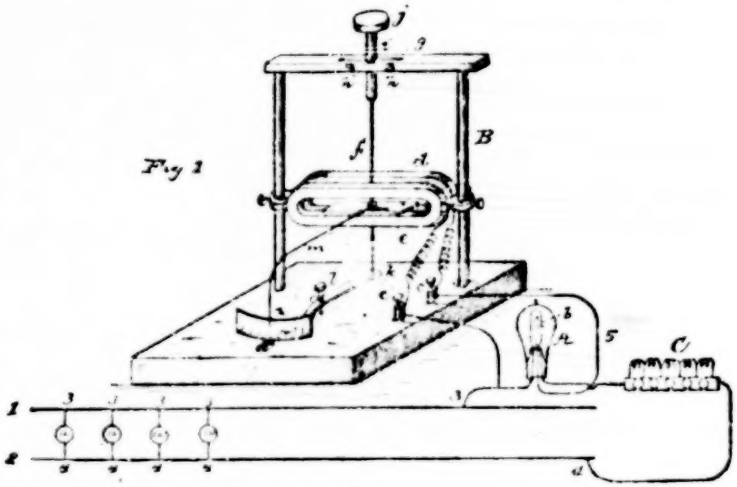
in suit (Finding LXVI, I R. 63). The art prior to that date begins with an invention of Thomas Alva Edison.

(a) The Edison Tube

Prior to 1884, the incandescent electric lamp as developed by Edison consisted of a vacuous glass tube or globe, containing a thin wire loop or filament, one end of which connected outside the globe to a resistance coil and thence to a generator, the other end being grounded outside the globe. The course of current through the filament in the partial vacuum caused it to become heated to incandescence. On October 21, 1884, Edison was granted United States patent No. 307,031, which announced:

> "I have discovered that if a conducting substance is interposed anywhere in the vacuous space within the globe of an incandescent electric lamp, and said conducting substance is connected outside of the lamp with one terminal, preferably the positive one, of the incandescent conductor, a portion of the current will, when the lamp is in operation, pass through the shunt-circuit thus formed, which shunt includes a portion of the vacuous space within the lamp. This current I have found to be proportional to the degree of incandescence of the conducter or candle power of the lamp. (Ex. J, IV R. 3297, lines 16–20).

Figure 1 of his patent showed this structure:



In this diagram, the filament circuit is wire *1*, *3* through filament *b*, resistance coils *C*, and wire *4* to the generator *2*. The "conducting substance" which is interposed "in the vacuous space within the globe" is the plate or electrode (unlettered) within the filament loop but not touching it, consisting of "a piece of platinum" (IV R. 3297, line 91). The "shunt-circuit" is from the plate electrode thence by wire *5* to contact *c* and coils *d* and *e* of a galvanometer *B*, then from the coil *e* of the galvanometer to contact *c'* and wire back to the filament circuit at *3*.

The description in the patent disclosed that (i) the vacuous space within the globe is a conductor of current between the plate electrode and the filamentary electrode, (ii) the strength of the current in the filament to plate circuit through the

vacuum within the globe depends upon the *temperature* of the filament, and (iii) the plate electrode is preferably connected to the *positive* side of the current supply. The claims of the patent are directed to the combination of the filament, plate and interconnecting circuit, including the galvanometer or indicating instrument. Claim 5, for example, is as follows:

> The combination, with an incandescent electric lamp, of a circuit having one terminal in the vacuous space within the globe of said lamp, and the other connected with one side of the lamp-circuit, and electrically controlled or operated apparatus in said circuit, substantially as set forth.

Structurally, the Fleming tube and its circuit as defined in the claims in suit are identical with those disclosed by Edison. Both have a vacuum globe containing two non-contiguous conductive elements, one susceptible of being heated, the other connected with the first by an outside circuit. Moreover, Fleming's claim 1 is patterned after the cited Edison claim 5, and structurally reads directly on the Edison disclosure.[1] Consequently the court below correctly held that these features of the Fleming patent cannot be treated as his discovery (Finding LXXII; I R. 67), and the plaintiff does not seriously dispute this.

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[1] See p. 108, *supra*.

(b) The Edison Tube as a Rectifier of Alternating Current

Edison disclosed that his two-electrode tube operated to pass current across the vacuous space within the tube between plate and filament. Fleming described the use of a substantially similar device to rectify alternating currents of Hertzian-wave frequency. But there was no novelty in such use, for it had been disclosed not only by others but by Fleming himself, years before the invention date of the patent here involved.

On January 9, 1890, more than ten years before he filed his application for that patent, Fleming acknowledged in a paper read before the Royal Society of London:

> It has been known for some time that if a platinum plate or wire is sealed through the glass bulb of an ordinary carbon filament incandescent lamp, this metallic plate being quite out of contact with the carbon conductor, a sensitive galvanometer connected between this insulated metal plate enclosed in the vacuum and the external *positive* electrode of the lamp indicates a current of some milliamperes passing through it when the lamp is set in action but the same instrument when connected between the *negative* electrode of the lamp and the insulated metal plate indicates no sensible current. This phenomenon in carbon incandescence lamps was first observed by Mr. Edison, in 1884, and further ex-

amined by Mr. W. H. Preece, in 1885. (Ex. I-1, IV R. 3413, 3414).

This 1890 paper further pointed out that the vacuous space is "unilateral" in its conductivity, that is, it permits current to flow from the hot carbon filament to the cooler metal plate "but not in the reverse direction" (IV R. 3415, 3417), and noted the ability of the tube to act as a rectifier of alternating current:

> When the lamp is actuated by an *alternating* current a *continuous* current is found flowing through a galvanometer, connected between the insulated plate and *either* terminal of the lamp. The direction of current through the galvanometer is such as to show that negative electricity is flowing from the plate through the galvanometer to the lamp terminal (IV R. 3416).

The then popular conception was that electricity flowed from the positive pole to the negative pole, but Edison's discovery made it necessary to revise this conception, and to accept the phenomenon of electricity's passing from negative pole to positive pole. Fleming's 1890 paper noted that it is *negative* electricity which is flowing from negative pole to positive pole, but emphasized that even this had been part of general *scientific* knowledge, as follows:

> The effect of heating the negative electrode in facilitating discharge through

vacuous spaces had previously been described by W. Hittorf ("Annalen der Physik und Chemie," Vol. 21, 1884, p. 90–139), and it is abundantly confirmed by the above experiments. We may say that a vacuous space bounded by two electrodes—one incandescent, and the other cold—possesses a unilateral conductivity for electric discharge when these electrodes are within a distance of the mean free path of projection of the molecules which the impressed electro-motive force can detach and send off from the hot negative electrode.

This unilateral conductivity of vacuous spaces having unequally heated electrodes has been examined by MM. Elster and Geitel (see "Wiedemann's Annalen," Vol. 38, 1889, Vol. 24, 1885, p. 83), who in experiments of various kinds have demonstrated that when an electric discharge across a vacuous space takes place from a carbon conductor to another electrode, the discharge takes place at lower electromotive force when the carbon conductor is the negative electrode and is rendered incandescent (IV R. 3421–3423).[5]

[5] Other papers on the same subject published by Fleming years prior to November 1904, expounded and elaborated upon this phenomenon. Proceedings of Royal Institution of Great Britain, February 14, 1896 (Ex. J–1, IV R. 3425); London Electrician, February 21 and 28, 1896 (Ex. K–1, IV R. 3443; Ex. L–1, V R. 3447; Physical Society of London, March 27, 1896 (Ex. N–1, V R. 3466).

Fleming's reference in his 1890 papers to the unilateral conductivity of the vacuous space between filament and electrode, and the consequent ability of the tube to derive a continuous current from an alternating current, recognized the Edison tube to be a rectifier of alternating current in general terms; and this knowledge entered the public domain by publication.[*]

Rectification was the result of unilateral conductivity for the following reason: If to the tube with its external circuit from filament to plate, there be delivered an alternating current, the unilateral conductivity of the internal space between filament and plate would allow the flow of current between them only during those parts of the alternating current cycles when the alternating current is of such direction that the plate is rendered positive relative to the body of the filament. Thus the alternating current applied to the tube flows in the plate to filament circuit of the tube only as a pulsating continuous or direct current made up of alternate half cycles of the alternating current having a common direction of flow. Thus, the function known as rectification of the alternating current is performed.

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[*] It is fundamental in patent law that an inventor's own prior publication made more than two years (now one year) before his application for a patent is a bar to any claims of the patent applicable to the published disclosure. Rev. Stat. §§ 4886, 4920; 35 U. S. C. § 31, 69. *Wianer* v. *Meccano, Ltd.*, 246 Fed. 663 (C. C. A. 6); *Mailhahn* v. *R. C. A. Victor Co.*, 89 F. (2) 317 (C. C. A. 4).

This mode of operation was a matter of general knowledge before the earliest date for Fleming's patent. It was specifically explained in a paper delivered by Fleming in 1896 (Ex. N–1, Experiment No. 27, V R. 3466, 3511). On February 17, 1897, at a meeting of the American Institute of Electrical Engineers in New York, Dr. Clark Howell described and illustrated the "Edison effect" in detail and mentioned that when the Edison tube was actuated by alternating current, unidirectional current resulted (Ex. M–1, V R. 3459, 3462); and in discussing Dr. Howell's paper, Dr. Kennelly specifically drew attention to this fact (V R. 3465).

In 1903, the deValbreuze patent, as we shall show, employed the two-electrode tube as a rectifier of alternating current (of Hertzian frequencies). And in October 1904, before the earliest date attributable to Fleming's patent, Wehnelt also disclosed the specific arrangement employed by Fleming, in which a source of alternating current was connected between the hot filament and cold electrode of a vacuum tube and was rectified by the unidirectional conductivity of the tube (Ex. O–1, P–1, V R. 3515). Indeed, Wehnelt improved the sensitivity of the Edison tube by substituting a better filament, capable of emitting a greatly increased flow of electrons.

Edison and Fleming employed carbon filaments in their vacuum tubes and heated the filament by

passing current through it. Since carbon is a poor electron emitter, and since the value of the current flowing between plate and filament depends upon a large electron flow from the filament, the current passing through the vacuous space in these tubes was not large, i. e., the sensitivity of the tube was small. The improvement in this respect, developed by Dr. Wehnelt and published in his paper of October 1904, consisted of a metal-oxide coating of the filament in Edison's two-electrode tube. Such oxide coating, when heated by the filament, emitted an enormously increased supply of electrons, greatly increasing the conductivity of the vacuous space.[24] In his article Wehnelt illustrated the application of the oxide-coated filament to a two-electrode tube and the use of the tube as a rectifier of alternating currents (Ex. O–1, translated in Ex. P–1; V R. 3515–3518). After describing the unidirectional conductivity of the tube in terms of the voltages necessary to force current through it between plate and filament, Wehnelt's article described the exact manner of connecting and rectifying the alternating current employed by Fleming (V R. 3516–3517), as follows:

Emission of Negative Ions by Incandescing Metallic Oxid. A glass tube *K* (Fig.

[24] Wehnelt's paper in the *Annalen der Physik* set forth in great detail the results of numerous tests on filaments coated with oxides of the alkaline earth metals barium, calcium, and strontium, and showed the enormously increased emission obtained therefrom (Ex. Q–1, translated in Ex. R–1; referred to in Ex. P–1, V R. 3515).

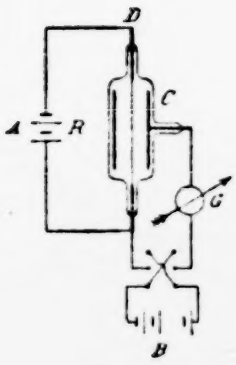

Fig. 1.

1), exhausted to a moderate extent, contains a brass cylinder C in the axis of which there is situated a thin platinum wire D covered with CaO. The wire can be heated to high temperatures by the current of two accumulators A. If I connect the wire D with the one pole, the cylinder C through a galvanometer G with the other pole, of a source of current B, then there only flows a current through the tube if D is connected with the negative pole of B. The experiment shows consequently that only negative ions are emitted from the incandescing oxid. * * *

Application of Discharge Tubes with Glowing Metal Oxid Cathodes in Practice. If in an exhausted discharge tube R (Fig. 4)[2] we push one or several metallic electrodes A close to the glowing metallic oxid electrode K (platinum sheet P covered with

[2] The cathode K is assumed to be turned 90° as regards the plane of the picture.

Fig. 4.

the CaO) then the discharge potential, if *A* is anode and *K* is cathode, amounts to only about twenty volts. If we reverse the direction of currents so that now *A* is cathode and *K* is anode, the discharge potential now amounts to some thousands of volts, since under deep pressures the cathode drop on metals takes on exceedingly high values. *If, therefore, we connect the electrodes A and K with an alternating source of current, the potential of which lies below the value which the cathode drop on the metallic electrode A has, then the tube acts as an ELECTRIC VALVE, in that it allows to pass through only one phase of the alternating current. The tube (Fig. 4) can consequently serve for the purpose of transforming alternating current into pulsating direct current.* [Italics supplied.]

It was therefore well known prior to Fleming, as was correctly held by the court below (Findings LXXI and LXXII; I R. 66–67), that the two-electrode vacuum tube shown by Edison

operated as a rectifier to receive alternating current and transform it into direct current.

(c) The Two-Electrode Vacuum Tube as a Wireless Detector

The knowledge in the prior art concerning the use of the uni-directional two-electrode tube to rectify alternating currents was not restricted to the rectification of low frequency current. Not only was its applicability to high frequency alternating currents a natural corollary of the tube's mode of operation with which the art was familiar; but its actual use to rectify high frequency currents for wireless detection[58] had been fully disclosed in the art antedating Fleming's patent.

To one skilled in the art, it was implicit in the earlier teachings concerning the Edison effect that the two-electrode tube would serve as a rectifying device of waves of wireless frequencies.

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[58] Many forms of detectors were known for detecting (or recognizing) that a signal has been received in a system of wireless telegraphy (see 1894 publication of Lodge, V R. 3876-3877). When the incoming signal energy was employed merely to "trigger" (i. e., close) a local battery circuit, as with the coherer (described at pp. 40-41, *supra*), the signal current could be employed without change, since the local battery supplied the pulsations of direct current for operating the indicator. When it was desired, however, to use the incoming signal current itself to actuate the indicator, the alternating current of the signal had to be rectified, i. e., converted into pulsations of direct current to which the indicator would respond, as was disclosed by de Valbreuze in 1903, for example (Ex. A-2, translated in Ex. B-2, V R. 3540-3547; Finding LXX, I R. 65-66).

None of the detailed treatises by Fleming, Howell, Kennelly and Wehnelt, discussing the rectifying action of the two-electrode tube, made any suggestion that this phenomena was dependent in any manner on the frequency of the alternating current. On the contrary, all treated it as applicable regardless of frequency (Ex. I–1, IV R. 3413; Ex. M–1; V R. 3459; Ex. P–1, V R. 3515). Indeed the work of J. J. Thompson, O. W. Richardson, and others in the years immediately prior to 1904, had identified the theory and operation of the Edison effect with the now familiar electron theory,[28] and had thus made obvious the potentialities of the two-electrode rectifier in the high-frequency field.[29] As the court below properly found, Thompson's and Richardson's experiments established that the incandescent filament of the Edison tube served to emit electrons, that the mass of these electrons was only 1 2000 of that of a hydrogen atom, and that their speed was so enormously high that the electron discharge device of Edison would operate practically without inertia.[30]

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[28] XLVI Philosophical Magazine (1898), 328 (Ex. S–1); XLVIII *Ibid.* (1899), 547 (Ex. T–1); V *Ibid.* (1903), 354, 429 (Ex. U–1, Z–1); IX Proceedings Cambridge Philosophical Society (1897), 244, 333 (Ex. X–1, Y–1); XI *Ibid.* (1901), 286 (Ex. V–1); XI Philosophical Transactions Royal Society (1903), 497 (Ex. W–1), I R. 680, 681.

[29] This is well explained by Miller, I R. 671.

[30] Because the electron is of infinitesimal weight, it requires only an infinitesimal interval of time to start and stop its flow, and the oscillatory period of even the highest frequency wireless wave is so extremely long, by comparison,

Consequently, it was to be expected that Edison's device would operate under both high and low frequencies in exactly the same way to pass the current in one direction between the filament and plate of the tube. As stated by the expert witness, Dr. Miller, in view of this knowledge in 1903 "any scientist at that date would have known it would so operate from his reading of the literature of the art. Indeed, he would have no reason to think otherwise" (I R. 678–684, at 682). That none in fact thought otherwise is clearly shown by the circumstances that despite exhaustive study of the phenomenon, no one suggested that the frequency would make any difference in the rectifying action of the device.[20]

But apart from these indications of the inherent efficacy of the Edison device as a rectifier of high frequency oscillations, which to the learned were unmistakable, there was specific disclosure by de Valbreuze of the application to wireless of the two-electrode vacuum tube. In his French patent No. 328,527 issued in 1903 (Ex. A–2, V R. 3540, translated in Ex. B–2, V R. 3547), de Valbreuze disclosed that the electronic vacuum tube would operate as a rectifier-detector of radio fre-

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that the electron flow will respond at once to such a wave and will even be regulated by minute fractions of a single high frequency cycle.

[20] Plaintiff itself, in demonstrating the Fleming device in the case of *Marconi Wireless Telegraph Company of America* v. *De Forest Radio Telegraph & Telephone Co.* 243 Fed. 551 (C. C. A. 2), used low frequency current (I R. 682).

quency currents, and he showed its use in the same circuit arrangement used by Wehnelt and by Fleming. The court below so found (Finding LXX, I R. 65–66), and the correctness of this finding is conceded by plaintiff (Pl. Brief, pp. 64–65). The text of the de Valbrueze patent read in part as follows:

> As receiver there is employed an apparatus which allows of re-transforming the alternating current into a continuous current, actuating a relay. For that recourse is had to apparatus called electric valves, placed as described hereinafter, and diagrammatically represented by Fig. 2. (V R. 3550).[*]

Claim 2 of the de Valbreuze patent repeaaed that his device would transform high frequency currents:

> The use of a device called an electric valve formed by a vacuum tube, or of several similar valves combined together, in order to transform into currents always in the same direction, the alternating currents of very rapid frequency transmitted to the receiving apparatus (V R. 3550).

And Figure 2 of the de Valbreuze patent showed two vacuum tubes K' and K'' in reversed position,

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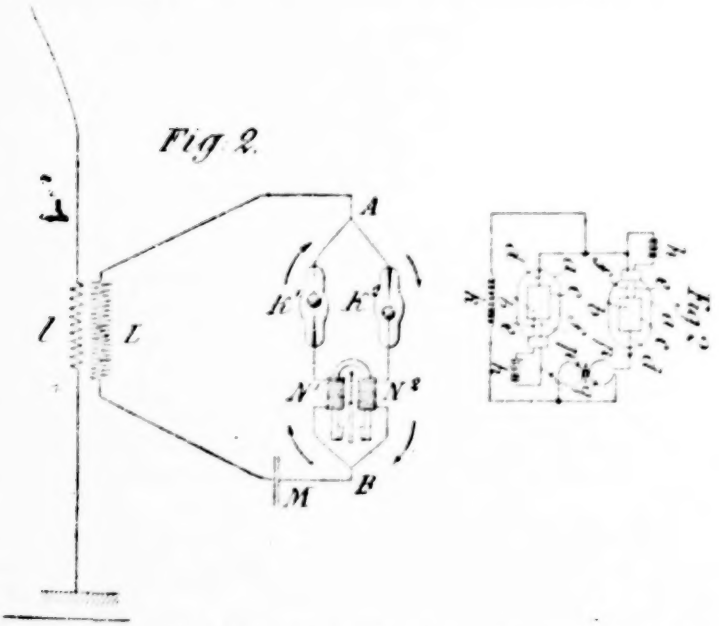
[*] Wehnelt also called his two-element tube an "electric valve" (see p. 129, *supra*), and so did Fleming in his specification (IV R. 2601, line 19, p. 107, *supra*). That is now a commonly used term to designate the two-element vacuum tube rectifier of the Edison-Wehnelt-de Valbreuze-Fleming type.

so that current would flow through one or the other of the valves during each half-cycle of the alternation of current.[62] The two half-wave rectifiers so connected operated as a full-wave rectifier, corresponding exactly to the two half-wave rectifiers shown by Fleming in Figure 2 of his patent. The identity of arrangement and operation is obvious from the following reproductions of Figure 2 of de Valbreuse and Figure 2 of the Fleming patent (the latter turned on its side to correspond with the orientation of the former):

de Valbreuse Patent *Fleming Patent*



[62] This was also known to Wehnelt. In his 1904 publication he stated: "By using the well known Graetz system of connection, both phases of the alternating current can be utilized" (Ex. O-1, translated in Ex. D 1; V R. 3518).

Thus prior to November 1904—Fleming's earliest date—it was well known that the rectifier vacuum tube called an electric valve would be suitable for use as a radio detector of high frequency waves, and it had been so applied by de Valbreuze.

The unidirectional operation of the vacuum tube of de Valbreuze, like that of Edison and Fleming, depends upon heating the cathode or filamentary element to cause the current of electrons to flow from it to the anode or plate. The cathode in the de Valbreuze tube, being a fine point, has a greater potential and current density per cm than the large surface of his anode. Hence, in an alternating current circuit, it heats more and liberates more electrons than does the anode, and therefore exhibits the unilateral conductivity which makes it a rectifier. The only difference between the de Valbreuze vacuum tube and that of Edison and Fleming is that in the de Valbreuze tube the cathode was heated partly by electric current and partly by bombardment by the ions derived from the residual gas in the tube, whereas in the Edison and Fleming tube the cathode was heated practically entirely by current. But this involved no inventive difference. It was well understood by the art as early as 1896 that the heating of the cathode to cause unidirectional current flow could be accomplished in several ways. Fleming himself suggested that the cath-

ode of a two-electrode tube be heated by concentrating on it the rays of a lamp, which Professor Thompson characterized as equivalent to heating it electrically (Ex. N-1, V R. 3514),[93] Edison had already taught the art that the sensitiveness of the rectifier—i. e., the strength of the rectified current—would be increased if the temperature of the cathode were increased (see pp. 110–112, *supra*),[94] and Fleming, in his patented device, utilized the identical mode shown by Edison—the local battery circuit—to heat the cathode. This was not claimed, and obviously could not have been claimed, as the element of novelty in Fleming's patent.

3. *Fleming's alleged invention was not entitled to patent in view of the prior art*

In view of the state of the art at the time of Fleming's alleged invention (November 16, 1904), it is clear that plaintiff cannot assert a patentable right to any of the basic elements of Fleming's disclosed structure. Comparison between the essential features of the Fleming patent and the most pertinent prior art, as presented in

[93] In addition to the modes of heating referred to, Wehnelt had used a speck of calcium oxide as his cathode and heated it by contact with an electrically heated member (Ex. O 1, translated in Ex. P 1, V R. 3515), and this is the mode employed in heating the cathode in practically all of the "heater type" or "unipotential-cathode" tubes so widely used today.

[94] Fleming's 1890 papers acknowledged that Hittorf had also recognized this fact (see p. 115, *supra*).

TABLE 2

tabular form in the accompanying Table 2, will disclose the virtual identity between Fleming's device and the prior art devices, in structure, operation, and result. Such comparison will similarly establish that claims 1 and 37 of the Fleming patent, even after the disclaimer, did not comply with the requirement of the patent laws that they specifically point out the particular contribution, if any, which the patentee made; and since these claims assert a right to more than Fleming was entitled to claim, they were invalid.[3]

It is apparent, therefore, that at the time of Fleming's alleged invention, the art was already conversant with the two-electrode vacuum tube of which the cathode electrode—the electron emitter—was heated in various ways to increase its emission of electrons. It was also known at that time that such a tube would have unilateral conductivity in the vacuous space between the electrodes, making it a rectifier of alternating current; that the tube would operate at high as well as at low frequencies; and that the two-electrode vacuum tube rectifier was useful as a detector in wireless apparatus. Fleming's use of the unidirectional conductivity of the Edison two-element tube to rectify incoming alternating current was consequently nothing more than the noninventive application of prior disclosures. And his use of

[3] Cf. *General Electric Co.* v. *Wabash Appliance Corp.*, 304 U. S. 364, 372.

the current thus rectified to operate an indicator in the same circuit was precisely what Edison and Wehnelt had done earlier.

Plaintiff purports to distinguish Fleming's alleged invention from the Edison-Wehnelt rectifier arrangement on the ground that Fleming showed a use of his device with currents alternating at frequencies of the order of Hertzian waves. The vagueness and uncertainty of this differentiation was enough to condemn it;[65a] but in any event, such use is entirely without novelty, for the usefulness of the tube to rectify Hertzian waves was easily discernable and indeed squarely disclosed in the art. The two-electrode tube of Edison and Wehnelt was known to be a rectifier of alternating currents without regard to frequency, and by its very electronic character was capable of rectifying the entire range of alternating current frequencies, from the upper limit of Hertzian waves to frequencies corresponding to an occasional reversal of a battery current input. The use of a rectifier to detect wireless waves was old in the art, and deValbreuze had disclosed use of a two-electrode tube for this purpose. That the battery heated tube was a more sensitive rectifier than that of deValbreuze is without moment, for the Edison

[65a] The Hertzian waves, as pointed out by Lodge (see pp. 36-37, *supra*), range from 186 cycles to 900,000,000 cycles; while audible frequencies range from 50 cycles to about 15,000 cycles. There is no dividing line between these frequencies, nor is either range sharply defined.

patent, Fleming in his 1890 papers, and many others had recognized that the sensitiveness of the two-electrode vacuum tube rectifier was improved by increasing the temperature of the cathode to full incandescence. And while the battery heated filamentary cathode of the Edison tube used by Fleming may have been a better electron emitter than deVallbreuze's fine-point cathode heated by the Hertzian waves,* such battery heating of the filament to increase its emission was known prior to Fleming. Consequently, none of these features can be claimed as the novelty in Fleming's device, as the court below properly found (Finding LXXII; I R. 67).

Even if Fleming's claims in suit (p. 108, *supra*) were limited to battery-heating of the filament, instead of purporting to cover all means for heating it, at best he either (1) used the well-known alternating current rectifier shown by Edison or Wehnelt to rectify high-frequency alternating

* Fleming himself, in his patent, acknowledged that when strong Hertzian waves are received, their alternating current will itself be sufficient to heat the filament to incandescence. Since it is this same current which flows through and heats the fine point of the deVallbreuze tube—which will be further heated by ionic bombardment—this filamentary point of deVallbreuze will be heated at least as much as Fleming's filament under the same conditions. Fleming's claims in suit are not limited to battery heating of the filament but cover as well the acknowledged alternative in which the current of the received signal heats the filament; hence, these claims cover and are directly anticipated by the deVallbreuze arrangement alone.

currents in circumstances not specifically shown by them, as found by the court below (Finding LXXIII, I R. 68), or (2) substituted the more sensitive rectifier of Edison or Wehnelt for the analogous rectifier of deValbreuze, who had already informed the art that such a device was desirable for the rectification of wireless waves. Whichever Fleming did, he produced no result which was not obvious (III R. 2139). Even if deValbreuze's disclosures could be disregarded, Fleming's contribution would amount to no more than a new use of an old device, as the court below found (Finding LXXIII; I R. 68), and since no new or unexpected operation was imparted to the Edison tube by using it to rectify high-frequency instead of low-frequency currents, the "new use" cannot support a patent monopoly.[1] Fleming's structure may also be characterized as the result of varying the degree or extent of operation of a disclosed process or device, which this Court has held does not attain the dignity of invention.[2] It was in fact to be expected from "observations of common experience" that once the feasibility was established of using the two-

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[1] *Smith v. Nichols*, 21 Wall. 112; *Pennsylvania R. R. Co. v. International etc. Co.*, 110 U. S. 490, 498; *Electric Cable Joint Co. v. Brooklyn Edison Co.*, 292 U. S. 69; *Cuno Engineering Corp. v. Automatic Devices Corp.*, 314 U. S. 84.

[2] *Thompson-Starrett Co. v. Otis Co.*, 271 U. S. 80; *Wells Co. v. Ford Motor Co.*, 263 U. S. 445, 451; *DeForest Radio Co. v. General Electric Co.*, 283 U. S. 664.

electrode tube to rectify alternating current, those familiar with the field "would seek to make use of known methods and appliances" to rectify wireless waves. (*cf. Concrete Appliances Co.* v. *Gomery*, 269 U. S. 177, 184); and once the rectifying properties of the two-element tube became known it was not long before the art sought to make use of the tube for alternating currents, such as wireless oscillations, as for example the two-electrode vacuum-tube rectifier which deValbreuze employed as a wireless detector in his patent.

Even the criterion utilized in cases of doubtful validity—the commercial success of the alleged invention—is not met by Fleming's device. The announcement of the Edison two-electrode tube excited world-wide interest, and scientists everywhere investigated it thoroughly (see pp. 113–122, *supra*), while the disclosure by Fleming of its use with high-frequency current evoked little comment. Measured by results and enduring use, comparison likewise favors Edison. The Fleming use was a fugitive one; a few were used experimentally in receiving stations, and later a number were sent to various Marconi receiving stations. But wherever they were installed, the sets were provided with crystal rectifier-detectors for alternate use (Finding LXVII, I R. 63), and within a year or two substantially all of the stations had discarded the Fleming tubes and were using crystals ex-

clusively (II R. 1374)." By contrast, the Edison tube-Wehnelt circuit is in large use today. Nearly every household A. C. radio set contains an Edison-Wehnelt rectifier operating to transform the low-frequency house lighting alternating current into direct current to operate or energize the tubes used for high-frequency uses."

In summary, the evidentiary findings of the court below concerning the disclosures in the prior art of the entire substance of the Fleming

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" To argue that the deVallereuze diode was not sufficiently sensitive as a detector does not distinguish it from Fleming's disclosure, for his device was also insensitive. Even with the powerful Marconi interests behind it, the Fleming valve made no lasting impression on the art. It simply echoed deVallereuze's teaching that a rectifier was a desirable detector. The Fleming rectifier, like that of deVallereuze, passed from the scene in the face of the better rectifier-detector, the crystal. And all of them finally made way for the DeForest three electrode tube which, as a detector, substituted modulation amplifying relay action for rectification. The function of rectification in nearly every modern radio set is limited to conversion of the house lighting alternating current into direct current to operate the tubes; and this is performed by an Edison Wehnelt rectifier.

" As will be shown hereinafter (pp. 169-173), the decision in *Marconi Wireless Telegraph Co. of America* v. *DeForest Radio Telephone & Telegraph Co.*, 236 Fed. 942 (S. D. N. Y.), affirmed, 245 Fed. 551 (C. C. A. 2), is not entitled to any weight in the present case. Although holding that the Fleming patent here involved was valid and was infringed by DeForest's three-electrode tubes, for collateral reasons both parties had agreed in the district court and the circuit court of appeals that the two electrode and the three electrode device were essentially alike, thus eliminating any controversy on the point crucial to this case.

device are adequately sustained by the evidence, and would have justified an ultimate finding of invalidity for lack of invention. This Court may itself make such a finding as a basis for affirming the judgment below. Cf. *Stelos Co.* v. *Hosiery Motor Mend Co.*, 295 U. S. 237.

4. *The patent is invalid because of improper disclaimer*

There is no doubt that the Fleming patent, as issued on November 7, 1905, was partially invalid at least, for, as the court below correctly found (Finding LXXI, I R. 66-67), claim 1 of the patent, before the 1915 disclaimer, applied word for word to the earlier Edison patent and also read upon the arrangements disclosed in the 1890 and 1897 publications. Under settled law, such partial invalidity would defeat the entire patent unless the invalid portion were properly and seasonably disclaimed.[7] A disclaimer was filed in 1915, ten years after the patent issued, which the court below held constituted unreasonable delay invalidating both the disclaimer and the patent (I R. 106). This conclusion, which we believe was proper, is further sustainable upon the independent ground that the subject matter of the disclaimer was improper. Both grounds, which were urged by defendant in the court below, are

[7] Revised Statutes, §§ 4917, 4922; 35 U. S. C. §§ 65, 71; *Easton* v. *Simon, Ascher & Co.*, 282 U. S. 445, 452.

here advanced as additional grounds for affirmance of the judgment as to the Fleming patent. *Stelos v. Motor Metal Hosiery Corp.*, 295 U. S. 237.

(a) Unreasonable Delay in Disclaiming

For some ten years after its issuance, the Fleming patent was held out to the public as a monopoly covering its claimed features, including even Edison's device of a two-element electronic vacuum tube. Then on November 17, 1915, the plaintiff as assignee of Fleming filed a disclaimer in which it disclaimed the combinations of claim 1 and other claims—

> except as the same are used in connection with high frequency alternating electric currents or electric oscillations of the order employed in Hertzian wave transmission.[*]

The invalidity of the disclaimer was urged by the defendant before the court below, and although the court made no findings of fact on the issue, it held in its opinion that there had been unreasonable delay in disclaiming. The court referred to Fleming's original claim of the use of the two-electrode tube to rectify both low and high frequencies, and said (1 R. 106):

> In stating this feature in his patent specification as 'new and patentable, Fleming must have known that he was making a

[*] This disclaimer was filed at a time when plaintiff was about to sue a competitor (Pl. Brief, p. 70).

> claim that could not be sustained. There could have been no inadvertance in making this statement, and this matter alone would seem to be sufficient to render the Fleming patent invalid. True, he entered a disclaimer later, but the statutes which give relief where invention has been wrongfully claimed do so only on the condition that the inventor has not unreasonably neglected or delayed to enter the disclaimer. In the case at bar the disclaimer was not entered until eleven years after the patent had been taken out and long after other inventors had discovered other and different methods of making use of the Edison device without claiming to have invented it. We think that if ever there was a case of unreasonable delay in making the disclaimer it is presented in what is now before us and that the Fleming patent must be held invalid for that reason.

This holding is in full accord with both the record and the law. The record leaves no room for doubt that Fleming had full knowledge of Edison's work before he filed his patent application, for he had investigated it thoroughly (I R. 105–106). Yet he drew the specification for his patent to include Edison's vacuum tube whether used with current "of low frequency or of high frequency" (Ex. 22, IV R. 2601, lines 30–33) and stated that "the device may be used for rectifying either high frequency or low frequency

alternating currents of electrical oscillations" (*id.*, lines 97–102). His claim 1 was patterned closely upon Edison's claim 5, covering Edison's device without change (*cf. id.*, lines 125–129, with Ex. J., IV R. 3298, lines 50–54).

Since the record shows that Fleming's specification and claim 1 covered the Edison device and that Fleming had full knowledge of Edison's work, the court's conclusion that "there could have been no inadvertence" is well founded. *Cf. Euston* v. *Simon, Ascher & Co.*, 282 U. S. 445. At any rate, in view of the conceded delay of more than ten years in filing a disclaimer—covering a period in which the electronic tube was developed—the court's conclusion that there had been unreasonable neglect cannot be said to lack substantial evidence.[7] The unreasonableness of the delay in the circumstances of this case is emphasized by the fact, as found below, that the three-electrode tube had been fully developed and adopted by the United States before the disclaimer was filed (Finding LXXXI, I R. 74).

(b) The subject matter of the disclaimer is improper

The impropriety of the subject matter of the disclaimer constitutes an additional and inde-

[7] The absence of findings of fact on the matter of delay is not fatal, in view of the alternative ground (anticipation) relied upon below for the conclusion of invalidity, *cf. Stalos* v. *Motor-Metal Hosiery Corp.*, 295 U. S. 237.

pendent ground to sustain the conclusion below as to its invalidity. This was urged below, but not passed upon because of the court's conclusion that "the patent is void in any event for failure to make disclaimer within a reasonable time" (I R. 107).

A disclaimer intended to save a patent from invalidity because of erroneous or excessive claims, "is usually and properly employed" to surrender a separate claim "or some other distinct and separable matter, which can be excinded without mutilating or changing what is left standing." *Hailes* v. *Albany Stove Co.*, 123 U. S. 582, 587.[*] Since a disclaimer may not "change the character of the claimed invention" (*Milcor Steel Co.* v. *George A. Fuller Co.*, 316 U. S. 143 (1942)), and since every disclaimer "which does not surrender the whole claim, must add a new element" to it—which is not permissible—the surrender of a separable portion of the patent is an essential of a valid disclaimer. *Milcor Steel Co.* v. *George A.*

[*] The essence of a valid disclaimer lies in "disclaiming a part separated in the patent itself" (*Strause Gas Iron Co.* v. *Crane Co.*, 235 Fed. 126 (C. C. A. 2); *Corn Products Refining Co.* v. *Penick & Ford*, 63 F. (2) 26, 30 (C. C. A. 7)), or a part "distinguishable on the face of the specification" (*Grasselli Chemical Co.* v. *National Aniline Co.*, 26 F. (2) 305, 310 (C. C. A. 2)), as opposed to something comprehended in the "general language" of the patent. *Strause Gas Iron Co.* v. *Crane Co.*, supra; *Albany Steam Trap Co.* v. *Worthington*, 79 Fed. 966 (C. C. A. 2); *Simplex Ry. Appliance Co.* v. *Pressed Steel Car Co.*, 189 Fed. 70 (C. C. A. 2).

Fuller Co., 122 F. (2d) 292 (C. C. A. 2), affirmed 316 U. S. 143.

Tested by these rules, plaintiff's disclaimer under the Fleming patent was invalid because it added a new element thereto. The disclaimer made no change in the structure or mode of operation of the invention.[1] It sought only to change claim 1 to restrict the operation of the means already disclosed to high frequency current only instead of either high or low frequency current. The disclaimer thus added a new element, i. e., a source of high frequency alternating current, which before the disclaimer had expressly been treated as immaterial. The effect was the same as if the claim had been amended by adding a requirement not theretofore mentioned, such as "use of the disclosed structure in combination with a source of high-frequency current." This operated to "change the character of the claimed invention" and was therefore unauthorized by the disclaimer statute. *Milcor Steel Co.* v. *George A. Fuller Co.*, 316 U. S. 143.

It is submitted that upon the evidentiary findings below and upon the authorities here cited, an

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[1] Compare cases upholding disclaimers changing the structural features of an invention, for example *Carnegie Steel Co.* v. *Cambria Iron Co.*, 185 U. S. 403.

[2] Compare the attempted disclaimer of one chemical substance under a broad general claim covering a number of chemical substances, a form of disclaimer held void in *Grasselli Chemical Co.* v. *National Aniline Co.*, 26 F. (2) 105 (C. C. A. 2).

ultimate finding of invalidity of the disclaimer is clearly justified because of the impropriety of its subject matter. The ineffectiveness of the disclaimer for either this reason or because of unreasonable delay in filing invalidates the Fleming patent.

POINT IV

THE COURT BELOW PROPERLY HELD THE FLEMING PATENT NOT INFRINGED

The judgment below holding the Fleming patent not infringed applied to three types of three-electrode vacuum tubes which plaintiff charged as infringements: (1) the relay-detector, (2) the amplifier, and (3) the oscillator. After making detailed evidentiary findings as to the structure, mode of operation and result of Fleming's patented device and of the three-electrode tubes (triodes) used by the defendant, the court found as an ultimate fact that the triodes differed substantially from Fleming's tube in each of these essentials (Findings LXXV–LXXIX, I R. 69–73). We shall show that this conclusion is proper as to each type of triode used by defendant.

1. *The DeForest Three-Electrode Tube*

Prior to 1906, several vacuum tube devices were known to the art for use with wireless equipment. In the receiver, the Z under "Trigger Tube" was used (in which the received oscillations precipitated a discharge through the tube from an aux-

iliary battery) and the two-electrode tube of Edison-deVallbreuze-Fleming was employed as a rectifier (V R. 3876–3877). In the transmitter, the Hewitt gas-filled tube was used as a generator of continuous waves, as had been disclosed by de Valbreuze (Ex. A–2, Fig. 1, V R. 3544, 3549). The only amplifier which had been proposed in the art prior to 1906 was the "negative resistance" characteristic of the gas-filled Hewitt tube which produced amplification but was unsatisfactory (Ex. O, IV R. 3320; Ex. P, IV R. 3323). All these tubes were of the two-element or diode variety.[1] In 1906, Dr. Lee DeForest invented the three-electrode tube and obtained United States patent No. 879,532 therefor on February 18, 1908 (Ex. K, IV R. 3299), upon application filed January 29, 1907.

This tube and its circuits differ in structure from the prior devices in having a third electrode known as a grid (consisting of a mesh or widely-spaced turns of wire) interposed between but not touching the filamentary cathode and the plate or anode, the grid being connected to the filament outside the tube by a circuit entirely independent of the plate circuit, and the incoming alternating current being connected in this independent grid circuit. The plate circuit of the tube is connected

[1] Except possibly the Zehnder Trigger Tube (V R. 3876, 3877.

permanently to the positive end of a high voltage (direct current) battery known as a *B* battery, while the filament of the tube is connected permanently to the negative end of that battery. The filament is heated to incandescence by current from a local battery circuit (the *A* battery). By this arrangement the potential of the plate is always kept positive relative to that of the filament, as in the original Edison circuit, so that the stream of electrons emitted by the hot (negatively charged) filament will be greatly attracted by the positively charged plate. As a result the local direct current derived from the *B* battery passes continuously through the filament-to-plate circuit.

The incoming alternating current signal is received in the grid circuit, and changes the voltage on the grid, according to the strength and characteristic of the signal, making the grid alternately more positive and more negative than its initial condition. When the grid is negative, it tends to repel or impede the flow of electrons from the adjacent filament; when the grid is positive, it tends to increase and accelerate the flow, but being placed closer to the filament than is the plate, the grid exerts a more powerful effect on the flow of electrons than does the plate, so that a negative charge on the nearby grid can counter-

act or diminish the effect on the electrons near the filament of a much higher positive charge on the more distant plate. However, since the area of the openings between the wires of the grid is much greater than the area presented by the grid wires themselves, most of the electron stream from the filament, when not repelled by a negative charge on the grid, passes through the openings in the grid and thence to the positive plate. It was thus De Forest's discovery that a small change in potential on the grid would produce, by relay action, a disproportionately large change of the direct current in the plate circuit, and the direct current in the filament-to plate circuit, thus modified in proportion to the change of potential on the grid, would operate the indicator or detector in the plate circuit.

The ability of the relatively weak incoming signal potential on the grid to affect with proportionate variations the much more powerful current in the filament to plate circuit gives the tube its amplifying characteristic. The powerful *B* battery, which keeps the plate highly positively charged relative to the filament and can supply a large number of electrons to the filament to be emitted by it, provides a great deal of power for driving current through the plate circuit. As a

result the grid acts like a relay or throttle, whereby the small power input of the received oscillations controls the much greater power of the plate circuit. Since the output power in the plate circuit is much greater than, but faithfully controlled by, the lesser power in the input circuit, the input varied potential of the grid, operating the tube as a relay, is reproduced in facsimile, but much amplified, in the local current flowing in the plate circuit.

The amplifying powers of the triode of course operate equally well with high or low frequency variations of the grid potential. Moreover, the faculty of amplification enables the tube also to act as a self-sustaining generator of oscillations in a wireless transmitter. When so utilized, the triode's function is to generate a continuous oscillation which can be radiated by the antenna. The principle which enables it to generate oscillations may simply be stated. A small change in potential in the grid circuit will cause a much amplified change of current in the plate circuit. Hence, a small part of the plate current change may be utilized to create the grid voltage change necessary again to reproduce the plate current change, and this can go on indefinitely, so that the current in the plate circuit of the tube will maintain continuously an oscillatory variation. If a

sufficient part of the plate current is so used, it changes the potential on the grid sufficiently to reproduce in the plate current a larger variation, the "feed-back" part of which again produces a still larger variation of grid voltage. This action continues until a state of equilibrium is reached, with the plate circuit current oscillating continuously at its maximum value. That portion of the current in the plate circuit which is not being used to change the grid voltage may be applied to an antenna circuit, either directly or through a transformer, and will then be radiated from the antenna as a continuous Hertzian wave.

The same basic principle is employed with the De Forest tube when used in regenerative receivers, except that here the amount of plate current change used to change the potential of the grid is less than that necessary to reproduce the full change in the plate current. Because of this, the current change in the plate circuit dies out quickly unless an augmenting voltage is applied to the grid, as from an incoming signal. When such signal voltage is applied to the grid, a part of the amplified current change which it produces in the plate circuit is used to increase the voltage change on the grid, so that the plate current variation is rendered considerably stronger than if it were

effected only by the signal voltage on the grid. But as soon as the incoming signal ceases, the current variations in the plate circuit die out because the "feed-back" is insufficient to sustain them.

It was this three-electrode tube of DeForest, in the arrangements described above, which the defendant used, and which plaintiff charges constituted infringement of the Fleming patent; defendant used no two-electrode devices. (Finding LXVII; I R. 63).

2. The differences between the triode and the diode are substantial

The findings and conclusion of the court below, that the defendant's three-electrode tubes differed substantially from and hence did not infringe the Fleming device, are sustained not only by the general differences between the two structures in arrangement, operation and effect, but also by the efficacy of DeForest's device for purposes of which the Fleming tube were incapable—that is, amplification and oscillation.

(a) General Structure and Mode of Operation

The difference between Fleming's diode and the DeForest triode used by defendant is illustrated in the following comparative sketches made by

defendent's expert witness, Dr. Miller (Ex. I, IV R. 3283):

Fleming Tube and Circuit — *Defendant's Tube and Circuit*

MILLER DRAWING B

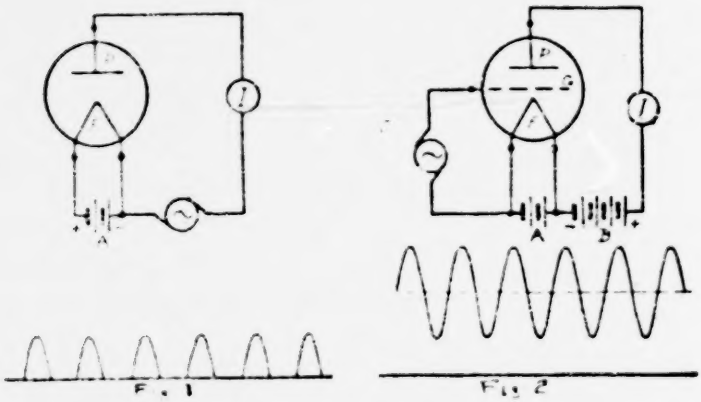


Fig. 1 Fig. 2

The Fleming tube, as we have seen, consists solely of a heated filament and a cold plate, the plate circuit being connected to the *negative* side of the filament so that no steady component of current will flow in the filament-to-plate circuit. The antenna circuit receiving the incoming signal energy is inductively coupled to the plate circuit by a transformer. The incoming signal energy — a high frequency alternating current — is fed directly into the plate circuit by the transformer, alternately rendering the plate positive and negative relative to the filament, and permitting the

current to flow between filament and plate when the latter is positive but not otherwise. The result is a unidirectional flow of a portion of the incoming alternating current, which operates the galvanometer *I* or other signal indicating instrument. The only energy operating the galvanometer is the relatively feeble energy of the signal itself; that energy is in no way augmented. Moreover, since only one-half of the incoming alternating current is permitted to pass through the vacuous space of the tube and through the galvanometer, the actual operating energy is never greater than one-half of the original signal energy.

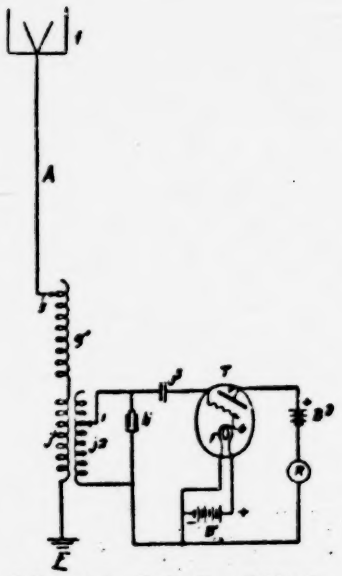
The DeForest three-electrode tube used by defendant, whether as detector, amplifier, or oscillator, comprises not only the two elements of the Edison tube used by Fleming but also a third element, the grid interposed between the filament and plate. The plate is connected permanently to the *positive* end of the local battery so that the electrons emitted by the hot filament will flow continuously to the positively charged plate. Since the plate remains positive, and is never rendered alternately positive and negative (as in Fleming's rectifying circuits), the tube tends *continuously* to pass a local direct current from the battery through the filament-to-plate circuit (which Fleming's tube did only half the time,

when the plate was positive relative to the filament). Being direct, this current does not require rectification. The input energy in the grid circuit is alternating current, but it is utilized solely to change the voltage of the grid, which regulates (by decreasing or increasing) the flow of the direct current from the battery. It is the flow of this locally produced direct current which operates the indicating device in the plate circuit, and not the incoming alternating current energy, as in Fleming's circuit; the DeForest tube uses the incoming energy only to impress different electrical potentials on the grid, thus accelerating or retarding the flow of the local continuous current.

These differences in arrangement, mode of operation and result between Fleming's and DeForest's tube are rendered even more acute when the DeForest device is used for particular purposes.

(b) The Three-Electrode Tube as a Detector

Defendant's three-electrode vacuum tube, when used in a detector circuit, is shown as follows (Ex. 83, I R. 70):



DeForest Audion, Used by Navy (Exhibit 83).

Fleming's tube, as we have shown, functioned solely as a rectifier of alternating current, as did Wehnelt's and Edison's in the circuits known in 1890. The defendant's tubes, however, had either no rectifying action whatever, or only an insignificant and unwanted rectification. There was in fact no need for rectification, since the current operating the indicator device (such as the earphones) was direct current from the local battery, and the incoming alternating current signal was used solely to vary the potential of the grid and thus correspondingly modulate the direct current of the plate circuit, to reproduce in it, by relay action, an amplified replica of the variation in grid potential.

Defendant used two forms of detectors: (1) one in which the desired negative voltage was maintained on the grid by a small battery, known as a *C* battery, and (2) one in which this function was performed by the incoming current passing through a condenser shunted by a very high resistance leakage path.[*]

In neither type is the incoming signal rectified to operate an indicator in the received current circuit, and in neither type does any rectification occur in the filament-to-plate circuit. In the first type (*C* battery-biased), no useful rectification occurs in any circuit. In the second type of detector (grid condenser-grid leak) such slight rectification as does occur is employed, not to operate an indicator, but merely to charge the grid condenser which takes the place of the *C* battery. In all forms of the three-electrode tube, the initial charge on the grid controls the local battery plate current (flowing as the electron stream), and determines whether the grid will give to that current, by relay action, a variation which is a true amplified replica of the incoming signal (as is desired in amplifiers and oscillators), or whether it will give it a variation which is an amplified

[*] The "grid leak" usually employed has a resistance of about 5,000,000 ohms, approximately the resistance of a pencil mark on a piece of paper.

replica of the *modulation* of the incoming signal, as is desired in a detector.

In the *C* battery detector, the grid is so initially charged by the *C* battery that it initially cuts down the plate current to a low value. Thus when it is alternately made more positive and more negative by the incoming signal, by its relay action on the electron stream, it alternately tends to allow large increases and to cause small decreases of the plate current from its initial value. These attempted variations of the plate current during the interval of a signal, when they are passed through a choking device (as a galvanometer, a telephone receiver or an iron-core transformer), are averaged up by such choking device. Such averaging of the large increases and small decreases in the current yields a net increase of current during the interval of a signal, such increase being proportional to the amplitude or strength of the signal. As the amplitude or strength of the signal is its intelligence carrying modulation,* the plate current, varied proportionally thereto, is made to *reproduce* the modulation of the signal in amplified form, by the relay action of the tube. The three-electrode detector thus *reproduces* the intelligence in the local battery current by modulation-

* In code transmission, the amplitude is raised to maximum for the duration of a dot or dash and dropped to a minimum value or zero at the end of a dot or dash. In the case of speech or modulated continuous wave transmission, the amplitude is intermediately varied at an audio frequency.

amplifying relay action; it controls by relay action a new current which operates the indicator; it does not rectify the weak signal current to operate an indicator in the received signal circuit.

The "grid condenser-grid leak" detector has essentially the same mode of operation. Normally, an incoming wireless signal is carried by a continuous carrier wave of high frequency. When the wave arrives, the first few impulses charge the condenser with negative charges until a basic voltage is reached which is a balance between the average of the incoming pulses and the leakage through the high resistance which shunts the condenser. Thereafter, the basic voltage charge on the condenser and grid follows the average of the audio-modulation borne by the carrier wave. The grid, having a basic potential thus varied in accordance with the audio-modulation of the incoming signal, by relay action controls the electron stream as in the first type, except that its basic control is in this case the audio frequency variation of its potential produced by the grid leak and condenser. Hence, the average voltage on the grid, by relay action, varies the averaged value of the plate current to make it *reproduce* in its variations the modulation of the signal in amplified form (I R, 626–632).

Even if there is theoretically some preliminary flow of signal energy to the grid condenser while it is charging, resulting in a slight rectification of the current before the condenser is charged to

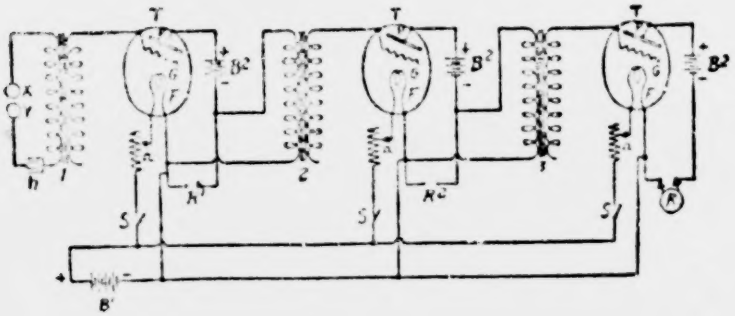
its average potential, such flow is only temporary and in any event is not used to operate any indicator as in the Fleming device. The only indication of the signal in defendant's detectors is that of the averaged variation of the direct current in the plate circuit. The defendant's indicating device in the plate-to-filament circuit is operated solely by the large local energy, which usually is thousands of times greater than the incoming signal energy. Indeed, even if the signal energy (high frequency alternating current) could get over into the plate circuit, it could not operate the indicating device or have any effect upon it.

The triodes used in defendant's detectors served not as rectifiers, but as relay devices repeating, in the locally generated current in the plate circuit, amplified replicas of voltage changes produced on the grid by the incoming alternating current, suitably modified. In the first type above, the modification was obtained by use of a small local *C* battery in the grid circuit, giving it an initial negative charge. In the second type, it was obtained by employing the grid condenser and leak to cause the averaged grid potential to follow the audio modulation of the incoming signal. The court below therefore properly found that defendant's detectors differ from Fleming's in arrangement, operation and result (Findings LXXV, LXXVII, LXXIX, I R. 69–73).

(c) The Three-Electrode Tube as Amplifier

The three-electrode tubes used by defendant as amplifiers were audio frequency amplifiers. One example was the De Forest "Audion Amplifier" used by the Navy Department, and illustrated as follows (Ex. 85, I R. 72):

DE FOREST AUDION AMPLIFIER
USED BY NAVY



Another example of defendant's low frequency amplifiers is that used in the "T. P. S." set. The instrument shown above is a unit consisting of three *iron core* transformers to each of which is connected the input of an *amplifier* tube, all three tubes and their circuits being alike. The instrument was

> * * * of the three-stage type; each stage consisted of an iron-core transformer, 1, 2, 3, three-element audion T, battery B,

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[2] Telegraphy through the earth's surface, as shown in the early Dolbear patent No. 350,299 (Ex. N 4, not reproduced) and by Preece (Ex. 123, not reproduced, and Ex. S 6, V R. 4163).

resistancer switch S, telephone R, and a filament lighting battery B′, which was common to all three stations. These elements were mounted in a wooden cabinet and the variable portions of the apparatus were operable on the outside. The terminals X Y were connected to the telephone binding posts or terminals of a receiver. The battery B′ was a separate piece of apparatus and connected to terminals on the amplifier. The amplifier element T was renewable. The circuit connections used are as shown in the diagram (Ex. D 2, not reproduced, see I R. 686).

In both types of defendant's amplifiers, however, the triode is connected to an audio-frequency circuit and is employed to amplify audio-frequency current, as is obvious from the arrangement and structure of the amplifiers.* This meant that the incoming high frequency signal was either converted to, or reproduced as, an audio-frequency signal before it was fed to defendant's amplifiers. There is no evidence and plaintiff indeed does not contend that defendant ever used any of these tubes as radio frequency amplifiers; consequently, defendant's amplifiers

* Defendant's amplifiers, when used in a radio receiver, were connected to the telephone terminals, i. e., in an audio-frequency circuit (I R. 635, 636), for the telephone must be in an audio-frequency circuit in order that an operator may hear the sign l. *Iron* core transformers are useful only in low frequency circuits, *air* core transformers being used for high frequency circuits.

are not within the language of Fleming's claim 37, which is limited to Hertzian waves of inaudible frequencies, nor within the language of claim 1, which by the disclaimer in 1915 was restricted to high frequency waves (see p. 189 *supra*).

Even if used with high-frequency currents, there would be no similarity between defendant's amplifiers and the Fleming patent, for in the amplifiers there is no rectification as in Fleming; there is only a direct current, the amount of which by relay action is made to vary in accordance with the variation of voltage on the grid, to *reproduce* in the plate current, a replica of the input signal.[*]

The difference between the Fleming two-electrode tube and defendant's three-electrode tubes operating in the amplifier circuit is illustrated in Dr. Miller's sketch shown at p. 148 *supra*. In the Fleming circuit the input energy is rectified, i. e., one-half of each wave cut off (see lower left-hand figure, p. 148, *supra*), each half wave starting from zero, rising to maximum and falling to zero. In the three-electrode amplifier, on the contrary, the current is not rectified in either the

[*] The natural grid voltage is such that the tube will operate on the straight portion of the characteristic curve, whereby variation of grid voltage equally above and below the normal value will cause equal variation of plate current above and below the normal value. Generally, although not necessarily, a C battery is inserted in the grid circuit in order to hold the operation of the tube on the desired part of the characteristic (IV R. 3116-3118).

input or the output circuit. The change in voltage on the grid controls a wholly different circuit, i. e., the plate circuit, in which the direct current rises and decreases in amplitude in accordance with the voltage changes on the grid (p. 142, et seq. *supra*). As already stated, the input energy to defendant's amplifiers was invariably of audio-frequency. Had it been of high frequency, i. e., above the audible range, the output would be a variation of the amplitude of the plate current at the same high frequency, and this variation would be so rapid that nothing would be heard in the phones.

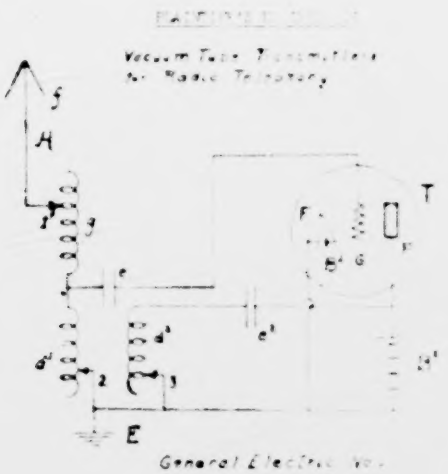
Thus, the defendant's amplifiers are not detectors and do not rectify. Their action is purely that of a relay, the grid voltage controlling the large local energy of the local *B* battery, to produce an *amplified* reproduction of the signal. This most important function and result of the triode amplifier is not attained and not possible in the Fleming device, as plaintiff in fact concedes in its brief (Pl. Brief 56–58). Since the devices function differently, infringement is not established even though there may be nominal or verbal similarity between plaintiff's patent and defendant's structure. *Westinghouse* v. *Boyden*, 170 U. S. 537.

The findings of the court below that the Fleming patent contains no disclosure of a device capable of amplifying (Finding LXXIV, I R. 68, 69) and that the three-electrode amplifier func-

tions in a radically different manner from that contemplated by Fleming (Finding LXXVI, I R. 72, 73), are thus clearly supported by the evidence.

(d) The Three-Electrode Tube as Oscillator

Defendant's three-electrode tubes, when used as "oscillators" in wireless transmitters, are typified by the General Electric No. 2, which is illustrated as follows (Ex. 116, IV R. 2792):

General Electric No. 2

The device, whose function is to send out a continuous wave, operates as follows: The grid and plate circuits are coupled by the coils d' d^2 so that any disturbance in either circuit is inductively communicated to the other. The path of the direct current in the plate circuit is from battery B' to the filament F, thence to plate P and back to battery. The alternating component

of this current is shunted from plate P through condenser c^2, coil d^2, wire 3, filament F to plate P'.[52]

The alternating component of the large plate current, caused by the rise of current in the coil d', is communicated to the grid circuit by means of the shunt circuit, causing the grid circuit still further to increase the alternations in the plate circuit (by the amplifying action of the tube), until a state of equilibrium is attained in the plate and grid circuits, after which the alternations continue at a constant amplitude. These alternations are impressed on the antenna by the coupling transformer d' d^2 and are sent out as high frequency waves.

In this arrangement, the three-electrode tube operates as an oscillator producing a wave to be transmitted. The Fleming device, on the other hand, is a receiver only; it is in no sense a transmitter, could not function as a transmitter, and could not be used to send out a continuous wave.[53]

[52] The condenser c^2 prevents the battery B^2 from short circuiting through coil d^2; and a choke coil (not shown) in the battery lead directly adjacent to the battery B^2 prevents the alternating component from flowing by way of the battery.

[53] Plaintiff's suggestion in the court below that the defendant's oscillator is a reversal of the Fleming or Edison valve is wholly unfounded, for there is no known way of reversing the Fleming device. It has only one circuit, and whether the current applied thereto is direct current or alternating current, the result is the same: current flows through the

Its sole function is to permit the measurement or indication of rectified high frequency current, and Fleming's patent so recites (V R. 2600, lines 25–30). It is overwhelmingly established that the two-electrode tube, with or without a battery, cannot cause oscillations, and plaintiff now concedes this (Pl. Brief 56, 58). Indeed, plaintiff asserts (*Id.* 57) that it—

> has never claimed that the Fleming patent describes amplification, oscillation or * * * use of gas or external field (to produce these effects), or that Fleming knew these things.

The plaintiff thus concurs in the finding of the court below in these respects (Findings LXXIV, LXXVI; I R. 68–79, 72–73). It urges, however, that because defendant's detectors, amplifiers, and oscillators use unidirectional conductivity, they in-

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device in one direction only. If the applied current is direct current, the flow will be continuous; if alternating current, the current flow in the circuit will be a series of pulsations of direct current. The same is true even if the circuit be split in two halves, as suggested by Waterman.

Nor is the three-electrode tube reversible in any sense. In fact, one of its important characteristics is that it is unidirectional only, i.e., changes in the grid circuit are reflected in the independent current of the plate circuit, but changes in the plate circuit do not go back through the tube. Even when fed back by a feed back connection, the reproduction through the tube is still unidirectional. This feature was recognized by de Valbreuze, Wehnelt, Fleming, and others as a characteristic of the Edison and similar two-electrode tubes, years before the patent in suit was applied for.

fringe the Fleming patent. But as shown above (p. 110–127 *supra*), and as the court below properly found (Findings LXXI, LXXII; I R. 66–67), this feature was attributable to Edison and to the investigations which were published and became part of the public domain long before the application for the Fleming patent. Charges of infringement may not be based upon an element in a patented device which the prior art had disclosed. *United States* v. *Berdan Fire Arms Co.*, 156 U. S. 552. The court below correctly found, therefore, that the Fleming patent disclosed no device capable of oscillating (Finding LXXIV, I R. 68, 69) and that the three-electrode oscillators differ in arrangement, mode of operation, and result from anything contemplated in the Fleming patent (Finding LXXVIII, I R. 73).

3. *Commercial Success of the Three-Electrode Device*

The rapidity with which the triode replaced the older form of tubes, and its signal contributions to the art of communication, add to the evidence of its substantial dissimilarity to Fleming's diode. As the court below found, the speedy advancement of the art was attributable to the differences between the three-electrode tube and Fleming's tube, and not to matter contemplated in the Fleming patent (Findings LXXIV and LXXVII, I R. 68, 73). DeForest's device was in every sense a

true relay or amplifier, and by locating a telephone or other indicating device in the powerful local plate circuit and controlling it by the weaker input circuit, greater signal strength and fidelity of detection and reproduction resulted.

Few inventions since the telephone have wrought more revolutionary changes and established more new industries than has this new instrumentality. The three-electrode tube shortly after its invention was developed by the telephone companies into "a most successful speech amplifier or telephone relay" (I R. 710), and it is to the inertialess relay-amplification possible with this instrument that we owe our long distance telephone, and wireless broadcast transmitting stations and receivers, talking moving pictures, and public address systems. Dr. Eccles, an English scientist of high standing, wrote in 1919 that

> it is the three-electrode valve, and not the valve with two electrodes, that has been responsible for the overthrowing of the old methods and apparatus. That it has been a veritable revolution can be seen by comparing the common practice in wireless telegraphy of 1914 with that of 1919 (Ex. W, I R. 653).

Dr. Van Der Bijl, one of the highest wireless authorities in this country (Ex. L, IV R. 3304), agreed that

> the insertion of the grid into the valve resulted in a device of tremendous potentiali-

> ties—one that can justly be placed in the same category with such fundamental devices as the steam engine, the dynamo, and the telephone.

and added that

> the insertion of the grid has made the audion a device of immense practical importance and enabled it to perform functions that would otherwise have been impossible.

By way of summary, and to show more clearly the substantial differences between Fleming's and the defendant's tubes, we have prepared a table (Table 3) listing in parallel columns the distinctive criteria of infringement: of arrangement of parts, mode of operation and result, of the Fleming patent and of DeForest's three-electrode tubes. Comparison of these columns emphasizes the correctness of the finding below that defendant's device differed in arrangement, mode of operation and result from that of Fleming (Findings LXIX–LXXVII; I R. 64–73). The ultimate finding of noninfringement (Finding 1; I R. 117) necessarily follows from any one of these differences.[56]

[56] *Knapp v. Morse*, 150 U. S. 221; *American Fruit Growers, Inc. v. Brogdex Co.*, 283 U. S. 1.

TABLE 3

STRUCTURE

Fleming tube and circuit	Defendant's (DeForest) tube and circuit
(1) Electron-emitting filament heated by battery, or by input current.[1]	(1) Electron emitting filament heated by battery.[1]
(2) Cold plate.[1]	(2) Cold plate.[1]
(3) (absent)	(3) Interposed grid, connected in circuit to filament.
(4) (a) Incoming alternating current connected in a circuit between plate 2 and filament (1), the alternating current to be of high or [illegible] frequency.	(4) (a) (absent)
(b) (absent)	(b) Incoming alternating current connected in grid-to-filament circuit.
(5) (absent)	(5) High voltage local battery connected in the plate-to-filament circuit, with its positive end to plate and its negative end to filament.
(6) (absent)	(6) Means in the grid-to-filament circuit for controlling the initial negative charge on the grid relative to the filament, either a low voltage C battery connected in the grid circuit or a condenser bridged by a high resistance connected in the grid circuit.

[1] These two elements were in the prior art. See Table 2.

STRUCTURE—Continued

Fleming tube and circuit	Defendant's (DeForest) tube and circuit
(7) (a) A galvanometer in the circuit to which the incoming alternating current is applied, which is energized by the one-way flow of the incoming alternating current permitted by the unidirectional conductivity of the tube	(7) (a) (absent).
(b) (absent).	(b) An indicator actuated by the fluctuation of the local battery current in the plate-to-filament circuit

OPERATION

(1) The plate is alternately made positive and negative relative to the filament by the incoming alternating current	(1) The plate remains positive relative to the filament at all times
(2) (absent)	(2) The plate circuit current is derived from the high voltage local battery in the plate-to-filament circuit
(3) The rectified alternating current in the single circuit of the device flows through and actuates the indicator.	(3) In the amplifiers, oscillators, and C battery-biased grid detectors, any minor unidirectional current existing in the grid-to-filament circuit, to which the incoming alternating current is applied, is simply waste

OPERATION—Continued

Fleming tube and circuit	Defendant's (DeForest) tube and circuit
(4) Not so used in any circuit.	(4) In the "grid condenser-grid leak" detector, the unidirectional current in the grid circuit is used to charge the grid condenser to give it a basic negative charge or bias relative to the filament. The basic static charge on the grid tends to become more negative when the amplitude of the received oscillation is greater, and less negative when the amplitude of the received oscillation is less, thus automatically following the audio-frequency variation in amplitude (modulation) of the oscillations, and causing those audio-frequency variations to be reflected in the plate circuit current.
(5) Limited by disclaimer to rectification of high (Hertzian wave) frequencies.	(5) All defendant's *amplifiers* act to *reproduce*, in the plate current variation, a substantial replica of the audio-oscillations introduced into the grid circuit, without rectification.

RESULT

(a) The Fleming device *rectifies* alternating input currents applied to its indicator circuit, and applies them to actuate a galvanometer in the same circuit, reducing their amplitude in the process.	(a) (absent).

RESULT—Continued

Fleming tube and circuit	Defendant's (DeForest) tube and circuit
(b) The Fleming device is not a relay and as disclosed cannot amplify or oscillate and does not *reproduce* anything in a new local current.	(b) The tube is a true *relay*, and an *amplifier*, and is capable of sustaining its own operation as an oscillation generator, without other elements acting within the tube envelope. As a detector, the tube is likewise a true relay and acts by "modulation-amplifying relay action" to *reproduce* in a new current in the plate circuit an amplified replica of the grid-received modulation.

4. *Plaintiff's favorable decision in 1916 against the DeForest three-electrode tube is not entitled to weight in this case*

Plaintiff relies upon *Marconi Wireless Telegraph Co. of America* v. *DeForest Radio Telephone & Telegraph Co.*, 236 Fed. 942 (S. D. N. Y.), affirmed 243 Fed. 551 (C. C. A. 2), which held the Fleming patent here involved to be valid and infringed by DeForest's three-electrode tubes. That decision, however, is entitled to little weight on either of these issues, for both parties had there agreed, for collateral reasons, that the two-electrode and three-electrode vacuum tubes were essentially alike, thus eliminating any controversy on the matter crucial to the decision here.

In the *DeForest* case, the plaintiff herein alleged infringement of the Fleming patent in

suit by DeForest's three-electrode tubes used as detectors by the DeForest Radio Telephone & Telegraph Company. The DeForest Company counterclaimed upon eight patents, six relating to two-electrode tubes, and two relating to the *three*-electrode tube. Marconi then confessed judgment as to infringement of both of DeForest's *three*-electrode patents (236 Fed. 942, 943; 243 Fed. 560, 561), and the case thereupon proceeded upon the Fleming patent here involved and the six remaining DeForest patents, all for *two*-electrode tubes. Both parties were actually using three-electrode tubes, and were suing on their respective two-electrode patents. Each was claiming that its own two-electrode patents were being infringed by the three-electrode devices of the other. Consequently, it was to the interest of both parties to have the court find substantial similarity between the patented two-electrode and the allegedly infringing three-electrode devices, and by the same token to have the court minimize the differences between the two types.[*] And both parties accordingly informed Judge Mayer of the district court that they considered the two-element and three-element tubes to operate on the

[*] The same observation applies to the minimizing, before Judge Mayer, of the difference between the *B* battery of the three-electrode circuit, which supplied the direct output current to the filament-to-plate circuit, and a mere sensitizing battery attached to the plate of the two-electrode tube, contributing no power to the output of the two-electrode tube.

same principle. The court quite naturally construed the prior art in the light of that concession, saying (236 Fed. 942, 953):

> In reading this literature it must be remembered that both sides agree that the DeForest two-element and three-element bulbs operate on the same principle.

The record in that case embodies no indication of the highly significant facts that by 1916 (the date of the decision) the Fleming valves had been discarded almost entirely as detectors in wireless communication apparatus, that ordinary crystals had been substituted in their place, and that the only vacuum tube in wide use was the three-electrode tube (Finding LXVIII, I R. 63). These circumstances render of little weight the district court's holding that the two-element device had brought into the art a "new, valuable, and easily obtainable detector which has gone into important commercial use."

The affirmance of the judgment by the circuit court of appeals is likewise deprived of weight by the parties' agreement and the inadequate record as to the desuetude of the two-electrode detector. The circuit court of appeals said (243 Fed. 561, 565):

> The detectors called by defendant "Marconi's earlier infringement" or the "two-electrode audion" are especially complained of, though since *it is agreed that the "two*

> *and three-electrode audions" operate on the same basic principle,* no reason appears why defendant must not contend that the same things which admittedly infringe the confessed patents also infringe all the counter-claim patents. [Italics supplied.]

In consequence of the fundamentally erroneous assumption on the part of the two Federal courts (premised upon the parties' agreement on the crucial issue: substantial similiarity of operation) and the courts' misconception of the commercial importance of Fleming's device, their opinions were properly accorded little value by the Court of Claims on the question of whether defendant's three-electrode detectors function in substantially the same way as Fleming's two-electrode tubes. And for like reasons, the decision is entitled to no more weight on the issue of validity. Since neither the district court nor the circuit court of appeals appreciated that the art prior to Fleming knew a rectifier would act as a detector, and that an electronic device that would rectify oscillations of low frequency would likewise rectify radio frequency waves, their contrary conclusions (243 Fed. 561, 563) can hardly be cited as authority in a case where these misconceptions do not exist.[88]

After the affirmance of its decision as to validity and infringement, the district court extended

[88] The finding of the Court of Claims with respect to the de Valbreuze patent alone (Finding LXX, pp. 64–66) discloses this misunderstanding in the *DeForest* case.

its decree to amplifiers and oscillators, on the theory that the Fleming valve was inherently capable of oscillating. 261 Fed. 393. This extension is in effect repudiated by plaintiff, for it now admits that "a simple diode cannot amplify, because it merely changes the form of the received currents" (Pl. Brief 56), while it concedes that the triode is both an amplifier and an oscillator (*id.* 57).[57]

CONCLUSION

For the foregoing reasons the judgment of the Court of Claims with respect to all claims except

[57] The devices called "amplifiers" in the *DeForest* opinion extending the decree were totally unlike the amplifiers in this case. The word "amplifier" was used to designate an assemblage of apparatus comprising two or more detectors, as Judge Mayer's opinion shows. Since the Government's amplifiers comprised no detectors, Judge Mayer's "amplifier" decision is in effect a holding that the defendant's amplifiers here do not infringe, for to find infringement he had to find that the DeForest "amplifiers" really were "detectors". Plaintiff's experts admitted in the record of the present case, and plaintiff now concedes (Pl. Brief 58), that amplification or oscillation was obtained in the demonstrations before Judge Mayer in the *DeForest case* "by gas inside the tube or by an electric field outside the tube", i. e., by converting the tube into a "negative resistance" device or by supplying the equivalent of DeForest's third electrode. In *Hewitt* v. *American Tel. and Tel. Co.*, 272 Fed. 194, Judge Mayer reversed his former viewpoint and held that the amplification obtained by gas characteristics (the manner in which the two-electrode valve was "demonstrated" before him in the *DeForest* case) is a wholly different thing from the relay amplification and oscillation attained by grid control, as in a three-electrode device.

claim 16 of the Marconi patent No. 763,772, and with respect to the Fleming patent No. 803,684, should be affirmed.

Respectfuly submitted,

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APRIL 1943.

APPENDIX

The Act of June 25, 1910, c. 423, 36 Stat. 851 (35 U. S. C. § 68) provided:

> That whenever an invention described in and covered by a patent of the United States shall hereafter be used by the United States without license of the owner thereof or lawful right to use the same, such owner may recover reasonable compensation for such use by suit in the Court of Claims: * * * *Provided further,* That in any such suit the United States may avail itself of any and all defenses, general or special, which might be pleaded by a defendant in an action for infringement, as set forth in Title Sixty of the Revised Statutes, or otherwise * * *.

This was amended by the Act of July 1, 1918, c. 114, 40 Stat. 704, to read as follows:

> That whenever an invention described in and covered by a patent of the United States shall hereafter be used or manufactured by or for the United States without license of the owner thereof or lawful right to use or manufacture the same, such owner's remedy shall be by suit against the United States in the Court of Claims for the recovery of his reasonable and entire compensation for such use and manufacture: * * * *Provided further,* That in any such suit the United States may avail itself of any and all defenses, general or special, that might be pleaded by a de-

fendant in an action for infringement, as set forth in Title Sixty of the Revised Statutes, or otherwise * * *.

Section 3 (b) of the Act of February 13, 1925, c. 229, 43 Stat. 936, 939, as amended by the Act of May 22, 1939, c. 140, 53 Stat. 752, 28 U. S. C. § 288 (b), provides:

> In any case in the Court of Claims, including those begun under section 180 of the Judicial Code, it shall be competent for the Supreme Court, upon the petition of either party, whether Government or claimant, to require, by certiorari, that the cause be certified to it for review and determination of all errors assigned, with the same power and authority, and with like effect, as if the cause had been brought there by appeal. In such event, the Court of Claims shall include in the papers certified by it the findings of fact, the conclusions of law, and the judgment or decree, as well as such other parts of the record as are material to the errors assigned, to be settled by the Court.
>
> The Court of Claims shall promulgate rules to govern the preparation of such record in accordance with the provisions of this section.
>
> In such cases the Supreme Court shall have authority to review, in addition to other questions of law, errors assigned to the effect that there is a lack of substantial evidence to sustain a finding of fact; that an ultimate finding or findings are not sustained by the findings of evidentiary or primary facts; or that there is a failure to make any finding of fact on a material issue.

Sections 4917 and 4922 of the Revised Statutes (35 U. S. C. §§ 65, 71) provide:

> SEC. 4917. Whenever, through inadvertence, accident, or mistake, and without any fraudulent or deceptive intention, a patentee has claimed more than that of which he was the original or first inventor or discoverer, his patents shall be valid for all that part which is truly and justly his own, provided the same is a material or substantial part of the thing patented; and any such patentee, his heirs or assigns, whether of the whole or any sectional interest therein, may, on payment of the fee required by law, make disclaimer of such parts of the thing patented as he shall not choose to claim or to hold by virtue of the patent or assignment, stating therein the extent of his interest in such patent. Such disclaimer shall be in writing, attested by one or more witnesses, and recorded in the Patent Office; and it shall thereafter be considered as part of the original specification to the extent of the interest possessed by the claimant and by those claiming under him after the record thereof. But no such disclaimer shall affect any action pending at the time of its being filed, except so far as may relate to the question of unreasonable neglect or delay in filing it.
>
> SEC. 4922. Whenever, through inadvertence, accident, or mistake, and without any willful default, or intent to defraud or mislead the public, a patentee has, in his specification, claimed to be the original and first inventor or discoverer of any material or substantial part of the thing patented, of which he was not the original and first inventor or discoverer, every such patentee,

his executors, administrators, and assigns, whether of the whole or any sectional interest in the patent, may maintain a suit at law or in equity, for the infringement of any part thereof, which was bona fide his own, if it is a material and substantial part of the thing patented, and definitely distinguishable from the parts claimed without right, notwithstanding the specifications may embrace more than that of which the patentee was the first inventor or discoverer. But in every such case in which a judgment or decree shall be rendered for the plaintiff, no costs shall be recovered unless the proper disclaimer has been entered at the Patent Office before the commencement of the suit. But no patentee shall be entitled to the benefits of this section if he has unreasonably neglected or delayed to enter a disclaimer.

U. S. GOVERNMENT PRINTING OFFICE: 1963

No. 373

In the Supreme Court of the United States

OCTOBER TERM, 1942

THE UNITED STATES, CROSS-PETITIONER

v.

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA

CROSS-PETITION FOR A WRIT OF CERTIORARI TO THE COURT OF CLAIMS

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In the Supreme Court of the United States

OCTOBER TERM, 1942

No. 373

THE UNITED STATES, CROSS-PETITIONER

v.

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA

CROSS-PETITION FOR A WRIT OF CERTIORARI TO THE COURT OF CLAIMS

On September 2, 1942, Marconi Wireless Telegraph Company of America, the plaintiff in the Court of Claims, filed a petition for writ of certiorari in *Marconi Wireless Telegraph Company of America* v. *The United States*, No. 369, seeking a review of those portions of the interlocutory and final judgments of the Court of Claims of the United States, rendered November 4, 1935, and April 6, 1942, respectively, which hold invalid certain claims of United States Patent No. 763,772 granted to Guglielmo Marconi on June 28, 1904, and hold certain claims of United States Patent

No. 803,684, issued to John Ambrose Fleming on November 7, 1905, not infringed by the United States. A brief in opposition to the petition is being prepared and will be filed on behalf of the United States.

The Solicitor General on behalf of the United States prays that in the event the Court grants the petition in No. 369, but only in that event, a cross-writ of certiorari be directed to the Court of Claims to review that portion of the judgment rendered April 6, 1942, which awards damages against the United States for infringement of Claim 16 of the Marconi patent. The certified transcript of record filed in No. 369 includes those portions of the record upon which this cross-petition is based.

OPINIONS BELOW

The opinion of the Court of Claims on the issues of validity and infringement (R. 7–116) is reported at 81 C. Cls. 671; its opinion in the accounting proceeding (R. 117–182) is not yet reported.

JURISDICTION

The interlocutory judgment of the Court of Claims upholding the validity of Claim 16 of the Marconi patent, in pursuance of which an accounting was held, was rendered November 4, 1935. The final judgment after accounting proceedings was rendered April 6, 1942. Time in which to file a petition and cross-petition for writs of certiorari was extended by the Chief Justice for a period

of 60 days from July 6, 1942 (R. 2523). The jurisdiction of this Court is invoked under section 3 (b) of the Act of February 13, 1925, as amended.

QUESTIONS PRESENTED

(1) Whether the Court of Claims erred in holding Claim 16 of the Marconi tuning patent (No. 763,772) valid and infringed. A subsidiary question is whether in the circumstances the court erred in refusing to consider evidence material to these issues introduced in the accounting proceedings.

(2) Whether in the absence of any finding or evidence which would have supported a finding that the patented receiver disclosed or attained the principal advantage attained by the receiver used by the United States, the Court of Claims could properly use the value of that advantage as a measure of compensation against the Government.

STATEMENT

The patent involved in this case and, with the Fleming patent (No. 803,684), involved also in No. 369, is United States Patent No. 763,772, granted to Guglielmo Marconi on June 28, 1904, and known as the Marconi four-circuit tuning patent (Pl. Ex. 21, Petition, Appendix C). This patent, now expired, related to wireless transmitting and receiving apparatus. More specifically, it relates to means for providing a stronger transmitted

signal and a more selective reception than had been attained prior to Marconi's disclosure. The alleged invention comprised a variably tuned antenna circuit inductively coupled through an oscillation transformer to a tuned closed oscillating circuit in both the transmitter and receiver. The patent specified that each of the four circuits should be tuned to the same frequency in order to secure the desired objects of strong signals and of selective reception. (See Finding XXXVIII, R. 31.)[1]

The patent included twenty claims, of which fifteen were involved in the suit below. Two of these claimed tuning the two transmitter and the two receiver circuits to the same wave length or frequency. Six were directed to the transmitter alone, and claimed tuning the transmitter circuits to the same frequency. The remaining seven claims in suit, including Claim 16, were directed to the receiver alone, and claimed tuning the two circuits at the receiver (*i. e.*, the antenna or open circuit, and the detecting circuit) to the same frequency.

The Court of Claims held that all of these claims except Claim 16 were anticipated by the prior work of John Stone Stone (Findings LVII and LVIII,

[1] References to Findings of Fact unless otherwise indicated are to those appearing in the Court of Claims decision of November 4, 1935.

R. 56–57). Claim 16,[2] while claiming means for tuning the two receiver circuits to the same frequency as did the six other receiver claims in suit, was held to be distinguished from them and from the prior art because of the additional element of an adjustable condenser connected with the open circuit and in shunt with the primary winding (j′) of the transformer (j′–j²) of the receiver. The court below found that the purpose of this condenser, as indicated in "the tables on page 4 of the specification * * *, is to enable the electrical periodicity or tuning of the open circuit of the receiver to be altered." (Finding LX, R. 57.) It concluded that Claim 16 was valid and had been infringed by the United States (R. 75).

During both the initial hearing and the subsequent hearing on accounting the Government contended and introduced evidence to show that Claim 16, to the extent valid at all, was not infringed. The evidence showed and the court found that the laws regarding the relationship of capacity and

[2] "16. At a receiving station employed in a wireless-telegraph system, the combination of an oscillation transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiver conductor at one end and capacity at the other end, an adjustable condenser in a shunt connected with the open circuit and around said transformer coil, a wave-responsive device electrically connected with the other coil of the oscillation transformer, and means for adjusting the two transformer circuits in electrical resonance with each other, substantially as described."

inductance to achieve the tuning of an alternating current circuit were known prior to the Lodge patent (No. 609,154) (also in suit in the court below), which antedated the Marconi patent, and that Lodge taught the art to apply these laws to the so-called "open" antenna circuit (Findings XXXVI, LXI, R. 29–30, 57). The evidence also established and the court found that persons skilled in the art knew prior to Marconi's patent how to adjust the condensers shown in Stone's earlier patent to achieve the desired tuning, even though Stone's drawing did not show that his condensers were adjustable (Finding LIII, R. 47–51). In addition, the Fessenden patent as filed [3] prior to the earliest date proven for Marconi, showed an adjustable condenser in shunt with all the inductance coils in the antenna circuit of a wireless receiver; and the Pupin patent,[4] also prior to Marconi, not only showed a similar arrangement, but fully explained the laws governing its operation, which were known at the time of Fessenden's application in 1899. (Findings XXXVI, LIII, R. 29–30, 47.)

As appears from the face of the patents, the only novel difference between the condenser arrangement shown by Marconi and that disclosed by Fessenden and Pupin is that in every instance in which the condenser (h) is present in the

[3] Patent No. 706,735, Pl. Ex. 171, pages, 90, 93; Def. Exs. LL and CCCC, Fig. 1.

[4] Patent No. 640,516, Def. Exs. U–2 and KK (Fig. 2).

tables on page 4 of the Marconi specification, referred to by the court in the quotation *supra*, p. 5, a variable inductance tuning coil (g′) not bridged by the condenser is employed,[5] whereas in the Fessenden and Pupin constructions there were no inductance coils not bridged by the condenser. The evidence shows that the same difference exists between Marconi's claimed invention and the receivers used by the Government, where the variable condenser alleged to infringe is employed in the open circuit. The court below in its findings of fact reproduced the drawings of the two types of circuit employed by the Government, and these drawings show that in each instance the condenser (h) in its solid-line position[6] bridges all the inductance coils (that is, both g and j) in the circuit between the aerial and ground (Finding 23, April 6, 1942, R. 139).

The evidence shows that this difference in arrangement produces a difference in mode of operation of the circuits yielding diametrically opposed results: In the Marconi arrangement the presence

[5] The text of the Marconi patent (p. 1, lines 56–59) states: "The system also requires as *essential elements* thereof the inclusion in the lines (at both stations) from the aerial conductor to the earth of *variable inductances* * * *." (Italics supplied.) The only variable inductance disclosed in the antenna circuit of the receiver is the tuning coil (g′), which is *not* bridged by the condenser (h) (Finding XXXVIII, R. 31–32).

[6] The dotted-line position is an alternative arrangement of the condenser not alleged to infringe (see Finding 23, April 6, 1942, R. 139).

of the condenser in series between tuning coil g' and the earth, makes the condenser act in *series* with the antenna-to-earth capacity and causes the primary tuned circuit to respond to *decreased* wave lengths;[7] in the Government's structure the presence of the condenser in parallel with *all* the inductance coils in the circuit, places it in *parallel* with the antenna-to-earth capacity and causes the primary tuned circuit to respond to *increased* wave lengths.[8] The court below, in the accounting proceeding, found in effect that the shunt-connected condenser in cross-petitioner's receiver enabled the receiver to be tuned to longer wave lengths than would be the case with the normal connection (Findings Nos. 28, 29 and 45, April 6, 1942, R. 143, 156). It made no finding that the Marconi circuit was designed for this purpose or achieved this result and the only testimony was to

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[7] *Tuska*, R. 2509, XQQ. 266, 268; *Wheeler*, R. 2434 (Q. 55), 2438, 2451, 146 Q.; Def. Ex. BBB; *Waterman*, R. 357-358; *Loftin*, R. 977.

[8] *Pickard*, R. 2328-2335; *Tuska*, R. 2498, Q. 107.

[9] The experts who testified below were agreed that the Marconi shunt-condenser-connection was merely a "by-path" around only the coupling coil j' (not bridging the antenna tuning coil g'; see note 7, *supra*) and had no important modifying effect on the general mode of operation. The only significant result of the condenser as used in the Marconi patent was to effect a loose coupling arrangement, which was not used in the Government's structure. The decrease in wave length caused by the condenser as used was slight and incidental. (*Tuska*, R. 2509, XQQ. 266, 268; *Loftin*, *Wheeler*, *Dow*, R. 977; 2434 (Q. 55), 2477 (124 Q.), 2465 (255 XQ.); 2364, 2367; *Waterman*, R. 357, 358).

the contrary.[2] It simply found in its decision of November 5, 1935, that the Government's receivers had "apparatus coming within the terminology of Claim 16" (Finding LXIII, R. 60), and, in its decision after the accounting proceeding, that "The adjustable condenser in such a circuit had the function and effect similar to that possessed by the adjustable condenser of the Marconi patent * * *." (Finding 24, April 6, 1942, R. 139.)

In the accounting proceeding the Marconi Company proved, and the court below found (Findings 29 and 45, April 6, 1942, R. 143, 154), that in the Government's receiver the shunt-connected condenser enabled the receiver to be tuned to longer wave lengths than would be the case with the normal connection, and enabled the periodicity of the open circuit to be broadly changed. The court then found that the same advantages could have been attained by the prior-art method of using an additional inductance coil in the antenna circuit, and the cost of such additional coils would have been $66,130.67, of which the court allowed the plaintiff 65% ($42,984.93) with interest. The court declined to consider evidence adduced by the Government which explained the functions of the condenser in the Marconi arrangement and showed that the advantage of cross-petitioner's device was not attained by the device covered by claim 16 of the Marconi patent. (Opinion, April 6, 1942, end of page 61, R. 176–177.

SPECIFICATION OF ERRORS TO BE URGED

The Court of Claims erred:

(1) In finding as an ultimate fact that claim 16 of the Marconi patent was valid and was infringed, without first determining its scope in view of the prior art.

(2) In failing to make a finding of fact as to the particular advantage achieved by the shunt condenser in the open antenna circuit of the Marconi patent, and in making a finding of infringement in the absence of such finding.

(3) In failing to find as a fact that the disclosure of the Marconi patent upon which claim 16 is based did not possess the principal advantage of cross-petitioner's structure but possessed a different advantage not used by cross-petitioner.

(4) In basing compensation upon the principal advantage present in cross-petitioner's structures, when such advantage was not disclosed or attained in the patent in suit.

(5) In not revising its findings of fact to conform to the entire evidence in the case where evidence necessarily admitted in the accounting proceedings, to establish a basis for compensation, disclosed incompleteness and error in the findings of fact theretofore made in relation to the infringement of claim 16 of the Marconi patent (No. 763,772).

REASONS FOR GRANTING THE WRIT

1. Although the Government is of opinion that neither the questions presented by the petition in No. 369 nor those presented by this cross-petition are of sufficient importance to call for a review by this Court, it submits that if the petition in No. 369 is granted, similar action should be taken in this case. The questions raised herein are at least of equal interest and it would seem desirable for the Court to review all related matters in controversy between the parties if it reviews any. A review in No. 369, unless limited to the Fleming patent, would involve a consideration of all the Marconi tuning claims in suit, including Claim 16 so far as it covers four-circuit tuning.

2. On November 10, 1900, the earliest date established for the Marconi patent (Finding XLI, R. 37), the use of the feature which was held to establish the validity of Claim 16, namely, the use of a condenser in shunt with the transformer primary for the purpose of varying the periodicity of the open circuit, was old in the art. The prior art is exemplified by the Fessenden patent (No. 706,735) granted August 12, 1902, on an application filed December 13, 1899 (Finding XLII, R. 37), and by the Pupin patent (No. 640,516) Def't's. Exh. KK, Fig. 2.) Both show the use of a Def't's. Exh. KK, Fig. 2.). Both show the use of a condenser in shunt with the primary of the transformer coil and both adjust the values of these condensers to vary the periodicity of the circuit.

Claim 16, therefore, is anticipated by these patents, unless it be limited to the feature of a coil not bridged by the condenser in shunt. Cf. *Knapp* v. *Morss*, 150 U. S. 221; *American Fruit Growers, Inc.*, v. *Brogdex Co.*, 283 U. S. 1. But so limited, it was not infringed by the structure used by the Government.

The settled rule is that, to infringe, a structure must be substantially the same as the patented structure in arrangement, mode of operation, and result.[10] The evidence hereinbefore summarized (pp. 5–9) shows that the combination of elements in, mode of operation of, and result attained by the Government's structure are different from those of the Marconi disclosure when Claim 16 is limited in the manner necessary both on principle and to establish its novelty over the prior art; that the circuits of the Fessenden and Pupin patents, which automatically increase the wave length, are substantially the same as the Government's circuits and fully justify the Government's manner of using the condenser to attain an increased wave length;[11] and that the circuit claimed by Marconi does not attain the advantage of increased wave length on the basis of which the Court of Claims computed its award against the United States on the accounting.

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[10] *Westinghouse* v. *Boyden Power Brake Co.*, 170 U. S. 537; *Holland Fur. Co.* v. *Perkins Glue Co.*, 277 U. S. 245, 257; *Sanitary Refrigerator Co.* v. *Winters*, 280 U. S. 30, 42; *Craftint Mfg. Co.* v. *Baker*, 94 F. (2d) 369, 373 (C. C. A. 9).

[11] *Knapp* v. *Morss*, *supra*.

3. In basing the amount of the judgment upon the advantage of increased wave length attained by the Government's receiver, without finding that such advantage was disclosed or attained by the patented structure, the Court of Claims reached a result which conflicts in principle with decisions of this Court (*Westinghouse Co.* v. *Wagner Mfg. Co.*, 225 U. S. 604; *Dowagiac Mfg. Co.* v. *Minnesota Plow Co.*, 235 U. S. 641; *Sheldon* v. *Metro-Goldwyn Pictures Corp.*, 309 U. S. 390, 402) and of circuit courts of appeals.[12]

CONCLUSION

For the reasons stated, it is prayed that if the petition for a writ of certiorari in No. 369 is granted to review the decision of the Court of Claims with respect to the Marconi patent (No. 763,772), this petition for a review of the same decision of the Court of Claims with respect to Claim 16 of that patent be granted also.

CHARLES FAHY,
Solicitor General.

SEPTEMBER 1942.

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[12] *Cincinnati Car Co.* v. *New York Rapid Transit Corp.*, 66 F. (2d) 592 (C. C. A. 2); *Stromberg Motor Devices Co.* v. *Detroit Trust Co.*, 44 F. (2d) 958 (C. C. A. 7).

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No. 373

In the Supreme Court of the United States

OCTOBER TERM, 1942

THE UNITED STATES, PETITIONER

v.

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA

ON WRIT OF CERTIORARI TO THE COURT OF CLAIMS

BRIEF FOR THE UNITED STATES

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BRIEF FOR THE UNITED STATES

OPINIONS BELOW

The opinion of the Court of Claims on the issues of validity and infringement of the patent in suit (I R. 7–116)[1] is reported at 81 C. Cls. 671; its opinion in the accounting proceedings (I R. 117–182) is not yet officially reported.

JURISDICTION

The interlocutory judgment of the Court of Claims concerning validity and infringement pur-

[1] The record citations refer to the volume and page.

suant to which an accounting was held, was rendered November 4, 1935 (I R. 75); the final judgment, after the accounting proceedings, was rendered April 6, 1942 (I R. 182). The petition for a writ of certiorari was filed on September 3, 1942, (III R. 2524), pursuant to an extension of time granted by the Chief Justice (III R. 2523), and was granted on December 14, 1942. The jurisdiction of this Court is invoked under Section 3 (b) of the Act of February 13, 1925, as amended.

QUESTIONS PRESENTED

(1) Whether claim 16 of Marconi patent No. 763,772 was infringed by the United States.

(2) Whether claim 16 of the Marconi patent, if infringed, was valid, or whether it was void for anticipation in the prior art.

(3) A question subsidiary to these two questions is whether the Court of Claims erred in refusing to consider evidence, introduced in the accounting proceedings, material to the issues of validity and infringement.

(4) Whether, even if the claim was valid and was infringed by the United States, the court below properly adopted as a measure of compensation the value of the principal advantage attained by the arrangement used by the Government, in the absence of any finding or any evidence to support a finding that such advantage

was disclosed or attained by Marconi's arrangement.

STATUTE INVOLVED

The Appendix, *infra*, pp. 51–52, contains the pertinent provisions of the Act of June 25, 1910, c. 423, 36 Stat. 851, as amended by the Act of July 1, 1918, c. 114, 40 Stat. 704 (35 U. S. C. § 68), and the pertinent provisions of Section 3 (b) of the Act of February 13, 1925, c. 229, 43 Stat. 936, 939, as amended by the Act of May 22, 1939, c. 140, 53 Stat. 752 (28 U. S. C. § 288b).

STATEMENT

On July 29, 1916, respondent Marconi Wireless Telegraph Company of America (herein called plaintiff) brought this suit in the Court of Claims under the Act of June 25, 1910, to recover compensation for the allegedly unauthorized use by the United States (herein sometimes called defendant) of inventions alleged to have been covered by four patents, two issued to Guglielmo Marconi, one to Sir Oliver Lodge, and one to Sir John Ambrose Fleming.

The court below held that one Marconi patent, reissue No. 11,913 was not infringed, and that the Lodge patent No. 609,154 was valid and infringed.[2] As to these, no review has been sought by either party.

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[2] The final judgment rendered after the accounting proceedings awarded plaintiff $34,827.70 plus interest for infringement of the Lodge patent. This award is not here involved.

The court below further held that the Fleming patent No. 803,684 had not been infringed and that all the claims in suit (except claim 16) of the other Marconi patent, No. 763,772, were invalid (I R. 75,117). This ruling concerning the Fleming patent and the invalidity of the Marconi patent is now before this Court in *Marconi Wireless Telegraph Company of America* v. *The United States*, No. 369, this Term.

In respect of claim 16 of the Marconi patent, No. 763,772, the court below rendered an interlocutory judgment on November 4, 1935, holding it valid and infringed, and after accounting proceedings, rendered its final judgment (I R. 182), on April 6, 1942, awarding compensation to plaintiff in the amount of $42,984.93 plus interest for such infringement. The decision concerning claim 16 of the Marconi patent is the subject of this proceeding.

Marconi patent No. 763,772 was granted to Guglielmo Marconi on June 28, 1904, and related to wireless transmitting and receiving apparatus. It disclosed an arrangement claimed to provide a stronger transmitted signal and a more selective reception than had been attained prior to Marconi's disclosure (Finding XLI; I R. 37).[3] Claim

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[3] Findings identified by roman numerals were made by the Court of Claims in connection with its interlocutory judgment of November 4, 1935; findings identified by arabic numerals were made by the Court of Claims after accounting proceedings, and in connection with its final judgment of April 6, 1942.

16 of this patent relates to an alleged improvement in receiving apparatus only (Finding XL; I R. 32; cf. I R. 174, 180).

The earlier receiver claimed to have been improved by Marconi consisted of two circuits: the antenna-circuit and the detector-circuit. The antenna-circuit, which received the transmitted oscillations (signals), had an antenna at one end and a connection to earth at the other; the detector-circuit was coupled to the antenna-circuit through a transformer, and included devices for detecting and translating the signals transmitted (Fig. 13 of Lodge patent, Ex. 20, I R. 26; Finding XXVII; I R. 24). Marconi's alleged invention required, in the receiver, a variably tuned antenna-circuit inductively coupled through an oscillation transformer to a tuned closed oscillating-circuit. The invention also required two similar circuits (antenna circuit and closed circuit) in the transmitter, and the patent specified that each of the four circuits in the transmitter and receiver should be tuned to the same frequency in order to secure the desired objects of strong signals and of selective reception. (See Finding XXXVIII; I R. 31.)

The patent included twenty claims, of which fifteen were involved in the suit below.[4] Of these, seven claims, including claim 16,[5] were directed to the receiver alone; they claimed tuning the two circuits at the receiver (i. e., the antenna or open

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[4] Claims 1, 2, 3, 6, 8, 10, 11, 12, 13, 14, 16, 17, 18, 19, and 20.

[5] Claims 2, 13, 14, 16, 17, 18, and 19.

circuit, and the detecting-circuit) to the same frequency (Finding XL; I R. 32).

The Court of Claims held that six of these seven claims were anticipated by the prior work of John Stone Stone (Findings LVII and LVIII; I R. 56–57), but held claim 16 valid and infringed (I R. 75).

SUMMARY OF ARGUMENT

I

The finding of the court below that the Government's receivers infringed claim 16 of the Marconi patent is unsupported by substantial evidence. The distinctive feature of the claim which the court below held saved it from invalidation by the prior art was not shown nor found to be present in the Government's receivers; on the contrary, the record requires the conclusion that the condenser arrangement used by the Government—the device alleged to infringe—differed substantially in association, operation, and result from the arrangement disclosed in claim 16. Moreover, the court made no findings of fact as to these criteria of infringement to sustain its ultimate finding of infringement.

II

If, however, claim 16 is to be so broadly construed as to lead to the conclusion that it was infringed by the Government's condenser arrangement, the claim is invalid because the Government's arrangement was specifically disclosed in the art prior to

Marconi, namely, in the earlier patents of Pupin and Fessenden. The record requires the finding and conclusion that the structure, mode of operation, and result of the Government's arrangement are the same as those disclosed by Pupin and Fessenden; and consequently that claim 16, if it also relates to that arrangement, was void for anticipation in the prior art.

III

The error in the conclusions of the court below that claim 16 of the Marconi patent was valid and infringed was revealed in the record on the first hearing prior to the interlocutory judgment of November 4, 1935; it was further apparent from the absence of evidentiary findings as to substantial identity of arrangement, operation, and result necessary to sustain the conclusion of infringement. The record on the accounting proceeding which followed the interlocutory judgment served to emphasize that claim 16 was either invalid or not infringed. The evidence, necessarily introduced in the accounting proceedings to show the proper apportionment of the value of the advantages of the Government's device between the contributions of Marconi and those of others, demonstrated that Marconi's device and the Government's structure had an entirely different arrangement, operation, and result; and further, that the advantages of the Government's de-

vice were derived not from the Marconi patent but from the prior art disclosures of Pupin and Fessenden. The court below erred in refusing to consider the evidence, introduced in the accounting proceedings, as to these matters.

IV

Even assuming the patent was valid and infringed, the court below erroneously measured the damages. The court correctly found that the Government's arrangement produced the advantages of increased wavelength and sensitivity in tuning and saving in space and weight. The court made no findings, however, and there was no evidence which would have sustained any findings, that such advantages had been contributed by the patented device of Marconi. It was therefore error for the court to adopt these advantages of the Government's receivers as the measure of compensation awarded to the plaintiff.

ARGUMENT

Marconi's claim 16 reads as follows (Ex. 21, IV R. 2596):

> 16. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, *an adjustable condenser in a shunt connected with the*

open circuit and around said transformer-coil, a wave-responsive device electrically connected with the other coil of the oscillation-transformer, and means for adjusting the two transformer-circuits in electrical resonance with each other, substantially as described. [Italics added.]

The subject matter of this claim is shown as follows in Figure 2 of the Marconi patent, *h* being the "adjustable condenser", *f'*, *A*, *g'*—*E* being the "open circuit" (or aerienna-circuit) and *j'* being the "transformer coil" (Ex. 21, IV R. 2590:

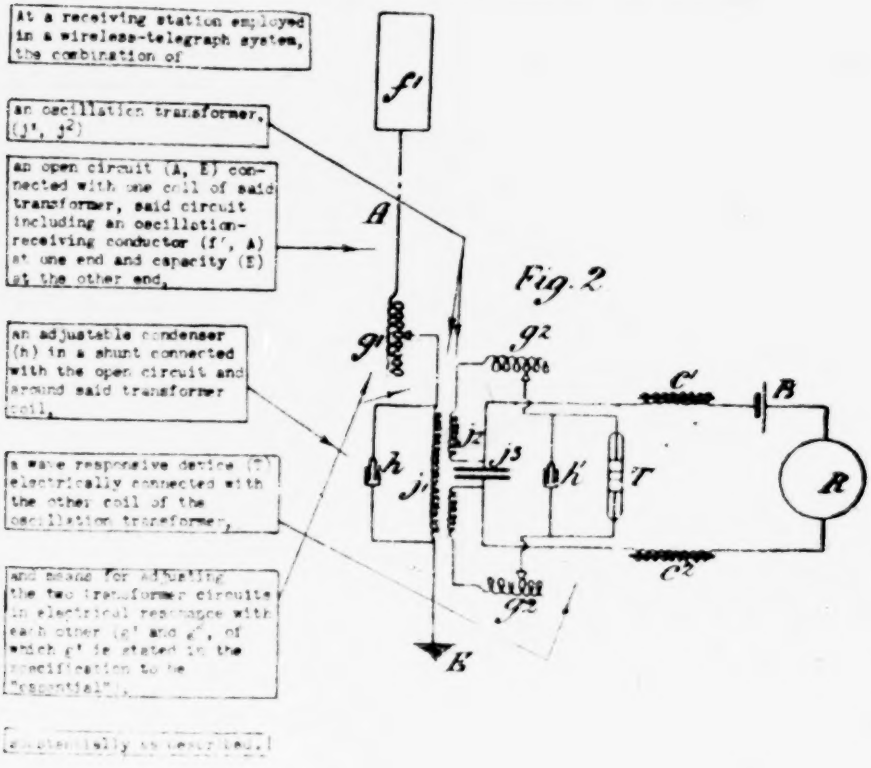

Fig. 2

Like the six other receiver claims which the court below held invalid for anticipation, claim 16 claimed means for tuning the two circuits at the receiver to the same frequency. Claim 16, however, was held to be distinguished from these other claims (and hence from the prior art) by its inclusion of the adjustable condenser *h* connected with the open circuit and in shunt with (i. e., forming a bypath around) the transformer coil *j'*. (See Marconi Figure 2, *supra*, p. 9; Finding LX; I R. 57; cf. I R. 174, 180.)

Since this is the distinctive feature of the claim which saves it from invalidation by the prior art, the question of infringement must turn upon whether or not the Government, in the allegedly infringing receivers, used its condenser in substantially the same association to operate in substantially the same way, and to produce substantially the same result, as the condenser in the arrangement disclosed by Marconi.

If any one of these three requisite elements of similarity is not found in the defendant's device, there can be no infringement.* The court made no specific findings on these three criteria of infringement; moreover, as we shall show in Point I, the evidence requires the conclusion that no one of these criteria was present in the Govern-

* *Westinghouse* v. *Boyden Power Brake Co.*, 170 U. S. 537, 569; *Ciniotti Unhairing Co.* v. *American Fur Refining Co.*, 198 U. S. 399, 414; *Holland Furniture Co.* v. *Perkins Glue Co.*, 277 U. S. 245, 257; *Sanitary Refrigerator Co.* v. *Winters*, 280 U. S. 30, 42; *Craftint Mfg. Co.* v. *Baker*, 94 F. (2d) 369, 373 (C. C. A. 9).

ment's use of its condenser, and hence that no infringement of claim 16 was shown. Consequently, the conclusion of the court below is clearly erroneous because unsupported by substantial evidence and because without subordinate findings of fact to sustain it (Act of May 22, 1939; see Appendix, p. 51, *infra*). Indeed, as we shall show in Point II, if claim 16 is to be so broadly construed as to lead to the conclusion that there was infringement, the claim must necessarily be invalid, for the condenser arrangement used by the Government was specifically disclosed in the art prior to Marconi. This permits, in our view, only two alternatives: that claim 16 was not infringed, or that it is invalid. On either view, the decision below is erroneous. This error was emphasized at the accounting proceedings which followed the interlocutory judgment of validity and infringement; for it was there made clear that the association, operation and result of the Government's condenser arrangement were the same as those disclosed in the art prior to Marconi. The court below should therefore have rectified its prior ruling as to infringement, as requested by the Government prior to entry of final judgment (Point III).

But in any event, even assuming that the claim was valid and infringed, the measure of damages invoked by the court below was erroneous. The advantages which were shown to have been derived from the mode of operation of the Government's arrangement were adopted as the measure of compensation awarded to the plaintiff, although

there was no finding, nor any substantial evidence to support a finding, that such operation and advantages had been disclosed or attained by Marconi's arrangement. In Point IV, we shall show that the use of such advantages as the measure of recovery was therefore improper.

POINT I

The Government's receivers did not infringe Marconi's Claim 16

The record establishes that there are critical differences between claim 16 and the receivers used by defendant; these differences relate to the arrangement, the operation, and the result of the devices in controversy. The essential distinctions between claim 16 and the defendant's receivers negate the conclusion that defendant infringed the claim, and that conclusion is unsupported by substantial evidence.

1. Arrangement

In the Marconi arrangement as disclosed in claim 16, the variable condenser *h* does *not bridge* the variable inductance tuning coil *g'* (see Figure 2, Marconi patent No. 763,772, *supra* p. 9); and this variable tuning coil is stated in the patent to be an *essential* element of Marconi's alleged invention.[1] In contrast, the variable condenser *h* used by the Government in the two types of receivers alleged to infringe claim 16 is invariably

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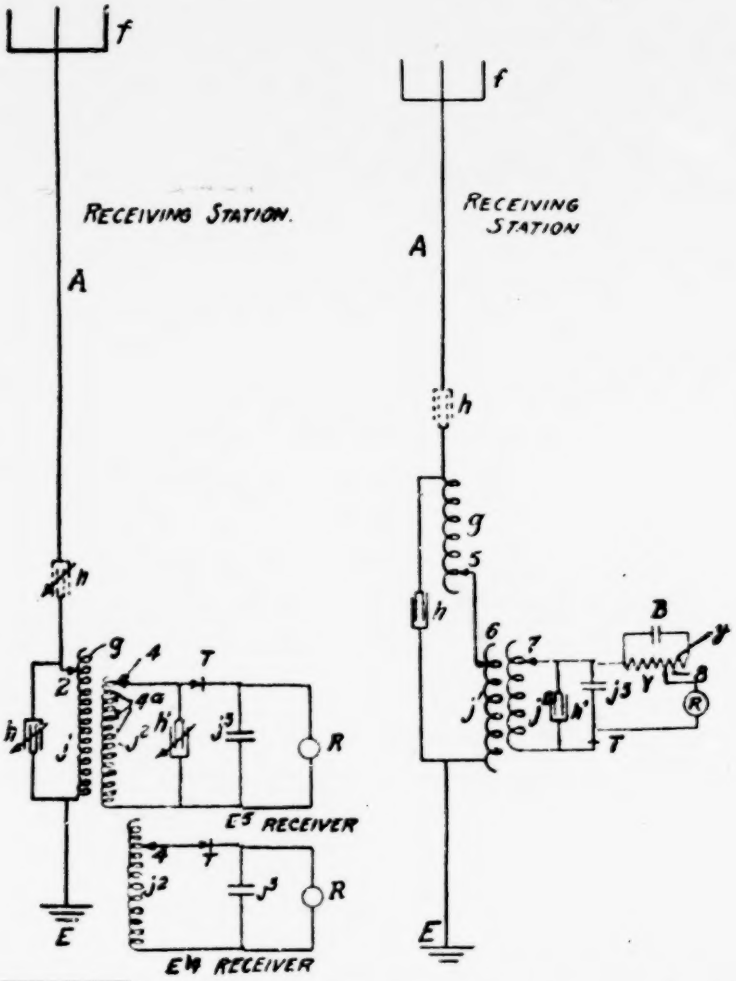
[1] The text of the Marconi patent (p. 1, lines 56-59) states:

"The system also requires as essential elements thereof the inclusion in the lines (at both stations) from the aerial conductor to the earth of variable inductances * * *."

connected across *all* the inductance coils (j' and g) in the open circuit (f, A, E), as the following diagram will show:



The only variable inductance disclosed in the antenna circuit of the receiver is the tuning coil q' which is not bridged by the condenser h (Finding XXXVIII, I R. 31–32). In every instance in which the condenser h is present in the tables on page 4 of the Marconi specification, referred to by the court below in Finding LX, the "essential" unbridged coil q' is present.

This fact was indeed expressly found by the court below after the accounting.[8] Plainly, therefore, there is a basic distinction in arrangement between the receiver circuits covered by claim 16 and defendant's circuits.

2. Operation and result

The difference in arrangement of the circuits produces important differences in their operation and results which may be succinctly described as follows: In the Marconi arrangement, the presence of the condenser in *series* between the inductance coil g' and the earth E makes the condenser act in *series* with the antenna-to-earth capacity and tends to cause the primary tuned circuit to respond to *decreased* wave lengths;[9] in the Government's structure, the presence of the condenser in *parallel* with *all* the inductance coils of the circuit places it in *parallel* with the an-

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[8] Finding 23, I R. 139. This finding relates to the Government's condenser h in its *solid-line* position in the Figures above reproduced, which constituted part of Finding 23. The *dotted-line* position is an alternative arrangement of the condenser, not alleged to infringe claim 16 (Finding 23, I R. 139).

[9] *Dow*, III R. 2364 (Q. 18), 2367; *Tuska*, III R. 2509, X QQ. 266, 268; *Wheeler*, III R. 2434 (Q. 55), 2436 (70 Q), 2451 (Q. 146); Def. Ex. BBB, V R. 4114; *Waterman*, I R. 357 (top), 358 (bottom); *Loftin*, II R. 977. The experts called by plaintiff to testify were Waterman, Tuska, and Pickard; those called by the Government were Loftin, Wheeler, Dow. (See quotations in n. 14, *infra*, p. 17.)

tenna-to-earth capacity and causes the primary tuned circuit to respond to *increased* wave lengths.[10]

Marconi's condenser arrangement has the advantage of shunting or bypassing most of the energy of the antenna circuit around the coupling coil *j'*, thus constituting a means for loosening the coupling between the antenna and secondary circuits. This is different from and possibly an improvement over other loose coupling means theretofore known to the art: the swamping inductances used by Stone (Findings LV and LVII, I R. 52, 56) and the physical separation of coils used by Lodge (Fig. 13, I R. 26; II R. 1018). But the Government does not use the Marconi bypass arrangement for loose coupling; it uses only the earlier alternatives of Stone and Lodge.

To explain the difference in operation and result, we shall advert first to certain accepted laws of radiotelegraphy.

(a) *General Principles*

An electrical circuit can be tuned to a given wave length only by the use of inductance and capacity *in series with each other*. For illustration we insert a diagram showing four forms of a tuned circuit:

[10] *Pickard*, III R. 2328–2335; *Tuska*, III R. 2498, Q. 107.

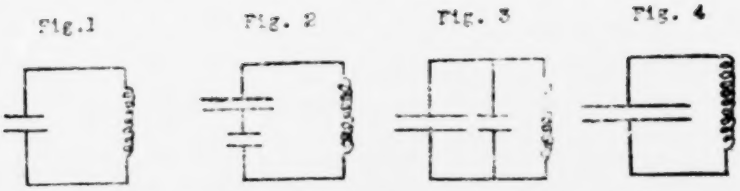

Figure 1 is the conventional tuned circuit containing inductance (the coil on the right) and capacity (the condenser, i. e., the parallel plates on the left) in series. Figure 2 shows two condensers in series with each other in the circuit, and sequentially in series with the inductance. In such case, the total capacity in the circuit is restricted to that of the smaller condenser, even if the larger condenser is so large as virtually to be a direct wire connection.[2] The third figure shows two condensers in parallel with each other in the circuit which is in series with the inductance. In that case, the total capacity equals the sum of the two capacities and the result is the same as if one larger condenser were used, as in the fourth figure. When these elementary concepts are applied to this case, it will be seen that Marconi's arrangement is the same and functions in the same way as the circuit in Figure 2, while the Government's arrangement is that of Figure 3.

(b) *Marconi's Circuit*

As the court below found (Finding XXXVI, I R. 30), in the open antenna-circuit connected at one end to an aerial wire and at the other end to the earth, the elevated wire and the surface of the

[2] Waterman, I R. 358; Tuska III R. 2509, X Q. 266, 268.

earth are respectively capacity areas and constitute the two plates of a condenser, with the air between acting as a dielectric (i. e., an electrical insulator between the two plates). Marconi's condenser *h* and the antenna-earth capacity (another condenser) are thus sequentially in series in the circuit which includes the inductance coil *g'*. (See Figure 2, p. 9.) Since the size of Marconi's condenser *h* is given as .0046 microfarads in the Marconi specification [12] and the antenna-earth capacity is established as .00024 microfarads,[13] the condenser *h* is so large with respect to the antenna-earth capacity that condenser *h* is almost like a continuous wire in this association. There is no dispute about this principle.[14] Consequently, in the Marconi arrangement, tuning of the circuit is accomplished by the inductance *g'* and the antenna-earth capacity. (See Figure 2, p. 9, *supra.*)

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[12] P. 4, col. 3, under "receiving station."

[13] Wheeler, III R. 2437; Tuska, III R. 2509.

[14] Plaintiff's experts Waterman, Tuska, and Pickard each brought this out. Thus Waterman testified (I R. 358):

"It is a curious fact which must be borne in mind in dealing with wireless telegraph circuits that for the purposes of the high-frequency oscillatory currents a large condenser acts almost like a continuous wire, and when placed in a circuit in a series or tandem relation with a small condenser it has very little effect."

Tuska similarly testified (III R. 2509, XQ. 266) that the Marconi condenser *h*

"is so large that it can be neglected. When one has a very large condenser connected in series with a very small condenser, you can neglect the larger one."

See also Pickard, III R. 2330, 2331, 2334.

Since those skilled in the art understand that the antenna-earth constitute a condenser,[15] it is customary in diagrammatical drawings to omit symbolic representation of the capacity actually existing between the antenna and earth elements of the drawing. When this capacity is shown by symbol to aid its visualization, the complete antenna-circuit covered by claim 16, as shown in Marconi's Figure 2, is as shown on p. 19 (the dotted lines symbolizing the antenna-to-earth capacity):

The tuned circuit, therefore, is the heavy line circuit g', A, f' via antenna-earth capacity to E, and condenser h. Since for reasons already stated the condenser h acts substantially as a continuous wire, the effect of coil j' on the tuning of the antenna circuit is negligible.[16] Accordingly, the maximum wave length to which the tuned antenna circuit resonates is determined by the number of turns of inductance coil g', the variable inductance which Marconi stated to be the essential element for tuning his circuit.[17]

Condenser h cannot lengthen this wave length. Increasing its capacity would be ineffective since it is already so large compared to the antenna-earth capacity that only the latter capacity functions. Reducing the value of h to less than the

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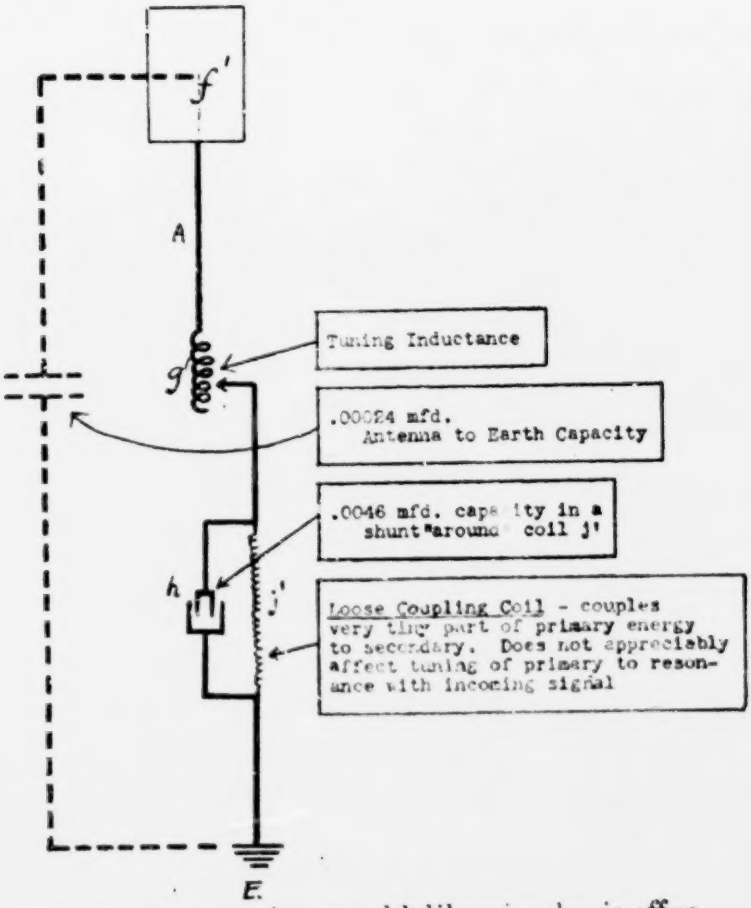
[15] This was recognized and explained by Lodge prior to the alleged Marconi improvement (Finding XXXVI, I R. 201).

[16] Tuska, III R. 2569; Waterman, I R. 378 (cf. Fig. 2, p. 16, *supra*).

[17] Marconi patent 763,772, p. 1, lines 56-59; Finding 19, I R. 156.



antenna-earth capacity would likewise be ineffective, for this would merely reduce the product of the capacity and inductance of the circuit, and so shorten the wave length.[18]

[18] The wave length to which a circuit resonates is determined by the product of the total effective capacity and the total effective inductance in the circuit. The accepted formula, used by all the experts, is: Wave length, in meters = $1884 \sqrt{L \times C}$, where L is inductance in microhenries, and C is capacity in microfarads (Lavender, III R. 2520).

The real function of the condenser *h* as used by Marconi, is to effect a "loose coupling" between the two receiver circuits to improve sharpness of tuning. There are two paths for the current flowing from antenna to earth: the condenser *h* and the coil *j'*. By placing his condenser *h* in the shunt arrangement described, Marconi caused substantially all of the current of the antenna circuit to flow through the condenser *h* and only about two percent to flow through the coil *j'*. The energy of the antenna circuit thus distributed to the shunt condenser *h* was "by-passed" *around* the primary coupling coil *j'* and hence not coupled to the secondary coil *j''*; only the small part of the energy (2%) running through the transformer primary coil *j'* was coupled to the secondary coil *j''*. By thus distributing only a small part of the energy to the transformer primary coil, the effect of one transformer circuit on the total energy of the other is reduced; that is, the coupling between the two circuits is made loose.[19] This loose coupling between *j'* and *j''* tends to give best results and sharpest tuning in Marconi's circuit. (See Findings XXXVIII, XXXIX; I R. 31, 32; II R.

[19] Loftin, II R. 977, 1073; Wheeler, III R. 2434–2437, 2442–2443, 2446–2448; Waterman, I R. 357.

1018, 1019, 1073.) [20] As already stated, the coil *j'* being substantially bypassed,[21] has as a practical matter no effect on the tuning of the primary circuit. The antenna circuit, as regards tuning, corresponds with Fig. 2, p. 16, *supra.*

(c) *The Government's Circuits*

In the Government's receivers the condenser, being differently connected (see figures, *supra,* p. 13), has an entirely different effect. Its capacity is added to the antenna-to-earth capacity and tends to increase the wave lengths. Moreover, it

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[20] The energy could also be distributed and the coupling loosened either by relative physical movement of the transformer coils toward and from one another (Loftin Ex. M-2, Fig. 4) or by use of Stone's swamping inductances (*id.* Fig. 5). However, as pointed out by plaintiff's expert Waterman (I R. 373), the choice of these methods "is a mere matter of detail" in the combination. Marconi used his condenser *h* merely as another means of distributing the energy of the antenna circuit to effect loose coupling of the transformer circuits.

The trivial character of this feature of claim 16 is indicated by Waterman's testimony (I R. 357) that the "condenser *h* has no important or modifying effect on the general mode of operation" and by the unrebutted testimony of defendant's expert Loftin (II R. 977) that condenser *h* "is an arrangement rarely used in tuning the antenna or open circuit through varying the effect of the coil of the winding which it shunts," and is "merely one of the empirical methods employed by the art."

[21] Tuska, III R. 2509, 2168; Wheeler, III R. 2434–5, 55 Q.

does not serve to effect any loose-coupling arrangement.

As will be seen from the diagram above at page 13, the condenser (*h*) in the Government's receivers does not constitute a bypass around the coupling coil (*j'*), but instead is in parallel with all the inductance coils (*j'* and *g*) in the circuits and is thereby in parallel with the antenna-earth capacity (*f-E*). The presence of the two capacities thus in parallel in the circuit which is in series with the inductance gives a total capacity equal to the *sum* of the two capacities (Figs. 3 and 4 *supra*, p. 16). The result is the same as would be obtained if a larger antenna or increased inductance were used, with the additional effect that the current in the tuning coils is enabled to build up to a value even greater than that in the antenna.[22] In short, as the court below found after the accounting proceedings, the condenser in the Government's receivers enabled them to be tuned to longer wave lengths than would be the case with the ordinary series circuit and increased the sensitivity of reception (Findings 28, 29, and 45, I R. 143, 156).

The court below made no finding that the Marconi circuit was designed for this purpose or achieved this result, and the pertinent testimony

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[22] This was known to the art prior to Marconi, as will be shown in Point II, pp. 24–31, *infra*.

was to the contrary.[23] The court simply found, in its interlocutory decision of November 5, 1935, that the Government's receivers had "apparatus coming within the terminology of claim 16" (Finding LXIII, I R. 60), and, in its final decision after the accounting proceedings, that the Government's condenser in the circuit employed "had the function and effect similar to that possessed by the adjustable condenser of the Marconi patent" (Finding 24, I R. 139) as to which it had made no specific finding.

The mere fact that the Government's arrangement falls within the literal language of claim 16 of course does not justify a finding of infringement;[24] and, as we have shown above, the "function and effect" of the two arrangements differ substantially. The court below failed to make any evidenciary findings of fact as to this very material issue. Had it made such findings, it would have been clear that the difference in arrangement, relative to the antenna-earth capacity and the tuning inductance, produces such a difference in mode of operation and result that no infringement can exist.

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[23] Tuska, III R. 2509, XQQ. 266, 268; Loftin, Wheeler, Dow, II R. 977; III R. 2434 (Q. 55), 2477 (124 Q.), 2465 (255 XQ.), 2364, 2367; Waterman, I R. 357, 358.

[24] See cases *supra* n. 6, p. 10, especially *Westinghouse* v. *Boyden Power Brake Co.*, 170 U. S. 537.

Point II

If the Government's receiver infringes claim 16, that claim is void for anticipation by the prior patents to Pupin and Fessenden

We have urged in Point I that the differences between the device disclosed in claim 16 and that in defendant's receivers are such as to preclude the conclusion that the latter infringed the former. If, however, we are mistaken in this, and claim 16 is broad enough to cover defendant's receivers, claim 16 is necessarily void because of prior patents.

The broad principles involved in tuning a receiver such as those of the Government involved in suit, were all known prior to Marconi. The evidence showed and the court below found that "the laws regarding the relationship of capacity and inductance to achieve the tuning of an alternating current circuit were known prior to Lodge" patent No. 609,154 (also in suit in the court below), which antedated the Marconi patent, and that Lodge taught the art to apply these laws to the so-called "open" antenna-circuit (Findings XXXVI, LXI; I R. 29–30, 57). The evidence also established and the court found that prior to Marconi's patent persons skilled in the art knew how to adjust the condensers shown in the earlier Stone patent No. 714,756 (Ex. Q–3) to achieve the

desired tuning, even though Stone's drawing did not show that his condensers were adjustable.[25]

In addition to these general principles, the prior art contained the precise arrangement utilized in the Government's receivers. The Fessenden patent No. 706,735,[26] for which application was filed in 1899, prior to the earliest date proven for the Marconi invention, showed an adjustable condenser in shunt with all the inductance coils in the antenna-circuit of a wireless receiver; and the Pupin patent No. 640,516,[27] also prior to Marconi, not only showed a similar arrangement, but fully explained the laws governing its operation, which were known at the time of Fessenden's application (Findings XXXVI, LIII, I R. 29–30, 47). It is our position, therefore, that since the arrangement of the condenser in the Government's receivers is the same as that disclosed prior to Marconi, the Marconi claim 16, if construed to apply to the Government's arrangement, is anticipated by the prior patents to Pupin and Fessenden, and as so construed is, therefore, void.

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[25] Finding LIII, I R. 47–51; Finding XXVII, last sentence, I R. 24; Finding XLIII, 3rd paragraph, I R. 38–39; Finding LII, I R. 47.

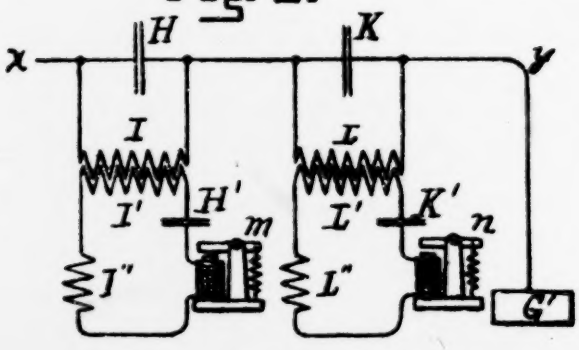
[26] Ex. LL, same as Plaintiff's Ex. 171, p. 90–97, in record prior to interlocutory decision of November 4, 1935, IV R. 3039.

[27] Ex. KK, same as Ex. U–2, V R. 3595. The latter exhibit was referred to by the court below as showing prior knowledge of the laws of tuning (I R. 30), and as prior art relied on as anticipating Marconi (Finding LI, I R. 45, 46).

1. Pupin

Upon an application of May 28, 1895, Pupin received patent No. 640,516 on January 2, 1900 (Ex. KK, U2), prior to Marconi's earliest invention date.[28] Figure 2 of this patent is as follows:

Fig. 2.



This Pupin patent discloses a receiving system in which an open receiving circuit *x*-*G'* connected to earth at *G'* is also connected to the primary coil *I* or *L* of an oscillation transformer, and to a condenser *H* or *K* in parallel with the primary coil. The secondary coil of the transformer (*I'* or *L'*) is in circuit with a suitable detecting device *m* or *n*.

In his drawing, Pupin's receiving system receives its oscillating current not from wireless waves as in Marconi's patent, but from a telegraph wire transmitting the alternating current and connected at *x*. However, Pupin contemplated applying the same technique to receiving oscillations transmitted by other means, as his specification points out:

[28] Nov. 10, 1900, Finding XLI, I R. 37.

> Where in the claims I specify the combination of a line-wire or a line with one or more resonant circuits * * *, I wish it to be distinctly understood that I do not limit myself to any specific means or method of transmitting from one station to another nor to any specific connection between the transmitting and receiving stations * * *. (Pupin patent, Def. Ex. U–2, p. 3, lines 64–73, V R. 3598.)

The immateriality of the mode of transmission, in this connection, is borne out by the fact that the effect upon Pupin's receiving apparatus is the same whether the oscillating current comes from the transmitter by wire or by way of electro-magnetic waves (Dow, III R. 2378–81; Loftin, II R. 938–941).

Pupin's patent explains (p. 1, lines 46–52) that if the circuit *H-I* (or *K-L*) is tuned to the same periodicity [28a] as the current in the wire *x–G'* (which corresponds to the antenna circuit and has the earth connection *G'*), the current flowing in primary coil *I* (or *L*) will be greater than that in the rest of the circuit (p. 1, lines 10–14), and hence will transmit maximum energy to the secondary coil *I'* (or *L'*) and in consequence to the operating coil of translating device *m* (or *n*). The Pupin specification (p. 1, lines 9–14) states:

[28a] As representative of any "desired frequencies" or periodicity, Pupin suggested 150 cycles and 250 cycles per second (Ex. U–2, p. 2, lines 70, 74, 107, V R. 3597). Maxwell's Laws apply to the full range of Hertzian wave frequencies including those, as was known in 1894, cf. Brief for United States in No. 369, this Term, footnote 14 and text pp. 36–37.)

> If a condenser be inserted in a line and a self-induction coil be connected in shunt with this condenser, then an alternating current impressed upon the line will under certain conditions be greater in the shunt-circuit than in the line itself.

The conditions under which this occurs are stated to be that—

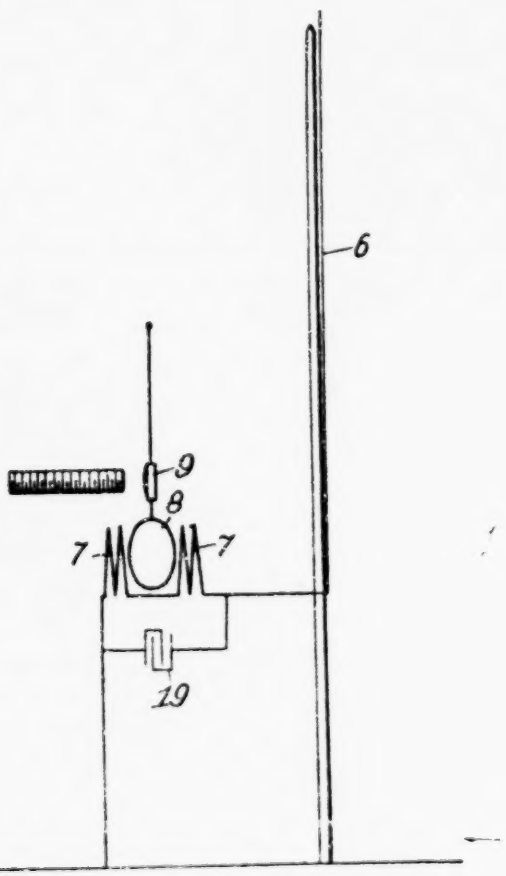
> the capacity of the condenser and the self-induction of the shunt-coil must be so related as to bring the shunt-circuit in resonance with the line-current. (P. 1, lines 33–36.)

It is thus clear that Pupin uses the condenser *H* or *K* (in parallel with the capacity existing between the elevated wire *x* and the earth *G'*) across all the inductance coils *I* or *L* of the circuit to be tuned to resonance with the incoming oscillation, and builds up the current in this resonant circuit to increase the sensitivity of reception.

The same operation and effect characterize the Government's receivers. These receivers use the condenser *h* in parallel with the antenna-earth capacity across all the inductance coils of the primary circuit, so that the two capacities add to each other, thus increasing the wave length, and building up the current in the primary transformer coil to improve the sensitivity of the receiver (Pickard III R. 2334; *supra*, n. 22, p. 22). The Government's arrangement, mode of operation, and result, are thus the same as those of Pupin.

2. Fessenden

The Fessenden patent uses the same arrangement as Pupin in a wireless-wave receiver. Upon application filed December 15, 1899, also prior to Marconi's invention date, patent No. 706,735 was granted August 12, 1902, to Fessenden (Ex. 171, p. 93, IV R. 3039; Ex. CCCC (not printed)). Figure 1 of this patent disclosed the following radio receiver:



This Fessenden receiver comprised an oscillation transformer consisting of a primary coil 7

and a movable secondary coil 8; an open circuit (6 to earth) connected with coil 7, the circuit including an oscillation receiving conductor 6 at one end and capacity (earth) at the other end; a condenser 19 in a shunt connected with the open circuit and around said coil 7; and a wave-responsive device 9 connected with the other coil 8.

As originally filed, the Fessenden application claimed, described, and illustrated this entire arrangement, comprising the open antenna circuit 6, the primary of which included inductance coils 7 shunted by a condenser 19 (Def. Ex. CCCC[235]). By amendment the purpose of this disclosure was stated to be the obtaining of a current in the shunt circuit greater than that in the antenna loa i or line by tuning the shunt or wheel circuit to resonance with the signals being received (*id.*). This purpose was the same, and the principles of operation of the shunt circuit were the same, as those disclosed in the earlier Pupin patent. Like Pupin's condenser *H*, Fessenden's condenser 19 is placed in parallel with the capacity existing between the antenna wire and the earth, and is connected across *all* the inductance coils of the circuit being made to resonate with the incoming wave length. This increases the wave length of resonance compared to that obtainable if the condenser were omitted, and tends to increase the current in such coils. The arrangement disclosed

[235] Not printed, see transcript.

and claimed, in light of the knowledge of the art, clearly suggested the amendment.[28c]

In defendant's receivers, just as in the Fessenden patent, the condenser *h* is placed in parallel with the antenna-to-earth capacity and is connected across *all* the inductance coils of the antenna circuit so that the two capacities add, in effect constituting one larger capacity acting in series with such tuning coils. The arrangement, mode of operation, and results achieved are thus identical.

Because of the correspondence between the defendant's structures and those disclosed in the pre-Marconi patents of Fessenden and Pupin, claim 16 of the Marconi patent, if construed to include the Government's structures, would necessarily include the identical prior art devices and hence be invalid for anticipation.[29] If claim 16 is to be saved from anticipation, it must be construed as directed solely to Marconi's specifically disclosed arrangement (*supra*, p. 16) and thus as having an operation and result different from the arrangement common to Fessenden, Pupin, and the defendant.[30] Such interpretation of claim 16

[28c] See authorities in Brief for United States in No. 369, this Term, footnotes 25 and 26 and text pp. 63–64.

[29] *Knapp* v. *Morss*, 150 U. S. 221; *American Fruit Growers, Inc.* v. *Brogdex Co.*, 283 U. S. 1.

[30] As shown in Point I (pp. 16–21, *supra*), such construction is entirely reasonable, since there is at least substantial evidence to support a finding that Marconi's condenser *h* is arranged differently, operates differently, and produces a different effect.

to avoid invalidity would, as we have shown in Point I, exclude the defendant's receivers and require a decision of noninfringement.

Point III

Evidence introduced at the accounting proceedings, bearing upon validity and infringement, should have been considered by the court below in rendering final judgment on those issues

In Points I and II, we have shown that there is no substantial evidence to support the conclusion of the court below that claim 16 was valid and infringed and, on the contrary, that the evidence required the opposite conclusion. To sustain our position we have treated the record as a unit and, accordingly, have cited pertinent portions not only of the hearing preceding the interlocutory judgment of November 4, 1935, but also of the hearing in the accounting proceedings which followed.[21] The basic evidence as to the structure of the Government's device, and its identity with that disclosed by Pupin and Fessenden, was introduced at the first hearing. We believe that the court below by a mere comparison of the drawings in Fessenden and Pupin's patents, which were prior to Marconi, and the drawings of the Government's receivers—all of which were in evidence at the earlier hearing—should have found at the close of that hearing that Marconi's claim 16, if infringed, was invalid for anticipation. Moreover, the court

[21] The record of the accounting proceedings begins at III R. 2313.

below made no evidentiary findings of fact whatever directed towards the criteria of infringement, to support its ultimate finding that there was infringement.[32] It is our position, therefore, that the record of the hearings preceding the interlocutory judgment alone requires the conclusion that claim 16 was not infringed, or if infringed, was not valid.

If we are mistaken in our contention that this conclusion can rest upon the earlier record standing by itself, it plainly is required by the entire record. And we submit that, in the circumstances of this case, the evidence which was required to determine the accounting issue may be, and should have been, considered by the court below upon the questions of validity and infringement. Since the question of the propriety of considering the evidence in the accounting proceeding turns upon the peculiarities of the development of this case, we shall first describe the course of events giving rise to the procedural problem.

The parties had stipulated that the first hearing be limited to the issues of validity and infringe-

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[32] This alone would warrant reversal of the judgment under Section 3 (b) of the Act of February 13, 1925, as amended (see Appendix, p. 51, *infra*). Even before the amendment of May 22, 1939, § 3 (b) of the 1925 Act authorized this Court to "review, in addition to other questions of law, errors assigned to the effect that an ultimate finding or findings are not sustained by the findings of evidentiary or primary facts; or that there is a failure to make any finding of fact on a material issue."

ment, pursuant to Rule 39 of the Court of Claims which provides:

> In any patent suit it shall be competent for the parties to stipulate that the hearing in the first instance be limited to the issues of validity and infringement and when no such stipulation can be reached by the parties the court may order such procedure to be followed.
>
> If the patent is held valid and infringed by the United States the court shall so adjudge and the case shall thereafter proceed according to law.

At the first hearing, the operation and result of claim 16 were not brought out by either party, since both parties were proceeding on the assumption—plainly evident from the course of the hearing and the questions propounded to the expert witnesses—that claim 16 would stand or fall with the other six claims covering the receiver which the court below held to be invalid for anticipation. Claim 16 was a relatively minor aspect of these seven receiver claims, and was not given particular emphasis by either side (see n. 20, p. 21, *supra*) until the interlocutory judgment held that it alone out of the fifteen Marconi claims was valid and infringed. At the accounting, of course, both parties gave much more detailed attention to claim 16 and to the arrangement in the Govern-

ment's receivers alleged to infringe, as well as to similar devices in the prior art.[33]

After the first hearing, the court below rendered a judgment on November 4, 1935, holding claim 16 of the Marconi patent valid and infringed, but expressly reserving final judgment "until the amount of reasonable compensation for damages or profits is determined in accordance with the stipulation of the parties" (I R. 75).

The court below made findings of fact, but made no findings, either evidentiary or ultimate, concerning the mode of operation and results of Marconi's and the Government's arrangement to support its conclusion of infringement. And upon the assumption that this was due to the absence of evidence upon which such findings could be made, the conclusion as to infringement can be justified only as a preliminary or interlocutory determination prior to the accounting proceeding, and subject to reconsideration upon the final judgment after a full development of the evidence of infringement.

At the accounting proceedings, in order to establish the amount of compensation to which

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[33] The Commissioner of the Court of Claims who reported proposed findings of fact to the court at the conclusion of the first hearing, specifically mentioned the absence of evidence in the record as to the mode of operation and result of the condenser described in Claim 16. *Record Ct. Cl.* No. 33,642, Proposed Finding of Fact LXII, June 26, 1933, p. 2216.

the plaintiff was entitled, plaintiff adduced evidence to show the advantages derived by the Government from its alleged use of the device disclosed in claim 16. In order to establish a basis for a proper apportionment of value, evidence was then introduced by the Government to show that the proven advantages were derived not from the Marconi arrangement but from the Fessenden and Pupin prior art disclosures. These advantages necessarily inhered in the mode of operation and the results attained by the devices involved, and to justify their inclusion in the award, their attribution to the Marconi claim was of course requisite. Consequently, evidence was fully developed at the accounting proceedings showing the actual operation and effect of the condenser arrangements disclosed by Marconi, and Pupin and Fessenden, and of that which was employed in the Government's receivers.

At the close of the accounting proceedings, and upon the basis of the entire record, the Government requested the court to make numerous evidentiary findings of fact as to the mode of operation of the Marconi and the Government's devices and of the devices disclosed by Pupin and Fessenden,[34] and also requested the ultimate finding that—

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[34] Defendant's exceptions to the commissioner's report on the accounting (Record in C. Cls. No. 33642, pp. 4719–4799).

> the mode of connecting the primary condenser in parallel with the antenna-to-earth capacity used by the defendant followed the disclosure of [Pupin and Fessenden], and hence does not infringe the Marconi claim 16 which is based upon a different arrangement, operating in a different manner to obtain a different result.[32]

The court, however, declined to make any additional findings on the issues of validity and infringement, holding that the—

> question of infringement of Marconi claim 16 by the apparatus designated in Finding LXIII of the prior decision is not before us in the present accounting. In order to forestall further controversy, however, we have found validity and infringement as an ultimate fact (Findings 1 and 23) in our special findings of fact. (I R. 176.)

The court further stated in its opinion that its original decision "established the scope of claim 16 when it held the same infringed," and that the

> sole purpose and function of an accounting in a patent infringement case is to ascertain the amount of compensation due, and no other issue can be brought into the accounting to change or alter the court's prior decision. (I R. 177.)

In failing to make the requisite evidentiary findings of fact to support its conclusions as to

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[32] Record in C. Cls. No. 33642, p. 4799.

validity and infringement, and in declining to consider the evidence adduced at the accounting proceeding bearing upon these issues, we believe the court below was in error. The judgment of November 4, 1935, was interlocutory in nature, the court below having expressly reserved final judgment until after the accounting I R. 75; consequently, the court had full power to modify it in order to accord with the entire record at the close of the proceedings. A decree holding a patent to be valid and infringed and ordering an accounting proceeding before a master is not a final decree, but merely interlocutory, even though accompanied by a permanent injunction. *John Simmons Co.* v. *Grier Bros. Co.*, 258 U. S. 82; see *McGourkey* v. *Toledo & O. C. Ry.*, 146 U. S. 536, 545.[38] Consequently, the court may modify such a decree after the accounting proceedings, in rendering final

[38] While there was originally no right to appeal from an interlocutory decree of a federal court holding a patent valid and infringed and referring the matter to a master for an accounting (*Barnard* v. *Gibson*, 7 How. 649; *Humiston* v. *Stainthorp*, 2 Wall. 106), the Act of March 3, 1911, as amended (28 U. S. C. § 227a), now permits appeals from such decrees. Similarly, an interlocutory judgment of validity and infringement by the Court of Claims is reviewable prior to the accounting proceedings on a writ of certiorari from this Court. *United States* v. *Esnault-Pelterie*, 299 U. S. 201; 303 U. S. 26. But review at this stage is permissive only; and defendant may wait until final judgment, as in the case at hand. This also holds true in the district courts. *Bingham Pump Co.* v. *Edwards*, 118 F. (2d) 338 (C. C. A. 9).

judgment. *Bingham Pump Co.* v. *Edwards*, 118 F. (2d) 338 (C. C. A. 9); see *John Simmons Co.* v. *Grier Bros. Co.*, 258 U. S. 82, 88, 89; *Individual Drinking Cup Co.* v. *Errett*, 297 Fed. 733, 741 (C. C. A. 2); *David Bradley Manuf'g Co.* v. *Eagle Manuf'g Co.*, 57 Fed. 980, 985 (C. C. A. 7), certiorari denied 154 U. S. 500; *Bassick Mfg. Co.* v. *Larkin Automotive Parts Co.*, 23 F. (2d) 92 (D. C. N. D. Ill); *cf. McGourkey* v. *Toledo & O. C. Ry.*, 146 U. S. 536 (mortgage foreclosure); *Perkins* v. *Fourniquet*, 6 How. 206, 208 (distribution of property to heirs).

The reason and policy underlying these principles make them as fully applicable to a patent proceeding in the Court of Claims where an accounting involving such judicial questions as apportionment and evaluation follows a preliminary determination as to validity and infringement, and requires further proceedings in the Court of Claims upon such questions. *Cf. McGourkey* v. *Toledo & O. C. Ry.*, 146 U. S. 536, 545. Since the Court of Claims retained power to modify its preliminary determination as to validity and infringement, and since the record before the court on the accounting clearly contained evidence requiring a finding of nonfringement (i. e., differences in mode of operation and result), the court below erred in considering itself bound by its initial and preliminary judgment as to validity and infringement.

This conclusion is not inconsistent with the conceded general rule that the court's power to modify

an interlocutory conclusion does not justify the master or commissioner in admitting, in the accounting proceedings, evidence designed *solely* to attack the court's interlocutory holding of validity and infringement. *Flat Slab Patents Co.* v. *Turner,* 285 Fed. 256 (C. C. A. 8), certiorari denied 262 U. S. 752. For the very existence of the power to modify assumes that evidence or other matter bearing upon the validity of the interlocutory order may subsequently come to the court's attention and justify modification of that order. *Cf. John Simmons Co.* v. *Grier Bros. Co.,* 258 U. S. 82; *Bingham Pump Co.* v. *Edwards,* 118 F. (2d) 338 (C. C. A. 9). This case squarely presents the occasion for the exercise of that power, because the very issues left for ultimate judicial determination after the interlocutory judgment required the consideration of evidence which demonstrated the error in the earlier conclusion.

Point IV

The Court of Claims erroneously adopted as a basis of compensation advantages attained by the Government's receivers, but not attainable by Marconi's device

After its interlocutory judgment of November 4, 1935, holding claim 16 valid and infringed, the court below ordered an accounting proceeding to be held before a Commissioner, in order to determine the "reasonable and entire compensation" to which the plaintiff was entitled under the Act of June 25, 1910, as amended (I R. 75; see Appendix, pp. 51, 52). In the accounting pro-

ceeding, the Commissioner found it necessary to employ, as the basis for compensation, the value of the advantages contributed to the Government structures by the subject matter of Marconi claim 16, measured for the most part by the cost of obtaining such advantages through alternative constructions. The court below adopted this basis (I R. 180–181). It thus became necessary first to determine what advantages were derived from the Marconi contribution, as distinguished from the contributions of others.

Plaintiff proved, and the court correctly found (Findings 29, 30; I R. 143–144), that *defendant's* arrangement of the condenser in its circuit (1) increased the wavelength range of the receiver; (2) saved the space and weight of additional loading coils; and (3) increased the current in the primary coil of the oscillation transformer, thus improving sensitivity. Plaintiff made no effort to show that the arrangement disclosed by Marconi's patent had any of these advantages. Defendant then introduced evidence showing that the condenser arrangement disclosed by Marconi had none of these advantages;[37] and that on the

[37] Marconi's arrangement of the condenser, as explained above in detail, put it in series with the antenna-to-earth capacity where it could not operate to increase the wavelength range of the receiver. Marconi actually increased his wavelength range by using additional loading coil q' (see n. 39, p. 47, *infra*, and compare tunes 3 and 4 in the table on page 4 of the Marconi patent) and thus did not save the space and weight of these additional coils. Again, in Mar-

contrary the advantages of the Government's condenser arrangement were those realized in the same way in Fessenden's and Pupin's prior inventions.[38]

Defendant requested, both before the Commissioner and the court below, that evidentiary findings be made not only as to the advantages of the Government's condenser arrangement, but also as to whether the advantages were achieved by the arrangement disclosed by Marconi, or by the earlier arrangements of Pupin and Fessenden, as a basis for determining which of the proven advantages, if any, of defendant's structure had been derived from the Marconi disclosure. The defendant further asserted, before both Commissioner and court, that none of the proven advantages of defendant's arrangement was derived from the Marconi disclosure; hence, that even if claim 16 was valid and infringed, plaintiff was

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coni's arrangement the condenser did not operate to increase the current in the primary coil of the oscillation transformer, but on the contrary operated to reduce it to only about 2% of what it would have been in a straight series connection. (See pp. 20, 21, *supra*.)

[38] The Pupin and Fessenden patents concerned were in evidence prior to the court's interlocutory decision of November 4, 1935 (Def. Ex. U–2; Pl. Ex. 171, p. 98, *et. seq.*). These patents were prior to Marconi in point of time and disclosed the feature of defendant's arrangement alleged to infringe claim 16. Hence, as shown in Point II (pp. 24–39, *supra*), Pupin and Fessenden anticipate and invalidate the claim if it applies to defendant's arrangement.

entitled to nominal damages only (see n. 34, p. 36, *supra*).

The court below made evidentiary findings of fact as to the mode of operation and advantages of the defendant's structure, but refused to consider or make findings based on evidence adduced by the Government explaining the functions of the condenser in the Marconi arrangement and showing that the advantages of the Government's device were not contributed by the Marconi disclosure. Instead, the court used the advantages achieved by the Government's arrangement as the basis for compensation, without finding that Marconi's arrangement contributed such advantages (I R. 175–178).

It measured the value of the increased wavelength range by the cost of the additional inductance coils which would have been necessary to attain that advantage without employing the Government's condenser arrangement, and found that the cost of such additional coils would have been $56,113.17. It further found that the other minor advantages attained by the Government's arrangement of the condenser (increased sensitivity and the saving in space and weight resulting from eliminating the necessity of such extra coils) were worth $2.50 per receiver, or a total of $10,017.50. Of the total amount of $66,130.67 taken to represent the advantages of defendant's arrangement,

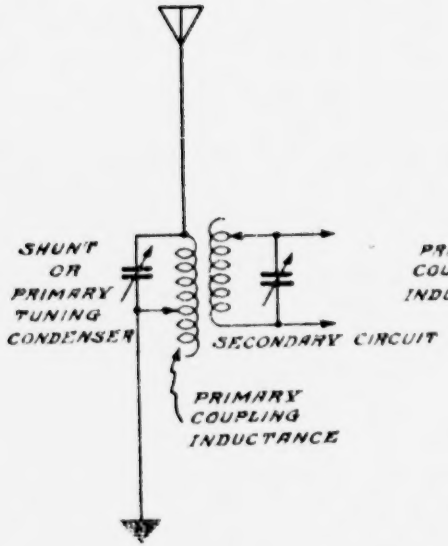
the court below allowed the plaintiff 65%, or $42,984.93 with interest thereon, advancing no explanation for the percentage selected (I R. 151–157).

We submit that in the absence of any finding—or of any evidence which would support a finding—that the evaluated advantages were contributed by plaintiff's patent, the ruling of the court below as to compensation was in error.

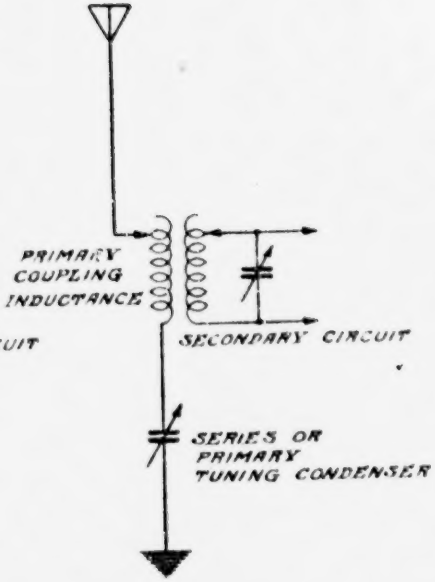
1. The court made findings as to the advantages of defendant's device only

In its final findings of fact, the court below explained (Finding 27, I R. 141–142) by means of diagrams reproduced hereafter, that with the inductance and capacity of the circuit in series with the antenna-earth capacity (middle diagram), regardless of the maximum value of the condenser, no longer wave length can be received than could be received without the condenser; and that the wave-length range can be increased by adding more inductance, as by a loading coil (right diagram), as well as by a shunt-connected condenser bridging all the inductance coils in the circuit (left diagram, called "Parallel Connection"):

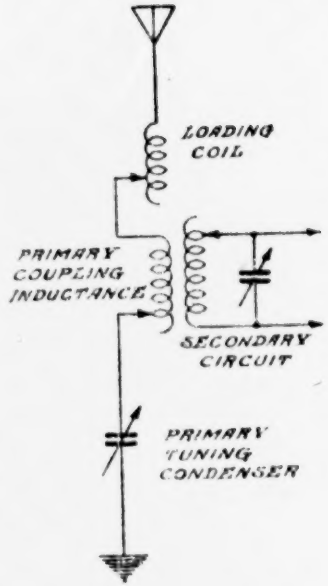
But the parallel connection shown is not the arrangement of the Marconi circuit, for it omits Marconi's adjustable inductance g' between the



PARALLEL CONNECTION



SERIES CONNECTION



SERIES CONNECTION
WITH LOADING COIL

condenser and the antenna which Marconi claimed as part of the "means for adjusting the two transformer-circuits in electrical resonance with each other," and which he stated to be "essential" (see note 7, p. 12, *supra*, and Fig. 2 of Marconi patent, page 9, *supra*). The shunt-connected condenser shown in the court's diagram is rather that of the Government's circuit, which differs in arrangement, operation, and result from that of Marconi, as shown in points I and II (pp. 12–31, *supra*).

The court below properly found that the condenser *h* in the defendant's receivers "enables the primary circuit to be tuned to the relatively longer wavelengths" when the condenser is shifted to the so-called "parallel connection" (Finding 28, I R. 143). But there is no finding nor any indication in the court's opinion that any connection of the Marconi condenser *h* "enables the primary circuit to be tuned to the relatively longer wavelengths."

The court properly attributed to defendant's arrangement the other and minor advantages of saving in space and weight and increase in sensitivity, resulting from attaining longer wavelength without additional loading coils (Findings 29, 30; I R. 143–4). But here again there is no finding, nor any indication in the court's opinion, that the arrangement of the condenser disclosed by Marconi accomplished these advantages.

2. The record shows that the advantages found for defendant's arrangement were not contributed by Marconi

As shown just above, all the advantages found for defendant's arrangement of the condenser were based on the fact that defendant's arrangement enabled longer wavelengths to be attained without the use of additional loading coils, and hence without the added cost and disadvantages of such coils; but the court made no finding that the arrangement necessary to attain these advantages was disclosed in the Marconi patent.

As shown in Point I (*supra*, pp. 12–23), Marconi arranged his condenser *h* (upon which claim 16 is based) in such a manner that it did not and could not operate to increase the wavelength, or to eliminate the necessity for additional loading coils to increase the wavelength. Indeed, when he used that condenser arrangement, he relied entirely on additional load coils to increase the wavelength.[39]

It is thus clear that Marconi's arrangement of the condenser did not attain the major advantage

[39] It will be seen from the table on page 4 of the Marconi patent that when Marconi desired to increase the wavelength of resonance of the circuit employing the condenser *h* (tunes 3 and 4) he added more loading coils *g'* (tune 4) than were used in tune 3. He did not eliminate their use. Marconi did not change the adjustment of his condenser *h* when he changed from tune 3 to tune 4 in the table on page 4 of his patent, and indeed to have done so could only have decreased the wavelength, as his condenser *h* was arranged to operate in series with the antenna-to-earth capacity. (See Point I, *supra*, p. 12–21.)

of an increased wavelength, nor the other advantages dependent on elimination of additional loading coils.[40] It follows that the advantages found for defendant's arrangement were not contributed by the Marconi disclosure.

3. The advantages of the defendant's arrangement were contributed by the earlier Pupin and Fessenden disclosures

The record shows that the advantages found to inhere in the Government's arrangement, far from being derived from Marconi, were in fact attributable to the disclosures of Pupin and Fessenden, which were prior to Marconi.

The court below found that after Lodge's disclosure, those skilled in the art were informed that the laws of resonance set forth in Pupin's patent were applicable to the so-called open antenna-circuits of wireless apparatus.[41] And as shown in Point II, above, the Pupin patent and the patent to Fessenden both showed, prior to Marconi's patent, the arrangement of the condenser in parallel with the antenna-to-earth capacity, as it was employed by defendant. This arrangement, by the laws of resonance known prior to Marconi's contribution,[42] caused the condenser capacity to be

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[40] Moreover, as shown under Point I, Marconi's arrangement served to decrease the current in the coupling coil *j'* as compared to that in the antenna, and not to increase the current in the coil, as did defendant's arrangement (p. 20, *supra*).

[41] Finding XXXVI, I R. 29–30. Indeed, the Pupin patent itself had so indicated (see quotation from Pupin patent, p. 27, *supra*).

[42] Finding XXXVI, I R. 29–30.

added to the antenna-to-earth capacity, thus (as compared to a circuit having no such condenser) both increasing the wave length and increasing the current in the primary coil of the transformer, all without the necessity of additional loading coils.

Since these earlier patents contributed the advantages found by the court below, and did so by the same means as were used by defendant, these advantages could not have been contributed by Marconi's disclosure, as they had already been disclosed to the art.

4. The court below contravened settled rules of law governing apportionment in patent accounting

It is settled that a plaintiff in infringement is entitled to recover from the defendant only the value contributed by his patented device. *Dowagiac Mfg. Co.* v. *Minneapolis Moline Plow Co.*, 235 U. S. 641; *Westinghouse Co.* v. *Wagner Co.*, 225 U. S. 604, 615; *cf. Sheldon* v. *Metro-Goldwyn Pictures Corp.*, 309 U. S. 390; *Mason* v. *Graham*, 23 Wall. 261, 277; *Egry Register Co.* v. *Standard Register Co.*, 23 F. (2d) 438 (C. C. A. 6).

As we have shown, the advantages of longer wavelength range and greater sensitivity in the Government's receivers, insofar as derived from the condenser arrangement in question, were contributed not by Marconi's disclosure upon which claim 16 is based, but exclusively by Pupin, Fessenden, and the Government. Since it had no part in creating these advantages, Marconi's patent can furnish no basis for any participation in

their value. In holding otherwise, the court below contravened the settled rules of accounting in infringement proceedings.

CONCLUSION

For the foregoing reasons the judgment of the Court of Claims with respect to claim 16 of the Marconi patent 763,772 should be reversed.

Respectfully submitted.

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FEBRUARY 1943.

APPENDIX

The Act of June 25, 1910, c. 423, 36 Stat. 851 (35 U. S. C. § 68), provided:

> That whenever an invention described in and covered by a patent of the United States shall hereafter be used by the United States without license of the owner thereof or lawful right to use the same, such owner may recover reasonable compensation for such use by suit in the Court of Claims: * * * *Provided further*, That in any such suit the United States may avail itself of any and all defenses, general or special, which might be pleaded by a defendant in an action for infringement, as set forth in Title Sixty of the Revised Statutes, or otherwise * * *.

This was amended by the Act of July 1, 1918, c. 114, 40 Stat. 704, to read as follows:

> That whenever an invention described in and covered by a patent of the United States shall hereafter be used or manufactured by or for the United States without license of the owner thereof or lawful right to use or manufacture the same, such owner's remedy shall be by suit against the United States in the Court of Claims for the recovery of his reasonable and entire compensation for such use and manufacture: * * * *Provided further*, That in any such suit the United States may avail itself of any and all defenses, general or special, that might be pleaded by a defend-

> ant in an action for infringement, as set forth in title sixty of the Revised Statutes, or otherwise * * *.

Section 3 of the Act of February 13, 1925, c. 229, 43 Stat. 936, 939, as amended by the Act of May 22, 1939, c. 140, 53 Stat. 752 (28 U. S. C. § 288*b*), provides:

> (b) In any case in the Court of Claims, including those begun under section 180 of the Judicial Code, it shall be competent for the Supreme Court, upon the petition of either party, whether Government or claimant, to require, by certiorari, that the cause be certified to it for review and determination of all errors assigned, with the same power and authority, and with like effect, as if the cause had been brought there by appeal. In such event, the Court of Claims shall include in the papers certified by it the findings of fact, the conclusions of law, and the judgment or decree, as well as such other parts of the record as are material to the errors assigned, to be settled by the Court.
>
> The Court of Claims shall promulgate rules to govern the preparation of such record in accordance with the provisions of this section.
>
> In such cases the Supreme Court shall have authority to review, in addition to other questions of law, errors assigned to the effect that there is a lack of substantial evidence to sustain a finding of fact; that an ultimate finding or findings are not sustained by the findings of evidentiary or primary facts; or that there is a failure to make any finding of fact on a material issue.

U. S. GOVERNMENT PRINTING OFFICE 1943

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DEC 4
CHARLES ELMORE CROPLEY

IN THE

Supreme Court of the United States

OCTOBER TERM, 1942

No. 373

THE UNITED STATES,
Cross-Petitioner,

v.

MARCONI WIRELESS TELEGRAPH COMPANY OF AMERICA,
Cross-Respondent.

BRIEF FOR CROSS-RESPONDENT IN OPPOSITION TO CROSS-PETITION FOR WRIT OF CERTIORARI

ABEL E. BLACKMAR, JR.,
RICHARD A. FORD,
Counsel for Cross-Respondent.

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Statement

A considerable number of the statements set forth in cross-petitioner's petition and argument are controverted by cross-respondent (plaintiff).[1] Reference is made to plaintiff's brief in support of its own petition (in case No. 369) and to the argument herein, for statements of plaintiff's position on some of these points.

For purposes of the cross-petition, we desire to call this Court's attention to the following additional facts:

The case was originally heard before the Court of Claims under a stipulation "that the issue of reasonable

[1] To avoid confusion, we will hereinafter refer to the parties as "plaintiff" and "defendant", rather than as "cross-respondent" and "cross-petitioner".

compensation or damages and profits be postponed until the *determination* by the court of the issues of validity and infringement of the various patents in suit.'"[2] (Finding LXXXIII of November 4, 1935; R., pp. 74-75.) Following this stipulation, the 1935 interlocutory judgment of the Court of Claims held that claim 16 of Marconi patent No. 763,772 was valid and had been infringed and that plaintiff was entitled to compensation for defendant's use of the subject matter thereof. (R., p. 75.) Defendant made no motion for a new trial with respect to this decision; recognized, in statements made to the Court of Claims, that the claim had been held valid and infringed; and permitted plaintiff to expend a large amount of time and money to prove the amount of compensation to which the Court of Claims had held that it was entitled.

In the course of the accounting proceeding, defendant, on the supposed issue that certain radio receivers not specifically covered by the interlocutory decision of the court below differed from those named therein as infringing devices,[3] offered a large amount of highly technical and, in a number of respects, contradictory evidence which, it now appears, was in reality directed to the issues of validity and infringement. This testimony (together with some offered on behalf of the plaintiff) appears at pages 2313 to 2522 of the transcript of record.

As these issues of validity and infringement had already been determined by the Court of Claims, in accordance with the stipulation of the parties, plaintiff was not called upon to meet this new evidence directed to these issues. For the reasons stated by the court below in its opinion (R.,

---

[2] Emphasis throughout this brief is ours.

[3] This issue was later shown, and is now recognized by defendant, to have been false.

pp. 175-178), this evidence had no place in the record on the accounting proceeding: it would have been excluded by the Commissioner if offered for the purpose for which defendant now seeks to use it, namely, to secure a reversal of the interlocutory decision of validity and infringement.

On the final hearing before the Court of Claims, defendant devoted a large share of its argument and briefs to the question of whether the interlocutory judgment of that court, holding that claim 16 was valid and had been infringed by defendant, was correct. The argument was based (as is the argument before this Court) almost entirely on evidence submitted by defendant on the accounting proceeding.[4]

Summary of Argument

Plaintiff submits: (1) that a review by this Court of the decision of the court below with respect to other claims of Marconi patent No. 763,772 will give no occasion for a review of the decision with respect to claim 16 of that patent; (2) that, under the circumstances of the present case, the issues of validity and infringement of claim 16 must be determined on the evidence that was before the court below when it decided those issues in its interlocutory judgment, or, in the alternative, the case should be remanded for additional evidence and findings; (3) that there was no error in the decisions below with respect to that claim; and (4) that those decisions involve no conflict with prior decisions of this or other courts.

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[4] The only testimony on the original trial to which defendant now refers in support of its argument is that of Waterman (R., pp. 357-358) and Loftin (R., p. 977). Neither of these references supports defendant's present argument. (See pp. 7-8, *infra*.)

ARGUMENT

POINT I

A Review of the other Claims of the Marconi Patent will Give no Occasion for a Review as to Claim 16

Neither of the reasons set forth by plaintiff in its petition in case No. 369 for this Court's reviewing the decision below with respect to the other claims of Marconi patent No. 763,772 applies to the decision that claim 16 was valid and infringed. This decision was not in conflict with prior decisions: it was in accord with them (see Point IV, *infra*). Furthermore, to reduce or take away plaintiff's recovery for defendant's use of the subject matter of that claim would not alleviate the failure of justice: it would aggravate it.

Defendant suggests that a review of the other claims would involve a consideration of claim 16 "so far as it covers four-circuit tuning" (cross-petition, p. 11). However, claim 16 has an added feature (the parallel condenser), not present in any other claim, and is a specific claim differing from all the others in this respect. As the court below held that that feature distinguished the claim from those broadly directed to "four-circuit tuning", a review of the correctness of the decision as to the other claims would not involve consideration of this distinguishing feature of claim 16.

POINT II

It would be Contrary to Orderly Practice to Review, on the Basis of Evidence Adduced by Defendant on the Accounting Proceeding, the Decision of the Court of Claims as to Validity and Infringement of Claim 16

In accordance with usual practice in equity cases, as embodied in Rule 39 of the Court of Claims, and in ac-

cordance with the stipulation of the parties, entered into pursuant to that Rule (see pp. 1-2, *supra*), the issues of validity and infringement of claim 16 were determined by the interlocutory judgment of the Court of Claims. In the absence of a reopening of these issues by the trial court, plaintiff was entitled to consider that the issues were no longer open before that court.

Although the doctrine of "law of the case" is only a rule of practice and the Court of Claims had the power to reconsider the issues, yet the rules of that court (providing for a stipulation such as was here entered into and also for a timely motion for a new trial and amendment of the findings) specify the practice to be followed for the redetermination of issues once decided and show clearly that it is the practice of that court to *determine* the issues of validity and infringement before ordering an accounting to ascertain the extent of plaintiff's damages.[5]

If defendant had desired to submit additional evidence on those issues or reargue the question, the proper procedure would have been to make a motion for a new trial and for amendment of the findings. No such motion was made. Instead, defendant chose to offer *new* evidence on issues already determined and to offer it on the accounting

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[5] Rule 39 of the Court of Claims and the pertinent part of Rule 91 are set forth in the Appendix (*infra*, p. 11).

This practice, as to the finality of interlocutory judgments on the issues of validity and infringement of a patent, is not confined to the Court of Claims. See *Flat Slab Patents Co.* v. *Turner*, 285 Fed. 257, 273 (C. C. A., 8th Circ.; certiorari denied, 262 U. S. 752); *Timius Olsen Co.* v. *Baldwin-Southwark Corp.*, 25 F. Supp. 885, 886.

proceeding—thereby avoiding the necessity of applying to the court for permission to place such evidence before it.[6]

(a) We respectfully submit that it would be a dangerous precedent to consider here the evidence adduced on the accounting proceeding and thus to approve the procedure adopted by defendant. If the issues determined by an interlocutory decree can be attacked before a referee or master in the same case, without permission of the court which entered the decree, the very purpose of interlocutory decrees and of subsequent references to referees or masters to determine subsidiary questions would be undermined and the function of interlocutory decrees largely nullified.

(b) If the findings of the Court of Claims that claim 16 of Marconi patent No. 763,772 was valid and infringed are not to be accepted by this Court, then, we submit, there are two considerations which should require this Court to remand the case to the lower court for additional evidence and findings on these issues. These two considerations are as follows:

(1) As defendant assigns as error the alleged failure of the Court of Claims to make certain findings of fact (Cross-petition, p. 10), and as it is not the function of this Court to make basic findings of fact, the case should be remanded for such findings. *Seminole Nation* v. *United States*, 316 U. S. 286, 300.

(2) As plaintiff properly considered that the issues of validity and infringement of claim 16 were closed, it made no real effort to meet the new evidence which defendant now seeks to use to secure a reversal of the interlocutory

[6] As stated above, the evidence was offered and admitted before the Commissioner on the accounting proceeding on a theory later admitted to be without foundation.

judgment. If such evidence were now to be considered on the issues of validity and infringement, it would mean that those issues would be determined on evidence adduced by defendant to which plaintiff has not replied in full.

We respectfully submit, however, that the questions involved with respect to claim 16, both as to validity, infringement, and recovery, are not of sufficient public or legal importance to warrant the additional time, labor, and money that would necessarily be involved, both before this Court and before the Court of Claims, either in a review or a remand of these issues.[7]

POINT III

There was no Error in the Decision of the Court of Claims in so far as Defendant Seeks Review Thereof

The only evidence to which defendant refers, that was before the Court of Claims when it held that claim 16 of the Marconi patent was valid and infringed, is that of Waterman (R., pp. 357-358) and Loftin (R., p. 977). (Cross-petition, p. 8.) All that Waterman there said was that the parallel condenser of the patent "has no important or modifying effect on the *general mode of operation*",— *i. e.*, on the tuning of the four circuits together.[8] All that Loftin said was that the parallel condenser was an arrangement "used in *tuning* the antenna or open circuit through vary-

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[7] In this connection, it should be remembered both that the decision is in accord with prior decisions on that claim (see Point IV, *infra*), and that the patent has expired so that plaintiff will not hereafter be able to assert this claim against any other party.

[8] The testimony on R., p. 358 deals with the condenser *h'*, which is in a different circuit.

ing the effect of the coil of the winding which it shunts" and that it was "one of the 'empirical' methods employed by the art." Neither of these statements either supports or suggests defendant's present argument as to the mode of operation of the Marconi circuit.

Defendant fails to refer to Water man's testimony (R., pp. 356-357, 389-390) that the parallel condenser is inserted "as a further means of tuning the circuit", and that the parallel connection of the antenna tuning condenser in defendant's receivers shown in Plaintiff's Exhibits 79 and 95 constituted the arrangement of Figure 2 of the Marconi patent—the figure upon which claim 16 was based. These statements were not controverted by any of defendant's witnesses. They were accepted by the Court of Claims and infringement of that claim by those receivers was found (Finding LXIII, R., p. 60).

The Fessenden and Pupin patents, primarily relied upon before this Court by the defendant, were both introduced in evidence prior to the interlocutory judgment.[2] But defendant did not *then* consider these patents of sufficient importance with respect to claim 16 to attempt to show, either by testimony or by argument, that they invalidated or limited the scope of the claim.

On the other hand, defendant's witness Stone (whose early disclosures were held by the Court of Claims to have invalidated the *other* claims of this Marconi patent) said (R., pp. 819-820):

> "The first *very clear and complete exhibition* of the use of a continuously variable tuning condenser in shunt to the primary of a transformer in a wireless telegraph receiver, so far as I am aware, is contained

[2] The Fessenden patent No. 706,735 was a part of plaintiff's Exhibit 171 and the Pupin patent No. 640,516 was defendant's Exhibit U-2.

in the specifications and drawings of the English patent to Marconi, No. 7777, of 1900."

This English patent[10] referred to by Stone corresponded with Marconi's United States patent No. 763,772 and Figure 2 thereof was identical with Figure 2 of the American patent. The shunt condenser described by Stone constitutes the distinguishing feature of claim 16.

We respectfully submit that, on the basis of the record before the Court of Claims, there was no error in its decision that claim 16 of Marconi patent No. 763,772 was valid and infringed.

POINT IV

There is no Conflict, as to Claim 16, between the Decisions of the Court of Claims and Prior Decisions of this or other Courts

As all prior courts which had considered the validity and infringement of claim 16 had held the claim valid and, with one exception, infringed,[11] the decision of the Court of Claims was not in conflict with any of these prior decisions.

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[10] Plaintiff's Exhibit 34, included in the exhibits certified as incorporated in the findings of the court below.

[11] See the cases cited at pages 4-5 of our petition in case No. 369. The exception, as to infringement, is *Marconi Wireless Telegraph Company* v. *Kilbourne & Clark Mfg. Co.*, in the Ninth Circuit. (See our petition for certiorari, p. 5, and supporting brief, pp. 16-17, 28.) In that case, claim 16, together with all the other claims in suit of the Marconi patent, was held valid but not infringed—not for the reason here urged by defendant, but because, in that court's opinion, the apparatus there claimed to infringe did not utilize the principle of four-circuit tuning.

The Court of Claims found (R., p. 139; Finding 24) that

> "The adjustable condenser in such a circuit [the circuit of defendant's receivers] had the function and effect similar to that possessed by the adjustable condenser of the Marconi patent * * * and was for the purpose of varying the periodicity of the primary circuit with which it was associated."

The Court below, therefore, *followed* the settled rule for determining the issue of infringement, as established in the cases cited by defendant in the footnotes on page 12 of its cross-petition, and in a host of other cases.

As to the cases cited by defendant in its third Reason for Granting the Writ (cross-petition, p. 13), the decision of the court below, on the measure of plaintiff's compensation, is not in conflict therewith but, rather, follows the principle, repeatedly set forth by this Court,[12] that a patentee is entitled to the benefit of all advantages which flow from his invention, whether or not such advantages are set forth in his patent and whether or not they were appreciated by the patentee.

CONCLUSION

It is therefore respectfully submitted that defendant's cross-petition for a writ of certiorari herein should be denied.

Respectfully submitted,

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RICHARD A. FORD,
Counsel for Cross-Respondent.

December, 1942.

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[12] See *Radio Corporation* v. *Radio Engineering Laboratories*, 293 U. S. 1, 14; *Corona Co.* v. *Doran Co.*, 276 U. S. 358, 369; *Roberts* v. *Ryer*, 91 U. S. 150, 157.

Appendix

Rule 39 of the Court of Claims

In any patent suit it shall be competent for the parties to stipulate that the hearing in the first instance be limited to the issues of validity and infringement and when no such stipulation can be reached by the parties the court may order such procedure to be followed.

If the patent is held valid and infringed by the United States the court shall so adjudge and the case shall thereafter proceed according to law.

Extract from Rule 91 of the Court of Claims

Whenever either party desires to question the correctness or the sufficiency of the court's conclusions on its findings of fact or to amend the same, the complaining party shall file a motion which shall be known as a motion for a new trial. * * * Motions for new trial, except as provided by section 175 of the Judicial Code (U. S. Code, title 28, sec. 282), shall be filed within 60 days from the time the judgment of the court is announced.

SUPREME COURT OF THE UNITED STATES.

Nos. 369, 373.—October Term, 1942.

369	Marconi Wireless Telegraph Company of America, Petitioner, *vs.* The United States.	On Writs of Certiorari to the Court of Claims.
373	The United States, Petitioner, *vs.* Marconi Wireless Telegraph Company of America.	

[June 21, 1943.]

Mr. Chief Justice Stone delivered the opinion of the Court.

The Marconi Company brought this suit in the Court of Claims pursuant to 35 U. S. C. § 68, to recover damages for infringement of four United States patents. Two, No. 763,772, and reissue No. 11,913, were issued to Marconi, a third, No. 609,154, to Lodge, and a fourth, No. 803,684, to Fleming. The court held that the Marconi reissue patent was not infringed. It held also that the claims in suit, other than Claim 16, of the Marconi patent No. 763,772, are invalid; and that Claim 16 of the patent is valid and was infringed. It gave judgment for petitioner on this claim in the sum of $42,984.93 with interest. It held that the Lodge patent was valid and infringed, and that the Fleming patent was not infringed and was rendered void by an improper disclaimer. The case comes here on certiorari, 317 U. S. 620, 28 U. S. C. § 288(b), on petition of the Marconi Company in No. 369, to review the judgment of the Court of Claims holding invalid the claims in suit, other than Claim 16, of the Marconi patent, and holding the Fleming patent invalid and not infringed, and on petition of the Government in No. 373, to review the decision allowing recovery for infringement of Claim 16 of the Marconi patent. No review was sought by either party of so much of the court's judgment as sustained the Lodge patent and held the first Marconi reissue patent not infringed.

Marconi Patent No. 763,772.

This patent, granted June 28, 1904, on an application filed November 10, 1900, and assigned to the Marconi Company on March 6, 1905,[1] is for improvements in apparatus for wireless telegraphy by means of Hertzian oscillations or electrical waves. In wireless telegraphy, signals given by means of controlled electrical pulsations are transmitted through the ether by means of the so-called Hertzian or radio waves. Hertzian waves are electrical oscillations which travel with the speed of light and have varying wave lengths and consequent frequencies intermediate between the frequency ranges of light and sound waves. The transmitting apparatus used for sending the signals is capable, when actuated by a telegraph key or other signalling device, of producing, for short periods of variable lengths, electrical oscillations of radio frequency (over 10,000 cycles per second) in an antenna or open circuit from which the oscillations are radiated to a distant receiving apparatus. The receiver has an open antenna circuit which is electrically responsive to the transmitted waves and is capable of using those responses to actuate by means of a relay or amplifier any convenient form of signalling apparatus for making audible an electrically transmitted signal, such as a telegraph sounder or a loud speaker. In brief, signals at the transmitter are utilized to control high frequency electrical oscillations which are radiated by an antenna through the ether to the distant receiver and there produce an audible or visible signal.

All of these were familiar devices at the time of Marconi's application for the patent now in suit. By that time radio had passed from the theoretical to the practical and commercially successful. Four years before, Marconi had applied for his original and basic patent, which was granted as No. 586,193, July 13, 1897 and reissued June 4, 1904, as reissue No. 11,913. He applied for his corresponding British patent, No. 12039 of 1896, on June 2, 1896. Marconi's original patent showed a two-circuit system, in which the high-frequency oscillations originated in the transmitter antenna circuit and the detecting device was connected directly in the receiver antenna circuit. Between 1896 and 1900 he demonstrated on numerous occasions the practical success of

[1] On November 25, 1919, The Marconi Company assigned to the Radio Corporation of America all of its assets, including the patents here in suit, but reserved, and agreed to prosecute, the present claims against the United States, on which it had instituted suit on July 29, 1916.

his apparatus, attaining successful transmission at distances of 70 and 80 miles. During those years he applied for a large number of patents in this and other countries for improvements on his system of radio communication.[2]

The particular advance said to have been achieved by the Marconi patent with which we are here concerned was the use of two high frequency circuits in the transmitter and two in the receiver, all four so adjusted as to be resonant to the same frequency or multiples of it. The circuits are so constructed that the electrical impulses in the antenna circuit of the transmitter vibrate longer with the application to the transmitter of a given amount of electrical energy than had been the case in the previous structures known to the art, and the selectivity and sensitivity of the receiver is likewise enhanced. Thus increased efficiency in the transmission and reception of signals is obtained. The specifications of the Marconi patent state that its object is "to increase the efficiency of the system and to provide new and simple means whereby oscillations of electrical waves from a transmitting station may be localized when desired at any one selected receiving station or stations out of a group of several receiving-stations."

The specifications describe an arrangement of four high frequency circuits tuned to one another—two at the sending station associated with a source of low frequency oscillations, and two at the receiving station associated with a relay or amplifier operating a signalling device. At the sending station there is an open antenna circuit which is "a good radiator", connected with the secondary coil of a transformer, and through it inductively coupled with a closed circuit, which is connected with the primary coil of the transformer, this closed circuit being a "persistent oscillator." At the receiving station there is an open antenna circuit constituting a "good absorber" inductively coupled with a closed circuit capable of accumulating the received oscillations.

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[2] See Marconi Wireless Tel. Co. *v.* National Electric Signalling Co., 213 Fed. 815, 825, 829-31; Encyclopedia Britannica (14th Ed.) vol. 14, p. 869; Dunlap, Marconi, The Man and His Wireless; Jacot and Collier, Marconi—Master of Space; Vyvyan, Wireless Over Thirty Years; Fleming, Electric Wave Telegraphy, 426-443.

Marconi was granted eight other United States patents for wireless apparatus on applications filed between the filing dates of Nos. 586,193 and 763,772. They are Nos. 624,516, 627,650, 647,007, 647,008, 647,009, 650,139, 650,140, 668,315.

The patent, in describing the arrangement of the apparatus so as to secure the desired resonance or tuning, specifies: "The capacity and self-induction of the four circuits—i. e., the primary and secondary circuits at the transmitting-station and the primary and secondary circuits at any one of the receiving-stations in a communicating system are each and all to be so independently adjusted as to make the product of the self-induction multiplied by the capacity the same in each case or multiples of each other—that is to say, the electrical time periods of the four circuits are to be the same or octaves of each other".[3] And again, "In employing this invention to localize the transmission of intelligence at one of several receiving-stations the time period of the circuits at each of the receiving-stations is so arranged as to be different from those of the other stations. If the time periods of the circuits of the transmitting-station are varied until they are in resonance with those of one of the receiving-stations, that one alone of all the receiving-stations will respond, provided that the distance between the transmitting and receiving stations is not too small".

The drawings and specifications show a closed circuit at the transmitting station connected with the primary of an induction coil, and embracing a source of electrical current and a circuit-closing key or other signalling device. The secondary of the induction coil is connected in a circuit which includes a spark gap or other producer of high frequency oscillations and, in a shunt around the spark gap, the primary coil of an oscillation transformer and a condenser, preferably so arranged that its capacity can readily be varied. This shunt circuit constitutes one of the two tuned circuits of the transmitter, and is often referred to as the closed or charging circuit. The secondary coil of the trans-

[3] Capacity is the property of an electrical circuit which enables it to receive and store an electrical charge when a voltage is applied to it, and to release that charge as the applied voltage is withdrawn, thereby causing a current to flow in the circuit. Although any conductor of electricity has capacity to some degree, that property is substantially enhanced in a circuit by the use of a condenser, consisting of two or more metal plates separated by a non-conductor, such that when a voltage is applied to the circuit one plate will become positively and the other negatively charged.

Self-inductance is the property of a circuit by which, when the amount or direction of the current passing through it is changed, the magnetic stresses created induce a voltage opposed to the change. Although any conductor has self-inductance to some degree, that property is most marked in a coil.

See generally Albert, Electrical Fundamentals of Communication, Chs. V, VI, VII, and IX; Terman, Radio Engineering, Chs. II and III; Morecroft, Principles of Radio Communication, Chs. I, II, III; Lauer and Brown, Radio Engineering Principles, Chs. I and II.

former is connected in the open or antenna circuit, one end of which is connected with the earth, the other to a vertical wire antenna or an elevated plate. This antenna circuit also includes an induction coil, preferably one whose inductance is readily variable, located between the antenna or plate and the transformer.

The receiver consists of a similar antenna circuit connected with the primary coil of a transformer, and having a variable induction coil located between the antenna or plate and the transformer. A shunt circuit bridging the transformer and containing a condenser which is preferably adjustable may also be added. The secondary coil of the transformer is connected through one or more interposed inductance coils, "preferably a variable inductance", with the terminals of a coherer[4] or other suitable detector of electrical oscillations. The closed receiver circuit also contained one or more condensers.

The devices and arrangements specified are suitable for effecting the electrical transmission of signals in the manner already indicated. By the maintenance of the same high frequency throughout the four circuit system the cumulative resonance is attained which gives the desired increased efficiency in transmission and increased selectivity at the receiving station.

The patent describes the operation of the four circuits as follows, beginning with the transmitter:

"In operation the signalling-key *b* is pressed, and this closes the primary of the induction-coil. Current then rushes through the transformer-circuit and the condenser *c* is charged, and subsequently discharges through the spark-gap. If the capacity, the inductance, and the resistance of the circuit are of suitable values, the discharge is oscillatory, with the result that alternating currents of high frequency pass through the primary of the transformer and induce similar oscillations in the secondary, these

[4] A coherer was a device disclosed by Branly as early as 1891. It was used by Lodge in experiments described in the London Electrician for June 15, 1894, p. 189, and was in common use thereafter as a detector of radio waves until replaced by the crystal and the cathode-anode tube. The most common form consisted of a tube containing metal filings which, in their normal state, were a non-conductor. When placed in a circuit through which high frequency oscillations passed, the filings aligned themselves in a continuous stream through which the low frequency electrical current operating a key or other signalling device could pass. By means of a device which tapped the sides of the tube, the stream of filings was broken when the high-frequency oscillations ceased. Thus the coherer was a sensitive device by which weak, high-frequency signals could be made to actuate a low frequency current of sufficient power to operate a telegraphic key or other device producing a visible or audible signal.

oscillations being rapidly radiated in the form of electric waves by the elevated conductor (antenna).

"For the best results and in order to effect the selection of the station or stations whereat the transmitted oscillations are to be received I include in the open secondary circuit of the transformer, and preferably between the radiator *f* and the secondary coil *d*', an inductance-coil *g*, Fig. 1, having numerous coils, and the connection is such that a greater or less number of turns of the coil can be put in use, the proper number being ascertained by experiment."

The invention thus described may summarily be stated to be a structure and arrangement of four high frequency circuits, with means of independently adjusting each so that all four may be brought into electrical resonance with one another. This is the broad invention covered by Claim 20. Combinations covering so much of the invention as is embodied in the transmitter and the receiver respectively are separately claimed.[3]

Long before Marconi's application for this patent the scientific principles of which he made use were well understood and the particular appliances constituting elements in the apparatus combination which he claimed were well known. About seventy years ago Clerk Maxwell described the scientific theory of wireless communication through the transmission of electrical energy by other waves.[4] Between 1878 and 1890 Hertz devised apparatus for achieving that result which was described by de Tunzelmann in a series of articles published in the London Electrician in 1888. One, of September 21, 1888, showed a transmitter comprising a closed circuit inductively coupled with an open circuit. The closed circuit included a switch or circuit breaker capable of use for send-

[3] Of the claims in suit in No. 369, Claims 19 and 20 cover the four circuit system, while Claims 1, 3, 6, 8, 11 and 12 cover the two transmitter circuits and Claims 2, 13, 14, 17, 18 and 19 cover the two receiver circuits. Claim 10 merely provides that the four circuits be in resonance with each other and hence does not prescribe means of adjusting the tuning. Claim 11 likewise prescribes no means of adjustment. The other claims provide means of adjustment, either a "variable inductance" (Claims 1, 2, 3, 8, 12, 13, 18, and 19) or more generally "means" for adjusting the period of the circuits (Claims 3, 6, 14 and 17). Some of the claims merely provide means of adjusting the tuning of the antenna circuit (Claims 1, 2, 8, 12, and 13) and hence do not require that the closed circuits be tuned. Others either specifically prescribe the adjustable tuning of both circuits at transmitter (Claims 3, 6, or receiver (Claims 18 and 19, or both (Claim 20), or else prescribe means for adjusting the two transformer circuits to electrical resonance with each other, substantially as described (Claims 14 and 17).

[4] Maxwell, Theory of the Electromagnetic Field, 1865, Philosophical Transactions of the Royal Society (1864), 459; 1 Scientific Papers of James Clerk Maxwell, 526.

ing signals, and an automatic circuit breaker capable, when the switch was closed, of setting up an intermittent current in the closed circuit which in turn induced through a transformer an intermittent current of higher voltage in the open circuit. The open circuit included a spark gap across which a succession of sparks were caused to leap whenever the signal switch was closed, each spark producing a series of high frequency oscillations in the open circuit.

By connecting the spark gap to large area plates in the open circuit Hertz increased the capacity and thus not only increased the force of the sparks but also changed one of the two factors determining the frequency of the oscillations in the circuit, and hence the wave length of the oscillations transmitted. Hertz's receiver was shown as a rectangle of wire connected to the knobs of a spark gap, both the wire and the spark gap being of specified lengths of such relationship as to render the circuit resonant to the wave lengths in the transmitter. At times Hertz attached to the rectangle additional vertical wires which provided additional capacity, and whose length could readily be varied so as to vary the wave lengths to which the receiver was responsive, thus providing a "method of adjusting the capacity" of the receiver.[7] Thus Hertz at the outset of radio communication recognized the importance of resonance and provided means for securing it by tuning both his transmitting and receiving circuits to the same frequency, by adjusting the capacity of each.[8]

Lodge, writing in the London Electrician in 1894, elaborated further on the discoveries of Hertz and on his own experiments along the same lines. In one article, of June 8, 1894, he discussed phenomena of resonance and made an observation which underlies several of the disclosures in Marconi's patent. Lodge pointed out that some circuits were by their nature persistent vibrators, i. e.,

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7 See The London Electrician for September 21, 1888, p. 628.

Ebert, in The London Electrician for July 6, 1894, p. 333, likewise pointed out that Hertz's receivers are "so arranged that they show the maximum resonant effect with a given exciter; they are 'electrically tuned'".

8 De Tunzelmann shows that Hertz clearly understood the principles of electrical resonance. Some of his early experiments were designed to determine whether principles of resonance were applicable to high frequency electrical circuits. From them Hertz concluded that "an oscillatory current of definite period would, other conditions being the same, exert a much greater inductive effect upon one of equal period than upon one differing even slightly from it". *Id.* p. 626. Hertz knew that the frequency to which a circuit was resonant was a function of the square root of the product of the self inductance and capacity in the circuit and by [redacted] a formula similar to that now used he calculated the approximate frequency of the oscillations produced by his transmitter. *Id.*, September 28, 1888, 664 5.

were able to sustain for a long period oscillations set up in them, while others were so constructed that their oscillations were rapidly damped. He said that a receiver so constructed as to be rapidly damped would respond to waves of almost any frequency, while one that was a persistent vibrator would respond only to waves of its own natural periodicity. Lodge pointed out further that Hertz' transmitter "radiates very powerfully" but that "In consequence of its radiation of energy, its vibrations are rapidly damped, and it only gives some three or four good strong swings. Hence it follows that it has a wide range of excitation, *i. e.*, it can excite sparks in conductors barely at all in tune with it." On the other hand Hertz' receiver was "not a good absorber but a persistent vibrator, well adapted for picking up disturbances of precise and measurable wave-length." Lodge concluded that "The two conditions, conspicuous energy of radiation and persistent vibration electrically produced, are at present incompatible." (pp. 154-5).

In 1892, Crookes published an article in the Fortnightly Review in which he definitely suggested the use of Hertzian waves for wireless telegraphy and pointed out that the method of achieving that result was to be found in the use and improvement of then known means of generating electrical waves of any desired wave length, to be transmitted through the ether to a receiver, both sending and receiving instruments being attuned to a definite wave length.[9] A year later Tesla, who was then preoccupied with the wireless transmission of power for use in lighting or for the operation of dynamos, proposed, in a lecture before the Franklin Institute in Philadelphia, the use of adjustable high frequency oscillations for wireless transmission of signals.[10]

Marconi's original patent No. 586,193, which was granted July 13, 1897, and became reissue No. 11,913, disclosed a two-circuit system for the transmission and reception of Hertzian waves. The transmitter comprised an antenna circuit connected at one end to an aerial plate and at the other to the ground, and containing a spark gap. To the knobs of the spark gap was connected a transformer whose secondary was connected with a source of current and a signalling key. The low frequency current thereby induced in the antenna circuit was caused to discharge through the spark gap, producing the high frequency oscillations which

[9] Fortnightly Review, No. 101, February, 1892, 173, 174-5.

[10] Martin, Inventions, Researches and Writings of Nikola Tesla, pp. 346-8.

were radiated by the antenna. The receiver similarly contained an antenna circuit between an elevated plate and the ground, in which a coherer was directly connected. Marconi claimed the construction of transmitter and receiver so as to be resonant to the same frequency, and described means of doing so by careful determination of the size of the aerial plates.

The Tesla patent No. 645,576, applied for September 2, 1897 and allowed March 20, 1900, disclosed a four-circuit system, having two circuits each at transmitter and receiver, and recommended that all four circuits be tuned to the same frequency. Tesla's apparatus was devised primarily for the transmission of energy to any form of energy-consuming device by using the rarified atmosphere at high elevations as a conductor when subjected to the electrical pressure of a very high voltage. But he also recognized that his apparatus could, without change, be used for wireless communication, which is dependent upon the transmission of electrical energy. His specifications declare: "The apparatus which I have shown will obviously have many other valuable uses—as, for instance, when it is desired to transmit intelligible messages to great distances . . ."[11]

Tesla's specifications disclosed an arrangement of four circuits, an open antenna circuit coupled, through a transformer, to a closed charging circuit at the transmitter, and an open antenna circuit at the receiver similarly coupled to a closed detector circuit. His patent also instructed those skilled in the art that the open and closed circuits in the transmitting system and in the receiving system should be in electrical resonance with each other. His specifications state that the "primary and secondary circuits in the trans-

[11] Tesla's specifications state that the current should preferably be "of very considerable frequency". In describing apparatus used experimentally by him, the specifications state that the oscillations are generated in the charging circuit by the periodic discharge of a condenser by means of "a mechanically operated break", a means whose effects are similar to those of the spark gap generally used at this period in the radio art. He further states that the inductance of the charging circuit is so calculated that the "primary circuit vibrates generally according to adjustment, from two hundred and thirty thousand to two hundred and fifty thousand times per second". The range of radio frequencies in use in 1917 was said by a witness for the plaintiff to extend from 30,000 to 1,500,000 cycles per second. The range of frequencies allocated for radio use by the International Telecommunication Convention, proclaimed June 27, 1934, 49 Stat. 2391, 2459, is from 10 to 60,000 kilocycles (10,000 to 60,000,000 cycles) per second, and the spectrum of waves over which the Federal Communications Commission currently exercises jurisdiction extends from 10 to 500,000 kilocycles. Code of Federal Regulations, Title 47, Ch. I, § 2.71. Thus Tesla's apparatus was intended to operate at radio frequencies.

mitting apparatus" are "carefully synchronized." They describe the method of achieving this by adjusting the length of wire in the secondary winding of the oscillation transformer in the transmitter, and similarly in the receiver, so that "the points of highest potential are made to coincide with the elevated terminals" of the antenna, i. e., so that the antenna circuit will be resonant to the frequency developed in the charging circuit of the transmitter. The specifications further state that "the results were particularly satisfactory when the primary coil or system A' and its secondary C" [of the receiver] was carefully adjusted so as to vibrate in synchronism with the transmitting coil or system AC."

Tesla thus anticipated the following features of the Marconi patent: A charging circuit in the transmitter for causing oscillations of the desired frequency, coupled, through a transformer, with the open antenna circuit, and the synchronization of the two circuits by the proper disposition of the inductance in either the closed or the antenna circuit or both. By this and the added disclosure of the two-circuit arrangement in the receiver with similar adjustment, he anticipated the four circuit tuned combination of Marconi. A feature of the Marconi combination not shown by Tesla was the use of a variable inductance as a means of adjusting the tuning the antenna circuit of transmitter and receiver. This was developed by Lodge after Tesla's patent out before the Marconi patent in suit

In patent No. 609,154, applied for February 1, 1898 and allowed August 16, 1898, before Marconi's application, Lodge disclosed an adjustable induction coil in the open or antenna circuit in a wireless transmitter or receiver or both to enable transmitter and receiver to be tuned together. His patent provided for the use, in the open circuits of a transmitter and a receiver of Hertzian waves, of a self-induction coil between a pair of capacity areas which he stated might be antenna and earth. His specifications state that a coil located as described could be made adjustable at will so as to vary the value of its self-inductance; that the adjustment, to secure the "desired frequency of vibration or syntony with a particular distant station", may be attained either "by replacing one coil by another" or by the use of a coil constructed with a movable switch so related to the coil as to short circuit, when closed, any desired number of turns of the wire, "so that the whole or any smaller portion of the inductance available may be used in accordance with the correspondingly-

attuned receiver at the particular station to which it is desired to signal". Thus Lodge adjusted his tuning by varying the self-inductance of the antenna circuits, for, as he explained, the adjustment of wave lengths, and hence of frequency in the circuits, could be made by varying either or both the inductance and capacity, which are the factors controlling wave length and hence frequency in the antenna circuits.

Lodge thus broadly claimed the tuning, by means of a variable inductance, of the antenna circuits in a system of radio communication. His specifications disclose what is substantially a two-circuit system, with one high frequency circuit at the transmitter and one at the receiver. He also showed a two-circuit receiver with a tuned antenna circuit, his detector circuit at the receiver being connected with the terminals of a secondary coil wound around the variable inductance coil in the antenna circuit and thus inductively coupled through a transformer with the antenna circuit.[12] Lodge thus supplied the means of varying inductance and hence tuning which was lacking in the Tesla patent. He also showed a receiver which completely anticipated those of the Marconi receiver claims which prescribe adjustable means of tuning only in the antenna circuit (Claims 2, 13 and 18) and partially anticipated the other receiver claims.

The Stone patent No. 714,756, applied for February 8, 1900, nine months before Marconi's application, and allowed ~~February~~ December 2, 1902, a year and a half before the grant of Marconi's patent, showed a four circuit wireless telegraph apparatus substantially like that later specified and patented by Marconi. It described adjustable tuning, by means of a variable inductance, of the closed circuits of both transmitter and receiver. It also recommended that the two antenna circuits be so constructed as to be resonant to the same frequencies as the closed circuits. This recommendation was added by amendment to the specifications made after Marconi had filed his application, and the principal question is whether the amendments were in point of substance a departure from Stone's invention as disclosed by his application.

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12 Marconi's patent No. 627,650, of June 27, 1899, similarly showed a two-circuit receiving system, in which the coherer was placed in a closed circuit which was inductively coupled with a tuned antenna circuit. The Court of Claims found, however, that this patent did not clearly disclose the desirability of tuning both circuits.

Stone's application shows an intimate understanding of the mathematical and physical principles underlying radio communication and electrical circuits in general. It contains a critical analysis of the state of the art of radio transmission and reception. He said that as yet it had not been found possible so to tune stations using a vertical antenna as to make possible selective reception by a particular station to the exclusion of others. His effort, accordingly, was to transmit a "simple harmonic wave" of well defined periodicity to a receiver which would be selectively responsive to the particular frequency transmitted, and thereby to achieve greater precision of tuning and a higher degree of selectivity.

Stone discusses in some detail the difference between "natural" and "forced" oscillations. He says "If the electrical equilibrium of a conductor be abruptly disturbed and the conductor thereafter be left to itself, electric currents will flow in the conductor which tend to ultimately restore the condition of electrical equilibrium". He points out that a closed circuit containing a condenser and a coil is "capable of oscillatory restoration of equilibrium upon the sudden discharge of the condenser" and that "the electrical oscillations which it supports when its equilibrium is abruptly disturbed and it is then left to itself are known as the *natural vibrations* or oscillations of the system."

In addition to its ability to originate "natural vibrations" when its electrical equilibrium is disturbed, Stone says that an electrical circuit is also "capable of supporting what are termed *forced vibrations*" when electrical oscillations elsewhere created are impressed upon it. In contrast to the "natural" vibrations of a circuit, whose frequency depends upon "the relation between the electro-magnetic constants [capacity and self-inductance] of the circuit", the frequency of the "forced" vibrations is "independent of the constants of the circuit" on which they are impressed and "depends only upon the period [frequency] of the impressed force." In other words, Stone found that it was possible not only to originate high-frequency oscillations in a circuit, and to determine their frequency by proper distribution of capacity and self-inductance in the circuit, but also to transfer those oscillations to another circuit and retain their original frequency.

Stone points out that in the existing systems of radio transmission the electric oscillations are "naturally" developed in the

antenna circuit by the sudden discharge of accumulated electrical force through a spark gap in that circuit. Such oscillations are "necessarily of a complex character and consist of a great variety of superimposed simple vibrations of different frequencies". "Similarly the vertical conductor at the receiving station is capable of receiving and responding to vibrations of a great variety of frequencies so that the electro-magnetic waves which emanate from one vertical conductor used as a transmitter are capable of exciting vibrations in any other vertical wire as a receiver . . . and the messages from the transmitting station will not be selectively received by the particular receiving station with which it is desireus to communicate, and will interfere with the operation of other receiving stations within its sphere of influence."

In contrast to the two circuit system whose inadequacies he had thus described, Stone's drawings and specifications disclose a four circuit system for transmitting and receiving radio waves which was very similar to that later disclosed by Marconi. The transmitter included a source of low frequency oscillating current and a telegraph or signalling key connected in a circuit which was inductively coupled with another closed circuit. This included an induction coil, a condenser, and a spark gap capable of generating high frequency oscillations. It in turn was inductively coupled through a transformer with an open antenna circuit connected to an aerial capacity at one end and the earth at the other. The receiver included a similar antenna circuit, inductively coupled with a closed oscillating circuit containing an induction coil, a condenser, and a coherer or other detector of radio waves.

Stone thus recognized, although he used different terminology, the fact, previously observed by Lodge, that an open antenna circuit, so constructed as to be an efficient radiator, was not an oscillator capable of producing natural waves of a single well-defined periodicity, and consequently had a wide range of excitation. He adopted the same remedy for this defect as Marconi later did, namely to produce the oscillations in a closed circuit capable of generating persistent vibrations of well-defined periodicity, and then induce those oscillations in an open antenna circuit capable of radiating them efficiently to a distant resonant receiver. He states that the vibrations in his closed circuit "begin with a maximum of amplitude and gradually die away", a good description of

the results obtainable by a "persistent oscillator."[13] Similarly in his receiver Stone recognized that an open antenna circuit (Lodge's "good absorber") was not a highly sensitive responder to waves of a particular frequency, and accordingly he sought to augment the selectivity of tuning at the receiver by interposing between the antenna circuit and the responding device a closed circuit which would be a more persistent vibrator and hence render the receiving apparatus more selectively responsive to waves of a particular frequency. In so doing, however, as will presently appear, he did not disregard the favorable effect on selectivity of tuning afforded by making the antenna circuits resonant to the transmitted frequency.

Stone's application recommends that the inductance coils in the closed circuits at transmitter and receiver "be made adjustable and serve as a means whereby the operators may adjust the apparatus to the particular frequency which it is intended to employ". He thus disclosed a means of adjusting the tuning of the closed circuits by variable inductance. His original application nowhere states in so many words that the antenna circuits should be tuned, nor do its specifications or drawings explicitly disclose any means for adjusting the tuning of those circuits. But there is nothing in them to suggest that Stone did not intend to have the antenna circuits tuned, and we think that the principles which he recognized in his application, the purpose which he sought to achieve, and certain passages in his specifications, show that he recognized, as they plainly suggest to those skilled in the art, the desirability of tuning the antenna circuits as well. The disclosures

[13] That the closed circuit was intended to be a "persistent oscillator" is also brought out by Stone's emphasis on "loose coupling." Stone's application explained in detail the fact that when two circuits are inductively coupled together there normally result "two degrees of freedom", that is to say, the superposition of two frequencies in the same circuit because of the effect on each of the magnetic lines of force set up by the other. He discussed in detail methods of eliminating this superposition, which interfered with accurate selectivity of tuning, by so constructing his circuits as to be "loosely coupled." This he achieved by including in the closed circuits a large inductance coil, which had the effect of "swamping" the undesirable effect of the lines of force set up in the primary of the transformer by the current induced in the secondary. Since the turns of wire in the primary of the transformer constituted a relatively small part of the total inductance in the closed circuit the effect of those turns on the frequency of the circuit was minimized.

But the testimony at the trial was in substantial agreement that the looser the coupling the slower is the transfer of energy from the closed charging circuit to the open antenna circuit. Hence the use of loose coupling presupposes a charging circuit that will store its energy for a considerable period, i. e., that will maintain persistent oscillations.

of his application were thus an adequate basis for the specific recommendation, later added by amendment, as to the desirability of constructing the antenna circuits so as to be resonant to the frequency produced in the charging circuit of the transmitter.

The major purpose of Stone's system was the achievement of greater selectivity of tuning. His objective was to transmit waves "of but a single frequency" and to receive them at a station which "shall be operated only by electric waves of a single frequency and no others". He states:

"By my invention the vertical conductor of the transmitting station is made the source of electro-magnetic waves of but a single periodicity, and the translating apparatus at the receiving station is caused to be selectively responsive to waves of but a single periodicity so that the transmitting apparatus corresponds to a tuning fork sending but a single simple musical tone, and the receiving apparatus corresponds to an acoustic resonator capable of absorbing the energy of that single, simple musical tone only."

He says that "when the apparatus at a particular [receiving] station" is properly tuned to a particular transmitting station the receiver will selectively receive messages from it. He adds:

"Moreover by my invention the operator at the transmitting or receiving station may at will adjust the apparatus at his command in such a way as to place himself in communication with any one of a number of stations . . . by bringing his apparatus into resonance with the periodicity employed."

And with respect to the transmitter he says, "It is to be understood that any suitable device may be employed to develop the simple harmonic force impressed upon the vertical wire [antenna]. It is sufficient to develop in the vertical wire practically simple harmonic vibrations of a fixed and high frequency."

These statements sufficiently indicate Stone's broad purpose of providing a high degree of tuning at sending and receiving stations. In seeking to achieve that end he not unnaturally placed emphasis on the tuning of the closed circuits, the association of which with the antenna circuits was an important improvement which he was the first to make. But he also made it plain that it was the sending and receiving "apparatus" which he wished to tune, so that the sending "apparatus" "would correspond to a tuning fork" and the receiving "apparatus" to "an acoustic resonator capable of absorbing the energy of that single simple musical tone". And this he sought to achieve by "any suitable device".

Stone thus emphasized the desirability of making the entire transmitting and receiving "apparatus" resonant to a particular frequency. As none of the circuits are resonant to a desired frequency unless they are tuned to that frequency, this reference to the transmitting and receiving apparatus as being brought into resonance with each other cannot fairly be said to mean that only some of the circuits at the transmitter and receiver were to be tuned. To say that by this reference to the tuning of sending and receiving apparatus he meant to confine his invention to the tuning of some only of the circuits in that apparatus is to read into his specifications a restriction which is plainly not there and which contradicts everything they say about the desirability of resonance of the apparatus. It is to read the specifications, which taken in their entirety are merely descriptive or illustrative of his invention, compare *Continental Paper Bag Co.* v. *Eastern Paper Bag Co.*, 210 U. S. 405, 418, 419-20, as though they were claims whose function is to exclude from the patent all that is not specifically claimed. *Mahn* v. *Harwood*, 112 U. S. 354, 361; *McClain* v. *Ortmayer*, 141 U. S. 419, 423-5; *Milcor Steel Co.* v. *Fuller*, 316 U. S. 143, 146.

Stone had pointed out that the tuning of the antenna circuits shown in the prior art did not of itself afford sufficient selectivity. It was for that reason that he used the tuned closed circuit in association with the antenna circuit. But in the face of his emphasis on the desirability of tuning the transmitting and receiving apparatus, we cannot impute to him an intention to exclude from his apparatus the well known use of tuning in the antenna circuits as an aid to the selectivity which it was his purpose to achieve. The inference to be drawn is rather that he intended the tuned closed circuits which he proposed to add to the then known systems of radio communication, to be used in association with any existing type of vertical wire antenna circuit, including one so constructed as to be either resonant to a particular frequency, or adjustably resonant to any desired frequency, both of which involved tuning.

Stone's full appreciation of the value of making all of his circuits resonant to the same frequency is shown by his suggestion to insert, between the closed and antenna circuits at the transmitter and receiver, one or more additional closed circuits, so constructed as to be highly resonant to the particular frequency

employed. He says that the purpose of such an intermediate circuit is "to weed out and thereby screen" the antenna circuit at the transmitter and the detecting device at the receiver from any harmonics or other impurities in the wave structure.

He states: "This screening action of an interposed resonant circuit is due to the well known property of such circuits by which a resonant circuit favors the development in it of simple harmonic currents of the period to which it is attuned and strongly opposes the development in it of simple harmonic currents of other periodicities". His original application thus disclosed the advantage, where vibrations created in one circuit are to be impressed on another, of making the latter circuit resonant to the same frequency as the former, in view of the "well known property" of a resonant circuit to favor the "development" in it of forced vibrations of the same frequency as its natural periodicity.[14]

Stone's application shows that these principles of resonant circuits were no less applicable to the antenna circuit, and suggests the use of "any suitable device" to "develop" in the antenna circuit the "simple harmonic force impressed" upon it. It was then well known in the art that every electrical circuit is to some degree resonant to a particular frequency to which it responds more readily and powerfully than to others. Although the degree of resonance attained by a vertical wire is small, its natural resonance is no different in kind from that of a closed circuit such as Stone's screening circuit. Stone recognized this in his application. In describing the complex natural vibrations set up by a sudden discharge in an antenna circuit, such as that commonly used at the time of his application, Stone said that "the vibrations consist of a simple harmonic vibration of lower period than all the others, known as the fundamental with a great variety of superimposed simple harmonics of higher periodicity superimposed thereon." And he says that the oscillations developed in the charging circuit of his system "induce corresponding oscillations in the vertical wire", which are "virtually" forced vibrations, and "practically independent, as regards their frequency, of the constants of the second circuit in which they are induced"—a plain recognition

[14] Stone's recognition of the similarity between his antenna circuit and his screening circuit is further shown by his direction that the coupling between the screening circuit and the charging circuit, like that between the antenna and charging circuits where no screening circuit is used, be loose. See note 12, supra.

that the antenna circuit has electro-magnetic constants which affect its natural periodicity, and that that natural periodicity does have some effect on the frequency of the vibrations impressed upon the antenna circuit.[19]

Thus Stone did not, as the Marconi Company suggests, say that the antenna circuit had no natural periodicity. He recognized that its natural periodicity was less strongly marked than that of his closed circuit, and hence that the wave structure could be greatly improved by creating the oscillations in a closed circuit such as he described. But he also plainly recognized that the antenna circuit, like his screening circuit, was a circuit having a natural period of vibration which would therefore be more responsive to impressed oscillations of that same periodicity. Since he had previously said that "any suitable device may be employed to develop the simple harmonic force impressed upon the vertical wire", we think that Stone's specifications plainly suggested to those skilled in the art that they avail themselves of this means of developing in the antenna this simple harmonic force, and that they tune the antenna circuit in order to improve the strength and quality of the "forced" vibrations impressed upon it.

The Marconi Company argues that Stone's theory of "forced" oscillations presupposes that the open transmitter circuit be untuned. It is true that Stone said that such "forced" oscillations have a period of vibration which is "independent of the electrical constants of the circuit" on which they are impressed. But the fact that the "forced" vibration will retain its natural period whatever the frequency of the antenna circuit may be, does not preclude, as Stone showed, the tuning of that circuit so as to achieve maximum responsiveness to the vibrations impressed upon it. Stone's specifications indicate that he used the term "forced" merely as meaning that the vibrations are developed in another circuit and then transferred to the antenna by inductive coupling, as distinguished from "natural" vibrations which originate in the antenna or radiating circuit—in short that "forced" is merely used as a synonym for "induced". Thus he states is describing the operation of his transmitter, "The high frequency current . . . passing through the primary I, [of the antenna transformer] induces a corresponding high frequency electromotive

force and current in the secondary I_2 and forced electric vibrations result in the vertical conductor r . . . ."[15]

Hence there is ample support for the finding of the court below that

"By free oscillations is meant that their frequency was determined by the constants of the circuit in which they were generated. The Stone application as filed impressed these oscillations upon the open circuit, and therefore used 'forced' oscillations in the open circuit of the transmitter, that is, the frequency of the oscillations in the open circuit was determined by the frequency of the oscillations in the closed circuit.

"The effect of forcing vibrations upon a tuned and untuned circuit may be likened unto the effect of a tuning fork upon a stretched cord in a viscous medium. When the cord is vibrated by the tuning fork it has the same period as does the fork regardless of the natural period of the cord, but when the fork vibrations are in tune with the natural period or fundamental of the cord, then the amplitude of vibrations in the cord is a maximum".

Thus Stone's application, prior to Marconi, showed a four-circuit system, in which the oscillations were produced in a closed charging circuit and impressed on an open antenna circuit in the transmitter, and were similarly received in an open antenna circuit and by it induced in a closed circuit containing a detector. He showed the effect of resonance on the circuits resulting from their tuning to a desired frequency, and emphasized the importance of making the transmitting and receiving apparatus resonant to that frequency.

Stone's patent,[16] granted a year and a half before Marconi—although after Marconi's application was filed—makes explicit, as the patent law permits, what was implicit in Stone's application. By amendments to his specifications made April 8, 1902, he recom-

whether such period be that of

[15] Stone's language here makes it plain that throughout his allusions to a frequency developed in one circuit as being "impressed" or "forced" on another circuit when the two circuits are coupled through a transformer, are used figuratively or metaphorically only as synonymous with "induced". Scientifically the oscillations in the charging circuit are not impressed or forced on the other. The stress in the magnetic field of the first circuit sets up or induces corresponding stresses in the magnetic field of the other circuit. The resulting frequency in the second circuit is affected both by the frequency of the oscillations in the charging circuit and the inductance and capacity in the second circuit. The result may be the superposition of two frequencies in the second circuit. This may be avoided and a single frequency developed, as Stone showed, by tuning the second circuit so as to be resonant to the frequencies created in the first.

[16] At the insistence of the Patent Office Stone divided his original application, and was granted two patents, No. 714,756 for a method and No. 714,831 for apparatus. The former is the one particularly relied on here.

mended that the frequency impressed upon the vertical conductor at the transmitter "may or may not be the same as the natural period or fundamental of such conductor" and that the antenna circuit at the transmitter "may with advantage be so constructed as to be highly resonant to a particular frequency and the harmonic vibrations impressed thereon may well be of that frequency". Since Stone used a variable inductance to alter at will the frequency of the charging circuit, this direction plainly indicated that the frequency of the antenna circuit might also be variable, and suggested the inclusion of the well-known Lodge variable inductance in the construction of the antenna circuit to achieve that result. And since Stone had specified that "by my invention" the operator at the receiving station is able to "adjust" the receiving apparatus so as to place it in resonance with any particular transmitting station, his patent equally plainly suggested the use of the Lodge variable inductance as a means of adjusting the tuning of the receiving antenna.

Stone's 1902 amendments also suggested that "an elevated conductor that is aperiodic may be employed"—i. e., one having very weak natural periodicity and consequently "adapted to receive or transmit all frequencies". But this suggestion was accompanied by the alternative recommendation in the 1902 amendments that the antenna circuits at transmitter and receiver "may with advantage be made resonant to a particular frequency," i. e., be periodic. No inference can be drawn from this that only an aperiodic antenna was contemplated either by the application or the amendments. The application was sufficiently broad to cover both types, since both were suitable means of achieving under different conditions the results which the application described and sought to attain. The amendments thus merely clarified and explained in fuller detail two alternative means which could be employed in the invention described in the original application, one of those means being the construction of the antenna so as to be highly resonant, i. e., tuned, to a particular frequency.[17]

[17] This is borne out by the subsequent letter from Stone to the Commissioner of Patents dated June 7, 1902. Stone there refers to a letter by the Patent Office saying that the statement that a simple harmonic wave developed in the closed circuit "can be transferred to the elevated conductor and from the latter to the earth without change of form" is "an argument which the Office has no means of testing". Stone replied with arguments to show that the vibrations radiated by the antenna circuit would be sufficiently

The only respects in which it is seriously contended that Marconi desclosed invention over Stone are that Marconi explicitly claimed four circuit tuning before Stone had made it explicit by his 1902 amendment, and that Marconi disclosed means of adjusting the tuning of each of his four circuits whereas Stone had explicitly shown adjustable tuning only in the two closed circuits. But we think that neither Marconi's tuning of the two antenna circuits nor his use of the Lodge variable inductance to that end involved any invention over Stone. Two questions are involved, first, whether there was any invention over Stone in tuning the antenna circuits, and, second, whether there was any invention in the use of the Lodge variable inductance or any other known means of adjustment in order to make the tuning of the antenna circuits adjustable.

For reasons already indicated we think it clear that Stone showed tuning of the antenna circuits before Marconi, and if this involved invention Stone was the first inventor. Stone's application emphasized the desirability of tuning, and disclosed means of adjusting the tuning of the closed circuits His very explicit recognition of the increased selectivity attained by inductive coupling of several resonant circuits plainly suggested to those skilled in the art that the antenna circuit could with advantage be a resonant circuit, that is to say a tuned circuit, and hence that it was one of the circuits to be tuned. He stressed the importance of tuning "by any suitable device" the "apparatus" at transmitter and receiver, which included at both an antenna circuit.

Tuning of the antenna circuit was nothing new; Lodge had not only taught that the antenna circuits at transmitter and receiver should be tuned to each other but had shown a means of adjusting the tuning which was the precise means adopted by Marconi, and which Stone had, prior to Marconi, used to tune his closed circuit—the variable inductance. Tesla, too, had shown the tuning of the antenna circuit at the transmitter to the frequency developed by the charging circuit, and the tuning of both circuits at the re-

pure for practical purposes either if the antenna circuit were aperiodic, or if it had a fundamental which was of the same frequency as that of the forced vibrations impressed upon it, although they would not be pure if the antenna circuit had a marked natural periodicity and was untuned. This letter, while somewhat later in date than the amendments, reinforces the conclusion that the purpose of those amendments was to explain more fully the details of theory and practice necessary to the success of the idea underlying Stone's original invention.

ceiver to the frequency thus transmitted. Thus Marconi's improvement in tuning the antenna circuits is one of the principles which were well understood and stated by Stone himself before Marconi, and the mechanism for achieving which had previously been disclosed by Lodge and Stone.[18]

Since no invention over Stone was involved in tuning the antenna circuits, neither Marconi nor Stone made an invention by providing adjustable tuning of any of the circuits or by employing Lodge's variable inductance as a means of adjusting the tuning of the resonant four circuit arrangement earlier disclosed by Stone's application and patented by him. No invention was involved in employing the Lodge variable inductance for tuning either the closed or the open circuits in lieu of other structural modes of adjustment for that purpose. The variable inductance imparted no new function to the circuit; and merely making a known element of a known combination adjustable by a means of adjustment known to the art, when no new or unexpected result is obtained is not invention. *Peters* v. *Hanson*, 129 U. S. 541, 550-51, 553; *Electric Cable Co.* v. *Edison Co.*, 292 U. S. 69, 79, 80, and cases cited; *Smyth* v. *Sheridan*, 149 Fed. 208, 211; cf. *Bassick Co.* v. *Hollingshead Co.*, 298 U. S. 415, 424-5 and cases cited.

Stone's conception of his invention as disclosed by his patent antedated his application. It is carried back to June 30, ~~1899~~ 1899, seven months before his application, when, in a letter to Baker, he described in text and drawings his four circuit system for wireless telegraphy in substantially the same form as that disclosed by the application. His letter is explicit in recommending the tuning of the antenna circuits. In part he wrote as follows:

"Instead of utilizing the vertical wire [antenna] itself at the transmitting station as the oscillator, I propose to impress upon this vertical wire, oscillations from an oscillator, which oscilla-

[18] It is not without significance that Marconi's application was at one time rejected by the Patent Office because anticipated by Stone, and was ultimately allowed, on renewal of his application, on the sole ground that Marconi showed the use of a variable inductance as a means of tuning the antenna circuits, whereas Stone, in the opinion of the Examiner, tuned his antenna circuits by adjusting the length of the aerial conductor. All of Marconi's claims which included that element were allowed, and the Examiner stated that the remaining claims would be allowed if amended to include a variable inductance. Apparently through oversight, Claims 10 and 11, which failed to include that element, were included in the patent as granted. In allowing these claims the Examiner made no reference to Lodge's prior disclosure of a variable inductance in the antenna circuit.

tions shall be of a frequency corresponding to the fundamental of the wire. Similarly at the receiving station, I shall draw from the vertical wire, only that component of the complex wave which is of lowest frequency.

"If now the fundamental of the wire at the receiving station be the same as that of the wire at the transmitting station, then the receiving station may receive signals from the transmitting station, but if it be different from that of the transmitting station, it may not receive those signals.

. . . . . .

"The tuning of these circuits one to another and all to the same frequency will probably be best accomplished empirically, though the best general proportions may be determined mathematically."

On July 18, 1899, Stone again wrote to Baker, mathematically demonstrating how to achieve the single frequency by means of forced vibrations. He expressed as a trigonometric function the form taken by the forced wave "if the period of the impressed force be the same as that of the fundamental of the vertical wire." He also pointed out that the transmitting circuit which he had disclosed in his earlier letter to Baker, "is practically the same as that employed by Tesla", except that Stone added an inductance coil in the closed circuit "to give additional means of tuning" and to "swamp" the reactions from the coil of the oscillation transformer and thus loosen the coupling between the open and closed circuit of the transmitter.[19] His recognition of the effect upon the current in the antenna if it is of the same period as the charging circuit; his statement that his transmitting system was the same as that employed by Tesla; his recognition that the fundamental of the receiver should be the same as that of the transmitter antenna when used for the transmission of a single frequency, and finally his statement that all four circuits are to be tuned, "one to another and all to the same frequency," all indicate his understanding of the principles of resonance and of the significance of tuning the antenna circuits.

Stone disclosed his invention to others, and in January, 1900, described it to his class at the Massachusetts Institute of Technology. Before 1900 he was diligent in obtaining capital to promote his invention. Early in 1901 a syndicate was organized to finance laboratory experiments. The Stone Telegraph & Telephone Co. was organized in December, 1901. It constructed sev-

[19] See footnote 13, *supra*.

eral experimental stations in 1902 and 1903; beginning in 1904 or 1905 it built wireless stations and sold apparatus, equipped a Navy collier and some battleships, and it applied for a large number of patents. The apparatus used in the stations is described by Stone's testimony in this suit as having resonant open and closed circuits loosely coupled inductively to each other, at both the transmitter and receiver, and all tuned to the same wave length, as described in his letters to Baker and his patent.

We think that Stone's original application sufficiently disclosed the desirability that the antenna circuits in transmitter and receiver be resonant to the same frequency as the closed circuits, as he expressly recommended in his patent. But in any event it is plain that no departure from or improper addition to the specifications was involved in the 1902 amendments, which merely made explicit what was already implicit. *Hobbs* v. *Beach*, 180 U. S. 383, 395-7. We would ordinarily be slow to recognize amendments made after the filing of Marconi's application and disclosing features shown in that application. Cf. *Schriber-Schroth Co.* v. *Cleveland Trust Co.*, 305 U. S. 47, 57; *Powers-Kennedy Corporation* v. *Concrete Co.*, 282 U. S. 175, 185-6; *Mackay Radio Co.* v. *Radio Corporation*, 306 U. S. 86. But here Stone's letters to Baker, whose authenticity has not been questioned in this case, afford convincing proof that Stone had conceived of the idea of tuning all four circuits prior to the date of Marconi's invention. Cf. *Bickell* v. *Smith-Hanbury-Scott Welding Co.*, 53 F. 2d 356, 358.

It is well established that as between two inventors priority of invention will be awarded to the one who by satisfying proof can show that he first conceived of the invention. *Philadelphia & Trenton Ry.* v. *Stimpson*, 14 Pet. 448, 462; *Loom Co.* v. *Higgins*, 105 U. S. 580, 593; *Radio Corporation* v. *Radio Laboratories*, 293 U. S. 1, 11-13; *Christie* v. *Seybold*, 55 Fed. 69, 76; *Automatic Weighing Mach. Co.* v. *Pneumatic Scale Corp.*, 158 Fed. 415, 417-22; *Harper* v. *Zimmermann*, 41 F. 2d 261, 265; *Sachs* v. *Hartford Electric Supply Co.*, 47 F. 2d 743, 748.

Commercial success achieved by the later inventor and patentee cannot save his patent from the defense of anticipation by a prior inventor.[20] Compare *Smith* v. *Hall*, 301 U. S. 216 with

[20] Even if the lack of invention in Marconi's improvement over Stone—making it stable the tuning of the antenna circuits which Stone had said should be tuned—could be said to be in sufficient doubt so that commercial

Smith v. *Snow*, 294 U. S. 1. To obtain the benefit of his prior conception, the inventor must not abandon his invention, *Gaylor* v. *Wilder*, 10 How. 477, 481, but must proceed with diligence to reduce it to practice. We think Stone has shown the necessary diligence. Compare *Radio Corporation* v. *Radio Laboratories*, *supra*, 13, 14. The delay until 1902 in including in his patent specifications the sentences already referred to, which explicitly provide for tuning of the antenna circuits, does not in the circumstances of this case show any abandonment of that feature of Stone's invention since, as we have seen, the idea of such tuning was at least implicit in his original application, and the 1902 amendments merely clarified that application's effect and purport.

Marconi's patent No. 763,772 was sustained by a United States District Court in *Marconi Wireless Telegraph Co.* v. *National*

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success could aid in resolving the doubt, Thropp's Sons Co. v. Sieberling, 264 U. S. 319, 330; DeForest Radio Co. v. Electric Co., 283 U. S. 664, 685; Altoona Theatre v. Tri-Ergon Corp., 294 U. S. 477, 488, it has not been established that the alleged improvement contributed in any material degree to that success. Compare Altoona Theatre v. Tri-Ergon Corp., *supra*. Marconi's specifications disclose a large number of details of construction, none of which is claimed as invention in this patent, in which his apparatus differed from, and may have been greatly superior to, Stone's. Many of these formed the subject of prior patents. After his application for this patent, as well as before, Marconi made or adopted a great number of improvements in his system of wireless telegraphy. Two of his engineers have written that a major factor in his successful transmission across the Atlantic in December, 1901, was the use of much greater power and higher antennae than had previously been attempted, an improvement in no way suggested by the patent here in suit. Fleming, Electric Wave Telegraphy, 449-53; Vyvyan, Wireless Over Thirty Years, 22-33. Indeed both are agreed that in the actual transmission across the Atlantic tuning played no part; the receiver antenna consisted of a wire suspended by a kite which rose and fell with the wind, varying the capacity so much as to make tuning impossible. *Ibid.*

By 1913, when he testified in the National Electric Signalling Co. case, that "due to the utilization of the invention" of this patent he had successfully transmitted messages 6,600 miles, he had, after almost continuous experimentation, further increased the power used, developed new apparatus capable of use with heavy power, enlarged his antennae and adopted the use of horizontal, "directional" antennae, and made use of improved types of spark gaps and detecting apparatus, including the Fleming cathode-anode tube, the crystal detector, and sound recording of the signals—to mention but a few of the improvements made. He had also discovered that much greater distances could be attained at night. See Vyvyan, *supra*, 34-47, 55-60. The success attained by the apparatus developed by Marconi and his fellow engineers by continuous experimentation over a period of years—however relevant it might be in resolving doubts whether the basic four-circuit, tuned system disclosed by Marconi, and before him by Stone, involved invention—cannot, without further proof, be attributed in significant degree to any particular one of the many improvements made by Marconi over Stone during a period of years. The fact that Marconi's apparatus as a whole was successful does not entitle him to receive a patent for every feature of its structure.

Signalling Co., 213 Fed. 815, and his invention as specified in his corresponding British patent No. 7777 of 1900, was upheld in *Marconi* v. *British Radio & Telegraph Co.*, 27 T. L. R. 274, 28 R. P. C. 18. The French court likewise sustained his French patent, Civil Tribunal of the Seine, Dec. 24, 1912. None of these courts considered the Stone patent or his letters. All rest their findings of invention on Marconi's disclosure of a four circuit system and on his tuning of the four circuits, in the sense of rendering them resonant to the same frequency, in both of which respects Stone anticipated Marconi, as we have seen. None of these opinions suggests that if the courts had known of Stone's anticipation, they would have held that Marconi showed invention over Stone by making the tuning of his antenna circuit adjustable, or by using Lodge's variable inductance for that purpose. In *Marconi Wireless Telegraph Co.* v. *Kilbourne & Clark Mfg. Co.*, 229 Fed. 328, affirmed 265 Fed. 644, the district court held that the accused device did not infringe. While it entered formal findings of validity which the Circuit Court of Appeals approved, neither court's opinion discussed the question of validity and that question was not argued in the Circuit Court of Appeals.[21]

Marconi's reputation as the man who first achieved successful radio transmission rests on his original patent, which became reissue No. 11,913, and which is not here in question. That reputation, however well-deserved, does not entitle him to a patent for every later improvement which he claims in the radio field. Patent cases, like others, must be decided not by weighing the reputations of the litigants, but by careful study of the merits of their respective contentions and proofs. As the result of such a study

[21] A preliminary injunction restraining infringement was entered in Marconi Wireless Tel. Co. v. De Forest Tel. & Tel. Co., 225 Fed. 65, affirmed, 225 Fed. 373, both courts, without independent discussion of the validity of the patent, determining that the decision in the National Signalling Co. case justified the grant of preliminary relief. A preliminary injunction was also granted [illegible] Atlantic Communications Company, an action brought in the Eastern District of New York. Stone's letters were introduced in evidence in the Atlantic Communications Company case and the Kilbourne & Clark case. His deposition in the latter case, taken February 28 and 29, 1916, was incorporated in the record in this case. He there testified that he had refrained from producing proofs of the priority of his invention when called upon to testify in prior litigation in 1911 and 1914 because he wished the priority of his invention to be established by the owners of the patent, the Stone Telegraph Co. and its bondholders, in order to be sure that a bona fide defense would be made. He said that by 1915 [illegible], which he testified in the Atlantic Communications Co. case, he had concluded that the owners of the patent were not in a financial position to litigate, and that the Atlantic Co. "could make a bona fide Stone defense."

we are forced to conclude, without undertaking to determine whether Stone's patent involved invention, that the Court of Claims was right in deciding that Stone anticipated Marconi, and that Marconi's patent did not disclose invention over Stone. Hence the judgment below holding invalid the broad claims of the Marconi patent must be affirmed. In view of our interpretation of the Stone application and patent we need not consider the correctness of the court's conclusion that even if Stone's disclosures should be read as failing to direct that the antenna circuits be made resonant to a particular frequency, Marconi's patent involved no invention over Lodge, Tesla, and Stone.

Claim 16 of Marconi patent No. 763,772.

The Government asks us to review so much of the decision of the Court of Claims as held valid and infringed Claim 16 of Marconi's patent No. 763,772. That claim is for an antenna circuit at the receiver connected at one end to "an oscillation-receiving condactor" and at the other to a capacity (which could be the earth), containing the primary winding of a transformer, "means for adjusting the two transformer-circuits in electrical resonance with each other," and "an adjustable condenser in a shunt connected with the open circuit, and around said transformer-coil." Marconi thus discloses and claims the addition to the receiver antenna of an adjustable condenser connected in a shunt around the primary of the transformer. The specifications describe the condenser as "preferably one provided with two telescoping metallic tubes separated by a dielectric and arranged to readily vary the capacity by being slid upon each other". Marconi, however, makes no claim for the particular construction of the condenser.

Although the claim broadly provides for "means of adjusting the two transformer-circuits in electrical resonance", Marconi's drawings disclose the use of a variable inductance connected between the aerial conductor and the transformer-coil in such a manner that the variable inductance is not included in that part of the antenna circuit which is bridged by the condenser. The condenser is thus arranged in parallel with the transformer coil and in series with the variable inductance. In his specifications Marconi enumerates a number of preferred adjustments for tuning the transmitting and receiving stations, showing the precise equipment to be used to achieve tuning to the desired wave-length. The

two tunings which show the use of the adjustable condenser in the receiver antenna also make use of the variable inductance. And his specifications state: "In a shunt around said primary j^2 [the primary of the transformer] I usually place a condenser k . . . . An inductance coil g^1 of variable inductance is interposed in the primary circuit of the transformer, being preferably located between the cylinder f^2 [the aerial capacity] and the coil j^1."

In this respect the devices which the court below found to infringe Claim 16 exhibit somewhat different arrangements. Apparatus manufactured by the Kilbourne and Clark Company, and used by the Government, had a receiver antenna circuit containing a variable inductance in addition to the transformer coil, and having an adjustable condenser so constructed that it could be connected either in series with the two inductances, or in a shunt bridging both of them. Apparatus manufactured by the Telefunken Company showed a similar antenna having no variable inductance, but having an adjustable condenser so arranged that it could be connected either in series with the transformer coil, or in parallel with it by placing the condenser in a shunt circuit which would thus bridge all the inductance in the antenna circuit.

The Marconi patent does not disclose the function which is served by the adjustable condenser disclosed by Claim 16, except in so far as Marconi in his specifications, in describing the means of tuning the receiver circuits to a particular desired frequency, prescribes specific values for both the variable inductance and the adjustable condenser in the receiver antenna. The Court of Claims found that this indicated "that the purpose of the condenser connected in shunt with the primary winding of the transformer of the receiver, is to enable the electrical periodicity or tuning of the open circuit of the receiver to be altered".

The court thus based its holding that Claim 16 disclosed patentable invention on its finding that Marconi, by the use of an adjustable condenser in the antenna circuit, disclosed a new and useful method of tuning that circuit. The Government contends that the arrangement of the antenna circuit disclosed by Marconi's specifications—with the condenser shunted around the transformer coil but not around the variable inductance—is such that the condenser cannot increase the wave-length over what it would be without such a condenser, and that it can decrease that wave-length only when adjusted to have a very small capacity. The Government contends therefore that its principal function is

not that of tuning but of providing "loose coupling".[22] The Government does not deny that this precise arrangement is novel and useful, but it contends that its devices do not infringe that precise arrangement, and that Claim 16, if more broadly construed so as to cover its apparatus, is invalid because anticipated by the prior art, particularly the patents of Pupin and Fessenden.

As we have seen from our discussion of the other claims of the Marconi patent, the idea of tuning the antenna circuits involved no patentable invention. It was well known that tuning was achieved by the proper adjustment of either the inductance or the capacity in a circuit, or both. Lodge and Stone had achieved tuning by the use of an adjustable induction coil, so arranged that its effective inductance could readily be varied.

But capacity was no less important in tuning. De Tunzelmann's descriptions of Hertz's experiments show that Hertz, in order to make his receiving apparatus resonant to the particular frequency radiated by the transmitter, carefully determined the capacity of both, and indeed disclosed a means of adjusting the capacity of the receiver by attaching to it wires whose length could readily be varied. Marconi in his prior patent No. 586,193, granted July 13, 1897, which became reissue No. 11,913, had disclosed a two-circuit system for the transmission of radio waves in which both transmitter and receiver had large metal plates serving as capacity areas. His specifications describe the construction of transmitting and receiving stations so as to be resonant to the same frequency by calculation of the length of those metal plates, thereby determining the capacity of the antenna circuits of transmitter and receiver respectively. He states that the plates are "preferably of such a length as to be electrically tuned with the electric oscillations transmitted", and describes means of achieving this result so as to determine "the length most appropriate to the length of wave emitted by the oscillator". Claim 24 of his patent claims "the combination of a transmitter capable of producing electrical oscillations or rays of definite character at the will of the operator, and a receiver located at a distance and having a conductor tuned to respond to said oscillations . . .". The only means of achieving this tuning disclosed by the specifications is the determination

[22] See note 13, *supra*. Most of the current in the antenna circuit is said to pass through the condenser shunt and not through the transformer coil, thus minimizing the effect upon the frequency of vibrations in the antenna circuit of the magnetic stresses set up in the primary of the transformer by the current induced in the secondary.

of the capacity of the antenna of transmitter and receiver in the manner described.

Moreover the use of an adjustable condenser as a means of tuning was known to the prior art. Pupin in patent No. 640,515, applied for May 28, 1895, and granted January 2, 1900, before Marconi, disclosed the use of an adjustable condenser as a means of tuning a receiving circuit in a system of wired telegraphy. Pupin's patent was designed to permit the simultaneous transmission over a wire of several messages at different frequencies, and the selective reception at a given receiving station of the particular message desired, by tuning the receiving circuit to the frequency at which that message was transmitted. His specifications and drawings disclose at the receiver a telegraph key or other suitable detecting instrument located in a shunt from the wire along which the messages were passed. The shunt circuit included a condenser "of adjustable capacity", an adjustable induction coil, and a detecting instrument. His specifications state that "the capacity of the condenser H and the self-induction of the [induction] coil I being such that the natural period or frequency of the shunt or resonance circuit HI is the same as the period of one of the electromotive forces which produce the current coming over the line . . . this circuit HI will be in resonance with the current and therefore will act selectively with respect to it". He disclosed an alternative system in which a similar shunt circuit containing a condenser, already described as of adjustable capacity, and the primary of a transformer, was inductively coupled with another circuit containing the secondary of the transformer, an induction coil, an adjustable condenser, and a receiving device. He thus in effect disclosed an open receiving circuit with earth connection including the primary of an oscillation transformer—the secondary of which is connected in a circuit with a telegraph key or other suitable detecting instrument—and an adjustable condenser in a shunt bridging the primary of the transformer and thus connected in parallel with it.

Thus Pupin showed the use of an adjustable condenser as a means of tuning an electrical circuit so as to be selectively receptive to impulses of a particular frequency. It is true that his patent related not to the radio art but to the art of wired telegraphy, an art which employed much lower frequencies. But so far as we are informed the principles of resonance, and the methods of achieving it, applicable to the low frequencies used by

Pupin are the same as those applicable to the high frequency radio transmission and reception.

Fessenden, in patent No. 706,735, applied for Dec. 15, 1899, before Marconi, and granted Aug. 12, 1902, disclosed, in the antenna circuit of a radio receiver, a condenser in a shunt around a coil. The coil was used in effect as a transformer, by the magnetic lines of force set up when a current passed through it an indicator was caused to move, thereby either closing an electrical connection or giving a visible signal. Fessenden's specifications do not clearly disclose the purpose of his condenser, but they specify that it must be "of the proper size". He also discloses a condenser in a shunt circuit around the terminals of a spark gap in the antenna circuit of the transmitter, and his specifications prescribe that "This shunt-circuit must be tuned to the receiving-conductor; otherwise the oscillations produced by it will have no action upon the wave-responsive device at the receiving-station."

We have referred to the Pupin and Fessenden patents, not for the purpose of determining whether they anticipate Claim 16 of Marconi, as the Government insists, but to indicate the importance of considering them in that aspect, together with the relevant testimony, which the court below did not do. In the present state of the record we do not undertake to determine whether and to what extent these disclosures either anticipate Claim 16 of the Marconi patent or require that claim to be so narrowly construed that defendants' accused devices or some of them do not infringe Marconi.

Although the Pupin and Fessenden patents were in the record before the Court of Claims when it entered its decision finding Claim 16 valid and infringed, they were not referred to in connection with Claim 16 either in the court's opinion or in its findings, evidently because not urged upon that court by the Government as anticipating Claim 16. But this Court, in the exercise of its appellate power, is not precluded from looking at any evidence of record which, whether or not called to the attention of the court below, is relevant to and may affect the correctness of its decision sustaining or denying any contention which a party has made before it. *Muncie Gear Co.* v. *Outboard Motor Co.*, 315 U. S. 759, 766-8; Act of May 22, 1939, 28 U. S. C. § 2886; cf. *Hormel* v. *Helvering*, 312 U. S. 552, 556.

In order to determine whether this Court should consider the evidence which the Government now presses upon it, and should

on the basis of that evidence either decide for itself whether Claim 16 is valid and infringed or remand that question to the Court of Claims for further consideration, it is necessary to set out in some detail the relevant proceedings below. The case was referred to a special commissioner for the taking of testimony under a stipulation that the issue of reasonable compensation for damages and profits be postponed until the determination of the issues of validity and infringement. On June 26, 1933, the Commissioner filed a report in which he made the following findings with regard to Claim 16, which the Court of Claims later adopted in substance:

LXII. Claim 16 of Marconi # 763772 is directed to subject matter which is new and useful . . .

LXV. The receiving apparatus of the Kilbourne & Clark Company, shown in exhibit 95, and the receiver made by the Telefunken company, illustrated in exhibit 79, each has apparatus coming within the terminology of claim 16.

Both parties filed exceptions to the Commissioner's report. The Marconi Company excepted to part of finding LXII, and took several exceptions which were formally addressed to finding LXV. The Government, in a memorandum, opposed the suggested amendments to these findings. But the Government filed no exceptions to these two findings, nor did it, in its extensive brief before the Court of Claims, make any contention that Claim 16 either is invalid or was not infringed.

After the court had rendered its interlocutory decision holding Claim 16 valid and infringed, the case was sent back to the Commissioner to take evidence on the accounting. Much evidence was taken bearing on the function served by the condenser in the arrangement described in Claim 16 and in the Government's receivers, and in that connection the Pupin and Fessenden patents were again introduced in evidence by the Government. When the Pupin patent was offered the Commissioner stated: "Obviously, as I understand the offer of this patent of Pupin, it does not in any way attack the validity of Claim 16 of the Marconi patent in suit. As you state Mr. Blackmar, that has been decided by the Court, and I do not recall just now what procedure was followed after the decision and prior to the accounting proceeding; but the defendant had at that time opportunity for a motion for a new trial and presentation of newly-discovered evidence and all those matters." Accordingly, the Commissioner stated that he received the patent in evidence "for the sole purpose of aiding the wit-

ness and the Commissioner and the Court in an understanding of how the condenser in the Marconi patent operates." And in offering the Fessenden patent counsel for the Government similarly stated that it was offered "not to show invalidity but as showing justification for the defendant's use".

In its exceptions to the Commissioner's report on the accounting the Government asked the Court of Claims to make certain specific findings as to the mode of operation of the arrangements disclosed in the Pupin and Fessenden patents, and also to find that

"The mode of connecting the primary condenser in parallel with the antenna-to-earth capacity used by the defendant followed the disclosure of Pupin 640,516 and the Fessenden patent 706,735 . . . and hence does not infringe the Marconi claim 16 which is based upon a different arrangement, operating in a different manner to obtain a different result."

The Government contended that there was no finding of fact that Claim 16 had been infringed, and that the court, in the course of the accounting proceeding had by an order of October 22, 1937, reopened the entire subject of infringement. We agree with the court that the Commissioner's finding LXV, which the court adopted as finding LXIII, was a finding of infringement, and we see no reason to question the court's conclusion that its order had not reopened the subject of infringement.

In view, however, of the Government's apparent misunderstanding of the scope of the issues left open on the accounting we think that its request for a finding of non-infringement specifically addressed to the Pupin and Fessenden patents was a sufficient request to the court to reconsider its previous decision of infringement. And while most of the argument on the Government's exceptions to the Commissioner's report was based on evidence taken upon the accounting, the Government's briefs sufficiently disclosed to the court that the Pupin and Fessenden patents, at least, had been in the record prior to the interlocutory decision.

The court, in rejecting the Government's request for a finding of non-infringement stated: "The question of infringement of Marconi Claim 16 . . . is not before us in the present accounting." "The sole purpose and function of an accounting in a patent infringement case is to ascertain the amount of compensation due, and no other issue can be brought into the accounting to change or alter the court's prior decision." We cannot say

with certainty whether in rejecting the Government's request the court thought that it lacked power to reconsider its prior decision, or whether it held merely that in the exercise of its discretion it should not do so. Nor does it appear that, assuming it considered the question to be one of discretion, it recognized that in part at least the Government's request was based on evidence, having an important bearing on the validity and construction of Claim 16, which had been before the court but had not been considered by it when it held Claim 16 valid and infringed.

Although the interlocutory decision of the Court of Claims on the question of validity and infringement was appealable, *United States* v. *Esmault Pelterie*, 299 U. S. 201, 303 U. S. 26; 28 U. S. C. § 288 (b), as are interlocutory orders of district courts in suits to enjoin infringement, 28 U. S. C. § 227 (a); *John Simmons Co.* v. *Grier Bros. Co.*, 258 U. S. 82, 89, the decision was not final until the conclusion of the accounting. *Barnard* v. *Gibson*, 7 How. 649; *Hunnewell* v. *Stainthorp*, 2 Wall. 106; *Simmons Co.* v. *Grier Bros. Co.*, *supra*, 89. Hence the court did not lack power at any time prior to entry of its final judgment at the close of the accounting to reconsider any portion of its decision and reopen any part of the case. *Perkins* v. *Fourniquet*, 6 How. 206, 208; *McGourkey* v. *Toledo and Ohio Ry.*, 146 U. S. 536, 544; *Simmons Co.* v. *Grier Bros Co.*, *supra*, 90-91. It was free in its discretion to grant a reargument based either on all the evidence then of record or only the evidence before the court when it rendered its interlocutory decision, or to reopen the case for further evidence.

Whether it should have taken any of these courses was a matter primarily for its discretion, to be exercised in the light of various considerations which this Court cannot properly appraise without more intimate knowledge than it has of the proceedings in a long and complex trial. Among those considerations are the questions whether, as appears to be the case from such portions of the record as have been filed in this Court or cited to us by counsel, the Government failed to make any contention as to the validity or construction of Claim 16 in the proceedings leading to the interlocutory decision; whether the showing of noninfringement which it now makes is sufficiently strong, and the public interest that an invalid patent be not sustained is sufficiently great, to justify reconsidering the decision as to Claim 16 despite the failure of Government counsel to press its contention at the proper time; whether adequate consideration of the question of noninfringement can be had on the existing record, or whether additional tes-

timony should be received; and whether, balancing the strength or weakness of the Government's present showing of noninfringement against the undesirability of further prolonging this already extended litigation, the case is one which justifies reconsideration.

These are all matters requiring careful consideration by the trial court. In order that the case may receive that consideration, we vacate the judgment as to Claim 16 and remand the cause to the Court of Claims for further proceedings in conformity to this opinion.

If on the remand, the court should either decline to reconsider its decision of infringement, or should upon reconsideration adhere to that decision, it should pass upon the contention of the Government, urged here and below, as to the measure of damages, with respect to which the court made no findings. The Government's contention is that the variable capacity shunt of the accused devices bridged all the inductance in the receiving antenna circuit, and that even though those devices infringed they nevertheless embody an improvement over Marconi's Claim 16, in which only the transformer coil was bridged. In computing the damages the court measured them by 65% of the cost to the Government of the induction coils which would be required to replace in the accused devices the adjustable condensers as a means of tuning, taking into account the greater convenience and efficiency of condenser tuning. The allowance of only 65% was on the theory that if the parties had negotiated for the use of the invention the price would have been less than the cost to the Government of the available alternative means of tuning.

In computing the damages the court apparently did not take into account or attempt to appraise any contribution which may have been made by the improvement over Marconi which the Government asserts was included in the accused devices. The court found that where the condenser is connected in series with the inductance coils in the antenna it "can be used to shorten the natural resonant wave length of the antenna circuit but cannot lengthen it beyond what would be the resonant wave length if the condenser were not present." On the other hand, it found that when the condenser is connected in parallel it enables the periodicity of the antenna to be lowered, permitting the reception of longer wave lengths.

The computation of damages was based on the premise that the advantage to the Government resulting from the infringement was

derived from the ability which the accused devices had thus acquired to receive longer wave lengths. But there was substantial testimony that the arrangement disclosed by Marconi's specifications was in effect a connection in series which did not make possible reception of longer wave lengths, as did the arrangement in the accused devices. And the court nowhere found that the arrangement covered by Marconi's Claim 16 did make possible such reception. The appropriate effect to be given to this testimony is important in the light of the recognized doctrine that if a defendant has added "non-infringing and valuable improvements which had contributed to the making of the profits", it is not liable for benefits resulting from such improvements. *Westinghouse* v. *Wagner Mfg. Co.*, 225 U. S. 604, 614-15, 616-17; *Sheldon* v. *Metro-Goldwyn Corp.*, 309 U. S. 390, 402-406, and cases cited. Finding LXIII that the Government was using "apparatus coming within the terminology of Claim 16", and Finding 23 on the accounting that the accused devices "infringe Claim 16 of the Marconi patent", give no aid in solving this problem for they are not addressed to the question whether, assuming infringement, the Government has made improvements which, of themselves are non-infringing. That can only be afforded by findings which appraise the evidence, establish the scope of Marconi's claim and the nature and extent of the difference in function, if any, between the device claimed by Marconi and those used by the Government, and determine whether any differences shown to exist constitute a "non-infringing improvement" for which Marconi deserves no credit.

The judgment as to Claim 16 will be vacated and the cause remanded for further proceedings.

The Fleming Patent No. 803,684

The Fleming patent, entitled "Instrument for Converting Alternating Electric Currents into Continuous Currents" was applied for April 19, 1905, and granted on November 7, 1905 to the Marconi Company, as assignee of Fleming. Its specifications state that "this invention relates to certain new and useful devices for converting alternating electric currents, and especially high-frequency alternating electric currents or electric oscillations, into continuous electric currents for the purpose of making them detectable by and measurable with ordinary direct-current instruments, such as a mirror galvanometer of the usual type or any ordinary direct-current ammeter". Fleming's drawings and specifications show a

combination apparatus by which alternating current impulses received through an antenna circuit containing the primary of a transformer are induced in the secondary of the transformer. To one end of the secondary coil is connected a carbon filament like that of an incandescent electric lamp, which is heated by a battery. Surrounding, but not touching the filament, is a cylinder of aluminum open at the top and bottom, which is connected with the other end of the secondary. The cylinder and filament are enclosed in an evacuated vessel such as an ordinary electric lamp bulb. An indicating instrument or galvanometer is so located in this circuit as to respond to the flow of current in it. The specifications explain the operation of this device:

"This arrangement described above operates as an electric valve and permits negative electricity to flow from the hot carbon *b* to the metal cylinder *c*, but not in the reverse direction, so that the alternations induced in the coil *k* by the Hertzian waves received by the aerial wire *n* are rectified or transformed into a more or less continuous current capable of actuating the galvanometer *l* by which the signals can be read."

The specifications further state:

". . . the aerial wire *n* may be replaced by any circuit in which there is an alternating electromotive force, whether of low frequency or of high frequency . . ."

"Hence the device may be used for rectifying either high-frequency or low-frequency alternating currents of electrical oscillations . . .".

Only Claims 1 and 37 of the patent are in suit. They read as follows:

"1. The combination of a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for heating one of the conductors, and a circuit outside the vessel connecting the two conductors.

"37. At a receiving-station in a system of wireless telegraphy employing electrical oscillations of high frequency a detector comprising a vacuous vessel, two conductors adjacent to but not touching each other in the vessel, means for heating one of the conductors, a circuit outside of the vessel connecting the two conductors, means for detecting a continuous current in the circuit, and means for impressing upon the circuit the received oscillations."

The current applied to the filament or cathode by the battery sets up a flow of electrons (negative electric charges) from the heated cathode, which are attracted to the cold plate or anode when the latter is positively charged. When an alternating current

is set up in the circuit containing the cathode, anode, and secondary of the transformer, the electronic discharge from the cathode closes the circuit and permits a continuous flow of electricity through it when the phase of the current is such that the anode is positively charged, while preventing any flow of current through the tube when the anode is negatively charged. The alternating current is thus rectified so as to produce a current flowing only in one direction. *See DeForest Radio Co.* v. *General Electric Co.*, 283 U. S. 664; *Radio Corporation* v. *Radio Laboratories*, 293 U. S. 1; *Detrola Corporation* v. *Hazeltine Corporation*, 313 U. S. 259.

Claims 1 and 37 of the Fleming patent are identical in their structural elements. Both claim the vacuum tube, and the two electrodes connected by a circuit outside the tube, one element being heated. The claims differ only in that Claim 37 includes "means for detecting" the continuous or direct current in the anode-cathode circuit, and "means for impressing upon the circuit the received oscillations" from the transformer coil of the antenna circuit.

In the patent as originally issued there had been another difference between the two claims. Claim 37 describes the tube as being used "in a system of wireless telegraphy employing oscillations of high frequency". No such limitation was placed on Claim 1 as originally claimed, and the specifications already quoted plainly contemplated the use of the claimed device with low as well as high frequency currents. This distinction was eliminated by a disclaimer filed by the Marconi Company November 17, 1915, restricting the combination of the elements of Claim 1 to a use "in connection with high frequency alternating electric currents or electric oscillations of the order employed in Hertzian wave transmission", and deleting certain references to low frequencies in the specifications. The result of the disclaimer was to limit both claims to the use of the patented device for rectifying high frequency alternating waves or currents such as were employed in wireless telegraphy.

The earliest date asserted for Fleming's invention, as limited by the disclaimer, is November 16, 1904. Twenty years before, on October 21, 1884, Edison had secured United States Patent No. 307,031. In his specifications he stated:

> I have discovered that if a conducting substance is interposed in the vacuous space within the globe of an incandescent electric lamp, and said conducting substance is connected outside of the lamp with one terminal, preferably the positive

one, of the incandescent conductor, a portion of the current will, when the lamp is in operation, pass through the shunt-circuit thus formed, which shunt includes a portion of the vacuous space within the lamp. This current I have found to be proportional to the degree of incandescence of the conductor or candle-power of the lamp."

Edison proposed to use this discovery as a means of "indicating, variations in the electro-motive force in an electric circuit," by connecting a lamp thus equipped at a point where the current was to be measured. The drawings of his patent show an electric circuit, including a filament (cathode) and a plate (anode) both "in the vacuous space within the globe"—an electric light bulb. The shunt-circuit extends from the plate through a galvanometer to the filament. His specifications disclose that the vacuous space within the globe is a conductor of current between the plate anode and the filament; that the strength of the current in the filament-to-plate circuit through the vacuum depends upon the degree of incandescence at the filament; and that the plate anode is preferably connected to the positive side of the current supply. The claims of the patent are for the combination of the filament, plate and interconnecting circuit, including the galvanometer. Claim 5, a typical claim, reads as follows:

"The combination, with an incandescent electric lamp, of a circuit having one terminal in the vacuous space within the globe of said lamp, and the other connected with one side of the lamp-circuit, and electrically controlled or operated apparatus in said circuit, substantially as set forth."

The structure disclosed in Fleming's Claims 1 and 37 thus differed in no material respect from that disclosed by Edison. Since Fleming's original Claim 1 is merely for the structure, it reads directly on Edison's Claim 5 and could not be taken as invention over it.

Fleming used this structure for a different purpose than Edison. Edison disclosed that his device operated to pass a current across the vacuous space within the tube between filament and plate. He used this current as a means of measuring the current passing through the filament circuit. Fleming, in his specifications, disclosed the use of his tube as a rectifier of alternating currents, and in Claim 37 he claimed the use of that apparatus as a means of rectifying alternating currents of radio frequency. But in this use of the tube to convert alternating into direct

currents there was no novelty for it had been disclosed by others and by Fleming himself long before Fleming's invention date.

On January 9, 1890, ten years before Fleming filed his application, he stated in a paper read before the Royal Society of London:

"It has been known for some time that if a platinum plate or wire is sealed through the glass bulb of an ordinary carbon filament incandescent lamp, this metallic plate being quite out of contact with the carbon conductor, a sensitive galvanometer connected between this insulated metal plate enclosed in the vacuum and the external *positive* electrode of the lamp indicates a current of some milliampères passing through it when the lamp is set in action, but the same instrument when connected between the *negative* electrode of the lamp and the insulated metal plate indicates no sensible current. This phenomenon in carbon incandescence lamps was first observed by Mr. Edison, in 1884, and further examined by Mr. W. H. Preece, in 1885." Proceedings of the Royal Society of London, vol. 47, pp. 118-9.

Fleming's 1890 paper further pointed out that the vacuous space "possesses a curious unilateral conductivity"; that is, it permits current to "flow across the vacuous space from the hot carbon [cathode] to the cooler metal plate [anode], but not in the reverse direction." *Id.* 122. He noted the ability of the tube to act as a rectifier of alternating current, saying:

"When the lamp is actuated by an *alternating* current a *continuous* current is found flowing through a galvanometer, connected between the insulated plate and *either* terminal of the lamp. The direction of the current through the galvanometer is such as to show that negative electricity is flowing from the plate through the galvanometer to the lamp terminal." *Id.* 120.

Fleming's paper thus noted, contrary to the then popular conception, that it is negative electricity which flows from cathode to anode, but he emphasized that even this had been a part of general scientific knowledge, as follows:

"The effect of heating the negative electrode in facilitating discharge through vacuous spaces has previously been described by W. Hittorf ('Annalen der Physik und Chemie,' vol. 21, 1884, p. 90-139), and it is abundantly confirmed by the above experiments. We may say that a vacuous space bounded by two electrodes—one incandescent and the other cold—possesses a unilateral conductivity for electric discharge when these electrodes are within a distance of the mean free path of projection of the molecules which the impressed electromotive force can detach and send off from the hot negative electrode.

"This unilateral conductivity of vacuous spaces having unequally heated electrodes has been examined by MM. Elster and Geitel (see 'Wiedemann's Annalen,' vol. 38, 1889, p. 40), and also by Goldstein ('Wied. Ann.,' vol. 24, 1885, p. 83), who in experiments of various kinds have demonstrated that when an electric discharge across a vacuous space takes place from a carbon conductor to another electrode the discharge takes place at lower electromotive force when the carbon conductor is the negative electrode and is rendered incandescent." *Id.* 125-6.

Fleming's reference in this publication to the unilateral conductivity of the vacuous space between cathode and anode, and the consequent ability of the two to derive a continuous unidirectional current from an alternating current was a recognition that the Edison tube embodying the structure described could be used as a rectifier of alternating current. This knowledge, disclosed by publication more than two years before Fleming's application, was a bar to any claim for a patent for an invention embodying the published disclosure. R. S. §§ 4886, 4920; 35 U. S. C. § 31, 69. *Wagner* v. *Meccano Ltd.*, 246 Fed. 603, 607; cf. *Muncie Gear Co.* v. *Outboard Co.*, *supra*, 766.

It is unnecessary to decide whether Fleming's use of the Edison device for the purpose of rectifying high frequency Hertzian waves as distinguished from low frequency waves, involved invention over the prior art, or whether the court below rightly held that the devices used by the Government did not infringe the claims sued upon, for we are of the opinion that the court was right in holding that Fleming's patent was rendered invalid by an improper disclaimer. It is plain that Fleming's original Claim 1, so far as applicable to use with low frequency alternating currents, involved nothing new, as Fleming himself must have known in view of his 1890 paper, and as he recognized by his disclaimer in 1915, made twenty-five years after his paper was published and ten years after his patent had been allowed. Its invalidity would defeat the entire patent unless the invalid portion had been claimed "through inadvertence, accident, or mistake, and without any fraudulent or deceptive intention", and was also disclaimed without "unreasonable" neglect or delay. R. S. §§ 4917, 4922, 35 U. S. C. §§ 65, 71; *Enston* v. *Simon Ascher & Co.*, 282 U. S. 445, 452; *Altoona Theatres* v. *Tri-Ergon Corp.*, 294 U. S. 477, 493; *Maytag* v. *Harley Co.*, 307 U. S. 243.

We need not stop to inquire whether, as the Government contends, the subject matter of the disclaimer was improper as in

effect adding a new element to the claim. See *Milcor Steel Co.* v. *Fuller Co.*, 316 U. S. 143, 147-8. For we think that the court below was correct in holding that the Fleming patent was invalid because Fleming's claim for "more than he had invented" was not inadvertent, and his delay in making the disclaimer was "unreasonable". Both of these are questions of fact, but since the court in its opinion plainly states its conclusions as to them, and those conclusions are supported by substantial evidence, its omission to make formal findings of fact is immaterial. Act of May 22, 1939, 53 Stat 752, 28 U. S. C. § 288(b); cf. *American Propeller Co* v. *United States*, 300 U. S. 475, 479-80; *Great Lakes Dredge & Dock Co.* v. *Huffman*, No. 849, May 24, 1943.

The purpose of the rule that a patent is invalid in its entirety if any part of it be invalid is the protection of the public from the threat of an invalid patent, and the purpose of the disclaimer statute is to enable the patentee to relieve himself from the consequences of making an invalid claim if he is able to show both that the invalid claim was inadvertent and that the disclaimer was made without unreasonable neglect or delay. *Easten* v. *Simon Ascher & Co., supra.* Here the patentee has sustained neither burden.

Fleming's paper of 1890 showed his own recognition that his claim of use of his patent for low frequency currents was anticipated by Edison and others. It taxes credulity to suppose, in the face of this publication, that Fleming's claim for use of the Edison tube with low frequency currents was made "through inadvertence, accident or mistake", which is prerequisite to a lawful disclaimer. No explanation or excuse is forthcoming for his claim of invention of a device which he had so often demonstrated to be old in the art, and which he had specifically and consistently attributed to Edison. Nor is any explanation offered for the delay of the patentee—the Marconi Company—in waiting ten years to disclaim the use of the device with low frequency currents and to restrict it to a use with high frequency Hertzian waves which Edison had plainly foreshadowed but not claimed. For ten years the Fleming patent was held out to the public as a monopoly of all its claimed features. That was too long in the absence of any explanation or excuse for the delay, and hence in this case was long enough to invalidate the patent. The conclusion of the Court of Claims not only has support in the

evidence, but we can hardly see how on this record any other could have been reached.

The Marconi Company's contention that it nowhere appears that Fleming was not the first inventor of the use of the patented device to rectify high frequency alternating currents is irrelevant to the question of the sufficiency of the disclaimer. The disclaimer itself is an assertion that the claimed use of the invention with low frequencies was not the invention of the patentee, whose rights were derived wholly from Fleming. This improper claim for something not the invention of the patentee rendered the whole patent invalid unless saved by a timely disclaimer which was not made.

The Marconi Company also asserts that, as it is suing as assignee of the patentee, it is unaffected by the provisions of the disclaimer statutes, which it construes as restricting to the "patentee" the consequences of unreasonable delay in making the disclaimer and as exempting the assignee from those consequences by the sentence "But no patentee shall be entitled to the benefits of this section if he has unreasonably neglected or delayed to enter a disclaimer". 35 U. S. C. 71. As the court below found, the Marconi Company was itself the patentee to whom the patent was issued on the assignment of Fleming's application in conformity to 35 U. S. C. § 44. The right given by § 71 to the patentee or his assignees to sue for infringement upon a proper disclaimer obviously does not relieve the patentee from the consequences of his failure to comply with the statute because he acquired his patent under an assignment of the application. *Altoona Theatres* v. *Tri-Ergon Corp., supra; Maytag Co.* v. *Hurley Co., supra; France Mfg. Co.* v. *Jefferson Electric Co.*, 106 F. 2d 605, 610. Such a contention is not supported by the words of the statute and if allowed would permit the nullification of the disclaimer statute by the expedient of an assignment of the application. We need not consider whether one who has taken an assignment of a patent after its issuance would have any greater rights than his assignor in the event of the latter's undue delay in filing a disclaimer. Compare *Apex Electrical Mfg. Co.* v. *Maytag Co.*, 122 F. 2d 182, 189.

The judgment in No. 373 is vacated and the cause remanded to the Court of Claims for further proceedings not inconsistent with this opinion.

The judgment in No. 369 is affirmed.

So ordered.

Mr. Justice MURPHY took no part in the consideration or decision of this case.

SUPREME COURT OF THE UNITED STATES.

Nos. 369, 373.—October Term, 1942.

369	Marconi Wireless Telegraph Company of America, Petitioner, *vs.* The United States.	On Writs of Certiorari to the Court of Claims.
373	The United States, Petitioner, *vs.* Marconi Wireless Telegraph Company of America.	

[June 21, 1943.]

Mr. Justice Frankfurter, dissenting in part.

I regret to find myself unable to agree to the Court's conclusion regarding the invalidity of the broad claims of Marconi's patent. Since broad considerations control the significance and assessment of the details on which judgment in the circumstances of a case like this is based, I shall indicate the general direction of my views.

It is an old observation that the training of Anglo-American judges ill fits them to discharge the duties cast upon them by patent legislation.[1] The scientific attainments of a Lord Moulton are perhaps unique in the annals of the English-speaking judiciary. However, so long as the Congress, for the purposes of patentability, makes the determination of originality a judicial function, judges must overcome their scientific incompetence as best they can. But consciousness of their limitations should make them

[1] "Considering the exclusive right to invention as given not of natural right, but *for* the benefit of society, I know well the difficulty of drawing a line between the things which are worth to the public the embarrassment of an exclusive patent, and those which are not. As a member of the patent board for several years, while the law authorized a board to grant or refuse patents, I saw with what slow progress a system of general rules could be matured. . . . Instead of refusing a patent in the first instance, as the board was authorized to do, the patent now issues of course, subject to be declared void on such principles as should be established by the courts of law. This business, however, is but little analogous to their course of reading, since we might in vain turn over all the lubberly volumes of the law to find a single ray which would lighten the path of the mechanic or the mathematician. It is more within the information of a board of academical professors, and a previous refusal of patent would better guard our citizens against harassment by law suits. But England had given it to her judges, and the usual predominancy of her examples carried it to ours." Thomas Jefferson to Mr.

vigilant against importing their own notions of the nature of the creative process into Congressional legislation, whereby Congress "to promote the Progress of Science and useful Arts" has secured "for limited Times to . . . Inventors the exclusive Right to their . . . Discoveries." Above all, judges must avoid the subtle temptation of taking scientific phenomena out of their contemporaneous setting and reading them with a retrospective eye.

The discoveries of science are the discoveries of the laws of nature, and like nature do not go by leaps. Even Newton and Einstein, Harvey and Darwin, built on the past and on their predecessors. Seldom indeed has a great discoverer or inventor wandered lonely as a cloud. Great inventions have always been parts of an evolution, the culmination at a particular moment of an antecedent process. So true is this that the history of thought records striking coincidental discoveries—showing that the new insight first declared to the world by a particular individual was "in the air" and ripe for discovery and disclosure.

The real question is how significant a jump is the new disclosure from the old knowledge. Reconstruction by hindsight, making obvious something that was not at all obvious to superior minds until someone pointed it out,—this is too often a tempting exercise for astute minds. The result is to remove the opportunity of obtaining what Congress has seen fit to make available.

The inescapable fact is that Marconi in his basic patent hit upon something that had eluded the best brains of the time working on the problem of wireless communication—Clerk Maxwell and Sir Oliver Lodge and Nikola Tesla. Genius is a word that ought to be reserved for the rarest of gifts. I am not qualified to say whether Marconi was a genius. Certainly the great eminence of Clerk Maxwell and Sir Oliver Lodge and Nikola Tesla in the field in which Marconi was working is not questioned.

Isaac M'Pherson, August 13, 1813, Works of Thomas Jefferson, Wash. Ed., vol. VI, pp. 181-82.

"I cannot stop without calling attention to the extraordinary condition of the law which makes it possible for a man without any knowledge of even the rudiments of chemistry to pass upon such questions as these. The inordinate expense of time is the least of the resulting evils, for only a trained chemist is really capable of passing upon such facts, e. g., in this case the chemical character of Von Furth's so-called "zinc compound," or the presence of inactive organic substances. . . . How long we shall continue to blunder along without the aid of unpartisan and authoritative scientific assistance in the administration of justice, no one knows; but all fair persons not conventionalized by provincial legal habits of mind ought, I should think, unite to effect some such advance." Judge Learned Hand in Parke-Davis & Co. v. Mulford Co., 189 Fed. 95, 115 (1911).

They were, I suppose, men of genius. The fact is that they did not have the "flash" (a current term in patent opinions happily not used in this decision) that begot the idea in Marconi which he gave to the world through the invention embodying the idea. But it is now held that in the important advance upon his basic patent Marconi did nothing that had not already been seen and disclosed.

To find in 1943 that what Marconi did really did not promote the progress of science because it had been anticipated is more than a mirage of hindsight. Wireless is so unconscious a part of us, like the automobile to the modern child, that it is almost impossible to imagine ourselves back into the time when Marconi gave to the world what for us is part of the order of our universe. And yet, because a judge of unusual capacity for understanding scientific matters is, by a process of intricate ratiocination, able to demonstrate that anyone could have drawn precisely the inferences that Marconi drew and that Stone hinted at [illegible] on paper, the Court finds that Marconi's patent was invalid although nobody except Marconi did in fact draw the right inferences that were embodied into a workable boon for mankind. For me it speaks volumes that it should have taken forty years to reveal the fatal bearing of Stone's relation to Marconi's achievement by a retrospective reading of his application to mean this rather than that. This is for me, and I say it with much diffidence, too easy a transition from what was not to what became.

I have little doubt, in so far as I am entitled to express an opinion, that the vast transforming forces of technology have rendered obsolete much in our patent law. For all I know the basic assumption of our patent law may be false, and inventors and their financial backers do not need the incentive of a limited monopoly to stimulate invention. But whatever revamping our patent laws may need, it is the business of Congress to do the revamping. We have neither constitutional authority nor scientific competence for the task.

Mr. Justice ROBERTS joins in this opinion.

SUPREME COURT OF THE UNITED STATES.

Nos. 369, 373.—October Term, 1942.

Marconi Wireless Telegraph Company of America, Petitioner, 369 *vs.* The United States. The United States, Petitioner, 373 *vs.* Marconi Wireless Telegraph Company of America.	On Writs of Certiorari to the Court of Claims.

[June 21, 1943.]

Mr. Justice Rutledge, dissenting in part.

Until now law[1] has united with almost universal repute[2] in acknowledging Marconi as the first to establish wireless telegraphy on a commercial basis. Before his invention, now in issue,[3] etherborne communication traveled some eighty miles. He lengthened the arc to 6,000. Whether or not this was "inventive" legally, it was a great and beneficial achievement.[4] Today, forty years after

[1] Marconi v. British Radio Tel. & Tel. Co., 27 T. L. R. 274; Marconi v. Helsby Wireless Tel. Co., 30 T. L. R. 688; *Société* Marconi v. *Société Générale*, etc., Civil Tribunal of the Seine, 3d Chamber, Dec. 24, 1912; Marconi Wireless Telegraph Co. of America v. National Electric Signalling Co., 213 Fed. 815 (D. C.); Marconi Wireless Telegraph Co. of America v. Kilbourne & Clark Mfg Co., 265 Fed. 644 (C. C. A.), aff'g 239 Fed. 328 (D. C.)

[2] Cf., e. g., 14 Encyc. Britannica (14th ed.) 869.

[3] His earliest American patent, U. S. Patent No. 586,193, granted on July 13, 1897, later becoming Reissue Patent No. 11,913, is not in suit here. That patent did not embrace many of the crucial claims here involved and its product cannot compare in commercial usefulness with that of the patent in suit.

[4] Courts closer to it chronologically than we are have characterized it as a "conspicuous advance in wireless telegraphy"; "a real accomplishment" and the ideas involved in the patent were said to "have proven of great value to the world," to have brought about "an entirely new and useful result," "a new and very important industrial result" and "a wonderful conquest." "The Marconi patent stands out as an unassailable monument until new discoveries are made." Cf. the authorities cited in note 1, *supra*.

the event, the Court's decision reduces it to an electrical mechanic's application of mere skill in the art.

By present knowledge, it would be no more. School boys and mechinics now could perform what Marconi did in 1900. But before then wizards had tried and failed. The search was at the pinnacle of electrical knowledge. There, seeking, among others, were Tesla, Lodge and Stone, old hands and great ones. With them was Marconi, still young as the company went,[2] obsessed with youth's zeal for the hunt.

At such an altitude, to work at all with success is to qualify for genius, if that is important. And a short step forward gives evidence of inventive power. For at that height a merely slight advance comes through insight only a first-rate mind can produce. This is so, whether it comes by years of hard work tracking down the sought secret or by intuition flashed from subconsciousness made fertile by long experience or shorter intensive concentration. At this level and in this company Marconi worked and won.

He won by the test of results. No one disputes this. His invention had immediate and vast success, where all that had been done before, including his own work, gave but narrowly limited utility. To make useful improvement at this plane, by such a leap, itself shows high capacity. And that is true, although it was inherent in the situation that Marconi's success should come by only a small margin of difference in conception. There was not room for any great leap of thought, beyond what he and others had done, to bring to birth the practical and useful result. The most eminent men of the time were conscious of the problem, were interested in it, had sought for years the exactly right arrangement, always approaching more nearly but never quite reaching the stage of practical success. The invention was, so to speak, hovering in the general climate of science, momentarily awaiting birth. But just the right releasing touch had not been found. Marconi added it.

When to altitude of the plane of conception and results so immediate and useful is added well-nigh unanimous contemporary judgment, one who long afterward would overturn the invention assumes a double burden. He undertakes to overcome what

[2] He was only twenty-six years old at the time he applied for the patent in suit, but he had already made substantial contributions to the field.

would offer strong resistance fresh in its original setting. He seeks also to overthrow the verdict of time. Long-range retroactive diagnosis, however competent the physician, becomes hazardous by progression as the passing years add distortions of the past and destroy its perspective. No light task is accepted therefore in undertaking to overthrow a verdict settled so long and so well, and especially one so foreign to the art of judges.

In lawyers' terms this means a burden of proof, not insurmountable, but inhospitable to implications and inferences which in less settled situations would be permissible to swing the balance of judgment against the claimed invention. That Marconi received patents elsewhere which, once established, have stood the test of time as well as of contemporary judgment, and secured his American patent only after years were required to convince our office he had found what so many others sought, but emphasizes the weight and clarity of proof required to overcome his claim.

Marconi received patents here in England, and in France.[6] The American patent was not issued perfunctorily. It came forth only after a long struggle had brought about reversal of the Patent Office's original and later rejections. The application was filed in November, 1900. In December it was rejected on Lodge,[7] and an earlier patent to Marconi.[8] It was amended and again rejected. Further amendments followed and operation of the system was explained. Again rejection took place, this time on Lodge, the earlier Marconi, Braun and other patents. After further proceedings, the claims were rejected on Tesla.[9] A year elapsed, but in March, 1904, reconsideration was granted. Some claims then were rejected on Stone,[10] others were amended, still others were cancelled, and finally on June 28, 1904, the patent issued. French and British patents had been granted in 1900.

Litigation followed at once. Among Marconi's American victories were the decisions cited above.[11] Abroad the results were similar.[12] Until 1935, when the Court of Claims held it invalid

[6] U. S. Patent No. 763,772; British Patent No. 7777 of 1900; French Patent No. 305,060 of Nov. 3, 1900.

[7] British patent to Lodge No. 23,505.

[8] Cf. note 3 *supra.*

[9] U. S. Patent to Tesla No. 649,621, May 15, 1900, division of 645,576, March 20, 1900 (filed Sept. 2, 1897).

[10] Cf. text *infra.*

[11] Cf. note 1 *supra.*

[12] *Ibid.*

in this case, 81 Ct. Cl. 671, no court had found Marconi's patent wanting in invention. It stood without adverse judicial decision for over thirty years. In the face of the burden this history creates, we turn to the references, chiefly Tesla, Lodge and Stone. The Court relies principally on Stone, but without deciding whether this was inventive.

It is important, in considering the references, to state the parties' contentions concisely. The Government's statement is that they differ over whether Marconi was first to conceive four-circuit "tuning" for transmission of sound by Hertzian waves. It says this was taught previously by Tesla, Lodge and Stone. Petitioner however says none of them taught what Marconi did. It contends that Marconi was the first to accomplish the kind of tuning he achieved, and in effect urges this was patentably different from other forms found earlier.

Specifically petitioner urges that Tesla had nothing to do with either Hertzian waves or tuning, but in fact his transmitting and receiving wires could not be tuned.[13] Lodge, it claims, disclosed a tuned antenna, for either transmitter or receiver or both, but the closed circuits associated with the antenna ones were not tuned. Finally it is said Stone does not describe tuning the antenna, but does show tuning of the associated closed circuit. And Marconi tuned both.

Petitioner does not claim the general principles of tuning. It admits they had long been familiar to physicists and that Lodge and others fully understood them. But it asserts Lodge did not know what circuits should be tuned, to accomplish what Marconi achieved, and that, to secure this, "knowledge that tuning is possible is not enough—there is also required the knowledge of whether or not to tune and how much."

Likewise, petitioner does not deny that Stone knew and utilized the principles of tuning, but urges, with respect to the claim he applied them to all of the four circuits, that the only ones tuned,

[13] Tesla in fact did not use Hertzian waves. His idea was to make the ether a conductor for long distances by using extremely high voltage, 20,000,000 to 30,000,000 volts, and extremely high altitudes, 30,000 to 40,000 feet or more, to secure transmission from aerial to aerial. Balloons, with wires attached reaching to the ground, were his suggested aerials. His system was really one for transmitting power for motors, lighting, etc., to "any terrestrial distance," though he incidentally mentions "intelligible messages." As he did not use Hertzian waves, he had no such problem of selectivity as Marconi, Lodge, Stone and others were working on later.

in his original application, were the closed circuits and therefore that the antenna circuits were not tuned; although it is not denied that the effects of tuning the closed circuits were reflected in the open ones by what Stone describes as "producing *forced* simple harmonic electric vibrations of the same periodicity in an elevated conductor."

The Stone amendments of 1902, made more than a year after Marconi's filing date, admittedly disclose tuning of both the closed and the open circuits, and were made for the purpose of stating expressly the latter effect, claimed to be implicit in the original application. Petitioner denies this was implicit and argues, in effect, that what Stone originally meant by "producing *forced* . . . vibrations" was creating the desired effects in the antenna *by force*, not by tuning; and therefore that the two methods were patentably different.

It seems clear that the parties use the word "tuning" to mean different things and the ambiguity, if there is one, must be resolved before the crucial questions can be stated with meaning. It will aid, in deciding whether there is ambiguity or only confusion, to consider the term and the possible conceptions it may convey in the light of the problems Marconi and Stone, as well as other references, were seeking to solve.

Marconi had in mind first a specific difficulty, as did the principal references. It arose from what, to the time of his invention, had been a baffling problem in the art. Shortly and simply, it was that an electrical circuit which is a good conserver of energy is a bad radiator and, conversely, a good radiator is a bad conserver of energy. Effective use of Hertzian waves over long distances required both effects. To state the matter differently, Lodge had explained in 1894 the difficulties of fully utilizing the principle of sympathetic resonance in detecting ether waves. To secure this, it was necessary, on the one hand, to discharge a long series of waves of equal or approximately equal length. Such a series can be produced only by a circuit which conserves its energy well, what Marconi calls a persistent oscillator. On the other hand, for distant detection, the waves must be of substantial amplitude, and only a circuit which loses its energy rapidly can transmit such waves with maximum efficiency. Obviously in a single circuit the two desired effects tend to cancel each other, and therefore to limit the distance of detection. Similar difficulty characterized the receiver, for a good radiator is a good absorber,

and that very quality disables it to store up and hold the effect of a train of waves, until enough is accumulated to break down the coherer, as detection requires.

Since the difficulty was inherent in a single circuit, whether at one end or the other, Marconi used two in both transmitter and receiver, four in all. In each station he used one circuit to obtain one of the necessary advantages and the other circuit to secure the other advantage. The antenna (or open) circuits he made "good radiators" (or absorbers). The closed circuits he constructed as "good conservers." By coupling the two at each end loosely he secured from their combination the dual advantages he sought. At the transmitter, the closed circuit, by virtue of its capacity for conserving energy, gave persistent oscillation, which passed substantially undiminished through the coupling transformer to the "good radiator" open circuit and from it was discharged with little loss of energy into the ether. Thence it was picked up by the "good absorber" open circuit and passed, without serious loss of energy, through the coupling transformer, into the closed "good conserving" circuit, where it accumulated to break the coherer and give detection.

Moreover, and for present purposes this is the important thing, Marconi brought the closed and open circuits into almost complete harmony by placing variable inductance in each. Through this the periodicity of the open circuit was adjusted automatically to that of the closed one; and, since the circuits of the receiving station were similarly adjustable, the maximum resonance was secured throughout the system. Marconi thus not only solved the dilemma of a single circuit arrangement, he attained the maximum of resonance and selectivity by providing in each circuit independent means of tuning.

In 1911 this solution was held inventive, as against Lodge, Marconi's prior patents, Braun and other references, in *Marconi* v *British Radio Tel. & Tel. Co.*, 27 T. L. R. 274. Mr. Justice Parker carefully reviewed the prior art, stated the problem, Marconi's solution, and in disposing of Braun's specification concluded it "did not contain even the remotest suggestion of the problem . . . , much less any suggestion bearing on its solution. . . ." As to Lodge, Mr. Justice Parker observed, referring first to Marconi:

". . . It is important to notice that *in the receiver* the mere introduction of two circuits instead of one was no novelty. A

figure in Lodge's 1897 patent shows the open circuit of his receiving aerial linked through a transformer with a closed circuit containing the coherer, *his idea being, as he states, 'to leave his receiving aerial to vibrate electrically without disturbance from attached wires.* This secondary circuit, as shown, *is not tuned to, nor can it be tuned to,* the circuit of the aerial. This, in my opinion, is exceedingly strong evidence that Marconi's 1900 invention was not so obvious as to deprive it of subject matter. In the literature quoted there is no trace of the idea underlying Mr. Marconi's invention, nor, so far as I can see, a single suggestion from which a competent engineer could arrive at this idea." (Emphasis added.)

It was therefore clearly Mr. Justice Parker's view, in his closer perspective to the origin of the invention and the references he considered, that in none of them, and particularly not in Lodge or Braun, was there anticipation of Marconi's solution.

He did not mean that the references did not apply "the principle of resonance as between transmitter and receiver" or utilize "the principle of sympathetic resonance for the purpose of detection of ether waves." For he expressly attributed to Lodge, in his 1894 lectures, explanation "with great exactness [of] the various difficulties attending the full utilization" of that principle. And in referring to Marconi's first patent, of 1896, the opinion states that Marconi "*for what it was worth* . . . tuned the two circuits [i. e., the sending and receiving ones] together as Hertz had done." (Emphasis added.)

From these and other statements in the opinion it is obvious that Mr. Justice Parker found Marconi's invention in something more than merely the application of the "principle of resonance," or "sympathetic resonance," or its use to "tune" together the transmitting and receiving circuits. For Marconi in his own prior inventions, Lodge and the other references, in fact all who had constructed any system using Hertzian waves capable of transmitting and detecting sound, necessarily had made use, in some manner and to some extent, of "the principle of resonance" or "sympathetic resonance." That principle is inherent in the idea of wireless communication by Hertzian waves. So that, necessarily, all the prior conceptions included the idea that common periodicity must appear in all of the circuits employed.

Nor did Mr. Justice Parker's opinion find the inventive feature in the use of two circuits instead of one, at any rate in the receiver. For he expressly notes this in Lodge. But he points out that Lodge added the separate circuit "to leave his receiving aerial

free to vibrate electrically without disturbance from attached wires." And he goes on to note that this secondary (or closed) circuit not only was not, but could not be, "tuned" to the aerial circuit. And this he finds "exceedingly strong evidence" that "Marconi's 1900 invention was not so obvious as to deprive it of subject matter." Lodge had "tuned" the antenna circuit, by placing in it a variable inductance. But he did not do this or accomplish the same thing by any other device, such as a condenser, in the closed circuit. And the fact that so eminent a scientist, the one who in fact posed the problem and its difficulties, did not see the need for extending this "independent tuning" (to use Marconi's phrase) to the closed circuit, so as to bring it thus in tune with the open one, was enough to convince Mr Justice Parker, and I think rightly, that what Marconi did over Lodge was not so obvious as to be without substance.

In short, Mr. Justice Parker found the gist of Marconi's invention, not in mere application of the general principle or principles of resonance to a four-circuit system, or in the use of four circuits or the substitution of two for one in each or either station; but, as petitioner now contends, in recognition of the principle that, whether in the transmitter or the receiver, attainment of the maximum resonance required that means for tuning the closed to the open circuit be inserted in both. That recognized, the method of accomplishing the adjustment was obvious, and different methods, as by using variable inductance or a condenser, were available. As petitioner's reply brief states the matter, "The Marconi invention was not the use of a variable inductance, *nor* indeed *any other specific way* of tuning an antenna—before Marconi it was known that electrical circuits could be tuned or not tuned, by inductance coils or condensers. His broad invention was *the combination of a tuned antenna circuit* and *a tuned closed circuit*." (Emphasis added.) And it is only in this view that the action of the Patent Office in finally awarding the patent to Marconi can be explained or sustained, for it allowed claims both limited to and not specifying variable inductance. That feature was essential for both circuits in principle, but not in the particular method by which Marconi accomplished it. And it was recognition of this which eventually induced allowance of the claims, notwithstanding the previous rejections on Lodge, Stone and other references including all in issue here.

In the perspective of this decade, Marconi's advance, in requiring "independent tuning," that is, positive means of tuning

located in both closed and open circuits, seems simple and obvious. It was simple. But, as is often true with great inventions, the simplest and therefore generally the best solution is not obvious at the time, though it becomes so immediately it is seen and stated. Looking back now at Edison's light bulb one might think it absurd that highly useful and beneficial idea had not been worked out long before, by anyone who knew the elementary laws of resistance in the field of electric conduction. But it would be shocking, notwithstanding the presently obvious character of what Edison did, for any court now to rule he made no invention.

The same thing applies to Marconi. Though what he did was simple, it was brilliant, and it brought big results. Admittedly the margin of difference between his conception and those of the references, especially Lodge and Stone, was small. It came down to this, that Lodge saw the need for and used means for performing the function which variable inductance achieves in the antenna or open circuit, Stone did the same thing in the closed circuit, but Marconi first did it in both. Slight as each of these steps may seem now, in departure from the others, it is as true as it was in 1911, when Mr. Justice Parker wrote, that the very fact men of the eminence of Lodge and Stone saw the necessity of taking the step for one circuit but not for the other is strong, if not conclusive, evidence that taking it for both circuits was not obvious. If this was so clearly indicated that anyone skilled in the art should have seen it, the unanswered and I think unanswerable question remains, why did not Lodge and Stone, both assiduously searching for the secret and both preeminent in the field, recognize the fact and make the application? The best evidence of the novelty of Marconi's advance lies not in any judgment, scientific or lay, which could now be formed about it. It is rather in the careful, considered and substantially contemporaneous judgments, formed and rendered by both the patent tribunals and the courts when years had not distorted either the scientific or the legal perspective of the day when the invention was made. All of the references now used to invalidate Marconi were in issue, at one time or another, before these tribunals, though not all of them were presented to each. Their unanimous conclusion, backed by the facts which have been stated, is more persuasive than the most competent contrary opinion formed now about the matter could be.

It remains to give further attention concerning Stone. Admittedly his original application did not require tuning, in Marconi's sense, of the antenna circuit, though it specified this for the closed one. He included variable inductance in the latter, but not in the former. His device therefore was, in this respect, exactly the converse of Lodge. But it is said his omission to specify the function (as distinguished from the apparatus which performed it) for the antenna circuit was not important, because the function was implicit in the specification and therefore supported his later amendment, filed more than a year following Marconi's date, expressly specifying this feature for the open circuit.

Substantially the same answer may be made to this as Mr. Justice Parker made to the claim based on Lodge. Tuning both circuits, that is, including in each independent means for variable adjustment, was the very gist of Marconi's invention. And it was what made possible the highly successful result. It seems strange that one who saw not only the problem, but the complete solution, should specify only half what was necessary to achieve it, neglecting to mention the other and equally important half as well, particularly when, as is claimed, the two were so nearly identical except for location. The very omission of explicit statement of so important and, it is claimed, so obvious a feature is evidence it was neither obvious nor conceived. And the force of the omission is magnified by the fact that its author, when he fully recognized its effect, found it necessary to make amendment to include it, after the feature was expressly and fully disclosed by another. Amendment under such circumstances, particularly with respect to a matter which goes to the root rather than an incident or a detail of the invention, is always to be regarded critically and, when the foundation claimed for it is implicit existence in the original application, as it must be, the clearest and most convincing evidence should be required when the effect is to give priority, by backward relation, over another application intermediately filed.

Apart from the significance of omitting to express a feature so important, I am unable to find convincing evidence the idea was implicit in Stone as he originally filed. His distinction between "natural" and "forced" oscillations seems to me to prove, in the light of his original disclosure, not that "tuning" of the antenna circuit as Marconi required this was implicit, but rather

that it was not present in that application at all. It is true he sought, as Marconi did, to make the antenna circuit at the transmitter the source of waves of but a single periodicity and the same circuit at the receiver an absorber only of the waves so transmitted. But the methods they used were not the same. Stone's method was to provide "what are *substantially forced* vibrations" in the transmitter's antenna circuit and, at the receiver, to impose "between the vertical conductor [the antenna] . . . and the translating devices [in the closed circuit] [other] *resonant circuits attuned* to the particular frequency of the electro-magnetic waves which it is desired to have operate the translating devices." (Emphasis added.) In short he provided for "tuning," as Marconi did, the transmitter's closed circuit, the receiver's closed circuit and the intermediate circuits which he interposed in the receiver between the open or antenna one and the closed one. But nowhere did he provide for or suggest "tuning," as Marconi did and in his meaning, the antenna circuit of the transmitter or the antenna circuit of the receiver. For resonance in the former he depended upon the introduction, from the closed circuit, of "substantially forced electric vibrations" and for selectivity in the latter he used the intermediate tuned circuits. Stone and Marconi used the same means for creating persistent oscillation, namely, the use of the separate closed circuit; and in this both also developed single periodicity to the extent the variable inductance included there and there only could do so. But while both created persistent oscillation in the same way, Marconi went farther than Stone with single periodicity and secured enhancement of this by placing means for tuning in the antenna circuit, which admittedly Stone nowhere expressly required in his original application. And, since this is the gist of the invention in issue and of the difference between the two, it will not do to dismiss this omission merely with the statement that there is nothing to suggest that Stone "did not desire to have those circuits tuned." Nor in my opinion do the passages in the specifications relied upon as "suggesting" the "independent" tuning of the antenna circuits bear out this inference.

When Stone states that "the vertical conductor at the transmitter station is made the source of . . . waves of but a single periodicity," I find nothing to suggest that this is accomplished by specially tuning that circuit, or, in fact, anything more than that this circuit is a good conductor sending out the single period waves

Co., supra. The amendment here should receive the same fate as befell the one there involved.

Stone's letters to Baker, quoted in the Court's opinion, show no more than his original application disclosed. There is no hint or suggestion in them of tuning the antenna circuits "independently" as Marconi did. And the correspondence gives further proof he contemplated introducing the inductance coil (or a device equivalent in function) into the closed circuit, but expressed no idea of doing the same thing in the open one.

In my opinion therefore the judgment should be reversed, in so far as it holds Marconi's broad claims invalid.